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Stable Isotope Diet Reconstruction of Feral Horses (*Equus caballus)* on the Sheldon National Wildlife Refuge, Nevada, USA

Megan K. Nordquist

A thesis submitted to the faculty of
Brigham Young University
in partial fulfillment of the requirements for the degree of

Master of Science

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ABSTRACT

Stable Isotope Diet Reconstruction of Feral Horses (*Equus caballus)* on the Sheldon National Wildlife Refuge, Nevada, USA

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Master of Science

Feral horse management has become a subject of significant controversy in the United States. This is because of differing opinions and minimal recent empirical data on feral horses. In recent years, numbers of feral horses have increased due to governmental horse removal restrictions (specifically the Wild Horse and Burro act of 1971). With increasing numbers of feral horses on rangelands, land managers are challenged with identifying the appropriate course of action for satisfying groups with differing opinions.

The purpose of this study is to characterize diet consumption through the use of stable isotope dietary analysis ($\delta^{15}N$ and $\delta^{13}C$). We did this in order to measure the impact of feral horse forage consumption on rangelands and to propose strategies for improving habitat management and conservation. We obtained tail hair isotopic values from tail hair removed while horses that were held in squeeze chutes following a roundup. Resulting isotopic values were compared to plant isotopic values using plant samples obtained from the geographical areas as the horses in order to characterize diet. Contribution of the various plant species to the tail hair mixture values was determined using the EPA program IsoSource©. Initial analysis of tail hair isotopes demonstrated seasonal variation. During summer months, shrubs (mostly *Artemesia spp*, and *Purshia Tridentate*), *Elymus elymoides*, *Juncus balticus*, and *Festuca idahoensis* were the predominantly consumed vegetative species. During fall months, *Leymus cinereus* and *Juncus balticus* played a more significant role in feral horse diet. In the winter, shrubs were more heavily consumed along with *Poa secunda*. Springtime showed a shift towards forb consumption. Changes in seasonal consumption of forages are most likely linked to forage availability as well as equine preference.

We analyzed plant metrics (specifically biomass, abundance, and cover) to compare a site with horses present to a site where horses had been removed the previous year and found relatively few differences between the two sites. With nearly all differences we found higher plant production (forage availability) on the site where horses were still present. In riparian areas however, there was more vegetation (specifically *Carex rossii*, *Juncus balticus*, and *Poa secunda*) on the site where horses had been removed. Within riparian areas, only *Bromus tectorum* (a plant not typically found in riparian areas but characteristic of degraded areas) showed significantly greater amounts of biomass on the site with horses present. Knowledge of plant species consumption will allow land managers greater ability to make scientifically based decisions regarding feral horse population control which is important in determining appropriate management levels of populations.

Keywords: feral horses, stable isotopes, diet, forage selection, forage availability, IsoSource

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LITERATURE REVIEW INTRODUCTION

Feral horses (*Equus caballus*)[1] have drawn increasing interest and attention in recent years. With mounting numbers of feral horses on rangelands, negative impacts have been identified involving native plant and animal species as well as abiotic components of the ecosystem (i.e. hydrology, soil structure, etc.). The purpose of this chapter is to convey available information regarding feral horse population and habitat use characteristics (particularly regarding diet and forage selection) by presenting 1) a general description of feral horse habitat selection, time allocation, band structure, foaling rates, and population dynamics, 2) a description of grazing and feeding habits, with a particular emphasis on differences in diet between feral horses and other ungulates with which they compete, and 3) a review of available literature regarding potential and actual impacts horses have on rangelands. This review includes a discussion of the affects on wildlife, vegetation impacts, consequence to riparian areas, and changes to soils as well as a statement about how to mitigate such impacts. It will discuss some of the current management techniques employed by the Bureau of Land Management as well as the United States Fish and Wildlife Services.

This chapter serves as a springboard and introduction to our particular area of study involving stable isotope diet reconstruction of feral horses on the Sheldon National Wildlife Refuge (NWR) using stable isotopic analysis. It also provides a description of the physical

[1] The term feral refers to animals that were once domesticated. All free-ranging horses currently on North American rangelands (the principal area of study) came from domestic stock after native wild North American horses went extinct in the late Pleistocene (approximately 10,000 ybp) (Berger 1986). Despite the fact that feral horses are typically referred to as free-ranging, wild, or feral, for ease and convenience we have lumped them all into the term, "feral horses" throughout this paper.

characteristics of the Sheldon NWR (including its geographical location, the habitat, climate, and elevation).

The final section of this chapter introduces the reader to the use of carbon and nitrogen isotopes in dietary characterization. The focus of this introductory material will center on hair isotopic analysis in determining diet.

GENERAL FERAL HORSE CHARACTERISTICS

Habitat Selection

Feral horses spend the majority of their time in shrublands and meadows at relatively high elevations (Berger 1986). When horses are not in high-elevation sites, they preferentially select streamsides, bogs/meadows, and mountain sagebrush habitats (Linklater *et al*. 2000). Subsequently, feral horses allocate the majority of their time in sites of those habitat types and sites adjacent to or within close proximity to those habitat types (Linklater *et al*. 2000). Lowland sagebrush habitats, south-facing aspects, steep slopes, bare ground, and forest remnants are avoided (Crane *et al*. 1997). Habitat types are selected or avoided by feral horses due to three different factors: food, water, and shelter (Miller 1983).

Of these three factors, the most influential in habitat selection is food. Specifically, forage availability and succulence of available forages are factors that dominate habitat selection (Duncan 1983; Crane *et al*. 1997; Salter & Hudson 1979). Feral horses will typically select habitats with large quantities of high quality forage (defined as areas with >90g/m^2 of green plant matter) and prefer areas with a high concentration of preferred forage species (Duncan 1983).

Water

The availability of water is second to forage availability in importance for determining feral horse habitat selection (Miller 1983). During summer months, feral horses spend the

majority of their time within 4.8 km of a water source (Miller 1983). However, during late fall, winter, and early spring areas farther from water sources may be frequented. Shifts are due to changes in forage species availability within a plant community through the seasons (Miller 1983). Interestingly, the distance that feral horses remain from a water source is correlated with the average 7-day temperature. Colder weather causes horses to maintain winter patterns, meaning they reside farther away from water sources, and warmer weather causes horses to maintain summer patterns, remaining closer to water sources (Miller 1983).

Seasonal Variability in Habitat Selection

Fall/Winter

During the fall and winter, feral horses are more likely to be found in areas of higher elevations, ridges and areas with north-facing aspects. During fall and winter forage availability is proportionately greater in higher elevations and horses are able to find more protection from inclement weather in these areas (Miller 1983, Linklater *et al*. 2000). Within these higher elevations and ridges, habitat use typically focuses on sagebrush/shrubland and grasslands (Miller 1983, Berger 1986). The next most used habitat types are juniper stands followed by meadows (Berger 1986).

Spring/Summer

Early in the spring, feral horses are often found in habitats similar to fall/winter habitats (shrublands and grasslands). This is likely due to foaling and mating during the early spring (Linklater *et al.* 2000). During late spring and early summer, feral horses are more likely to spend time in short grassy vegetation/flush zones with lower elevations and gentler slopes, such as river bottoms and stream valley floors (Linklater *et al*. 2000). One study reports that horses in

Wyoming's Red Desert prefer habitat with saltbush-winterfat present during late spring and early summer (Miller 1983).

Allocation of Feral Horse Time

Feeding

Time budgeting for feral horses revolves around the central concept of feeding. Feral horses spend as much time as possible throughout their day obtaining food. Grazing patterns of feral ponies in Assateague Island show they spend 55% of nocturnal hours foraging (Keiper 1980). Time that horses spend grazing is limited by the need for other activities such as resting, moving, drinking, socializing, and reproduction (Berger 1986; Duncan 1985; Miller 1983). The quality of forage in a given home range of horses also affects grazing time (Berger 1986). In areas with higher quality forage (greater proportion of green matter), horses spend significantly less time foraging, whereas in areas of lower-quality forage (less green matter), horses spend a significantly longer time foraging (Berger 1986).

Experiments show that the onset of feeding is under endogenous control. This means that when blood glucose concentrations are high, the onset of feeding is delayed whereas when blood glucose concentrations are low, horses begin foraging (Mayes & Duncan 1986). It is also possible that feeding lengths, as well as sleep patterns, are determined by circadian rhythms. Therefore, when a horse is not resting or sleeping, it is induced to eat (Mayes & Duncan 1986). Along with glucose concentrations and activity of the horse, gut-fill plays a role in the induction of feeding. When gut-fill levels are low, horses begin to feed and when gut-fill levels are high, horses refrain from eating (Mayes & Duncan 1986).

Differences in Time Allocation between Reproductive Categories

Males spend significantly less time feeding than females (both lactating and non-lactating). Lactating females spend significantly more time feeding than non-lactating females (Berger 1986). This incongruity between lactating and non-lactating females may be explained through hormonal control or circadian rhythms (Berger 1986; Mayes & Duncan 1986). Breeding mares spend more time feeding (6-8% increase) during times of nutritional stress such as the peak of lactation in the end of winter (Duncan 1985).

Seasonal Differences in Time Allocation of Feral Horses

Due to the high protein content of forages in the springtime, horses spend less time foraging and more time resting than they do during any other season (Duncan 1985). This equates to approximately 75% of springtime daylight hours spent in foraging activities (Salter & Hudson 1979). In the summer, there is an increase in time spent walking and standing alert as compared to the other seasons. This increase is likely due to higher numbers of mosquitoes and other pests in the area (Duncan 1985). During the fall and winter, horses spend more time resting in sheltered areas than during the other seasons. This is particularly true during heavy rain and colder temperatures (Duncan 1985).

Band structure

Males are born in about the same numbers as females (Linklater *et al*. 2000; Berger 1986), but feral horses typically live in harem groups with a dominant stallion and between 1 and 11 mares (Feist & McCullough 1976; Linklater *et al*. 2000). In 88% of bands, only 1 stallion exists (Berger 1986) but up to four dominant stallions per band have been observed (Linklater *et al*. 2000). Approximately 12% of bands have more than one stallion protecting them (stallions in all the bands will fight on behalf of the band) although one stallion maintains both dominance over the other non-dominant stallions as well as breeding access to females (Berger 1986). Non-

dominant males fight with outside males more frequently than dominant stallions (Berger 1986). Older males form multi-male breeding bands more frequently than younger males (Berger 1986). Stallions without a harem, called bachelor stallions, either form small groups, with two to three individuals, or live solitarily (Berger 1986). Males only show aggression towards each other in 5% of all male-male interactions, thus only an average of 3% of all males die each year from combat-related injuries (Berger 1986).

The degree of stability exhibited by bands is determined by the degree of force exerted by the dominant stallion as well as the fidelity of group members (Feist & McCullough 1976). Young mares show less fidelity to a band than older mares (Berger 1986). In 55% of all cases of mares leaving a band, it is due to physical exclusion by a stallion, while 45% of the time, it is due to mares wandering away (Berger 1986).

The size of home ranges for a band is positively correlated with band size (Linklater *et al*.2000). With both harem-structured and bachelor groups, bands frequently overlap in home range (this is true for both harem-structured groups as well as bachelor groups) (Feist & McCullough 1976; Berger 1986; Linklater *et al*. 2000). Due to this overlap in home ranges, stallions often leave their band (up to 1 km away) to investigate other horses and search for more potential females (Berger 1986).

Foaling

Foaling typically occurs in May or early June (Feist & McCullough 1976) though it occasionally will occur throughout the year (Berger 1986). In general, variability in ungulate birthing times of the year is a result of numerous factors such as predation (Estes 1976), nutrition (vegetation growth) (Anderson 1979; Rutberg 1984; Sadleir 1969), photoperiod (Spinage 1973;

Sadleir 1969), and past reproductive success/failure of individuals (Guinness *et al.* 1973). This is true of feral horses.

Foaling begins in females between the ages of 2-4 and continues annually until the female is approximately 22 years old. Often times, however, the female continues breeding past this date (Berger 1986; Wolfe 1986). In a population, 15-35% of the 2-year old females become pregnant and go on to reproduce each year. Once mares reach the age of 4, the frequency of pregnancy is 60-85% of the female population (Wolfe 1986).

Postpartum estrous cycles in the spring occur 11 days after parturition but are approximately 24 days later if parturition occurs in the winter instead of spring (Berger 1986). Due to physical stress during band take-over as well as harassment by new band stallions, pregnant mares in over-taken bands experience higher rates of prenatal loss than do stable bands (Berger 1986).

Gestation lengths are affected by social, physical, and ecological factors. Male foals induce a longer gestation length than female foals and larger/older mares have longer gestation rates than smaller/younger mares (Berger 1986). Foals are usually weaned between nine and 12 months but can be weaned up to 16 months in mares that are barren the year after a foal is born (Berger 1986; Feist & McCollough 1976).

Infanticide does not usually occur among feral horses; however stallions often show aggression towards male foals that are not their offspring (Berger 1986). Duncan (1982) reports the occurrence of infanticide when a male takes over a band and kills existing colt offspring.

Population Dynamics

The majority of feral horse deaths can be attributed to winter abrasion (extreme temperatures, inclement weather, lack of water and food). Most deaths (70% in the Great Basin)

occur at high altitudes (Berger 1986). Annual foal survival rates (in normal years) are between 90-95% which leads to an annual population increase between 15% and 23% (Berger 1986; USFWS 2009; Wolfe 1986). However, due to the high variability among factors affecting different feral horse populations in various regions, it is extremely difficult to make precise generalizations regarding population dynamics of feral horses (Wolfe 1986).

GRAZING AND FEEDING HABITS

General

Smith *et al*. (1998) in the *Southwestern Naturalist* report that feral horse diet consists of 91% grasses, 8% shrubs, and >1% forbs and unknowns and is consistent throughout the seasons. However, there were changes in habitat selection and a few of the consumed forages changed significantly throughout the year. Other studies report that diet does vary significantly throughout the year due to changes in forage availability. They also show that dietary quality as well as type varies seasonally (Salter & Hudson 1979).

Multiple studies reported gramineous plant species as the major constituent to feral horse diet in all seasons staying at or above 83% of the diet. Salter & Hudson (1979) report a value of 83% grasses. Smith *et al*. (1998) report 91% grasses. McInnis & Vavra (1987) report 88% grasses. Sedges (*Carex* spp.), found in bogs/meadows and streamsides, are also very important dietary components (Salter & Hudson *et al*. 1979; Crane *et al.* 1997). Shrubs and forbs play a significant though more limited role in feral horse diet (Krysl *et al.* 1984a).

The major grass components in feral horse diet most likely vary across sites depending on availability of forages. Several studies report the major constituents of feral horse diet. Hansen *et al*. (1977) in the *Journal of Range Management* claims the most important grasses are needlegrasses, wheatgrasses, and bromes. Krysl *et al*. (1984a) in the *Journal of Range*

Management report that needle and thread (*Stipa comata*), sandberg bluegrass (*Poa secunda*), thickspike wheatgrass (*Elymus lanceolatus*), Indian ricegrass (*Achnatherum hymenoides*), gray horsebrush (*Tetradymia canescens*), and winterfat (*Kraschenninnikovia lanata*) are the most important dietary constituents. Salter & Hudson (1979) in the book The Ecology of Reproduction in Wild and Domestic Mammals report that hairy wild rye (*Elymus innovates*) and fescues (*Festuca* spp.) are the most important species. McInnis & Vavra (1987) in the *Journal of Range Management* report bottlebrush squirreltail (*Sitanian hystrix*), bearded bluebunch wheatgrass (*Agropyron spicatum*), and thurbers needlegrass (*Stipa thurbariana*) as heavily selected dietary components.

Feral horses consume forages that average 7.5% crude protein during the summer and are 6.1% in the winter. During the summer, average dry matter consumption is 52%, while during winter, dry matter consumption is 39% (Krysl *et al.* 1984b).

Feral horse diet compared to other ungulates

Throughout the course of a season, most large herbivores consume a wide variety of plant species; however, large herbivores generally have a diet of less than six major plant species per season (Olsen *et al.* 1977). Feral horse diets are quite similar to those of some of the other grazing large ungulates in the same geographical area (Olsen *et al*. 1977; Hubbard *et al*. 1976). This is particularly true with other non-selective grazing ungulates such as domestic cattle (*Bos taurus*) and elk (*Cervus canadensis*), whose diets consist more frequently of grasses and sedges (Olsen *et al.* 1977; Hubbard *et al.* 1976). Dietary overlap between horses and other ungulates such as pronghorn antelope (*Antelocapra americana*) and mule deer (*Odocoileus hemionus*) is typically much lower (between 7% in summer and 26% in winter). The wide range of dietary overlap between these browsers and grazers suggests that feral horse interactions with other

ungulates are a combination of noncompetitive coexistence and exploitative competition (McInnis & Vavra1987).

Cattle/elk vs. Feral Horses

Due to the fact that horses, cattle, and elk all compete heavily for similar food resources, they directly compete whenever resources are scarce (Hansen & Clark 1977). Due to similarities in feral horse habitat and diet, the potential for competition between horses and cattle is high (Menard *et al*. 2002). Various studies report differing numbers of similarity between feral horse and cattle diet ranging somewhere between 59% to 84% (Hubbard *et al*. 1976; Hansen *et al*. 1977; Krysl *et al*. 1984a). Not only are similar vegetative species chosen for consumption by cattle and horses but the food sources are also selected in a similar order (Krysl *et al*. 1984a).

During the summer months, horses frequent marshlands more and spend more time grazing on short grasses than cattle (Menard *et al.* 2002). Horses remove more vegetation per unit body weight and also use the most productive plant communities/species to a greater extent than cattle which leads to greater nutrient extraction in horses (Menard *et al.* 2002). They crop grasses (particularly more succulent grasses) shorter to the ground and leave a mosaic of short and tall patches of grass which contributes to structural diversity (Menard *et al.* 2002). Daily food intake per body mass is 63% greater in horses than in cattle which is in part due to the fact that cattle diets are more digestible than horse diets (Menard *et al.* 2002). This is because cattle use forbs, shrubs, and broadleaf plants more heavily than horses (Menard *et al.* 2002).

Mule deer/pronghorn antelope vs. Feral Horses

Dietary selection patterns differ between browsing (such as pronghorn and mule deer) and grazing ungulates (horses and cattle). Browsing animals that are often in direct habitat competition with feral horses include species such as pronghorn antelope and mule deer

(*Odocoileus hemionus*). These species select for browse, which in most cases is limited to sagebrush (*Artemesia* spp.), curl-leaf mountain mahogany (*Cerocarpus ledifolius*), antelope bitterbrush (*Purshia tridentata*), and western juniper (*Juniperus occidentalis*) (Hanley & Hanley 1982). Horses and pronghorn show a relatively low dietary overlap (7% to 26% depending on the season). This was determined to be not significant (McInnis & Vavra 1987).

Horses show a larger variation in diversity of plant consumption than do mule deer (Hansen *et al*. 1977). Diets of feral horses and mule deer are between 1% (Hansen *et al*. 1977) and 11% similar (Hubbard *et al*. 1976). Thus there is no evidence that large herbivores (specifically horses, cattle, or elk) compete directly with mule deer for food resources (Hansen & Clark 1977).

FERAL HORSE IMPACTS ON RANGELANDS

Wildlife

Competition with Other Large Ungulates

On the Sheldon National Wildlife Refuge, observations illustrate that several ungulate species, particularly pronghorn, are kept out of water sources through physical exclusion by feral horses. This is accomplished mostly by dominant stud horses (USFWS 2009).

Miller (1983) studied feral horse interactions with other ungulates at water sources and found that horses excluded pronghorn from water sources every time there was an interaction. Pronghorn sometimes had to wait longer than 5 hours for access to water; showing strong evidence for interspecific competition. While horses are surrounding water sources (up to 119 horses have been observed at one water source), pronghorn have been seen to circle, then leave only to return and repeat the behavior. Pronghorn typically won't drink unless there is enough space between individuals to stay at least 3 m away from horses and cattle (Miller 1983).

Habitat degradation is the destruction of natural communities which eventually decreases the productivity and the functionality of an area. Typically when habitat degradation occurs, biodiversity is reduced and organisms which previously used the habitat are destroyed or displaced. When habitat degradation is caused by feral horses, this may also leave pronghorn fawns particularly vulnerable to predation. This may affect other wildlife species that depend upon vegetative cover to hide (USFWS 2009).

There have been several studies that have shown the impacts feral horses have had on other ungulates (other than pronghorn) occupying the same ranges. Ostermann-Kelm *et al*. (2008) studied the effects of feral horses on bighorn sheep numbers. It was shown that at feral horse occupied watering sites, there was a 76% reduction in the number of groups of bighorn at these sites and a similar increase in numbers of bighorn groups visiting other non-horse occupied watering sites. Such a change in habits and movement in bighorn could potentially affect their survival as well as their impact on the environment.

Competition with Other Animals

The presence of feral horses not only impacts large mammals, but can also impact reptiles and small mammals. Beever and Brussard (2004) studied the differences between horse-occupied and horse-absent sites on squamate reptiles and granivorous small mammals. It was determined that species richness was not different between occupied and unoccupied sites but the sites with horses showed less biotic integrity, meaning horse-occupied sites showed signs of habitat degradation as compared to unoccupied sites. There were 1.1-7.4 times more deer mice in horse-occupied sites, whereas there were more reptiles in horse-free sites. In areas where horses were excluded from springs, there was an increased number of small mammal burrow entrances (Beever *et al*. 2000). Species expansion combined with species reduction can lead to

changes in ecological roles as well as the impact on their immediate environment (Beever & Brussard 2004).

Feral horse populations have been shown to affect avian populations in Argentina. Zalba and Cozzani (2004) looked at the effects of grazing horses on abundance of birds. Some birds (such as the southern lapwing) are more common in horse grazed areas whereas other birds (such as pipits) are common in less grazed areas. Areas that have mostly tall grass show the highest species richness as well as the greatest total abundance of birds. Also, the presence of feral horses may be linked to increased egg predation by opportunistic carnivores, such as the culpeo fox (*Lycalopex culpaeus*), due to increased nest exposure (Zalba & Cozzani 2004).

Estuarine Systems

With regards to estuarine sites, where freshwater from streams mixes with saltwater from the sea's tide, the presence of horses correlates with less vegetation diversity, higher diversity of grazing birds, higher densities of crabs, and lower densities/species richness of fishes compared to sites without horses present (Levin *et al*. 2002). Predation upon various fish species increases in grazed areas (less vegetation means less cover for fishes) compared to ungrazed areas. The shift in vegetation in marsh areas may account for a shift in fish behavior which would lead to increased predation (Levin *et al.* 2002).

Vegetation

Feral ungulates (specifically feral horses, feral cattle, feral sheep and feral goats) influence vegetation community dynamics by lowering the above ground annual growth in saltmarsh and grass-shrub areas. The rate of succession and the spread of maritime forest are slowed in these areas due to grazing pressure. In a study by Beever *et al*. (2007), differences between high elevations and lower elevations showed that at higher elevation, vegetation reached

heights 2.8 times greater than vegetation grazed by horses only and that vegetation reached maximum heights 4.5 times greater than vegetation grazed by horses and cattle (Beever *et al*. 2000). Sites where feral horses had been removed for 10-14 years versus sites where feral horses continue to graze, show greater shrub cover, greater total plant cover, greater species richness, and greater frequency of native grasses, compared to exotic plants and grazing-resistant forbs, than did horse-occupied sites (Beever *et al.* 2007).

Horse grazing can significantly reduce the main grass species found in particular areas, especially marshland sites (Bassett 1980). Within these marshland sites, areas without horse grazing show significantly greater amounts of overall vegetative biomass than do sites with horse grazing (Levin *et al*. 2002). Feral horses may have indirect impacts on salt marsh communities by altering a habitat, potentially making it more or less suitable for certain species to exist in a particular ecosystem (Levin *et al.* 2002; Bassett 1980; Wood *et al*. 1987).

The removal of a key herbivore such as a feral horse has no significant impact on perennial plant cover in the desert. However, areas with feral horses removed show a significant increase in annual forbs and plant litter. Also species composition and dominance are altered and many species specific changes occur (Ryerson & Parmenter 2001).

Horse and cattle grazing can either perpetuate or decrease the rate of expansion of particular plant species. For example, in the Netherlands, *Sambucus nigra*, or Elder Bush, expansion is slowed by heavy cattle grazing. This is due to the fact that only ruminants are capable of detoxifying the cyanogenic glycosides found within this particular species. Whereas the rate of expansion of *S. nigra* is perpetuated when heavy horse grazing occurs. This is because horses, as hindgut fermenters, are incapable of detoxifying this species and as such it is

avoided. Thus grazing by different species may alter vegetation in different ways just as cattle and horse grazing affect vegetation (specifically Elder Bush) differently (Vulink *et al.* 1984).

Dung piles from feral horse populations may be viewed as a window into impact on vegetation. The vegetation on top of dung piles is significantly different than the vegetation in control plots. Once horse visitation has ceased in an area, the vegetation near abandoned dung piles shows increased total vegetation cover, species richness, diversity and evenness compared to areas with currently used dung piles. Non-native plant species are also frequently associated with dung piles as compared to control plots (Loydi & Zalba 2009).

Riparian Areas

Studies have shown that feral horses visit watering locations daily, typically during crepuscular hours. They typically inhabit areas that are within 4.8 km of water (Pellegrini 1971, Meeker 1979; Ganskopp & Vavra 1986; Miller 1983). Due to the daily visitation of feral horses to watering areas, riparian areas are negatively impacted from trampling, herbivory, and fecal/urine contamination (USFWS 2009).

Riparian Areas on the Sheldon NWR

Areas with springs present that have exclosures to prevent horses from entering the spring-area exhibit significantly greater plant species richness, percent cover, and abundance of grasses and shrubs. Figure 1 shows a photograph that was taken at the Sheldon National Wildlife Refuge at Big Spring Creek in September 2002. An exclosure was placed over the the square with the tall vegetation (cage is on the left) to protect against herbivory. Stubble height outside of the cage was found to be 4 cm and inside the cage, it was found to be 35 cm.

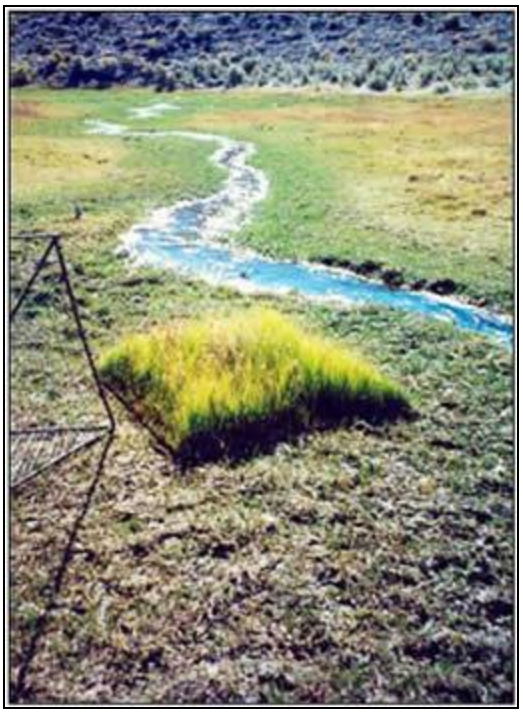

Figure 1. Shows the differences between an area where grazing was allowed and where grazing was excluded. Areas where grazing occurred showed stubble height of approximately 4 cm. The excluded area showed heights of approximately 35 cm. Figure taken from http://www.fws.gov/sheldonhartmtn/sheldon/horseburro.html, 2010.

Figure 2 contains two photographs taken from the Sheldon NWR in 2009. An exclosure study was set up in order to determine effects of grazing horses on riparian areas. The exclosures were set up at a height that allowed ungulates (such as mule deer and pronghorn antelope) to enter and graze but did not allow horses to enter (USFWS 2011).

Figure 2. Two photographs from the Sheldon NWR showing the difference in vegetation in two different riparian areas in horse excluded areas as well as horse occupied areas. Fences represent exclosures where horses are excluded but other ungulates are allowed.

Figure 3 shows the difference in a riparian area from before horses were removed from an area (horses present) to after a horse gather in the same area (horse numbers significantly reduced). The two photographs were taken one year apart at the same location (Big Spring Creek), at the same angle showing the same site. The upper was taken in August 2004 before the horse gather and the lower was taken in August 2005 after 293 horses had been removed from Big Spring Butte. The vegetative response from reduced grazing pressure is apparent but the restoration of woody vegetation will take many years to occur (USFWS 2011).

Figure 3. These two photographs were taken from the USFWS website for the Sheldon NWR. They show the same area one year apart when horses were present (2004) and when horses were reduced (2005). Taken from http://www.fws.gov/sheldonhartmtn/sheldon/horseburro.html, 2010

Soils

Soils are compacted after repeated use by multiple horses (USFWS 2008). With soil compaction and degradation, infiltration decreases, grasses and other vegetation are unable to grow, and soil is degraded and/or lost. Recovery from degradative impacts requires thousands of years in order to build the layers within soils. Even more time is needed within a desert climate such as is often found in the western United States where the majority of the United State's feral horses reside (USFWS 2008).

Feral Horse Management

Population growth rates on the Sheldon NWR have been estimated to be between 17 and 23% (USFWS 2009). Relatively little natural predation occurs on feral horses (occasionally a mountain lion will predate upon a foal but occurrences are rare according to USFWS managers)

and reproduction is high. The Bureau of Land Management (BLM) has estimated appropriate management levels (AMLs) for the numbers of feral horses in the western United States (Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, and Wyoming). All states (excluding Idaho and Oregon) have horse counts above the established AML (see Table 1, BLM 2010). Due to high population counts, feral horses in the Western United States (including the Sheldon NWR) are periodically "rounded-up" in an attempt to obtain desired appropriate management levels (AMLs). Grazing effects by large ungulates (particularly feral horses) may not be significant if populations are managed at appropriate levels (Detling 1998).

Table 1. These values represent each respective state's current population estimate information as of October 28, 2010. Most of the estimates represent direct counts and are not adjusted for animals not observed. AMLs are established as a randge with upper and lower levels. The numbers displayed here represent the upper limit (BLM 2010).

	Populations			Total
	Horses	Burros	Total	AML
AZ	400	2,248	2,648	1,676
CA	4,079	1,069	5,148	2,190
CO	888	0	888	812
ID	596	0	596	617
MT	150	0	150	120
NV	17,711	1,177	18,888	12,688
NM	119	0	119	83
OR	2,461	15	2,476	2,715
UT	2,724	164	2,888	1,956
WY	4,564	0	4,564	3,725
TOTAL	33,692	4,673	38,365	26,582

With increasing horse numbers, management budgets for horse conservation have increased as well. Table 2 shows the BLM budget breakdown for the BLM Horse and Burro Management Program since 2005. The majority of the budget is spent in removing horses that exceed AMLs from rangelands and caring for them in long-term holding facilities. Long-term holding facilities are employed in conjunction with the "no kill" policy adopted in the Wild and Free-Roaming Horses and Burros Act of 1971. After adoptions, horses and burros that are not adopted are placed in long-term holding facilities where they are fed and cared for until they are either adopted or they die. Increases in budgeting are allocated to offset increasing expenses for housing horses that have been removed from rangelands in long-term holding facilities. The increase in budgeting from 2009 to 2010 is due mostly to increased expenditures in land purchases in the mid-west. The purpose of these purchases is to increase the numbers of long-term holding facilities with hopes of decreasing feed expenses due to more productive grasslands which can hold larger numbers of grazing species.

Table 2. BLM Horse and Burro Management Program budget from 2005-2010. BLM officials reported that budgets are primarily used in helicopter gathers (and on costs associated with these) and caring for horses in long-term holding facilities (BLM 2010).

Budget Breakdown
2005 - $29,524,000
2006 - $29,051,000
2007 - $36,045,000
2008 - $36,362,000
2009 - $36,354,000
2010 - $63,986,000

SHELDON NATIONAL WILDLIFE REFUGE

Location

The Sheldon National Wildlife Refuge (NWR) in northwestern Nevada is located on Highway 140, 14 miles west of Denio, NV and 68 miles east of Lakeview, OR. It is home to many wildlife species including pronghorn antelope, bighorn sheep, mule deer, rabbits (including pygmy rabbits), greater sage grouse, several species of water birds, many species of migratory birds, and feral horses and burros (USFWS 2011).

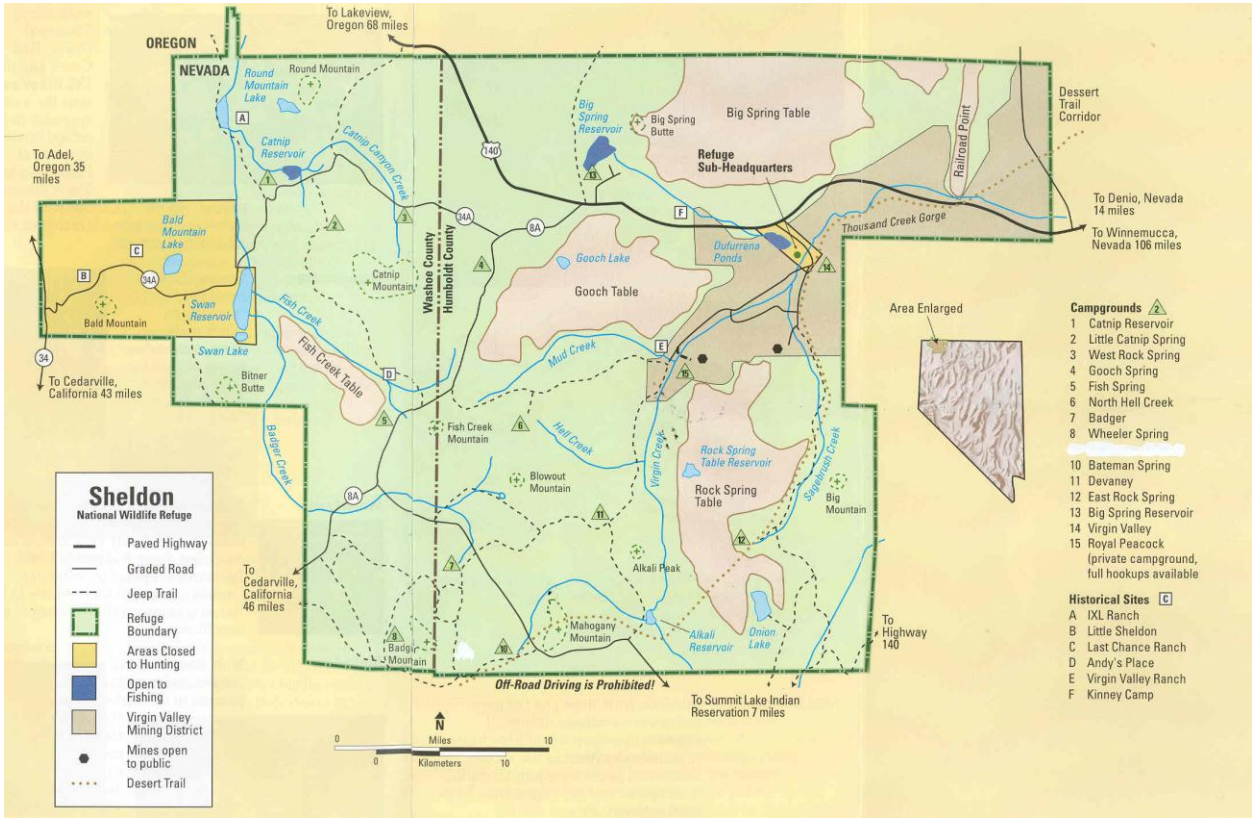

Figure 4. Map of the Sheldon NWR.

Function

The Sheldon NWR was formed in 1931 for three different purposes: 1. To provide habitat specifically for pronghorn antelope but also for secondary species such as mule deer, sage

grouse, and song-birds. 2. To protect threatened and endangered species (fish, wildlife, and plants). 3. To be used as a sanctuary for migratory bird species (USFWS 2011).

Habitat/Climate/Elevation

Habitat in the Sheldon NWR is high desert dominated by stands of sagebrush (basin big, mountain big, and arbuscula), rabbittbrush, juniper, mountain mahogany, aspen, meadows and playa. Climate is hot in summer and cold in winter; however, temperatures can vary greatly and can drop below freezing at any time of the year. Precipitation is rarely greater than 12 inches per year. Elevations range from 2,223 m to 1,280 m. As a general trend, elevation drops from west to east throughout the refuge (USFWS 2011).

CARBON AND NITROGEN ISOTOPES

How they are used

Stable isotope technology does not directly measure the nutritive value of various food sources. It measures the difference between atoms by their mass-to-change-ration. Isotopes are atoms of a common element with the same number of protons and electrons but differing numbers of neutrons than the common form (Sulzman 2007). There are approximately 300 stable isotopes (Hoefs 1997). As an example of an isotope, carbon normally has an atomic mass of 12 with the most common isotope of carbon being C^{13}. Thus C^{13} has an extra neutron with an atomic mass of 13 (Sulzman 2007).

Due to the fact that isotopes occur naturally, organisms will sequester them in their tissues through biochemical pathways as dietary nutrients are metabolized. For example, in plants, carbon enters the plant in the form of atmospheric CO_2 through various photosynthetic processes (Marshall *et al*. 2007). Nitrogen enters plants through detris sources. As these isotopes, as well at the element in its natural state, are brought into the plant they are stored in

species-specific ratios. Animals then take in the ratios of various isotopes through the consumption of plant material. When the isotopic signature is consumed, it remains in the animal's tissues specific to the plant species and growing conditions. Using isotope ratio mass spectrometry (IRMS), the isotope ratio can be determined by separating the charged atoms on the basis of their mass-to-charge-ratio (Sulzman, 2007). The result of the mass-to-charge ratio is a number that can be positive or negative. A positive "delta" (δ) indicates that the sample has more of the heavy isotope (ie. ^{13}C or ^{15}N) than does the standard and that a more negative value of "delta" (δ) indicates the sample being measured has less of the heavy isotope than the standard (Sulzman, 2007). In other words a more negative value is said to be depleted for the heavy isotope and a more positive value is said to be more enriched for the heavy isotope.

Stable isotope dietary information may be used in three different ways to reveal patterns of dietary change. First, one can compare isotope ratios from the same tissue type repeatedly over time. This will reveal both long and short term dietary variation (depending on length of time that the tissue is sampled). Second, one can compare the differences between assimilation of isotopes in different tissues. Due to the fact that various tissues assimilate isotopes at different rates, one can see short term dietary changes simply by comparing different tissues. Third, tissues with progressive growth (such as hair, feathers, teeth, and claws) will show an isotopic chronology of dietary changes (Dalerum *et al.* 2005).

Both carbon and nitrogen occur in two natural isotopic forms, ^{12}C, ^{13}C, ^{14}N, and ^{15}N. These isotopes are compared to a standard and reported as a ratio of the two isotopic forms in the written form of $\delta^{13}C$ and $\delta^{15}N$. The actual values are reported as parts per thousand (‰) (Ehleringer & Rundel 1988). All food sources should be corrected prior to further analysis. This is necessary in order to account for fractionation and assimilation during digestion (Phillips &

Gregg 2003). Tissues are typically more enriched in $\delta^{13}C$ and $\delta^{15}N$ than their food sources. But the degree of fractionation values differ between species, diets, and tissue types (Hobson & Clark 1992).

$\delta^{13}C$ and $\delta^{15}N$

Carbon isotopes ($\delta^{13}C$) will typically reveal some of the major biochemical fractions of the diet, specifically the lipid, carbohydrate, and protein fractions (DeNiro & Epstien 1978). $\Delta^{13}C$ values of tissue samples are closely related to the $\delta^{13}C$ values of plant samples (Teeri & Schoeller 1979; Ramsay & Hobson 1991). Whereas Nitrogen isotopes ($\delta^{15}N$) are only useful if the potential food sources had varying $\delta^{15}N$ values (many food sources can be confounded). Values of Nitrogen isotopes may be incorrect due to the presence of chemical fertilizers which have changed the distribution of the nitrogen isotopes in food sources (Deniro & Epstein 1981). $\Delta^{15}N$ values are often elevated (giving a falsely enriched appearance to tissue samples) after fasting or stress (Hobson *et al*. 1993). $\Delta^{15}N$ values increase going up trophic levels. As such they not only indicate diet but also trophic level (Ben-David *et al*. 1997).

Hair

Hair samples are generally more enriched in $\delta^{13}C$ values than other tissue samples (Tieszen *et al*. 1983). However, hair samples also have a much longer turn-over rate than other more metabolically active tissues (Tieszen *et al*. 1983). Hair has been used in many studies of various mammal species to extract $\delta^{13}C$ and $\delta^{15}N$ signatures which are then used to characterize diet (Chambers & Doucett 2008; Macko *et al*. 1999; O'Connell & Hedges 1999; Schoeninger *et al*. 1998) and track movements (Cerling *et al*. 2006). Hair is well-suited for isotope analysis because it grows quickly (van Scott *et al*. 1963) and once formed is biologically inactive and resistant to degradation (Macko *et al*. 1999). As such, isotopic chronologies, meaning a record

of isotopic values through time, can be formed, limited only by the length of hair (West *et al*. 2004; Dalerum *et al*. 2005).

IsoSource

Stable isotopes can be used to determine the relative contribution of various food sources to an animal's diet (Michener & Schell 1994). Determining the contribution of various sources to a mixture of isotopic signatures, as is the case with tail hair, can be accomplished through the use of a computer program called IsoSource which can be obtained and used from the website http://www.epa.gov/wed/pages/models.htm. It functions through the testing of all possible mixture ratios in increments of 1 to 100 (this number is set by the user). This is called the source increment and is typically 1% or 2%. Next, all possible combinations from the source increments are created and the predicted isotope signatures for the mixture are computed. Third, the observed mixture values, the tail hair for example, and the predicted mixture combinations (from IsoSource) are compared. If the predicted and actual values are the same or similar, within a certain value called the mass balance tolerance, generally 0.1%, it is a possible combination and is stored in the data set. All the possible combinations are reported. These are given a minimum and a maximum value which represents the range of possible contributions to the mixture (Phillips & Gregg 2003).

After output, it might be necessary to consider other factors that would rule out certain sources. This may include known dietary requirements (Minagawa 1992), observed food sources that are known not to be consumed, microhistological fecal analysis, etc (Phillips & Gregg 2003). After decreasing the amount of potential sources, it will be easier to narrow down the actual contributing sources as well as the percentage of contribution. Another option for decreasing the amount of potential sources is to combine sources that are statistically similar as

well as related enough to warrant source aggregation to decrease numbers of sources. This is called source aggregation (Phillips *et al*. 2005).

CONCLUSION

Many studies have reported the habits of feral horses. Despite previous research, there are still numerous gaps in data sets that are required in order to make informed and scientific decisions regarding feral horse management. By looking at the current knowledge we possess, it makes policy making easier and more beneficial to all parties involved. This chapter has attempted to inform the reader of such habits as well as impacts upon rangelands.

The concluding portion of the chapter has informed the reader of background specific to the research project entitled "Stable isotope diet reconstruction of feral horses on the Sheldon National Wildlife Refuge." A background of the particular study site was given informing the reader of what sort of conditions exist on the Sheldon NWR. After the study site characteristics, a brief introduction to the use of stable isotopes was presented. This introduction specifically introduced nitrogen and carbon isotopes with relation to tail hair isotopes, in the use of diet reconstruction.

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Stable Isotope Diet Reconstruction of Feral Horses (*Equus caballus)* on the Sheldon National Wildlife Refuge, Nevada, USA

ABSTRACT

Feral horse management has become a subject of significant controversy in the United States. This is because of differing opinions and minimal recent empirical data on feral horses. In recent years, numbers of feral horses have increased due to governmental horse removal restrictions (specifically the Wild Horse and Burro act of 1971). With increasing numbers of feral horses on rangelands, land managers are challenged with identifying the appropriate course of action for satisfying groups with differing opinions.

The purpose of this study is to characterize diet consumption through the use of stable isotope dietary analysis ($\delta^{15}N$ and $\delta^{13}C$). We did this in order to measure the impact of feral horse forage consumption on rangelands and to propose strategies for improving habitat management and conservation. We obtained tail hair isotopic values from tail hair removed while horses that were held in squeeze chutes following a roundup. Resulting isotopic values were compared to plant isotopic values using plant samples obtained from the geographical areas as the horses in order to characterize diet. Contribution of the various plant species to the tail hair mixture values was determined using the EPA program IsoSource©. Initial analysis of tail hair isotopes demonstrated seasonal variation. During summer months, shrubs (mostly *Artemesia spp*, and *Purshia Tridentate*), *Elymus elymoides*, *Juncus balticus*, and *Festuca idahoensis* were the predominantly consumed vegetative species. During fall months, *Leymus cinereus* and *Juncus balticus* played a more significant role in feral horse diet. In the winter, shrubs were more heavily consumed along with *Poa secunda*. Springtime showed a shift

towards forb consumption. Changes in seasonal consumption of forages are most likely linked to forage availability as well as equine preference.

We analyzed plant metrics (specifically biomass, abundance, and cover) to compare a site with horses present to a site where horses had been removed the previous year and found relatively few differences between the two sites. With nearly all differences we found higher plant production (forage availability) on the site where horses were still present. In riparian areas however, there was more vegetation (specifically *Carex rossii*, *Juncus balticus*, and *Poa secunda*) on the site where horses had been removed. Within riparian areas, only *Bromus tectorum* (a plant not typically found in riparian areas but characteristic of degraded areas) showed significantly greater amounts of biomass on the site with horses present. Knowledge of plant species consumption will allow land managers greater ability to make scientifically based decisions regarding feral horse population control which is important in determining appropriate management levels of populations.

INTRODUCTION

Feral horses (*Equus caballus*) have drawn increasing interest and attention in recent years. With mounting numbers of feral horses on rangelands, negative impacts have been identified involving native plant and animals species as well as abiotic components of the ecosystem (i.e. hydrology, soil structure, etc.) (Miller 1983; Ostermann-Kelm *et al*. 2008; Bassett 1980; Levin *et al*. 2002). With a lack of empirical data regarding feral horse habitat selection, ecological impacts, and forage consumption, it has been nearly impossible and highly debatable for land managers to agree on appropriate management levels for feral equine populations within various areas across the western United States.

By comparing forage availability to forage consumption, it is possible to determine which plant species horses are selecting. A knowledge of heavily selected plant species will lead to a better understanding of horse habitat selection which in turn leads to an understanding of horse impacts on various habitats.

Studies have reported the use of isotopic analysis to characterize animal diet for several decades (Ambrose & Deniro 1986; Deniro & Epstein 1978; Tiezen *et al.* 1983). The premise is that $\delta^{13}C$ and $\delta^{15}N$ signatures can be used to determine the contribution of various food sources to an animal's diet (Michener & Schell 1994). Hair has been used in many studies of various mammal species to extract $\delta^{13}C$ and $\delta^{15}N$ signatures which are then used to characterize diet (Chambers & Doucett 2008; Macko *et al*. 1999; O'Connell & Hedges 1999; Schoeninger *et al*. 1998) and track movements (Cerling *et al*. 2006). Hair is well-suited for isotope analysis because it grows quickly (van Scott *et* al. 1963) and once formed is biologically inactive and resistant to degradation (Macko *et al*. 1999). As such, isotopic chronologies (meaning a record of isotopic values through time) can be formed, limited only by the length of hair (West *et al*. 2004; Dalerum *et al*. 2005). Isotopes in domestic horse (*Equus caballus*) tail hair have been studied and short-term diet switches can be noted within isotope signatures (West *et al.* 2004).

The objective of this study is to reconstruct the diet of wild horses on the Sheldon National Wildlife Refuge (NWR) in Nevada using stable isotope analysis of feral horse tail hair and available forage species. We determined the dietary differences between various reproductive categories of wild horses (originally we tested studs, wet mares, dry mares but ultimately we combined wet mares and dry mares). We then compared dietary selection available forage found on the Sheldon NWR in order to determine whether horses were selecting forages based on availability or to determine whether they were targeting specific plant species

for consumption. We then compared plant biomass, abundance, and cover across a site with horses present to a site where horses had been removed the year before in order to determine whether significant differences exited between the two sites.

METHODS

Tail Hair Collection

Feral horses annually are removed from the Sheldon National Wildlife Refuge in Nevada, USA (see figure 5). In August 2009, 353 feral horses were captured near the Little Sheldon region (UTM coordinate: 11T 294052.83 E, 4639510.97 N) and removed from the refuge. During the processing (in preparation for adoption or spaying/vasectomizing), the longest available sections of hair were pulled at the root of the hair, placed in paper bags, and labeled. We sampled 59 dry mares, 57 wet mares, 63 foals, and 174 studs.

Habitat in the Sheldon NWR was high desert dominated by stands of sagebrush (basin big, mountain big, and low sagebrush), rabbittbrush, juniper, mountain mahogany, aspen, meadows and playa. Climate was hot in summer and cold in winter; however, temperatures can vary greatly and can drop below freezing at any time of the year. Precipitation was rarely greater than 12 inches per year. Elevations ranged from 2,223 m to 1,280 m. As a general trend, elevation dropped from west to east throughout the refuge (USFWS 2011).

Ten random samples were selected from each four reproductive categories (i.e. 10 mare samples and 10 stud samples for mass spectrometer analysis). The longest hair was analyzed from each horse. Hairs were cleaned by repeated rubbings with acetone, divided into 5-20 mm increments (typically 10 mm used), and weighed on a microgram balance (Sartorius, Data Weighing Systems, Elk Grove, IL) with a target weight of 200-500 µg (lengths varied according to weights needed for analysis). Each hair sample was then placed into tin capsules (Costech,

Valencia, CA) and combusted using a Costech (ECS 4010, Cornusco MI, Italy) elemental analyzer. The sample was passed through a continuous-flow isotope-ratio mass spectrometer (Delta-V, Thermo Fisher Scientific Inc., Waltham MA) to obtain $\delta^{15}N$ and $\delta^{13}C$ values.

Variance between reproductive categories was analyzed using ANOVA (R project, Institute for Statistics and Mathematics, Vienna University of Economics and Business). Differences between the groups, where present, were then determined through the Tukey-Kramer method. Due to the continuous nature of tail hair growth, a time frame was obtained to represent each tail hair (West *et al.*, 2004; mm/day). This allowed us to determine the seasonality patterns within the tail hair. Once compared to forage samples, we were able to determine the differences in diet sources not only through different seasons but throughout specific months of 2006 (this was the oldest date, most tail hairs only supplied data as far back as the end of 2007) to the sample time in 2009.

Forage Collection

Cover Map

United States Fish and Wildlife Service (USFWS) personnel developed a cover type map that classified vegetation communities on the Sheldon (NWR). This map was produced in 2009 by J.D. Tagestad and associates of the Department of Energy's Pacific Northwest National Laboratory (PNNL) in Richland, Washington. They used three Landsat 7 images from 2002, each at 30-m spatial resolution. The three images were converted to nine images using coefficients for brightness (a measure of overall reflectance), greenness (contrast between near-infrared and visible reflectance), and wetness (contrast between shortwave-infrared and visible/near-infrared reflectance)—also known as a TM Tasseled Cap transformation (Crist and Cicone 1984). An additional two images were incorporated—elevation from the USGS National

Elevation Dataset for the greater Sheldon area, and shaded relief using ERDAS Imagine—providing an 11-band image stack (Tagestad 2009). The elevation and shaded relief datasets were used to develop a range of topographic moisture conditions and a topographic moisture index (Tagestad 2009). Data from 130 ground truth polygons were collected from representative areas of fifteen cover types (Tagestad 2009).

Because traditional supervised classification techniques rely on normally distributed data, and because some spectral variables such as shaded relief and greenness often have non-normal distributions, standard classifications such as maximum likelihood can produce results that do not accurately represent the population (Tagestad 2009). To address this, PNNL researchers developed a customized nonparametric classification routine which compares every known pixel in the image to every unknown pixel, removing the dependency on the distribution of the data, and thereby representing a cover type with many different signatures rather than by integrating all signatures (Tagestad 2009). The output of this process was one of the fifteen vegetation cover classes that the pixel most closely matched (Tagestad 2009). Post-classification edit and analysis of the topographic moisture index produced two additional vegetation cover classes (basin big sagebrush was produced from big sagebrush areas with a high index value, and rocky mountain subalpine-montane mesic meadow was produced from wet meadow areas with a low index value) (Tagestad 2009). Manual edits were also applied to two locations of mountain mahogany (Tagestad 2009). Figure 6 shows the produced map.

Random Point Generation

Collecting a sample that would be representative of all vegetation available to the horse is paramount for accurate diet reconstruction. In order to represent not only species diversity, but also potential variation within species across the landscape, a series of random sampling

locations were selected within each vegetation class in both the Little Sheldon and Badger Mountain areas. Based on data from monitoring collars, it has been shown that the horses generally remain within a five miles of the respective catch site. Therefore, a 5-mile radius circle was created around each catch site (Little Sheldon catch site: 11T 294052.83 E, 4639510.97 N; Badger Mountain catch site: 11T 308412 E, 4616894 N; provided by USFWS personnel), and the vegetation raster map was limited to show only areas within this 5-mile radius of each catch site. These clipped areas then needed to be narrowed to distances accessible by road to sampling personnel in the field. A 0.5-mile buffer was set around all mapped roadways, and the circular areas were again clipped to exclude all locations outside this buffer (Figure 7).

Figure 8 shows the relative proportions of cover type for each 5-mile radius circle, the 0.5-mile road buffer areas, and the overall proportion across the Sheldon NWR. The graphs demonstrate that the area proportions of the buffer zones are very similar to those of the 5-mile radius areas.

Maps were converted from raster data to polygon features to facilitate random point generation using Hawth's Analysis Tools (www.spatialecology.com). In both areas thirty random points were generated for each of five major classes (basin big sagebrush, columbia plateau low sagebrush steppe, inter-mountain basins big sagebrush shrubland, inter-mountain basins montane sagebrush steppe, and inter-mountain basins semi-desert grassland), and ten points were generated for each of eight minor classes. Across the entirety of the Sheldon NWR, both the mixed salt desert scrub and greasewood flat classes were more prominent than the basin big sage class. However, basin big sage was considerably more prominent in the Little Sheldon and Badger Mountain areas than either the mixed salt desert scrub or the greasewood flat. As such, basin big sage was considered a major class and the others minor classes. The barren,

inter-mountain basins cliff and canyon, open water, north american arid west emergent marsh, and unclassified classes were not assigned sampling points due either to absence of the vegetation type within either study site, inaccessibility for foraging within the 5-mile radius areas, or inappropriateness for horse foraging. Random points were generated with a minimum distance of ten meters between points. Finally, UTM coordinates were determined for all points for later field sampling (Figure 9).

Field Plant Collection

Prior to entering the field, two random points from each vegetation class were selected in order of occurrence along various roads and vegetation was sampled at each selected site in both the Little Sheldon and Badger Mountain areas. Some random points were discarded for use due to road closures, inaccessibility on foot or within a vehicle, or deemed as an inaccurate vegetation classification. The random point coordinate location served as the southwest corner of each plot. A 5-meter tape was used to measure all four sides of the plot and markers were placed in each corner in order to create a 25 m^2 plot for use in plant collection for isotopic analysis. One example of each plant species present within the plot was clipped, placed in a paper bag, labeled, and returned to the laboratory.

Laboratory Plant Analysis

In the laboratory, plant samples were dried for 24 hours at 60˚C (Flinders & Hansen 1972). Samples were then ground using a 0.425 mm mill (Wiley Minimill, Thomas Scientific, Swedesboro, NJ) and shaken to produce a fine uniformly distributed sample.

Subsamples of collected plants were weighed using a microgram balance (Sartorius, Data Weighing Systems, Elk Grove, IL) with a target weight range of 600-700µg. Subsamples were combusted using a Costech (ECS 4010, Cornusco MI Italy) elemental analyzer then passed

through a continuous-flow isotope-ration mass spectrometry system (Delta-V, Thermo Fisher Scientific Inc., Waltham, MA) to determine carbon and nitrogen isotope levels.

IsoSource

Sponheimer *et al*. (2003a) demonstrated a mean carbon diet-hair fractionation (ε*) for a variety of herbivores. Horses were not specifically studied so an average value for all herbivores was taken and 3.2‰ was subtracted from all tail hair $\delta^{13}C$ values used for analysis. Sponheimer *et al.* (2003b) demonstrated nitrogen diet-hair fractionation values for a variety of species. Horses demonstrated a value of 6.5‰ which was subtracted from all tail hair $\delta^{15}N$ values used for analysis. The plant isotopic values were averaged according to species across the sites in order to combine sources for a stable isotope mixing model (Phillips *et al*. 2005). For all tail hair data points that occurred during 2009, plant data was collected for that same year as a direct comparison. For all other tail hair data points, plant data points that had been averaged across sites and years were used.

IsoSource version 1.3 is a Microsoft Visual Basic™ software package developed for multiple uses in stable isotope analysis including using isotopic ratios to determine the proportional contribution of several different sources to a mixture (as in using various plant sources that contribute to an isotope mixture which in this case we used a section of tail hair). All possible combinations of each source contribution are examined in a small increment which is a value determined by the user and a given mass balance tolerance value is stated by the user. All source combinations that result in the predicted mixture signatures within the stated tolerance value are considered feasible solutions. The results of IsoSource show a mean value for each source along with a range of possible source contributions (maximum and minimum values)

(Phillips & Gregg 2002). In this study, IsoSource was used to calculate ranges of potential source contributions of various plant species to the tail hair (the mixture).

Vegetation Collection

In order to classify vegetation availability for feral horses on the Sheldon NWR, the following plant metrics were obtained: plant productivity (in the form of dry biomass), plant cover, and a relative abundance score.

Biomass collection

Biomass samples were collected along 52 randomly located 50m transects. The direction of the tape from the central random was randomly determined. Along each transect, five 1-m^2 quadrates were placed at 10 m regular intervals. In each quadrat, total herbaceous vegetation was clipped and separated by species. Clipped plants were placed in brown paper bags for properly weighing, preserving, and drying. Samples were initially weighed in the field, however, inclement conditions influenced total plant water content, therefore, wet weight was excluded from data analysis. In the laboratory, samples were dried for 24 hours at 60°C (Flinders & Hansen 1972) and weighed to the tenths.

Plant cover

Plant cover was determined for each habitat type using the same transect and sample frequency as biomass. Cover samples were collected using a step-point method described by Evans and Love (1957). The surface feature (plants, bare ground, rock, litter) observed directly behind a notch in the tip of the boot was recorded for a total of approximately 100 points per plot. Total percent plant canopy cover was determined by dividing the total number of hits for that species by the total of all plant hits recorded. Percent cover was recorded for each individual

species, total grass, total forbs, total shrubs, and all "other" cover categories (bare ground, rock, pebble, cobblestone, dead shrub, litter, anthill, and manure).

Relative Abundance

Using the same transect description previously, a $5x5m^2$ quadrat was placed in the southwest corner of that plot. Within the $5x5m^2$ plot, each species present was observed and given a score according to the following scale: 1-absent (the specific plant species was absent from the plot), 2-poor (the specific plant species appeared to cover anywhere from 1 to 10% of the ground in the plot or had numbers of plants ranging from 1 to 10 depending on the species - smaller species were allowed to have more plants present while still falling in the poor abundance category while larger species such as shrubs were allowed few numbers while falling in this category), 3-fair (the specific plant species covered from 5 to 25% of the plot or had numbers of plants between 2 and 20, again depending on the size of the plant), 4-good (the specific plant species covered between 20 and 40% of the plot or had numbers of plants between 5 and 30), and 5-abundant (the specific plant species was by far the most dominant type of cover in the plot, with cover greater than 40% or numbers greater than 10 to 20, again depending on the size of the plant species in question). These values were given to each species in the plot relative to the abundance of that same species across the entire sampling area.

Statistical Analysis

Biomass, abundance, and cover data were analyzed through the use of Systat 13 (Systat Software Inc, Chicago, IL). Data was checked twice for normality. The first time it was transformed using the square root transformation, then it was tested a second time for normality using skewness and kurtosis values. Approximately half of the data was normal after transformation and the other half were still not normal. Normal data was analyzed with a

parametric test (ANOVA) and non-normal data was analyzed with a non-parametric test (Kruskal-Wallis).

Horse Density

Horse density was estimated by USFWS personnel in July of 2010. Numbers of feral horses were recorded from flight sightings of horse bands in various areas across the Sheldon NWR.

RESULTS

Plant Results

Differences between horse present and horse absent sites

It was determined that between the two sites studied (Little Sheldon and Badger Mountain), there were relatively few differences between plant productivity and availability. Only 26 out of 218 parameters were found to differ ($p < 0.05$) between the two sites (Table 3). Of those that did differ significantly 22 of the 26 had higher plant biomass on the Badger site (where horses had not been removed). Only *Artemisia arbuscula* (both abundance and cover), *Artemesia cana* (cover), and rock (cover) showed significantly higher amounts on the Little Sheldon site compared to the Badger site.

Further analysis comparing the differences between horse present and horse absent sites identified an interaction between site and habitat type. Thus, after looking specifically at various habitats between the two sites, there were more differences between sites.

Previous research has demonstrated that feral horses can have degradative impacts to riparian areas. After looking at the various habitat differences between the two sites studied, one habitat type, the mesic meadow, was of particular interest due to previous research which has demonstrated that feral horses can have degradative impacts to riparian areas (Levin *et al.* 2002;

Wood *et al.* 1987; Ganskopp & Vavra 1986). From all comparisons tested, only biomass showed significant differences and within the biomass sampled species, four plant species out of all plant species sampled showed significant differences (see table 5).

Plant species availability

Plant species available for feral horse consumption across the Badger Mountain and the Little Sheldon site were similar for biomass, abundance, and percent cover. Table 6 shows the top 10 results in biomass, abundance, and cover for our study plots. Shrubs and forbs were each included in the table as a combined entity. It should be noted that shrub biomass samples were not collected in this study.

Horse Density Results

Total density was found to be much higher in the Badger site than the Little Sheldon site. This was expected, as there was a roundup and subsequent removal of horses from the Little Sheldon site in August of 2009, just one year prior to the USFWS count (see figure 10).

$\delta^{13}C$ and $\delta^{15}N$ Results

Initial observation of isotopic results shows seasonal variation of feral horse diet with both carbon and nitrogen isotopes varying in similar patterns annually (see figure 11). There was no significant difference between animals within the same reproductive categories, the only difference being lengths of hair. The ten examples of each reproductive category were averaged and one value was represented per date.

Plant Isotopic Results

Plant isotope values showed little variation between sites and habitat types. This led to plant isotopes being averaged between the Little Sheldon site as well as the Badger Mountain

site. This was done for 2009 and for 2010. Plant isotopes were averaged between the two sample years and are shown in table 7.

Statistical Isotopic Results

Initially, analysis of variance of tail hair isotope results demonstrated that 75 out of 160 tests showed significance ($p < 0.05$) for differences between date and reproductive category. A Tukey-Kramer test was used for all significant results in order to determine where the significance between the various groups exists. Due to the significant results of the Tukey-Kramer tests, and the results from tail hair isotopic results, we selected 11 data points to run in IsoSource; studs and mares in Aug 2009, studs and mares in May 2009, studs and mares in Sept 2008, mares in Jan 2008, studs and mares in Aug 2007, combined values (studs and mares) in Nov 2006, and combined values (studs and mares) in July 2006.

IsoSource Results

Mean isotopic and range values (with minimum and maximum values) obtained from IsoSource are shown in figure 12.

In the summer of 2006, the major dietary constituents consisted mostly of FEID, BRTE, and shrubs. By winter of that year, ELEL, FEID, and POSE were the major dietary components. In the summer of 2007, studs consumed mostly JUBA, followed by shrubs and, then STTH while mares showed a preference for shrubs, JUBA, and ELEL. In the winter of 2008, mares consumed STTH, forbs, ELEL. During fall 2008, studs consumed LECI, JUBA , and ELEL in order of preference; mares consumed JUBA, shrubs, then ELEL. In the spring of 2009, studs ate PSSP, FEID, and ELEL and mares ate PSSP, BRTE, and STTH. Finally, in 2009 both mares and studs consumed shrubs in the greatest abundance followed by FIED and ELEL for mares JUBA and ELEL for studs.

DISCUSSION

Feral horse diet is largely determined by what food sources are available for consumption. Thus it logically follows that feral horse diet will change with changing seasons. Initial isotopic results demonstrated seasonal patterns with depleted and enriched carbon and nitrogen isotopic values (see figure 6). This finding is consistent with findings in previous literature (Salter & Hudson 1979). Dietary shifts throughout the seasons to a limited degree are dependent on the reproductive categories to which the horse belongs. Though no studies specify the reasons why horses choose the food sources that they do, previous literature has found that ungulates in general select forages on the basis of four morphological parameters: body size, type of digestive system, rumino-reticular volume to body weight ratio, and mouth size (Hanley 1982). Potential areas for future study could include why seasonality exists in forage selection of feral horse diet and why differences exist between reproductive categories (different dietary needs, dietary preferences, or spatial patterning differences between various bands and herds of horses).

Dietary selection among feral horses is also likely to be dependent on forage availability. With shrubs, forbs, *Elymus elymoides*, and *Poa secunda* commonly found in abundance across the Sheldon NWR (and more specifically within the Little Sheldon and the Badger Mountain areas where the horses of this study reside), it is likely that their presence and their ease of access significantly influence equine dietary selection. Interestingly, *Elymus elymoides* was a frequent prominent player in IsoSource results and *Poa secunda* was for the most part not an important component. *Festuca idahoensis* was less commonly found (in abundance, cover, and biomass) but it was still much more heavily selected for according to IsoSource results. It is interesting to note that *Festuca idahoensis* is an important native species that was nearly eliminated during the

turn of the twentieth century due to excessive overgrazing by sheep. The effects are still seen today. It is also interesting that feral horses still seek it out even though it is not as prevalent as other vegetative species. It is likely that some other factor is involved in feral horse dietary preference such as palatability. Table 8 shows various scores of palatability for horses of a few important gramineous species. In previous research, *Festuca idahoensis* has been reported to be the main grass selected in cattle and horse diets in Oregon (Vavra & Sneva, 1979).

Moderate levels of grazing of *Festuca idahoensis* actually promote plant vitality and can increase community stability. The amount of grazing that Idaho fescue can sustain is directly determined by the conditions of the site. It is difficult to determine the health of the vegetation and typically it is best to look at the long-term response of the vegetation (USDA Forest Service, 2011).

The differences between two sites – one with horses still present and one with horses removed the previous year – showed surprising results. With statistically higher amounts of vegetation on the Badger site (the site with horses present) compared to the Little Sheldon site, the likely explanation is that there is simply more vegetation on the Badger site than the Little Sheldon site. These differences are likely due to elevation, precipitation, soil types, or any number of other factors. Due to differing amounts of vegetation across the two sites, one can see that even within a few miles, certain areas have higher or lower carrying capacities. With differing carrying capacities, it is recommended that appropriate management levels of horse herd population sizes be adjusted according to individual sites (not just according to a large area such as an entire state).

After looking at the differences available between the vegetation across the habitats, it was determined that *Carex rossii*, *Juncus balticus*, and *Poa secunda* were significantly higher on

the Little Sheldon site than the Badger site. These are species frequently and abundantly found within riparian areas. The one species that was significantly higher in riparian areas on the Badger site than the Little Sheldon site was *Bromus tectorum* which is often found disturbed areas (Knapp 1996, Hunter 1991, Rice & Mack 1991). This disturbance was possibly caused by feral horse impacts (though other factors almost certainly have an impact).

MANAGEMENT IMPLICATIONS

The issues involved with the management of feral/wild horses are highly debatable and controversial. Issues include but are not limited to whether feral horses need to be removed from public lands, values at which appropriate management levels (AMLs) should be set, the most humane way to take care of excess horses, and how to deal with public relations and threats of litigation. Many have varying ideas as to how feral/wild horses should be managed and how rangeland integrity should be maintained for the benefit of all wildlife and for the well being of the horses. Options range from leaving current population as they are; eliminating excess horses (counts above AML) via euthanization and/or meat production, adoption programs, or transfer to long-term holding facilities; and completely removing horses from public rangelands. Unfortunately, relatively little experimental research has been conducted with feral/wild horses in recent years and as such relatively little is known about their behavior and their impact on their surroundings. Without knowledge of these facts, feral horse management will continue to be a controversial issue. Both managers and the general public will continue to be perplexed about the best way to handle this tenuous situation.

With the knowledge of what feral/wild horses are consuming on rangelands, policy makers and land managers can know better how to handle tenuous situations involving feral horses. Management strategies can become less emotionally based and more strategic. Tax

money (of which a considerable amount is spent on horse management annually) can be spent in more beneficial ways.

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Table 3. Significant differences between horse removed sites and horse present sites. This table shows mean values (with SEM values) for the various parameters of both the Little Sheldon and the Badger Mountain sites. Biomass is shown in kg/ha, abundance in a relative score, and cover in percentage of hits.

Parameter	Little Sheldon	Badger Mountain	Level of significance ($p<0.05$)
Biomass (kg/ha)			
Achnatherum thurbarianum	2.35±0.45	6.58±0.81	0.000
Annual Forbs	0.00±0.00	1.06±0.36	0.001
Elymus elymoides	5.62±0.50	8.86±0.77	0.000
Festuca idahoensis	1.52±0.73	7.09±1.15	0.000
Forbs	10.35±1.01	13.72±1.02	0.019
Grasses	44.61±8.39	43.70±2.06	0.916
Hesperostipa 53olumb	0.00±0.00	0.94±0.41	0.052
Oryzopsis hymenoides	0.00±0.00	0.09±0.09	0.013
Perennial Forbs	10.35±1.01	12.66±1.01	0.008
Stipa 53olumbiana	0.00±0.00	0.78±0.33	0.013
Abundance (relative score)			
Acnatherum nelsonii	0.00±0.00	0.98±0.30	0.002
Artemesia arbuscula	1.58±0.39	0.38±0.22	0.012
Cryptantha sp.	0.00±0.00	0.42±0.18	0.020
Elymus elymoides	2.23±0.27	3.10±0.23	0.007
Forbs	10.46±1.10	13.38±1.29	0.092
Grasses	10.19±0.82	13.02±0.81	0.018
Lupinus argenteus	0.54±0.26	1.27±0.29	0.013
Phlox hoodii	0.35±0.17	1.15±0.30	0.031
Shrubs	5.96±0.79	7.27±0.78	0.245
Tetradymia canescens	0.00±0.00	0.50±0.22	0.020
Cover (%)			
Artemesia cana	0.15±0.09	0.00±0.00	0.039
Elymus elymoides	2.62±0.49	6.00±0.81	0.001
Forbs	9.00±1.24	9.50±2.75	0.869
Grasses	27.46±3.41	24.04±3.64	0.496
Hesperostipa columbiana	0.00±0.00	0.81±0.31	0.005
Litter	6.31±1.38	12.04±1.33	0.000
Phlox hoodii	0.23±0.23	0.62±0.25	0.030
Rock	8.38±2.56	1.62±0.56	0.031
Shrubs	22.38±0.42	19.58±2.65	0.415
Stipa columbiana	0.00±0.00	1.08±0.40	0.001
Stipa nelsonii	0.00±0.00	0.23±0.13	0.039

Table 4. Sites analyzed during ANOVA showing habitat interactions, site interactions, or habitat and site interactions. Significant site differenced show differences between the Little Sheldon and the Badger Mountain sites. Significant habitat differences show differences between the 13 different habitat types found on the Sheldon NWR. Significant differences between both show differences between various habitats on the two sites.

Parameter	Site(*p*-value)	Habitat(*p*-value)	Both(*p*-value)
Biomass (kg/ha)			
Achnatherum thurbarianum	0.000	0.026	0.001
Carex rossii	0.724	0.005	0.000
Elymus elymoides	0.000	0.002	0.004
Forbs	0.019	0.000	0.000
Grasses	0.916	0.029	0.004
Poa Secunda	0.152	0.000	0.000
Abundance (relative score)			
Achnatherum thurbarianum	0.482	0.410	0.018
Elymus elymoides	0.006	0.156	0.355
Festuca idahoensis	0.494	0.002	0.820
Forbs	0.092	0.032	0.032
Grasses	0.018	0.608	0.063
Shrubs	0.245	0.001	0.041
Cover (%)			
Forbs	0.234	0.470	0.114
Grasses	0.171	0.005	0.290
Shrubs	0.076	0.001	0.242

Table 5. Significant differences between biomass of species in riparian areas. Mean values (with SEM values) are shown for both the Little Sheldon and the Badger Mountain sites in grams.

Parameter	Little Sheldon	Badger Mountain	Level of significance[a]
Biomass (kg/ha)			
Bromus tectorum	0.00±0.00	3.12±1.29	0.030
Carex rossii	6.74±1.70	1.62±1.08	0.035
Forbs	6.00±1.03	8.80±2.58	0.334
Grasses	72.86±15.00	56.62±7.52	0.350
Juncus balticus	14.10±1.67	6.27±1.89	0.012
Poa secunda	10.07±1.41	3.64±1.49	0.011

[a] p-values adjusted with Tukey's Honest significant difference.

Table 6. Biomass, abundance, and cover summed across the Badger Mountain and the Little Sheldon sites. Biomass values are in kg/ha, abundance are a summed abundance score value, and cover values are total number of hits per cover type out of 5100 total hits.

Biomass (kg/ha)		Abundance (relative score)		Cover (%)	
Forbs	3129	Forbs	620	Shrubs	1091
Poa Secunda	1884	Shrubs	344	Forbs	481
Elymus elymoides	1882	*Elymus elymoides*	139	*Poa secunda*	287
Bromus tectorum	1598	*Poa secunda*	124	*Elymus elymoides*	224
Stipa thurberiana	1160	*Stipa thurberiana*	68	*Festuca idahoensis*	152
Leymus cinereus	1142	*Festuca idahoensis*	62	*Stipa thurberiana*	124
Festuca idahoensis	1118	*Pseudoroegneria spicata*	44	*Juncus balticus*	123
Pseudoroegneria spicata	641	*Bromus tectorum*	39	*Leymus cinereus*	81
Carex rossii	618	*Achnatherum nelsonii*	26	*Agropyron cristatum*	78
Poa pratensis	396	*Juncus balticus*	23	*Lepidium perfoliatum*	60

Table 7. Plant isotopic values (‰) as an average between the Little Sheldon and the Badger Mountain sites. Values shown are an average between samples taken in 2009 and 2010. An average between all forb values is given as well as the most common forbs found in the area. Data are expressed as value ±SEM

Grasses/Sedges	$\delta^{13}C$	$\delta^{15}N$
Achnatherum nelsoni	-27.0±0.3	-0.7±0.5
Achnatherum occidentale	-26.6±0.2	-3.3±0.9
Achnatherum thurberiana	-26.9±0.4	-2.3±0.3
Bromus tectorum	-27.3±0.3	-2.3±0.3
Carex rossii	-28.4±0.4	-0.8±0.9
Elymus elymoides	-27.6±0.1	-1.4±0.2
Festuca idahoensis	-27.9±0.1	-2.7±0.2
Hesperostipa comata	-27.7±0.5	-0.6±0.6
Juncus balticus	-27.4±0.3	0.3±0.4
Koeleria macrantha	-26.9±0.6	-2.6±0.6
Leymus cinereus	-26.6±0.6	-1.7±0.6
Poa pratensis	-27.5±0.3	-2.8±0.5
Poa secunda	-27.3±0.3	-2.5±0.2
Pseudoroegneria spicata	-27.2±0.2	-2.5±0.3
Stipa columbiana	-26.2±0.6	-0.4±1.0
Stipa hymenoides	-26.9±0.4	-0.9±0.7
Forbs		
Averaged Value of all forbs	-27.8±0.1	-1.5±0.1
Balsamorhiza sagittata	-28.1±0.3	-0.9±0.6
Crepis acuminata	-28.1±0.2	-2.2±0.3
Eriogonum sp.	-29.1±0.2	-1.2±0.8
Lupinus argenteus	-28.0±0.3	-1.4±0.2
Phlox hoodii	-26.3±0.4	-1.5±0.3
Senecio canescens	-29.7±0.7	-1.3±0.7
Shrubs/Trees		
Averaged Value of Shrubs	-27.6±0.1	-1.1±0.1
Artemesia arbuscula	-27.8±0.2	-1.1±0.3
Artemesia tridentata ssp. tridentata	-27.7±0.4	-0.4±0.8
Artemesia tridentata ssp. vaseyana	-27.2±0.2	-0.2±0.3
Artemesia tridentata ssp. wyomingensis	-26.3±0.8	-2.0±0.7
Cerocarpus ledifolius	-25.8±0.5	-3.6±0.2
Chrysothamnus nauseosus	-28.0±0.2	-0.4±0.3
Chrysothamnus viscidiflorus	-28.2±0.1	-0.4±0.3
Grayia spinosa	-26.4±0.9	0.4±1.4
Populus tremuloides	-27.0±0.0	-0.1±0.2
Purshia tridentata	-26.2±0.2	-3.0±0.3
Salix sp.	-26.5±0.4	-1.4±0.6
Symphoricarpos oreophilus	-27.7±0.3	-2.7±0.3
Tetredymia canescens	-27.7±0.4	-1.4±0.3

Table 8. Ratings of gramineous plant palatability of key species found on the Sheldon NWR. Data taken from http://www.fs.fed.us/database/feis/plants/graminoid/index.html, 2011.

Plant species	Rating
Achnatherum nelsoni	Good in all seasons
Achnatehrum thurberiana	Good
Bromus tectorum	Good in spring and mild winters
Carex rossii	Fair
Elymus elymoides	Fair (palatability decreases as awns lengthen)
Festuca idahoensis	Good
Juncus balticus	Fair to moderately low
Poa secunda	Good
Pseudoroegneria spicata	Good

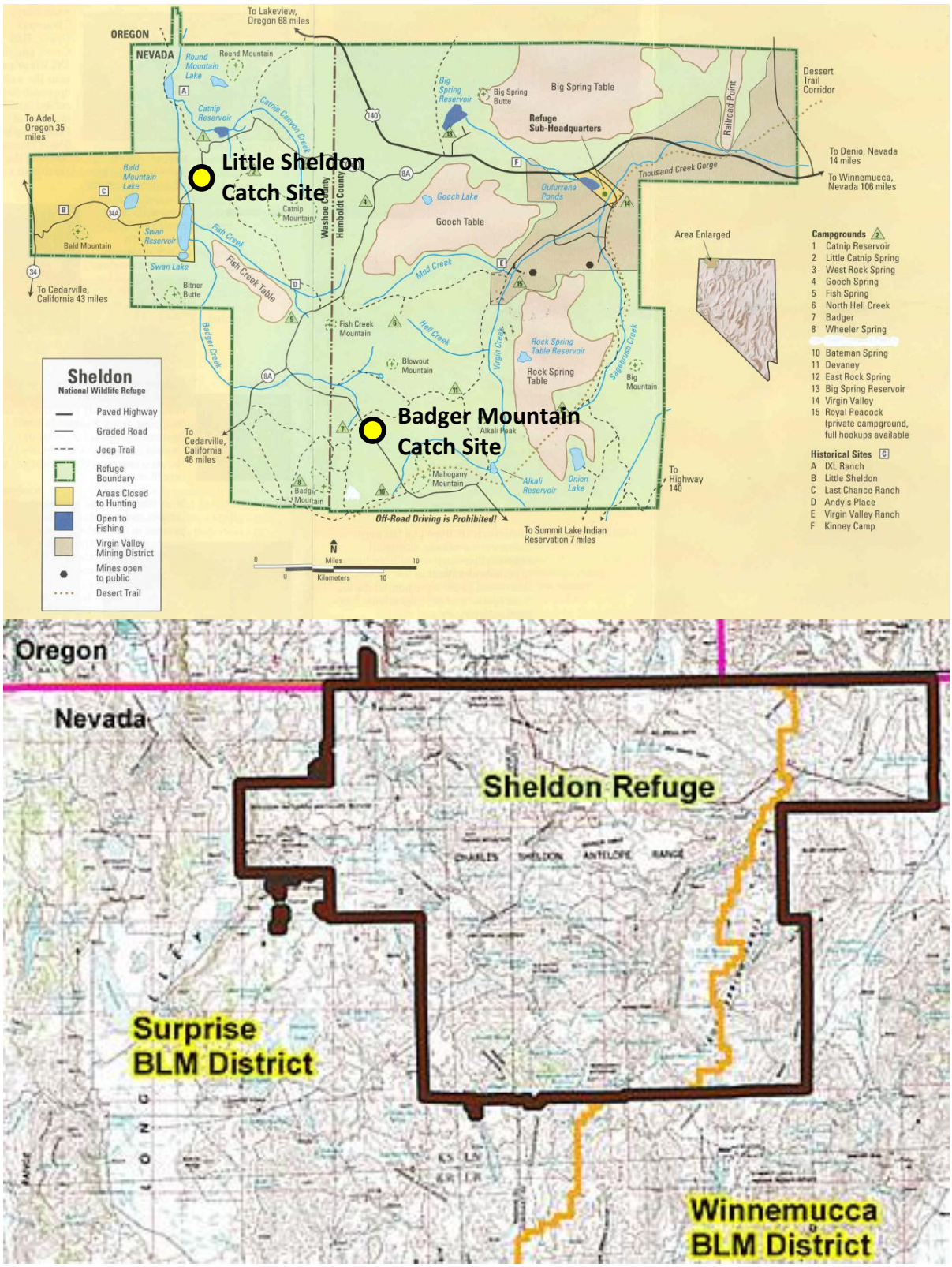

Figure 5. Map of the Sheldon NWR with two tail hair and plant sampling areas pointed out.

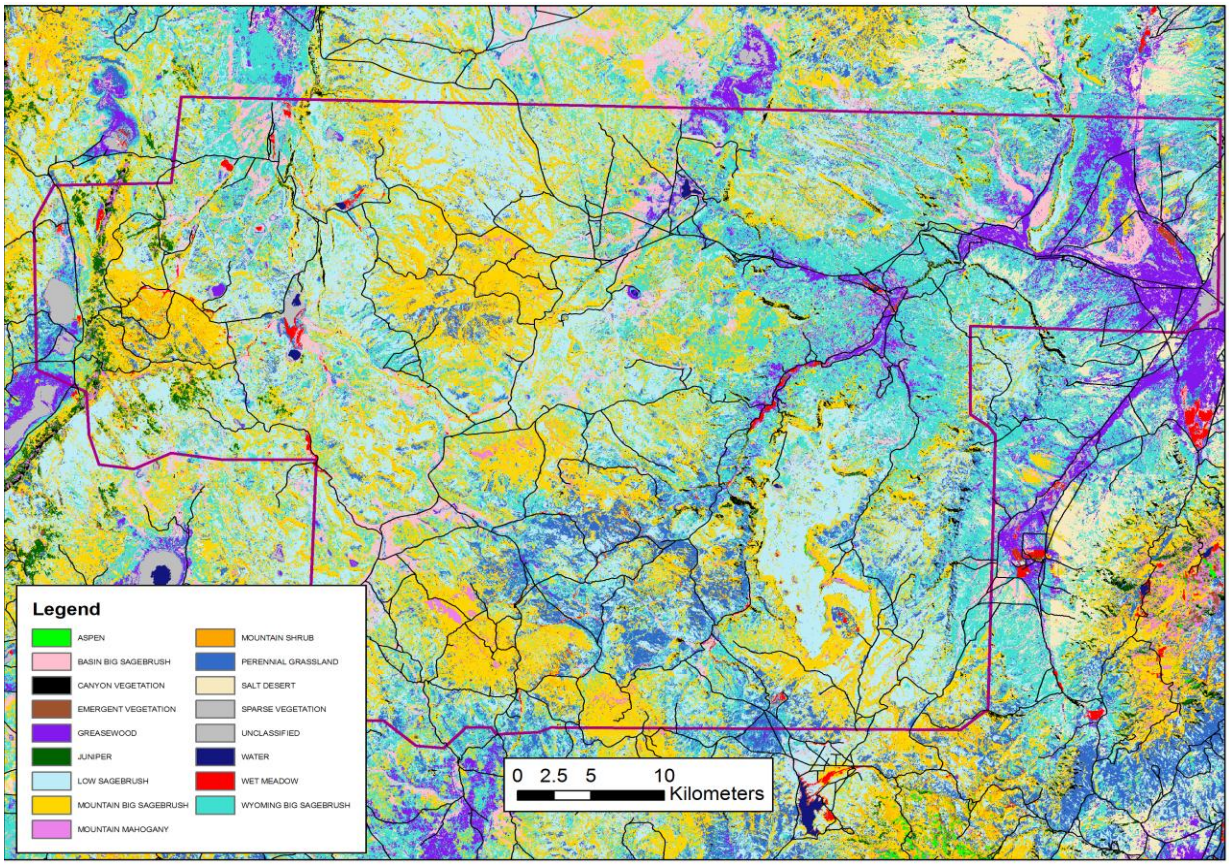

Figure 6. Map produced representing vegetation classes on the Sheldon NWR.

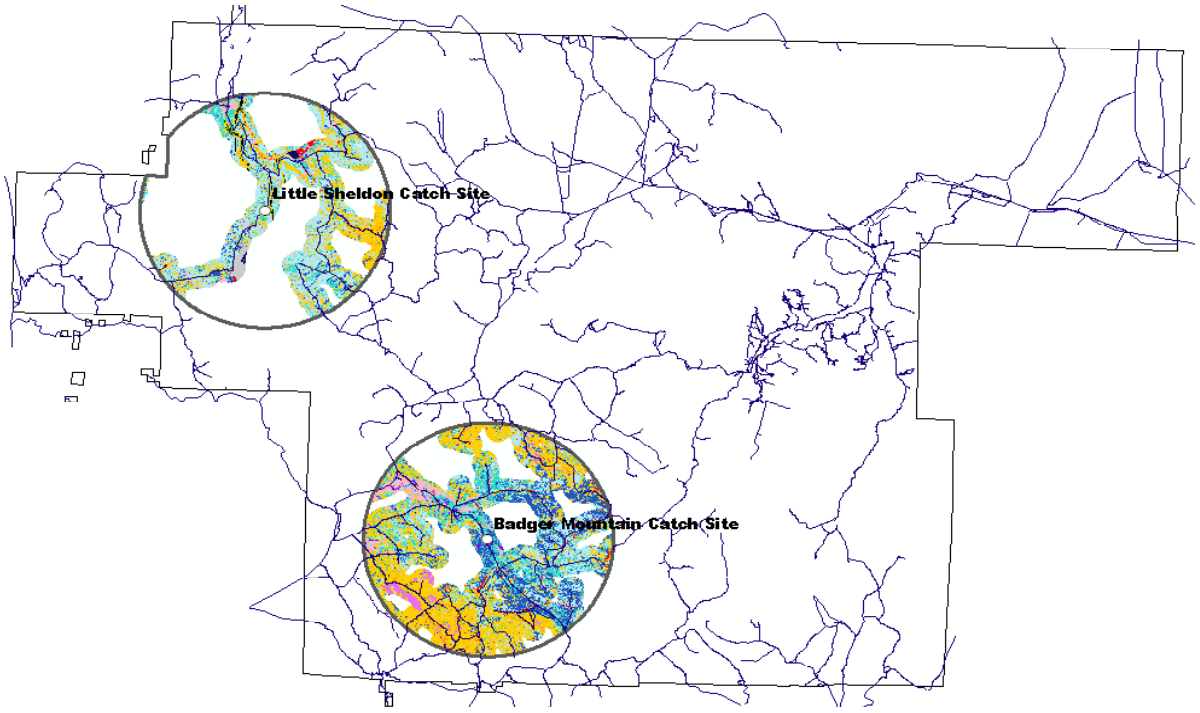

Figure 7. Potential areas for sampling based on 0.5-mile distance from roadways within 5-mile radius of each catch site.

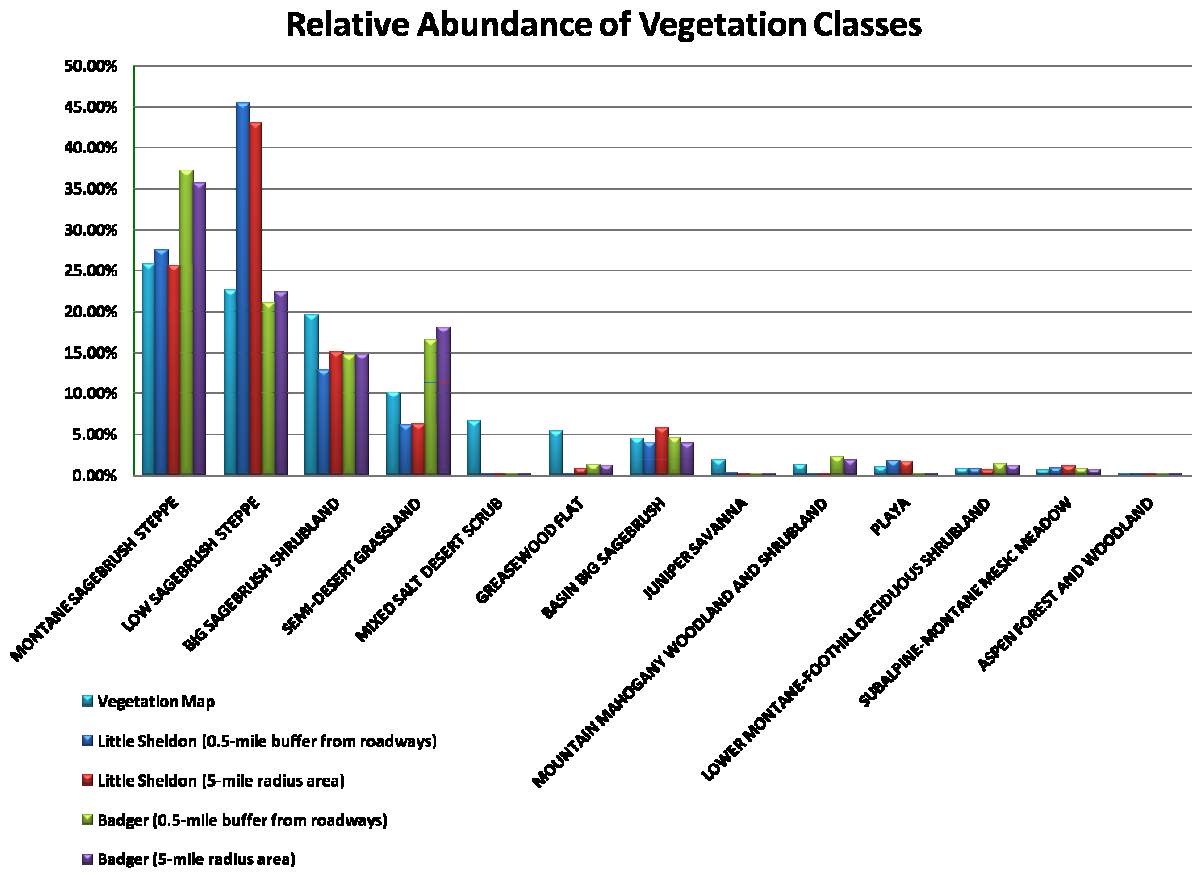

Figure 8. Proportion of vegetation classes across the Sheldon NWR.

a) Badger Mountain Points b) Little Sheldon Points

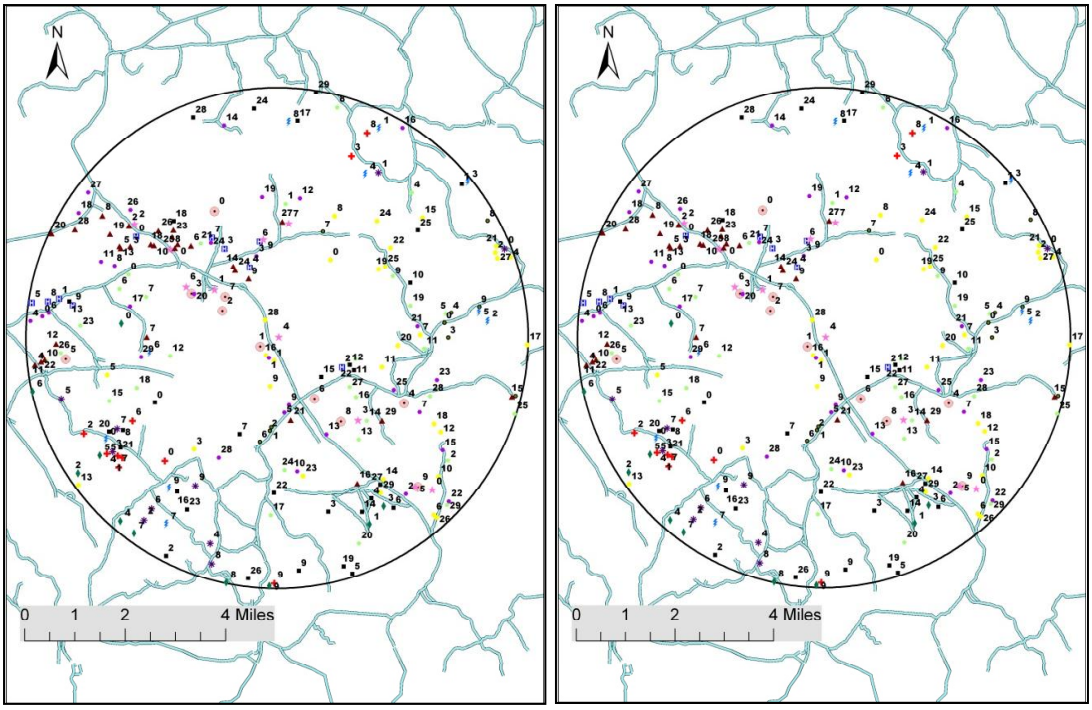

Figure 9. Maps generated through the use of ArcGIS November 2009 showing random points for a) the Badger area of the Sheldon NWR and b) the Little Sheldon area of the Sheldon NWR. 30 random points within 0.5 miles of a road were generated for the 5 main vegetation and 10 random points were generated for the remaining 8 vegetation types that are pertinent to the study. These maps were later used in field data collection.

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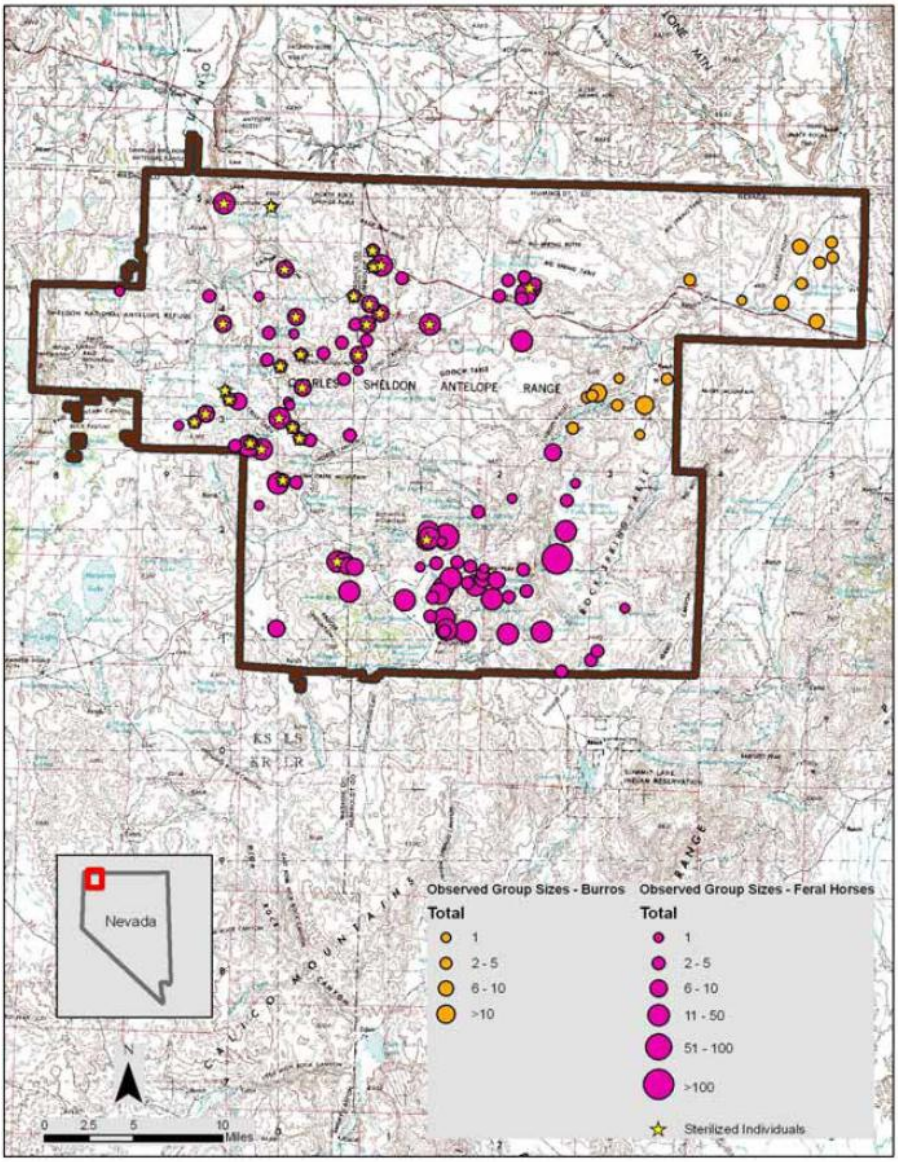


Figure 10. Feral horse group sizes and location across the Sheldon NWR as of July 2010. Stars indicate at least one sterilized individual present.

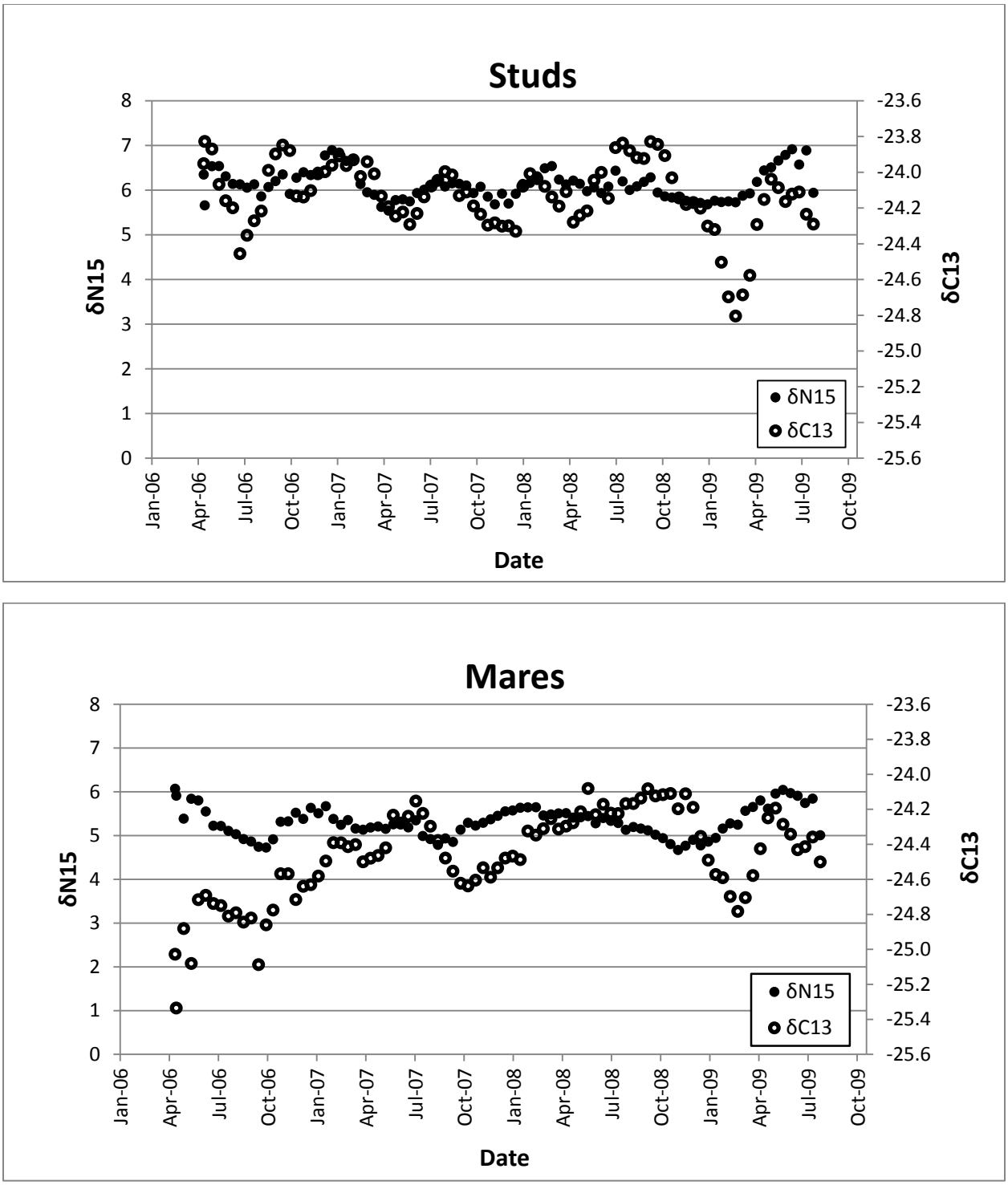
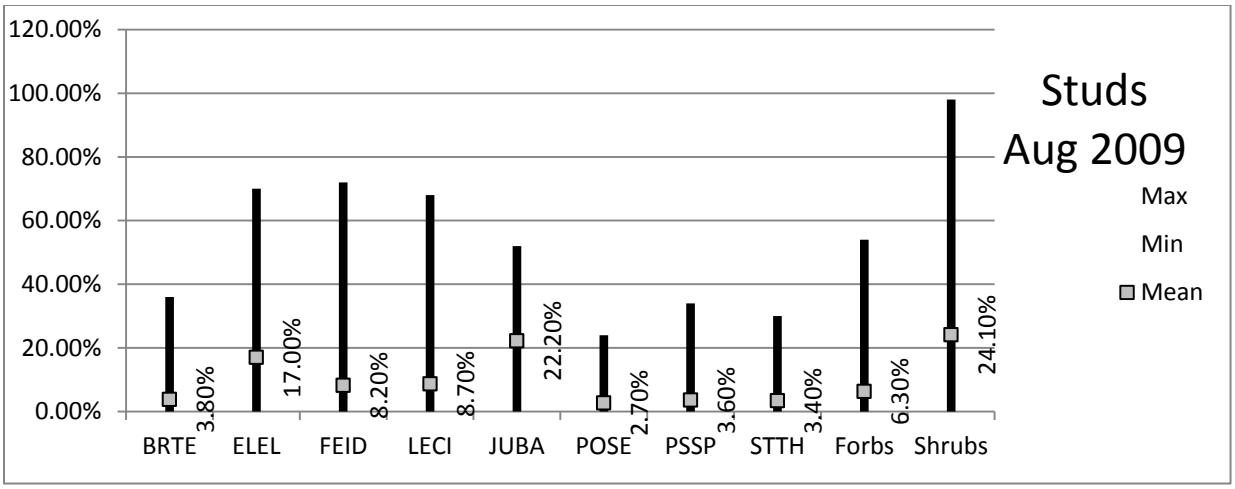


Figure 11. Seasonal variation of isotopic signatures within each reproductive category. Graphs shown are an average of 10 randomly selected individuals within each reproductive category.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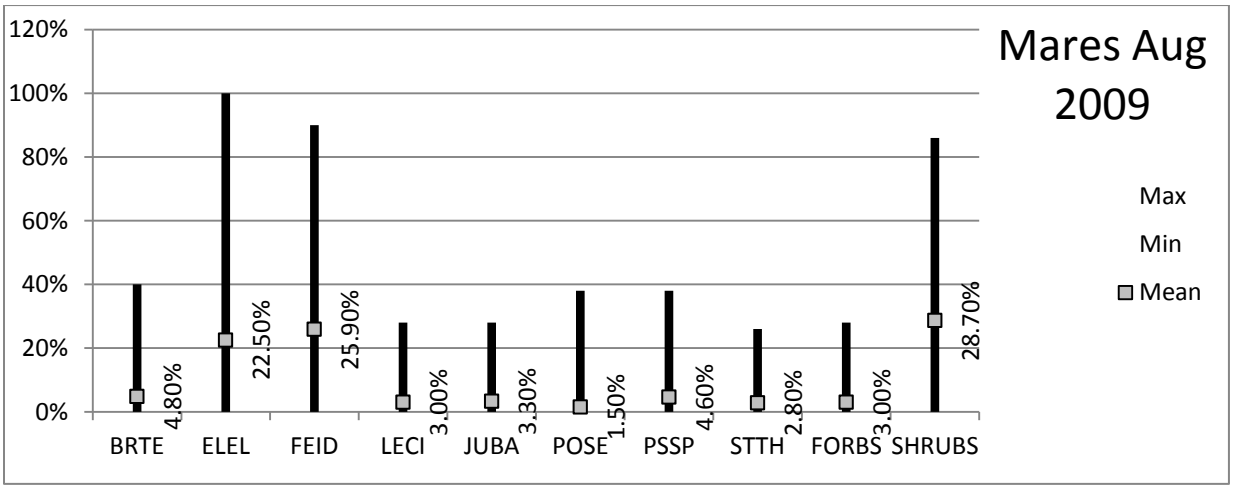
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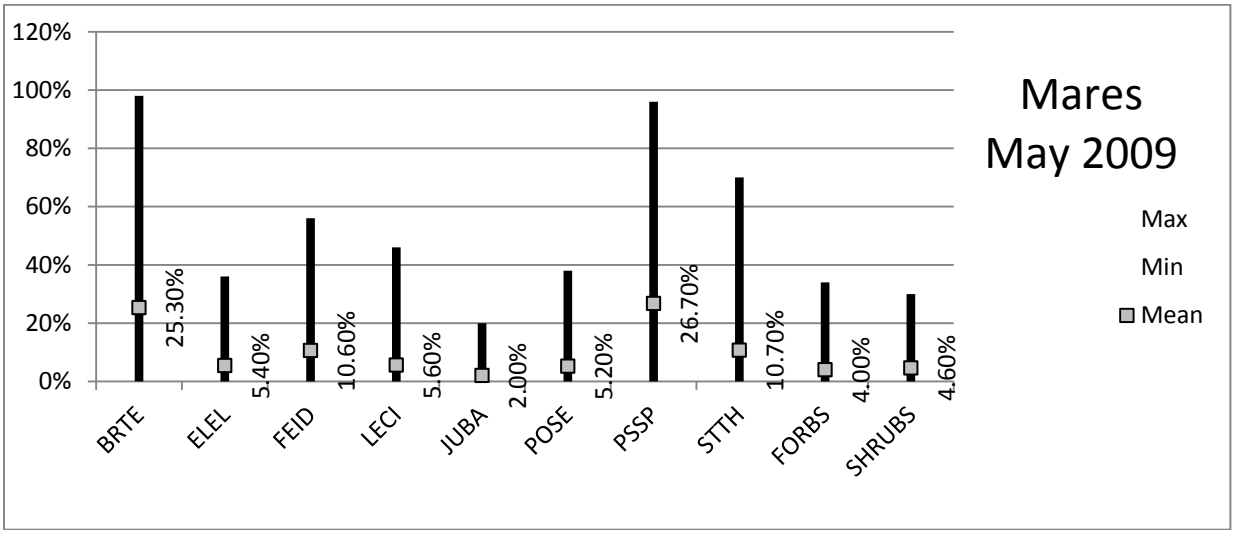
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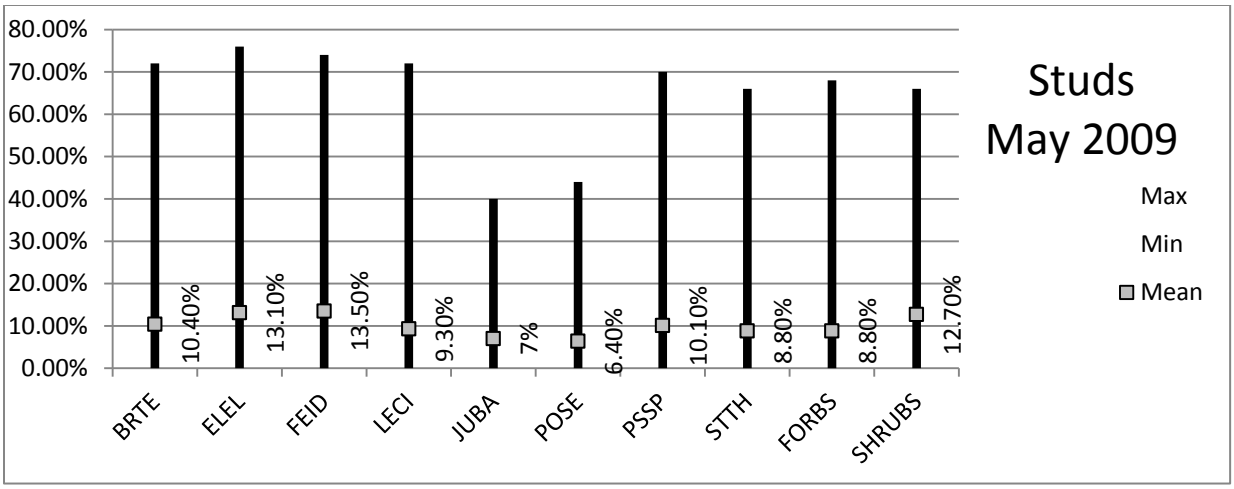
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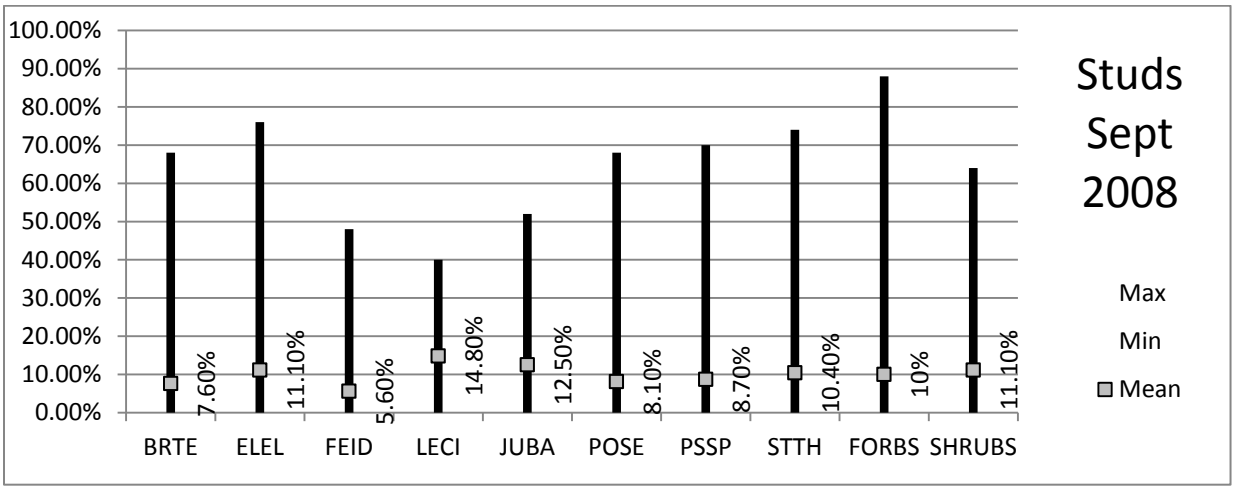
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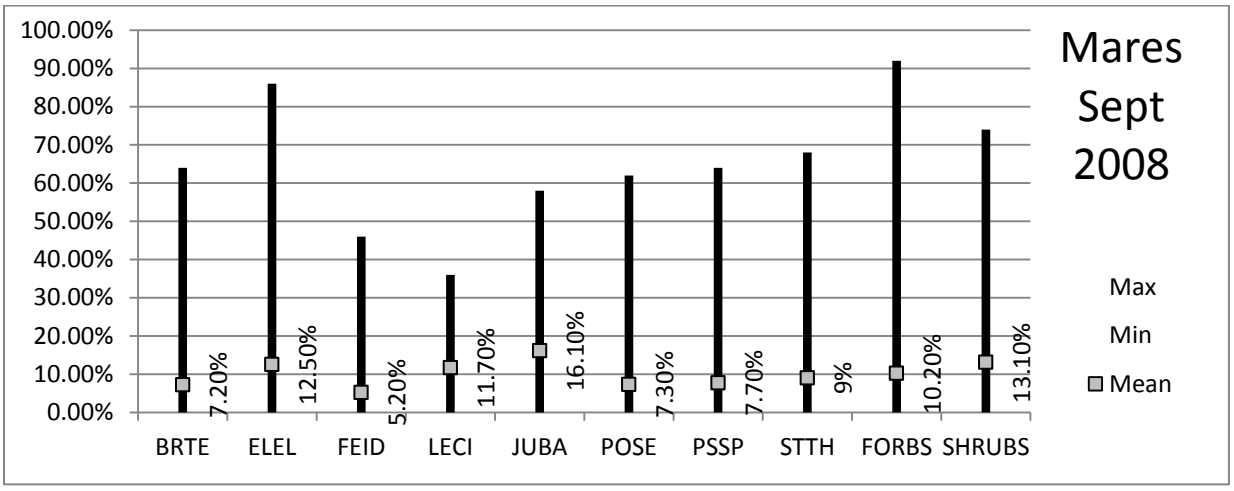
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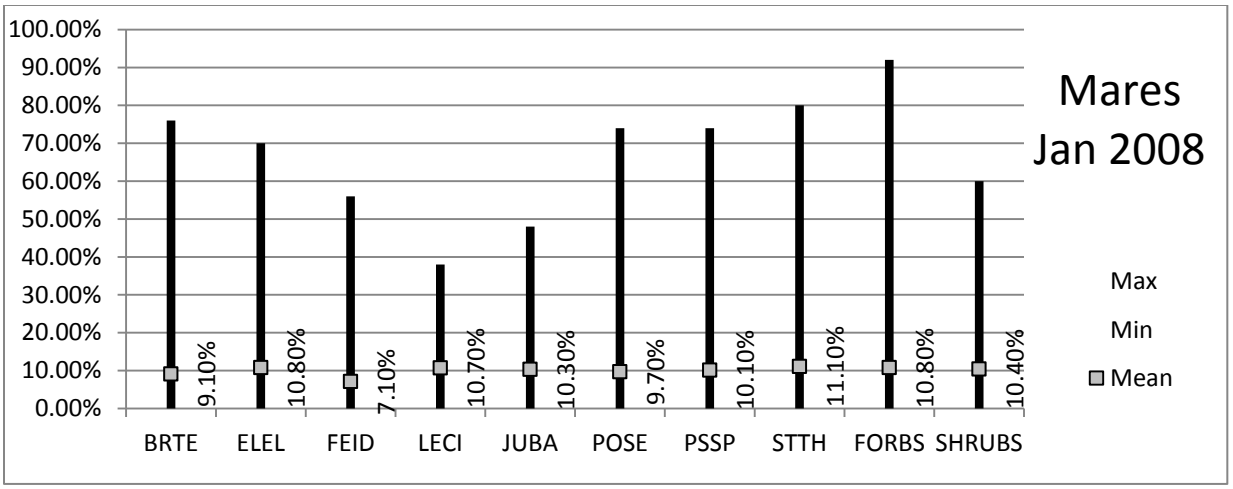
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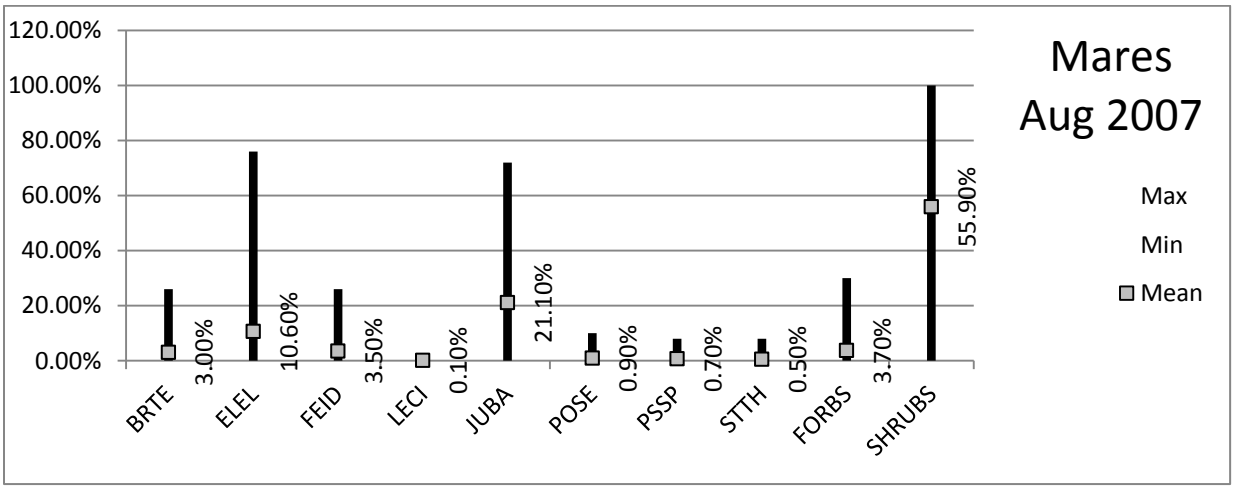
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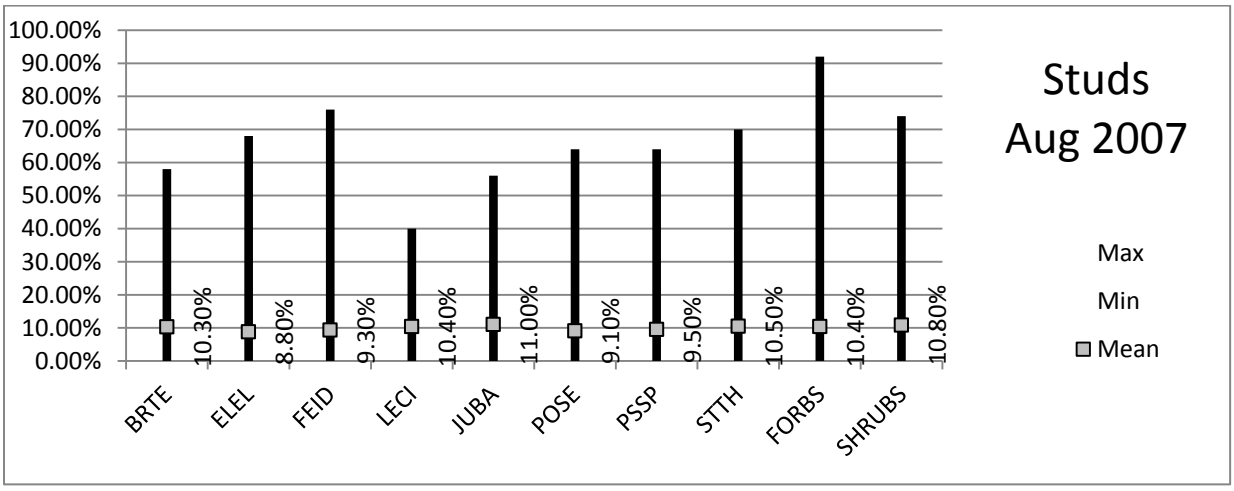
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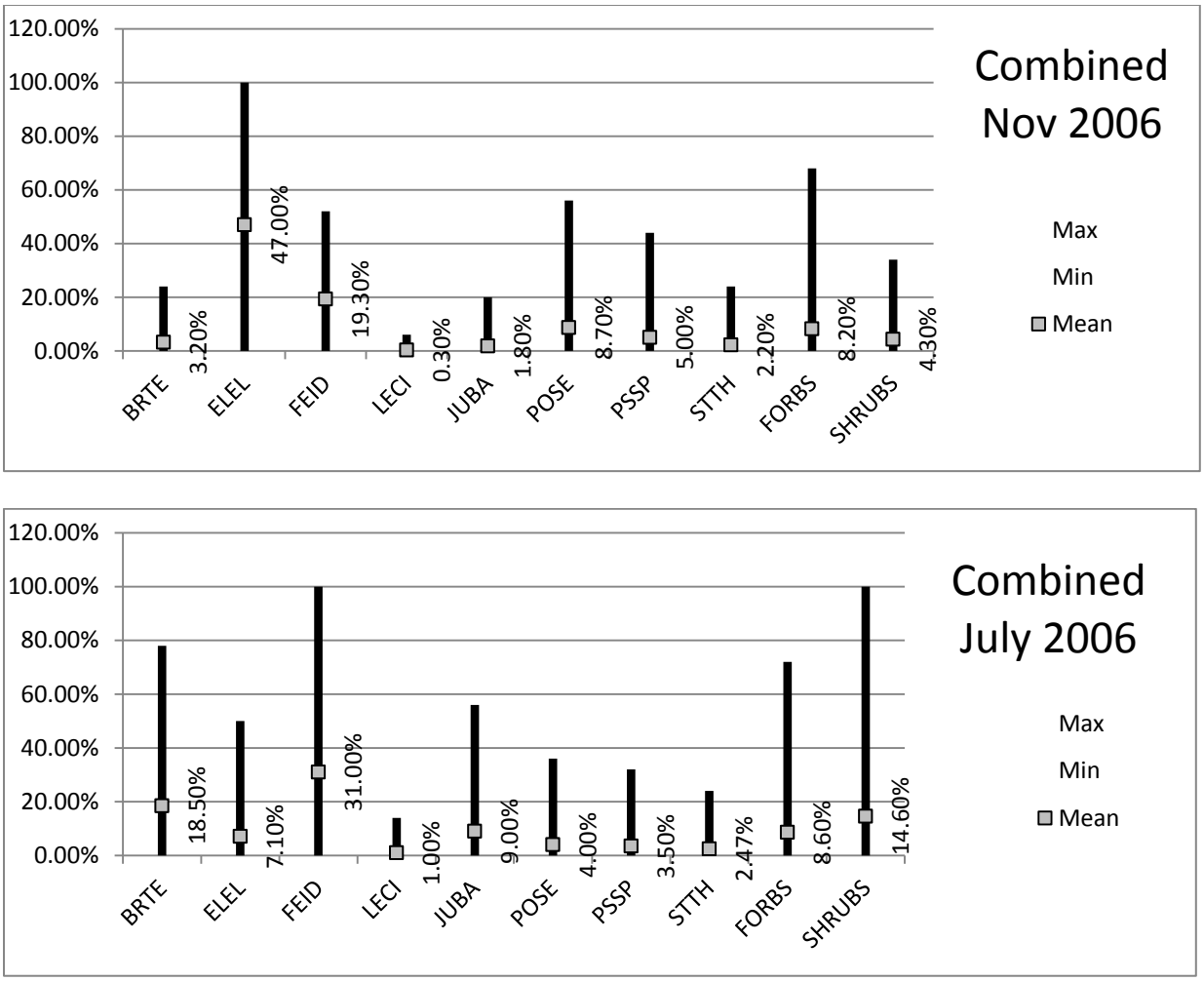

Figure 12. IsoSource results showing a maximum, minimum, and a mean value (as recommended by Phillips & Gregg 2003). BRTE: *Bromux tectorum*, ELEL: *Elymus elymoides*, FEID: *Festuca idahoensis*, LECI: *Leymus cinereus*, JUBA: *Juncus balticus*, POSE: *Poa secunda*, PSSP: *Pseudoroegneria spicata*, STTH: *Stipa thurberia*.

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Effect of Stress and Time for Recovery on the Amount of Compensatory Growth after Grazing

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Original papers

Effect of stress and time for recovery on the amount of compensatory growth after grazing

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Summary. We tested the hypothesis that the amount of compensatory growth after defoliation is affected by the level of stress at which plants grow when defoliated and by the length of time for recovery. Growth response to defoliation went from partial compensation when plants were growing at high relative growth rates (RGR) to overcompensation when plants were more stressed and growing at low RGR. Defoliation released plants from the limitation imposed by the accumulation of old and dead tissue and this release overrode the negative effect of biomass loss. Compensatory growth resulted from a higher RGR aboveground that was not associated with a reduction in RGR belowground. Time available for recovery had a major impact on the outcome of defoliation. With a short time for recovery, RGR was decreased by defoliation because an immediate increase in net assimilation rate was overridden by a reduction in the ratio of leaf area to plant weight. After defoliation, this ratio increased quickly due to a larger allocation to leaf growth and lower leaf specific weights, resulting in higher RGR. We conclude that the compensatory response to grazing depends on the type and level of stress limiting growth. Allocation and physiological responses to stress may positively or negatively affect the response to grazing and, simultaneously, grazing may alleviate or aggravate the effects of different types of stress.

Key words: Grazing – Growth – Stress – Allocation – *Briza*

The removal of plant tissue by grazing is rarely translated monotonically into a proportional reduction of final yield (McNaughton 1983). As a consequence of larger relative growth rates (Hilbert et al. 1981; Oesterheld and McNaughton 1988) grazed plants can partially or fully compensate for the tissue lost to grazers. Since plants in nature are not exposed to grazing in isolation but to several factors simultaneously (Chapin et al. 1987), the amount of compensatory growth can be affected by the level of stress imposed by factors such as light, nutrients, temperature, and water (McNaughton 1979; Maschinski and Whitham 1989). There are three basic reasons for this. First, the relative growth rates (RGR) of ungrazed plants will be different at different levels of stress (Hunt and Nicholls 1986) and, thus, the amount of change in RGR required to compensate will also be different (Hilbert et al. 1981). Second, the level of stress may affect the ability of plants to respond to grazing with an increase in RGR of the magnitude needed to compensate. Third, grazing may alleviate or aggravate the effect of the stress. When plants grow for several weeks at a constant density and at a constant level of resources, their relative growth rate declines with time (Hunt 1982; Causton and Venus 1981). This results from self-imposed stress caused by the increase in plant biomass, and therefore resource requirement, in relation to the amount of available resources. It may also result from ontogenetic factors such as reductions in mean leaf age. Stress is understood here as a reduction in the "attainment ratio" (Hunt and Nicholls 1986), which is the ratio between the actual RGR and the maximum potential RGR or R_{max} (Grime and Hunt 1975). One of the two major objectives of this paper is to test the hypothesis that the effect of grazing on plant growth varies according to the level of self-imposed stress. We start with a theoretical presentation of the problem that is intended for the consideration of the interaction between grazing and any type of stress. In discussing our empirical results, we consider potential differences between this particular self-imposed stress and several types of exogenous stress.

The second principal objective of this paper is to test the hypothesis that the response of plants to grazing involves a series of changes in allocation and growth parameters which respond to grazing with different time constants; as a result, the degree of compensatory growth will vary with the time of recovery from a grazing event.

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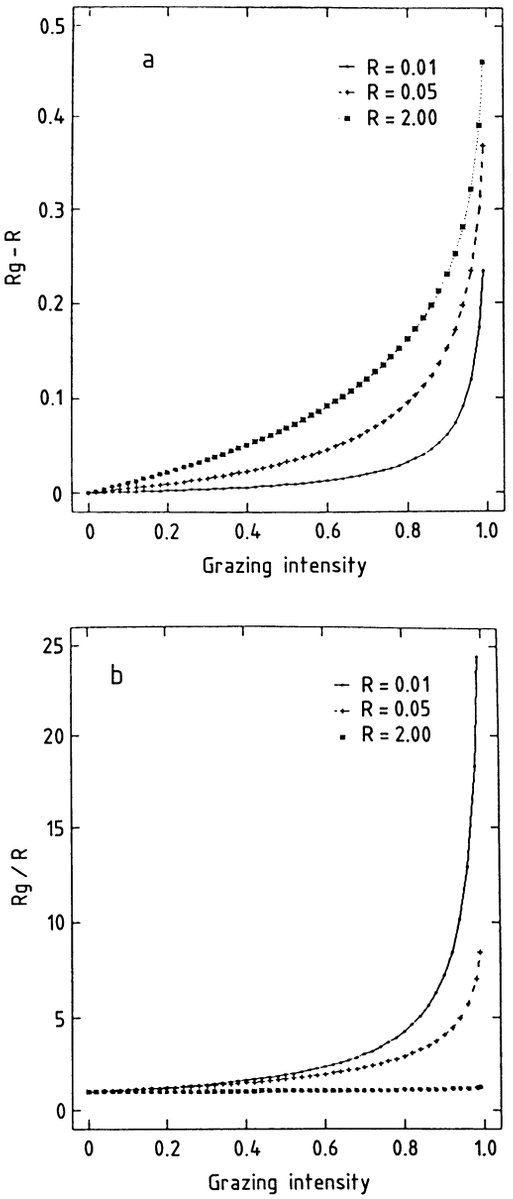

Fig. 1. a Absolute difference in relative growth rate between grazed and ungrazed plants necessary for full compensation at different grazing intensities and relative growth rates of control, ungrazed plants (R). Time for recovery was held constant at a value of 10 (from Hilbert et al. 1981, Fig. 4). **b** Proportional increase in RGR required for full compensation at different grazing intensities and relative growth rates of control, ungrazed plants (R)

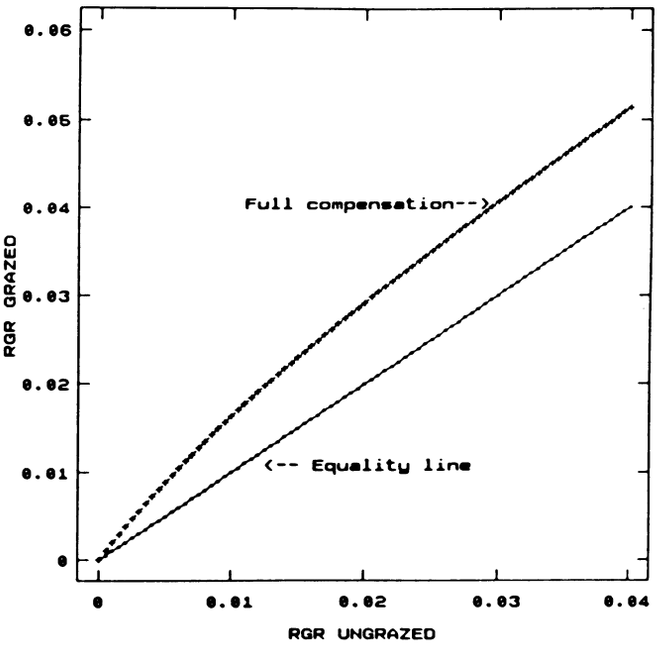

Fig. 2. Two important threshold lines in the theoretical relationship between relative growth rate of grazed and ungrazed plants. See text for explanation. This particular simulation of the full compensation line corresponds to a grazing intensity of 0.5, and a time of recovery of 56

Compensatory growth and stress

Hilbert et al. (1981) found that the amount of compensatory growth required by a grazed plant to equal productivity of an ungrazed plant depends on the RGR of the ungrazed plant. They specifically predicted that plants growing slowly were more likely to maximize production if grazed than those with an already high RGR. As a consequence, plants subjected to stress would be more likely to increase production following grazing.

There were two reasons for their prediction. First, the amount of change in RGR required by grazed plants to equal productivity of ungrazed plants is lower as RGR of ungrazed plants decreases (Fig. 1a) (the amount of change in RGR being defined as $R_g - R$ where R_g is RGR of grazed plants and R is RGR of ungrazed plants). Second, when plants are growing close to their maximum capacity (i.e. R close to R_{max}), grazing cannot increase RGR, and compensation is then unlikely.

While the latter argument is straightforward, we found through simple calculations that the former is sensitive to the way in which the change in RGR is expressed. When the change in RGR is not expressed in absolute terms ($R_g - R$), but in relation to R (i.e. R_g/R), the opposite conclusion is drawn (Fig. 1b): fast-growing plants require less change in RGR relative to R than slow growing plants. This can be illustrated by inspecting both graphs at, for example, a grazing intensity of 0.8: $R_g - R$ for plants growing at $R = 0.01$ is 0.032, and for plants growing at $R = 2.0$ is 0.16 (Fig. 1a); in contrast, R has to be increased by a factor of 4.23 if $R = 0.01$, and by a factor of 1.08 if $R = 2.0$ (Fig. 1b). Small values of $R_g - R$ represent much larger proportional changes at low than at high values of R. Is a large relative stimulation of RGR in plants growing slowly more likely than a small one in plants growing rapidly?

The answer to this question should be given by the actual shape of the relationship between R_g and R. Figs. 2 and 3 illustrate two important threshold lines in the theoretical relationship between R_g and R and the implications of such lines in terms of plant growth. Plants

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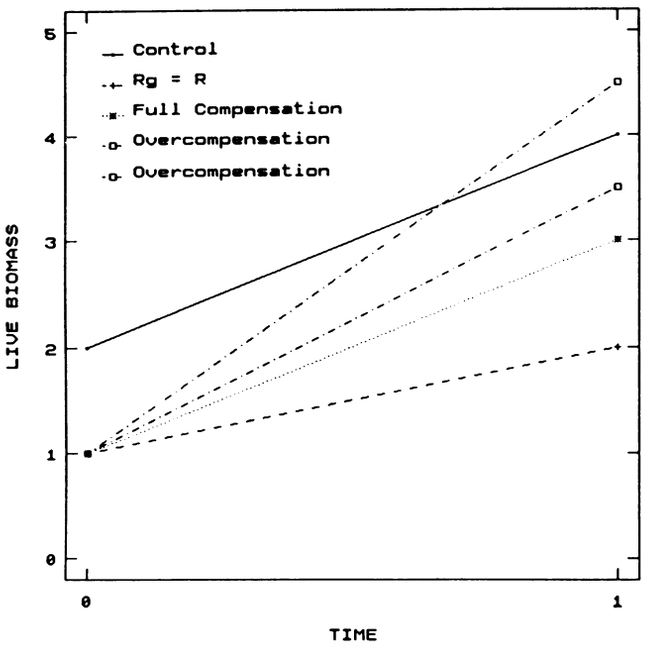

Fig. 3. Implications of the theoretical relationships shown in Fig. 2 on growth rates and final biomass of plants. Plants were hypothetically grazed at time 0 with an intensity of 50% and final biomass determined at time 1; plant growth rate is the slope of the curves. A grazed plant whose RGR equals that of an ungrazed plant ($R_g = R$) will show lower growth rates (the reduction being a direct function of grazing intensity) and lower final biomass. A grazed plant whose RGR falls on the full compensation line of Fig. 2 will equal growth rate of the corresponding ungrazed plant and its final biomass will be reduced in the amount removed by grazing. Finally, grazed plants whose RGR falls above the full compensation line will have higher growth rate than a corresponding ungrazed plant, but their final biomass can be lower or higher as indicated by the two lines labeled "overcompensation"

falling below the equality line in Fig. 2 would be damaged by grazing: grazing would reduce not only their productivity, but also the growth capacity of the remaining tissue. Plants falling between the equality line and the full compensation line in Fig. 2 would show partial compensation: a stimulation of relative growth rate by grazing, but not in the amount necessary to equal growth rate of ungrazed plants. Plants falling above the full compensation line would show overcompensation: relative growth rate is stimulated by grazing to such an extent that growth rate of grazed plants exceeds that of ungrazed plants. The full compensation line will depart from the equality line as either grazing intensity increases or time for recovery decreases. Notice, however, that overcompensation in terms of growth rates does not necessarily result in higher biomass of grazed plants (Fig. 3).

Assuming that the actual relationship between R_g and R is linear, it would have the form

$$R_g = a + bR \quad (1)$$

If $a \leq 0$ and $b \leq 1$, there would be no compensation because grazing would not increase relative growth rates; if $a > 0$ and $b \leq 1$, grazing would stimulate relative growth rates by a larger proportion in plants growing at lower rates, and $R_g - R$ would be a good predictor of the likelihood of compensation (Fig. 1a); in contrast, if $a \leq 0$ and $b > 1$ grazing would stimulate relative growth by a given proportion of R, and R_g/R would be more realistic as a measure of the change in RGR required to compensate (Fig. 1b). We know of no empirical determination of the actual relationship between R_g and R and this paper will provide one.

Grazing intensity in Hilbert et al.'s model is defined as percent of biomass removed. All experiments exploring the response to grazing under different levels of stress have defoliated the plants at a determined height. Since stress changes both plant allocation patterns and height (Hunt and Nicholls 1986), these studies confound stress and grazing intensity *sensu* Hilbert et al. (1981) or McNaughton (1979, 1985). The experiment to be reported here takes care of this potential problem by evaluating response to the removal of a constant proportion of biomass across different levels of stress (see Methods).

Compensatory growth and time for recovery

Most experimentation and theoretical speculation dealing with the response of plants to grazing has failed to consider time as an important variable (Oesterheld and McNaughton 1988; Brown and Allen 1989). Experiments and theory seem to be concerned with the result of a "growth race" between an intact, ungrazed plant and an initially handicapped, grazed plant. The race is terminated arbitrarily at some point and only the final result at that time is known or considered. The course of the race is unknown and it is frequently ignored or assumed to be monotonic.

Time for recovery has a major effect on the amount of change in RGR required to compensate: as time for recovery increases, the required change in RGR decreases (Hilbert et al. 1981). On the basis of observations on an African grass *(Themeda triandra)*, Oesterheld and McNaughton (1988) proposed a graphic model of the time course of changes in growth and allocation parameters. This paper will test the following predictions from that model:

1. RGR initially decreases after grazing, but later reaches values above those of control plants.
2. Grazed plants allocate resources in a way that results in a rapid restoration of the ratio between leaf area and total plant weight (La/W).
3. Those rapid changes in La/W are the result of a preferential allocation to leaf growth and the production of leaves with larger area per unit of mass.
4. Although RGR is initially depressed by grazing, net assimilation rates increase above control levels virtually immediately after grazing.

Methods

We provoked a range of relative growth rates by growing plants under constant conditions over 112 days. By clipping 8 groups of

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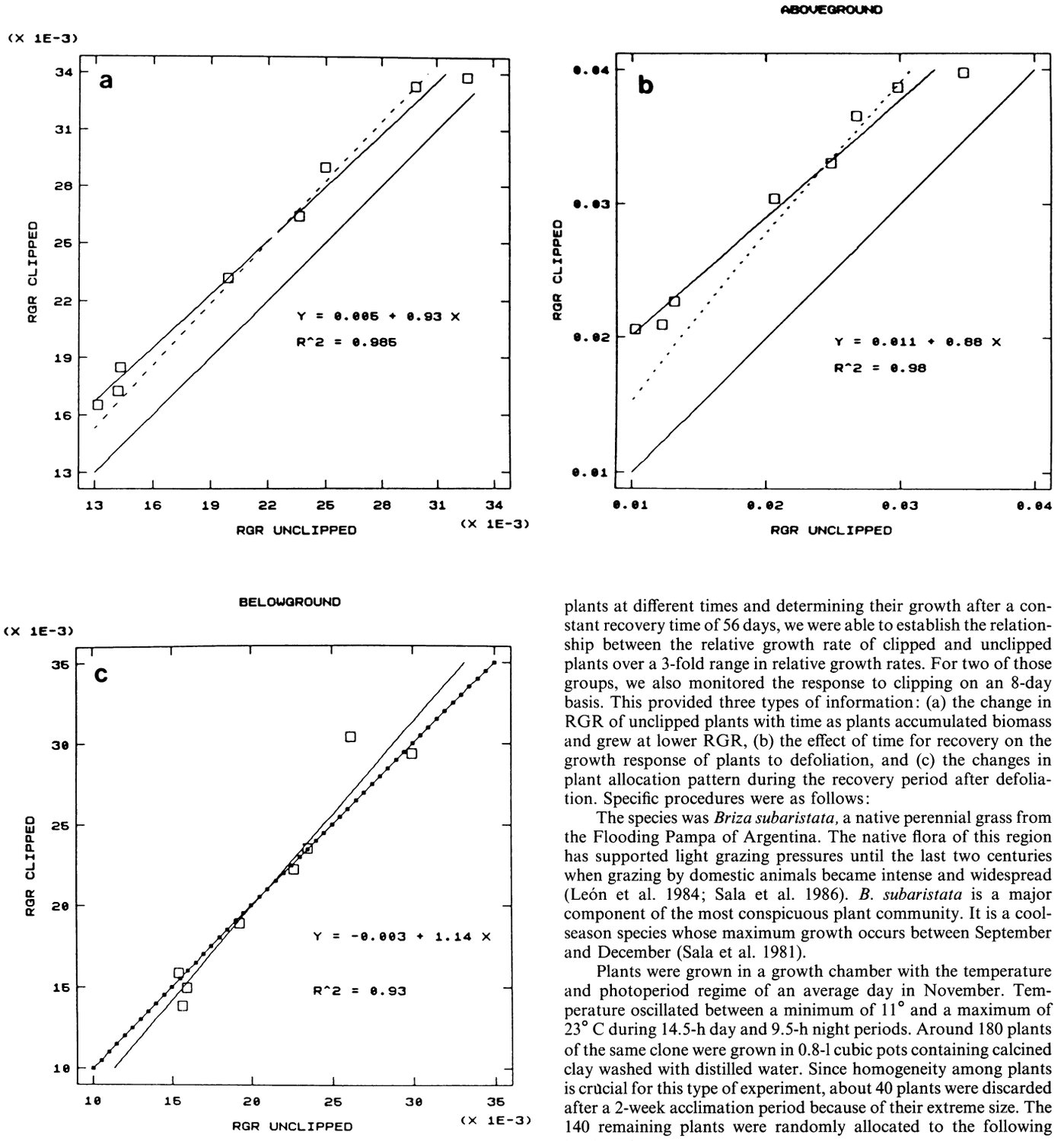

Fig. 4a–c. Relationship between relative growth rate (day^{-1}) of clipped and unclipped plants of *Briza subaristata* after a recovery period of 56 days. *Points* represent actual values; the *upper solid line* is the least-squares best fit; the *broken line* is the full compensation line; the diagonal (equality line $y = x$) was included as a reference. **a** entire plants (notice that the scale shows the original values after multiplication by 1000) **b** aboveground, **c** belowground (the full compensation and the equality lines are coincident because no belowground tissue is removed by clipping; scale as in [a])

plants at different times and determining their growth after a constant recovery time of 56 days, we were able to establish the relationship between the relative growth rate of clipped and unclipped plants over a 3-fold range in relative growth rates. For two of those groups, we also monitored the response to clipping on an 8-day basis. This provided three types of information: (a) the change in RGR of unclipped plants with time as plants accumulated biomass and grew at lower RGR, (b) the effect of time for recovery on the growth response of plants to defoliation, and (c) the changes in plant allocation pattern during the recovery period after defoliation. Specific procedures were as follows:

The species was *Briza subaristata,* a native perennial grass from the Flooding Pampa of Argentina. The native flora of this region has supported light grazing pressures until the last two centuries when grazing by domestic animals became intense and widespread (León et al. 1984; Sala et al. 1986). *B. subaristata* is a major component of the most conspicuous plant community. It is a cool-season species whose maximum growth occurs between September and December (Sala et al. 1981).

Plants were grown in a growth chamber with the temperature and photoperiod regime of an average day in November. Temperature oscillated between a minimum of 11° and a maximum of 23° C during 14.5-h day and 9.5-h night periods. Around 180 plants of the same clone were grown in 0.8-l cubic pots containing calcined clay washed with distilled water. Since homogeneity among plants is crucial for this type of experiment, about 40 plants were discarded after a 2-week acclimation period because of their extreme size. The 140 remaining plants were randomly allocated to the following treatments:

a. 60 plants remained unclipped throughout the experiment and were harvested in groups of 4 plants every 8 days (15 harvests, 4 plants/harvest).
b. 32 plants were clipped in groups of 4 at either day 0, 8, 16, 24, 32, 40, 48, or 56 and were harvested 56 days after clipping (8 harvests, 4 plants/harvest).
c. 24 plants were clipped at day 8. From then, 4 of them were harvested every 8 days (6 harvests, 4 plants/harvest).
d. 24 plants were clipped at day 40. From then, 4 of them were harvested every 8 days (6 harvests, 4 plants/harvest).

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The first group (60 plants) constituted a control of unclipped plants utilized for several comparisons. The second group consisted of the plants that were clipped when growing at different RGR and which were used to determine the shape of the relationship between R_g and R. Finally, the third and fourth groups, together with the plants of the second group clipped at days 8 and 40, allowed detailed monitoring of the different responses to clipping at both extremes of the gradient at an 8-day time scale.

Defoliation intensity (aerial biomass removed/aerial biomass of control plants) was kept constant across dates by clipping 40% of the mean aerial live fresh weight of control plants as determined at each clipping date. Defoliation took place progressively from the top of the plant downward until the desired amount had been removed. Litter above the final clipping height was removed and taken into account in production calculations, but did not contribute to the amount of biomass that had to be removed which was exclusively live tissue, largely leaf blades. The procedure resulted in a defoliation intensity of 42–47% on a dry weight basis across all dates. Leaf blade biomass of recently clipped plants was 25–40% of unclipped plants. There was no significant relationship (at $P<0.05$) between either of these variables and time. This indicates that the procedure was effective in controlling systematic variations in defoliation intensity across clipping dates which would have resulted in an interaction between stress and clipping intensity. The defoliation treatment never removed meristems.

Plants were watered every other day with 80 ml of distilled water. Nutrients were supplied by 80 ml of Hoagland solution every 8 days, just in the middle of an inter-harvest period. Clipped and unclipped plants were separated by a line of border plants and their location in the growth chamber was randomly changed every 8 days.

Results

After 56 days of recovery, R_g and R were linearly related (Fig. 4a, $r^2=0.985$, $P<0.00001$, $df=7$) by

$$R_g = 0.0046 + 0.93R \quad (2)$$

The intercept was significantly larger than 0 ($P<0.003$). The slope was not significantly different from 1 ($P<0.20$), but it was significantly lower than the slope of the full compensation line for that range of RGR ($P<0.05$). The larger RGR of clipped plants was due to a major increase in RGR of aboveground tissue which was not, however, at the expense of belowground growth. Relative growth rates of aboveground tissue of clipped and unclipped plants were related (Fig. 4b, $r^2=0.98$, $P<0.00001$, $df=7$) by

$$R_{g(\text{above})} = 0.0115 + 0.88R_{(\text{above})} \quad (3)$$

The intercept was significantly larger than 0 ($P<0.0001$), the slope was significantly lower than 1 ($P<0.05$), and significantly lower than the slope of the full compensation line ($P<0.05$). Relative growth rates of belowground tissue of clipped and unclipped plants were related (Fig. 4c, $r^2=0.93$, $P<0.0001$, $df=7$) by

$$R_{g(\text{below})} = -0.0029 + 1.143R_{(\text{below})} \quad (4)$$

This line was not statistically different from the equality line ($P<0.32$ for the intercept and $P<0.94$ for the slope) which indicates that clipping had no effect on belowground growth.

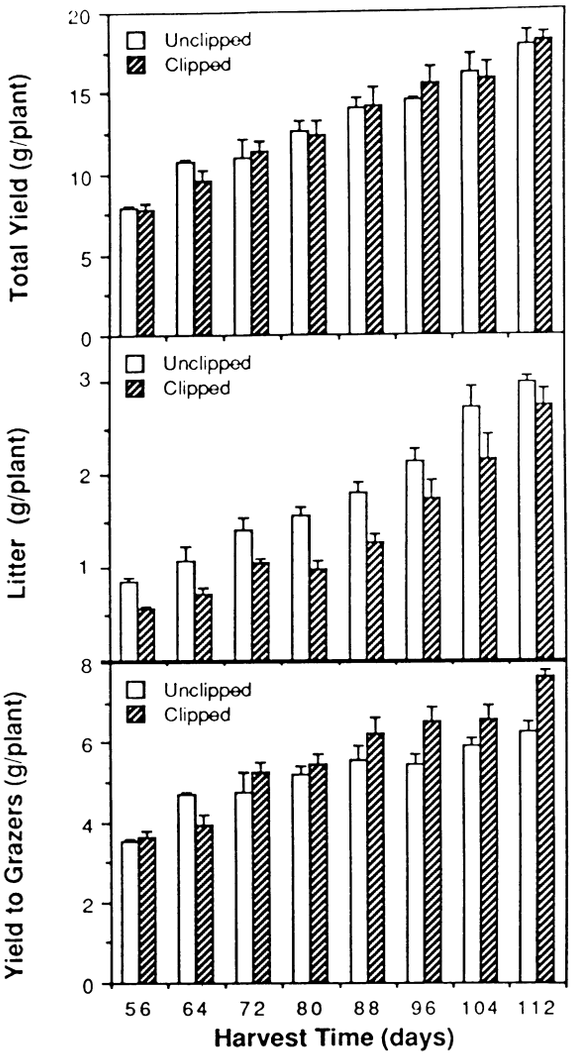

Fig. 5. Final yield of clipped and unclipped plants harvested at different times, but always 56 days after defoliation. A harvest time of 80, for example, corresponds to a 56-day recovery period for plants clipped on day 24. As harvest time increases relative growth rates decrease. Yield to decomposers was considered as litter accumulation, whereas yield to grazers was the sum of final live leaf biomass plus live offtake from clipping. *Bars* represent means + SE. ($n=4$)

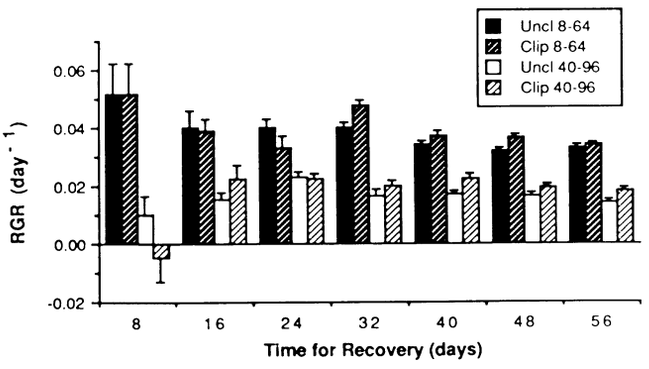

Fig. 6. Relative growth rate (day^{-1}) as a function of time for recovery. *Bars* are means + SE

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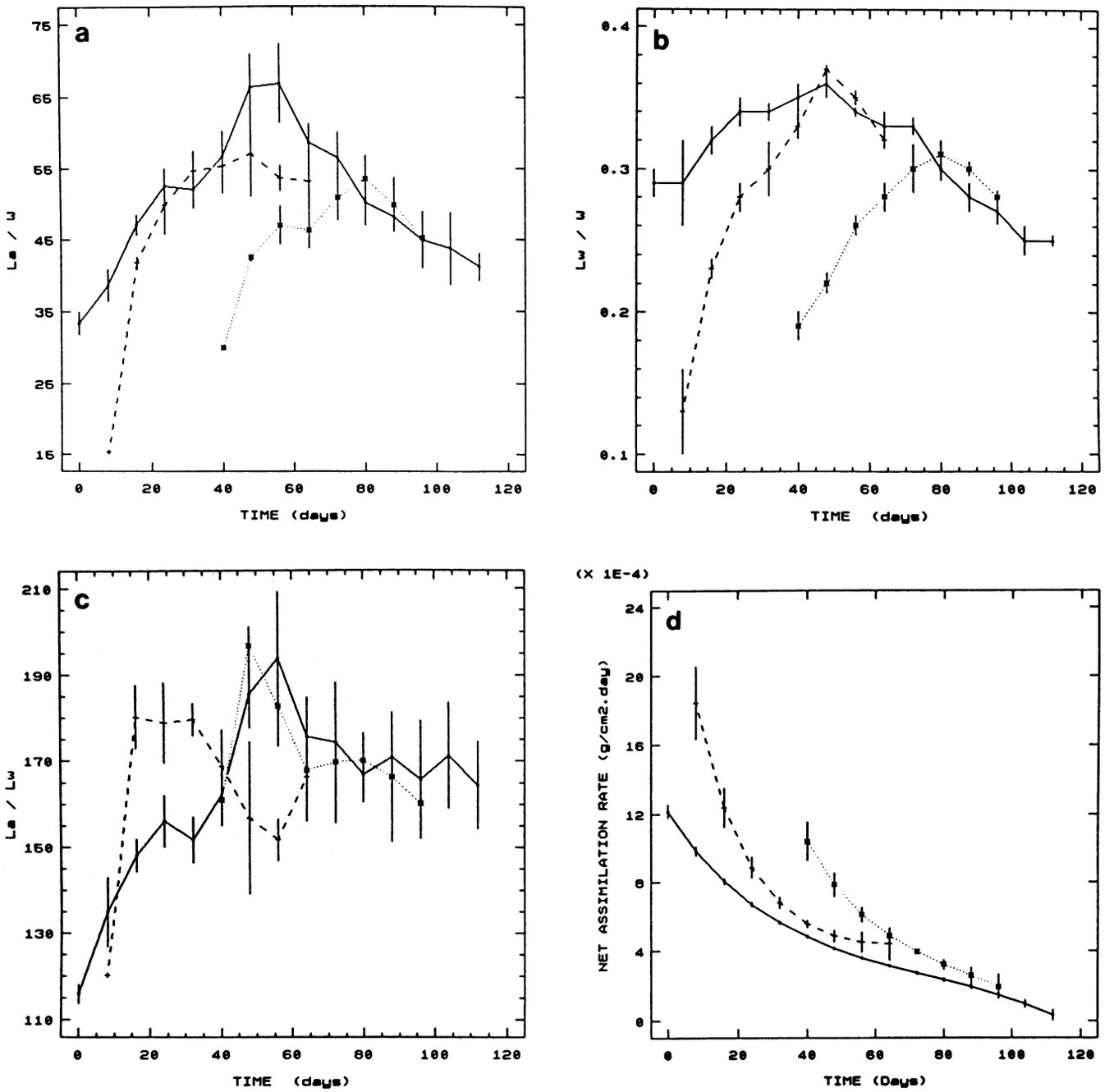

Fig. 7a–d. Changes in growth and allocation parameters for unclipped plants *(solid line)*, plants clipped on day 8 *(broken line)* and plants clipped on day 40 *(dotted line)*. Values are means ± SE. ($n = 4$). **a** Leaf area to plant weight ratio, La/W, in $cm^2.g^{-1}$ **b** Proportion of leaf weight (Lw/W) **c** Ratio of leaf area to leaf weight or the inverse of leaf specific weights (La/Lw) in $cm^2 \cdot g^{-1}$ **d** Net assimilation rate ($g \cdot cm^{-2} \cdot day^{-1} \times 10\,000$)

Total production, which includes final live, litter, and clipped-off biomass, was the same for clipped and unclipped plants regardless of the level of relative growth rates ($P < 0.9859$, Fig. 5). However, clipped and unclipped plants differed in the way their production was allocated. Assuming that ungrazed plants are eventually grazed at the end of the period considered, the yield to grazers (final aerial live biomass plus clipped off) was larger in clipped plants ($P < 0.0009$), particularly in those clipped later, whereas the yield to decomposers (litter) was larger in unclipped plants ($P < 0.0001$). The larger yield to grazers exhibited by clipped plants was not accompanied by any reduction in final live biomass or yield to producers ($P < 0.2361$).

All these results greatly depended on the time for recovery. With short time for recovery (16–24 days or less), relative growth rates were unaffected or reduced by clipping rather than increased (Fig. 6). When time for recovery became longer, defoliation resulted in a net increase in RGR. As a result, aboveground biomass of

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clipped plants reached control values 32–40 days after defoliation. Belowground biomass of clipped and unclipped plants was not different at any date.

Accompanying the recovery in growth exhibited by clipped plants, several changes in allocation pattern occurred, each of them with a particular timing. The ratio of leaf area to plant weight (La/*W*), which together with the net assimilation rate determines the RGR of a plant, was drastically reduced by the clipping treatment (Fig. 7a). Clipped plants quickly allocated resources toward an increase of La/*W* which reached values comparable to those of unclipped plants in about 16–24 days. La/*W* has two components: Lw/*W*, which is the ratio of leaf weight to plant weight, and La/Lw, which is the ratio of leaf area to leaf weight (the inverse of leaf specific weight). Lw/*W* was reduced by clipping (Fig. 7b) in the same way as La/W, but the increase of Lw/*W* during the time of recovery was slower. Clipped plants reached Lw/*W* values similar to those of unclipped plants only after 32–40 days. In contrast, the response of La/Lw was faster (Fig. 7c) and explains why recovery of La/*W* was faster than recovery of Lw/*W*. La/Lw increased less on plants clipped at day 40, a time when unclipped plants were reaching maximum values. This explains why the recovery of La/W was slower in plants clipped at day 40 than in plants clipped earlier.

Relative growth rates are the product of La/*W* by *E*, the net assimilation rate per unit leaf area. Since clipped plants never had higher La/*W* values than unclipped plants (Fig. 7a) and their mean relative growth rate was higher (Fig. 4a), their average *E* value must have been also higher. An approximation of the time course of *E* is given in Fig. 7d, which represents an estimation of *E* from fitting polynomials to raw data of leaf area and total biomass (Causton and Venus 1981). Net assimilation rates (*E*) were quickly (less than 8 days) doubled by clipping and gradually decreased toward values of unclipped plants.

Discussion

As plants grew over the 112-day period, their RGRs decreased as a consequence of the accumulation of old and dead tissue. The amount of RGR stimulation caused by defoliation was larger for plants growing at lower RGR. The results support the initial claim that full compensation was more likely to occur under stress (low RGR), but they also showed that this was not simply the result of the change in RGR needed to compensate being smaller (Hilbert et al. 1981). It was also a consequence of a larger response by plants growing under stress. Essentially, clipping increased RGR by a constant amount, the intercept of best fit lines in Figs. 4a and 4b, which was gradually reduced as RGR increased. From a comparison between the best fit lines and the equality and full compensation lines, we infer that the response to clipping along a range of self-imposed stress would go from damage to partial compensation to overcompensation as the intensity of stress increases. However, some evidence in the literature suggests that this conclusion may vary according to the type of stress that is causing variation in RGR.

Different types of stress may have a different effect on plant regrowth and, simultaneously, grazing may ameliorate or aggravate the effect of the stress. In our experiment, defoliation released the plants from the growth limitation imposed by their own accumulation of old and dead tissue and this release overrode the negative effect of the loss of biomass. This is in agreement with an axiom of animal husbandry practices which tend to maintain an optimum leaf area index which is much lower than the maximum attainable (Gifford and Jenkins 1982). The interaction between grazing and water stress (McNaughton 1979; Hodgkingson et al. 1976; Williamson et al. 1989; Olson et al. 1989) has also been reported as positive: grazing and defoliation enhance soil water conservation (McNaughton 1985; Archer and Detling 1986) and improve plant water status (Toft et al. 1987). When the gradient of stress is nutritional, however, the shape of the response continuum is less clear. Some studies have revealed lower compensatory responses at low levels of nutrient availability (McNaughton and Chapin 1985; Verkaar et al. 1986; Polley and Detling 1988; Chapin and McNaughton 1989), whereas some others showed that well fertilized plants are less likely to compensate than controls (Georgiadis et al. 1989). It is likely that the response is curvilinear with minimum compensation at both ends of the gradient and a maximum at an intermediate point. At low nutrient availability, compensatory growth would be limited because herbivory removes nutrients from the plant and they have to be reacquired from a deficient environment, and because defoliation can reduce a plant's ability to take up nutrients when they are in low supply (McNaughton and Chapin 1985; Chapin and McNaughton 1989). In contrast, at high nutrient availability, plants may be growing close to their maximum relative growth rates and grazing would not generate any compensatory growth (Hilbert et al. 1981; Georgiadis et al. 1989).

Another aspect of the interaction between grazing and stress is that stress may modify the amount that is consumed by herbivores. This aspect has received little attention from students of grass-ungulate relations, but has developed into an entire subdiscipline in the study of dicot-herbivore relations. In the case of dicots interacting with herbivorous insects and mammalian browsers, there is a clear negative association between stress and consumption due to the increase in secondary compounds observed in stressed plants (Coley 1987, 1988; Coley et al. 1985; Bryant et al. 1989). In grasses, most of the anti-herbivore defense consists of grazing avoidance by prostrate growth (McNaughton 1984; Malechek and Balph 1987) so that stress will affect consumption as long as it affects plant height. Unlike other studies exploring the interaction between defoliation and stress, this experiment was designed in such a way that the proportional removal of aboveground biomass was kept constant across the range of RGRs evaluated. When this is not controlled, and the particular source of stress being considered alters plant height and structure, plants growing at different levels of stress would be subjected to different

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intensity of tissue removal. For example, plants growing under water stress would be shorter (Coughenour 1985) and less defoliated than controls, whereas plants growing under flooding conditions may be taller (Jackson and Drew 1984) and thus more heavily defoliated than controls.

Our results contradict claims that overcompensation is most likely to occur under optimal growth conditions (Belsky 1986). They also limit the predictive power of simple models of compensatory growth such as that of Hilbert et al. (1981), whose predictions were based on required increases in RGR without considering how different stress types could alter the shape of the relationship between RGR of grazed and ungrazed plants.

Our experimental plants growing at low RGR overcompensated in terms of growth rates of live tissue and this resulted in overcompensation in the yield to grazers. However, total productivity of clipped and unclipped plants, which includes litter accumulation, was identical for all levels of RGR as a consequence of a larger litter accumulation in unclipped plants. Thus, the difference in RGR between clipped and unclipped plants was in part due to higher rates of biomass fixation per unit of biomass in clipped plants, but it was also due to higher leaf turnover in unclipped plants.

Consequently, the outcome of a defoliation event will be different depending on the response variable being considered. In decreasing order of likelihood, grazing will be likely to stimulate photosynthetic rates, relative growth rates, yield to grazers, live production or absolute growth rate, total production, final live biomass, and litter or standing dead accumulation. We draw this conclusion from the sequence of changes as time for recovery progresses and because, in most cases, compensation in terms of one variable is a necessary but not sufficient condition for compensation in terms of another variable. This order of likelihood of stimulatory responses clearly reflects a major part of the disagreement in the literature on compensatory growth. Many experiments have revealed overcompensatory responses in terms of net photosynthesis, but, to our knowledge, none has shown them in terms of litter accumulation.

Time available for recovery has a double effect on compensatory growth. First, as time for recovery increases, the absolute change in RGR required to fully compensate decreases (Hilbert et al. 1981). Grazing is less likely to increase growth if time for recovery is short. When one defoliation event is considered, both mathematical calculations (Hilbert et al. 1981) and empirical determinations (Oesterheld and McNaughton 1988; Maschinski and Whitham 1989) indicate that a longer time for recovery will result in a more positive response to grazing. The association between response and time for recovery is not monotonic, however, because there is a point during the recovery period at which defoliated plants become similar to undefoliated plants and no further compensation is observed (Alexander and Thompson 1982). Thus, the continuum of response to grazing as a function of defoliation frequency or time for recovery would also be curvilinear with a maximum at some intermediate value of defoliation frequency. To the left of the peak, plants would not have enough leaf area development to reach growth levels equal to ungrazed plants. To the right of the peak, clipped plants would spend time growing at rates of ungrazed plants.

This becomes more complicated when interactions between multiple defoliations are considered. Some studies have shown optimum values of productivity at clipping frequencies so high that they cannot be explained by time for recovery only. For example, *Kyllinga nervosa* showed a peak of productivity when defoliated daily compared to frequencies of 0.5, 3, 7, 20 days (McNaughton 1979). Although this is still consistent with the curvilinear continuum, the underlying mechanism must be different. This mechanism may be given by the interaction between time for recovery and grazing intensity. Plants grazed very frequently develop a very short prostrate canopy because grazing reduces competition for light and reduces growth in height (McNaughton 1984; Milchunas et al. 1988). Provided that they have the ability to grow below the height reached by the animals, plants grazed very frequently will also be grazed less intensively each time (Alexander and Thompson 1982). In contrast, plants that are allowed to recover for longer will grow tall and will be subjected to higher proportional removals.

A second aspect of the effect of time for recovery is that RGR and several allocation parameters exhibit dynamic change. Defoliation drastically changed the proportions of different organs. These proportions were gradually restored toward values exhibited by unclipped plants. Different allometric relationships were restored with different timing and this reflects different allocation priorities during the time for recovery. The sequence in which these changes took place was remarkably similar to that described for the African grass *Themeda triandra* (Oesterheld and McNaughton 1988). This similarity between two species with such a different evolutionary history and present habitat suggests that the sequence of changes and the allocation priorities are very regular across species.

Briza was particularly conservative in terms of its allocation to roots and this contrasted with observations for other species (Caldwell et al. 1981; Georgiadis et al. 1989). This contradicts the conclusion that compensatory growth aboveground is associated to inevitable losses belowground and agrees with field determinations of similar root biomasses inside and outside exclosures (Sims and Singh 1978a, b; Milchunas and Lauenroth 1989; van der Maarel and Titlyanova 1989).

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INTERACTIONS BETWEEN FERAL HORSES AND DESERT BIGHORN SHEEP AT WATER

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We studied sympatric populations of native bighorn sheep (*Ovis canadensis*) and feral horses (*Equus caballus*) to quantify their spatial and temporal overlap and to determine whether horses interfered with use of water by bighorn sheep. We observed no evidence of direct competition, but our field experiment, which involved placing desert-acclimated domestic horses near watering sites used by bighorn sheep, demonstrated that bighorn sheep avoided sites with horses nearby. The presence of domestic horses near a watering site preferred by bighorn sheep resulted in a 76% reduction in the number of groups of bighorn sheep coming to water at that location and a concomitant increase in the number of bighorn sheep watering at other sites. An experimental approach to studying competition between large mammals has been problematic and to our knowledge this study constitutes the 1st manipulative field experiment to test for competitive interactions between feral horses and native ungulates.

Key words: bighorn sheep, competition, *Equus caballus*, feral horses, *Ovis canadensis*, Peninsular Ranges, resource partitioning, wild horses

Desert bighorn sheep (*Ovis canadensis nelsoni*) and feral horses (*Equus caballus*) occur together in many arid regions of western North America where food, water, or both may be limited. Although these sympatric associations create the opportunity for behavioral interactions and potential resource competition, Berger (1985, 1986) questioned whether interactions between feral horses and bighorn sheep would result in niche segregation. A few studies have indicated that there is limited overlap in resource use by these species (Anonymous 1997; Beever and Brussard 2000; Bureau of Land Management 1996; Ganskopp and Vavra 1987), but none have examined the question of whether desert bighorn sheep (hereafter bighorn sheep) may be excluded from watering sites by feral horses.

We conducted a study to determine if interference competition for water existed between sympatric populations of feral horses and federally endangered bighorn sheep (United States Fish and Wildlife Service 2000) in an arid, water-limited region of southern California. We 1st assessed resource use by quantifying spatial and temporal overlap between feral horses and bighorn sheep near water, and then evaluated the responses of bighorn sheep to the presence of domestic horses tethered near a key water source.

MATERIALS AND METHODS

Study area.—Our study was conducted in Coyote Canyon in Anza-Borrego Desert State Park, a 2,429-km^2 natural area located in San Diego and Riverside counties in southern California. Research was focused in Coyote Canyon, a watershed that encompasses approximately 405 km^2 in the northwestern portion of the park. Approximate coordinates for the center of the study area are latitude 33.438°N, longitude 116.523°W. Coyote Creek traverses the canyon and forms the longest perennial stream in San Diego County, but there are only 3 short segments of the creek where water is present at the surface and available to animals during the summer months. Together, the Lower, Middle, and Upper Willows segments of Coyote Creek form 3 of the most verdant riparian wetlands in

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desert regions of southeastern California (Warner and Hendrix 1985). Within Coyote Canyon itself, riparian vegetation is found only in areas in close proximity to surface or subsurface water, extending over approximately 49 ha at Lower Willows, 22 ha at Middle Willows, and 16 ha at Upper Willows. Notably, these 3 areas of Coyote Canyon are included in the federally designated critical habitat for the endangered Peninsular bighorn sheep in southern California (United States Fish and Wildlife Service 2001).

Upland vegetation is dominated by chaparral at elevations above approximately 1,500 m and by pinyon pine (*Pinus monophylla*)–juniper (*Juniperus californica*) associations above approximately 1,200 m. At lower elevations, vegetation is dominated by agave (*Agave deserti*), ocotillo (*Fouquieria splendens*), cholla (*Opuntia*), palo verde (*Cercidium floridum*), creosote (*Larrea tridentata*), and palo verde–mesquite (*Prosopis*) associations (Ryan 1968; Sawyer and Keeler-Wolf 1995). Riparian areas are largely dominated by red willow (*Salix laevigata*), arroyo willow (*Salix lasiolepis*), cottonwood (*Populus fremontii*), and desert fan palm (*Washingtonia filifera*). Perennial shrub species such as mulefat (*Baccharis salicifolia*), narrow-leaved willow (*Salix exigua*), and arrow weed (*Pluchea sericea*) are mixed with willow-dominated vegetation.

The climate in the study area is characterized by hot summers, cool, wet winters, and a bimodal precipitation pattern (Dammitt 2000). Precipitation occurs mainly in November through February and July through September, with most rain falling during the winter. Between 1948 and 2003, annual precipitation averaged 149.1 mm, but was 29.7 mm and 118.6 mm in 2002 and 2003, respectively (Western Regional Climate Center, Borrego Desert Park Station). During the 2003 field season, major flash flooding in Coyote Canyon occurred on 1 and 21 August and substantially increased the water flow in Coyote Creek for several days after both flood events.

Human use of Coyote Canyon is highest at Lower Willows and considerably less at Middle and Upper Willows. Access to Middle and Upper Willows is limited by rough, 4-wheel-drive–only road access. A recreational equestrian trail passes through the canyon, but the entire canyon from Lower Willows through Upper Willows is closed to the public from 30 June to 1 September to minimize disturbance to bighorn sheep using the area for water. Our study was conducted during the summer months of 2002 and 2003, when the canyon was closed to public use.

Study populations.—Bighorn sheep in the Peninsular Ranges of California have been protected under state law since 1971, and were listed as a federally endangered species in 1998 (United States Fish and Wildlife Service 2000). During the period of this study, the estimated number of adult and yearling bighorn sheep in Coyote Canyon was approximately 35 (Torres 2003). This population estimate was obtained by using mark–recapture methodology and resighting radiocollared bighorn sheep from a helicopter (Torres 2003). Predators of bighorn sheep in the study area include mountain lions (*Puma concolor*), bobcats (*Lynx rufus*), and coyotes (*Canis latrans*).

Park records and anecdotal evidence indicate that feral horses were 1st introduced to Coyote Canyon around 1920. Data from periodic ground-based and helicopter surveys for bighorn sheep indicate that the population of feral horses in Coyote Canyon has ranged from 20 to 40 individuals from the 1970s through 2000 (Anza-Borrego Desert State Park, in litt.). Twenty-three feral horses were counted in a census of horses conducted via helicopter in May 2000, and 34 were individually identified during field studies in the summer of 2002. Because of drought and poor forage conditions in fall 2002 and winter 2002–2003, all 29 horses that remained in Coyote Canyon were captured in March 2003 and translocated to a wild horse sanctuary (foals, subadults, and adult females), or a Bureau of Land Management holding facility (adult males).

Evaluation of habitat overlap and interactions.—Ground reconnaissance trips were conducted during June and July 2002 to identify watering sites and to establish belt transects for estimating overlap in habitat use. We recorded surface water and bighorn sheep and horse sign (tracks and feces) via Trimble ProXR and Geo3 global positioning system units (Trimble, Sunnyvale, California), and estimated that there was 765, 490, and 360 linear m of suitable watering habitat for bighorn sheep and feral horses along the Lower, Middle, and Upper Willows areas of Coyote Creek, respectively. Fifty-six 1×100-m transects were then positioned along Coyote Creek at Lower Willows ($n = 28$), Middle Willows ($n = 21$), and Upper Willows ($n = 7$). In each of the 3 areas, transects were placed perpendicular to and centered on Coyote Creek at 20-m intervals. We recorded the presence or absence of feral horse and bighorn sheep feces and tracks in each of the one hundred 1-m^2 quadrats located along each transect. We excluded from analysis quadrats near the recreational equestrian trail, and where loose sand or extensive disturbance interfered with our ability to clearly distinguish sign.

From July through October 2002, we conducted observations of bighorn sheep and feral horses at Lower, Middle, and Upper Willows from 3 fixed locations for 30 days (10 days per site). Observations were conducted by teams of 2 or 3 people from dawn (approximately 0600 h) to dusk (approximately 1830 h). Ambient temperature was recorded every 30 min. Locations and behaviors of individual feral horses and groups of bighorn sheep were recorded upon initial sighting, and then via scan sampling (Altmann 1974) at 30-min intervals for as long as the animals were in sight. When bighorn sheep were within 100 m of riparian vegetation, their locations and behaviors were recorded at 5-min intervals in order to record their path of movement near water.

We also classified locations of each individual horse and group of bighorn sheep as being within riparian, wash, or upland habitat. We defined riparian habitat to be only those areas within 5 m of water or riparian vegetation (e.g., *Salix*). Areas near the creek having loose sand and sparse vegetation outside of riparian areas were considered wash habitat, and all other areas were considered upland. Locations of animals were later digitized into ArcView 3.3 (ESRI, Redlands, California). Overlap between bighorn sheep and feral horses was quantified by using ArcView 3.3 to overlay a 50×50-m grid over the

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study area (the viewshed at each riparian area) and counting the number of grid cells containing locations of bighorn sheep or feral horses at each of the Willow areas.

Horse experiment.—We implemented an experiment in summer (16 June–14 September) 2003 using tethered domestic horses to test the null hypothesis that horses had no effect on use of suitable watering areas at Lower Willows by bighorn sheep. This area was chosen because observational data collected in 2002 indicated that Lower Willows area was a high-use watering area for bighorn sheep. Because all feral horses had been removed from the canyon in March 2003, and the canyon was closed to the public, we were able to control for the presence and absence of horses. The experimental design included 10 days of baseline data collection with no horses present, followed by 25 days with horses present, and an additional 20 days with horses absent (nonhorse days). Each of the 25 days with horses (horse days) was randomly assigned a priori, and interspersed among the nonhorse days.

Each day, 1 or 2 observers used binoculars and spotting scopes to detect bighorn sheep coming to water. Upon initial sighting of bighorn sheep, we recorded their location (on a 10-m-resolution aerial photograph map), group size, group composition, and the date, time, ambient temperature, and wind speed. With the aid of a stopwatch timer, tape recorder, and binoculars, we recorded the location of the geographic center of the group at 30-s intervals. Animals separated by more than 100 m were considered separate groups. If multiple groups of bighorn sheep were in view at the same time, scan sampling alternated among groups so that locations were recorded at approximately 60-s intervals. The number and time of bighorn sheep visits to watering sites was recorded through a combination of observations and remote-triggered passive infrared Trailmaster cameras (Goodson and Associates, Inc., Lenexa, Kansas).

During the initial 10-day period of baseline data collection we determined that bighorn sheep drank at 4 discrete locations from Coyote Creek near Lower Willows that we termed watering sites 1–4. We chose to place the horses near site 1 between 1100 and 1500 h because bighorn sheep watered most frequently during this time period and at this location. On the 25 horse days, 2 or 3 desert-acclimated domestic horses were walked to the area and tethered to camouflaged metal posts for a 4-h period (from 1100 to 1500 h). Horses were able to move freely within an approximately 2-m-diameter circle, had constant access to a bucket of water, and were under close observation at all times. A horse handler, who had radio contact with the bighorn sheep observers, was stationed in a shade blind within 100 m of the horses to assist with any horse-related problems and to remove the horses at 1500 h. The horse handler's blind was out of view from the horses and from the bighorn sheep watering sites. The horses were individually tied at posts approximately 25 m apart, within 70 m of the water at site 1 and 150 m from site 2. From site 1, bighorn sheep had unobstructed views of the horses, but the rugged topography prevented bighorn sheep at sites 2, 3, and 4 from being able to see the horses and vice versa. Site 3 consisted of surface water 200–400 m downstream from the horses, whereas site 4 was >500 m away.

We were concerned that the presence of the horse handler and other horse equipment might influence behavior of bighorn sheep. The initial 10 baseline days of the study provided data on bighorn sheep in the absence of horses, equipment, or the horse handler. To test for potential effects of equipment and handler, equipment (shade blind, horse hitching posts, and water buckets) and no handler were placed at the site on 10 of 30 nonhorse days, and equipment and handler were placed at the site on 10 additional nonhorse days. The various treatments used in this experiment are referred to as baseline, equipment only, equipment plus handler, nonhorse (which includes no-horse days, equipment only, and equipment plus handler days), and horse days.

This study was performed in a humane manner and conformed to guidelines sanctioned by the American Society of Mammalogists (Gannon et al. 2007). Animal procedures were approved by and conducted according to University of California Protocol for Animal Use and Care no. 10670.

Statistical analyses.—We compared the number of transect quadrats containing sign from horses or bighorn sheep using Pearson's chi-square tests or Wilcoxon rank-sum tests (Sokal and Rohlf 1995) in S-PLUS 2000 Professional Release 2 (MathSoft, Inc., Cambridge, Massachusetts). We compared the total number of bighorn sheep and horses seen in 2002 at Upper, Lower, and Middle Willows using Pearson's chi-square tests, Fisher's exact test, or Wilcoxon rank-sum tests (Sokal and Rohlf 1995) in S-PLUS 2000 Professional Release 2 (MathSoft, Inc.).

We used Poisson regression or, when necessary, negative binomial regression in STATA 7.0 (Stata Corporation, College Station, Texas) to assess potential changes in watering patterns by bighorn sheep caused by the presence of horse equipment, the handler, or the horses. Poisson regression is an appropriate statistical model for discrete, count-based response variables (e.g., visits of groups of bighorn sheep); negative binomial regression is an alternative to Poisson when the count data exhibit excessive variation around the mean. We began our analysis by testing whether the rate of visitation by bighorn sheep to watering areas differed by treatment condition (baseline, equipment, or equipment plus handler) using mixed-effects negative binomial regression (StataCorp; Stata Corporation, College Station, Texas). In this regression model, site was treated as a random effect, and treatment as a categorical fixed-effect.

We 1st used fixed-effects Poisson regression (StataCorp 2003) to test whether the presence of horses caused a reduction in the number of bighorn sheep watering at Lower Willows per day. Next, we used fixed-effects Poisson regression to determine if the presence of horses was associated with temporal (periods 1, 2, or 3) or spatial (sites 1–4) shifts in the hourly visitation rate by bighorn sheep. For this analysis, we used the cluster option in STATA to group data by watering site (sites 1–4) and by time period (period 1 [0800–1100 h], period 2 [1101–1500 h], and period 3 [1501–1700 h]). Categorical covariates included treatment, whether horses were present the previous day (a lagged effect), whether precipitation occurred within the previous 24 h, and whether precipitation occurred

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Table 1.—Percentage (number) of 1-m^2 quadrats containing feral horse or bighorn sheep sign (hoofprints or feces) in transects at Lower (LW), Middle (MW), and Upper Willows (UW) in Coyote Canyon, Anza-Borrego Desert State Park, California, during summer 2002.

	Quadrats examined	Quadrats with horse prints	Quadrats with horse feces	Quadrats with sheep prints	Quadrats with sheep feces	Quadrats containing both sheep and horse sign
LW	2800	4.6 (130)	1.0 (28)	3.6 (102)	3.3 (93)	0.1 (4)
MW	2100	36.1 (758)	6.0 (125)	21.1 (444)	7.8 (163)	10.9 (228)
UW	700	41.7 (292)	33.9 (237)	2.1 (15)	1.7 (12)	1.9 (13)

within the previous 3 days. Continuous covariates included maximum air temperature per time period, maximum wind speed per time period, and day of data collection (1–55). A forward-stepping algorithm was used to build the model, with a P-value ≤ 0.10 based on a conditional t-test used as the criterion for inclusion in the model. All biologically plausible 2-way interactions and polynomial continuous variables were screened for inclusion in the model.

Because bighorn sheep are gregarious animals, animals within a group cannot be considered independent. Therefore, we conducted our analysis using the outcome variable ''number of groups of sheep'' rather than the number of individual bighorn sheep visiting a watering site per time period.

Results

Overlap in habitat use by bighorn sheep and feral horses.—We found that use of the 3 riparian areas by horses differed, as indicated by the presence of horse hoofprints (Pearson's $\chi^2 = 117.6$, $d.f. = 66$, $P < 0.001$) and horse feces (Pearson's $\chi^2 = 131.1$, $d.f. = 36$, $P < 0.001$; Table 1). Transects at Upper and Middle Willows contained more horse hoofprints than transects at Lower Willows ($Z = -5.29$, $P < 0.001$; $Z = -7.58$, $P < 0.001$, respectively). Horse hoofprints were found in 42%, 36%, and 5% of the quadrats examined at Upper, Middle, and Lower Willows, respectively, whereas horse feces were found in 34%, 6%, and 1% of the quadrats examined at Upper, Middle, and Lower Willows, respectively. Horse feces were significantly more common at Upper Willows than at Middle Willows ($Z = -4.29$, $P < 0.001$), and at Middle Willows than at Lower Willows ($Z = -5.19$, $P < 0.001$).

Tracks and fecal pellets from bighorn sheep were significantly more common at Middle Willows (21% and 8% of quadrats) than at Lower Willows (4% and 3% of quadrats; $Z = -5.90$, $P < 0.001$; $Z = -2.75$, $P < 0.001$, respectively) or Upper Willows (2% and 2% of quadrats; $Z = 3.96$, $P < 0.001$; $Z = 2.75$, $P < 0.001$, respectively). We found no difference in the number of fecal pellet groups from bighorn sheep at Lower Willows and Upper Willows. Quadrats containing both horse and bighorn sheep hoofprints or feces or both were found at all 3 riparian areas (Table 1). Evidence of overlap between the 2 species was more prevalent at Middle Willows (11%; Pearson's $\chi^2 = 69.0$, $d.f. = 26$, $P < 0.001$), than at both Upper and Lower Willows, where <2% of the quadrats contained sign of both species.

Observational data revealed that overlap in use of habitats near surface water by feral horses and bighorn sheep was highest at Middle and Upper Willows. Horses were detected in 24% of 50 × 50-m grid cells at Middle Willows and 27% of grid cells in the Upper Willows areas where bighorn sheep were also observed. Overlap in use of grid cells by the 2 species was much less (3%) in the Lower Willows area.

During the 30 observation days in 2002, we recorded 34 groups of bighorn sheep, for which we recorded 342 locations and behavioral observations. At least 1 group of bighorn sheep was observed on 19 of 30 days (Appendix I). We documented 25 (74%) of the 34 groups of bighorn sheep at water between 0800 and 1700 h. Bighorn sheep were seen more frequently at Middle Willows than Lower Willows ($Z = -2.63$, $P = 0.009$) or Upper Willows ($Z = -2.71$, $P = 0.007$). During the 30 observations days, we observed 31 groups of horses over 19 days (Appendix I) and recorded 1,468 locations of horses and behavioral observations. A larger number of individual horses was seen at Middle Willows than at Lower Willows ($Z = -2.31$, $P = 0.02$) or Upper Willows ($Z = -2.06$, $P = 0.04$), and at Upper Willows than at Lower Willows ($Z = -3.33$, $P < 0.001$). Horses commonly used riparian areas. We recorded horses in wash or riparian areas on 588 occasions between 0600 and 2000 h, and for an average of 4.9, 2.3, and 0.3 h per day at Upper, Middle, and Lower Willows, respectively.

We saw both bighorn sheep and feral horses on 11 days, but both species occurred simultaneously on only 4 occasions (Appendix I). Feral horses and bighorn sheep were never observed using water at the same time, nor were bighorn sheep ever observed to water when horses were in wash or riparian habitat within sight of the watering source. We did not detect evidence of direct interference competition (i.e., aggression) between feral horses and bighorn sheep, and therefore behavioral data are not presented. We observed 4 situations where horses and bighorn sheep were obviously in view of each other. In 2 cases, the horses did not appear to be aware of the bighorn sheep and the bighorn sheep were displaced (flushed) by the horses. In 1 instance, 2 females and a male walked within 35 m of 4 browsing horses in order to join another group of bighorn sheep nearby. In the 2nd instance, 2 females that were within 300 m of a group of horses fled a short distance uphill (<100 m) to rejoin a group of 14 other bighorn sheep and then continued browsing while the 12 horses came to water approximately 200 m below the bighorn sheep.

Horse experiment.—During 55 days of observation, we documented a total of 372 bighorn sheep coming to water in 82

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TABLE 2.—Percentage (number) of bighorn sheep groups observed at each watering site when tethered horses were present or absent near site 1. Data are from observations made between 1100 and 1500 h at Lower Willows of Coyote Canyon, Anza-Borrego Desert State Park, California, during summer 2003.

Watering site	Horses absent near site 1 ($n = 30$)[a]	Horses present near site 1 ($n = 25$)[a]
Site 1	53 (18)	3 (1)
Site 2	6 (2)	24 (7)
Site 3	6 (2)	13 (4)
Site 4	35 (12)	60 (18)

[a] Number of days of observation.

groups between 0800 and 1700 h. Most of these bighorn sheep (318 bighorns in 64 groups) watered between 1100 and 1500 h, the period during which horses were positioned near site 1 (Table 2). On 4 occasions we documented bighorn sheep running in apparent response to movement (e.g., shaking or turning their head or body) of the domestic horses tied near site 1.

Our Poisson regression models showed no effect of equipment or equipment plus the handler ($P > 0.10$) on the rate of bighorn sheep visits to water. Therefore, we pooled the 30 nonhorse days for comparisons with the 25 horse days. We found that the presence of horses near site 1 did not result in an overall reduction in the number of groups of bighorn sheep watering at Lower Willows that day. However, our final Poisson regression model (Table 3) indicated that when horses were present, there was a significant decrease in the rate of watering by bighorn sheep at site 1 and a corresponding significant increase in the rate of watering by bighorn sheep at sites 2–4, and particularly at site 4 (horses present × site 4, $P = 0.005$; Fig. 1). When horses were not present, there was no difference in watering rates by bighorn sheep at sites 1 and 4 (site 4, $P = 0.27$; Table 3). Coefficients for interactions between horses and time period were not significant, indicating there was no evidence of temporal partitioning of watering sites. Compared to referent conditions (i.e., site 1, during period 1, with no horses), significantly fewer bighorn sheep watered at site 2 ($P = 0.007$) and at site 3 ($P = 0.01$). More bighorn sheep watered during period 2 than during period 1 ($P < 0.001$; Table 3).

Maximum air temperature per time period and day of the study influenced the rate of bighorn sheep watering (Table 3). Incident rate ratios indicated that for each degree Fahrenheit the temperature increased, the visitation rates by bighorn sheep increased 4%. The negative and positive coefficients for the variables day and day^2, respectively, indicate that the rate of bighorn sheep visits to water by bighorn sheep initially increased as the study proceeded, but then leveled and eventually declined toward the end of the study. The covariates maximum wind speed per time period, precipitation in the previous 1 or 3 days, and presence of horses the previous day were not

TABLE 3.—Estimated maximum-likelihood coefficients for a Poisson regression model fitted to data on rates of watering (hourly visits to water with and without horses present) by bighorn sheep at 4 different sites in Coyote Canyon, Anza-Borrego Desert State Park, California, during summer 2003. The referent condition to which all other factors are compared is horses absent at site 1 during time period 1 (0800–1100 h).[a]

Parameter	Coefficient	95% CI for variable x	*P*-value	Incident rate ratio (IRR)	IRR 95% *CI*
Horses					
Absent[b]	0	—	—	—	—
Present	−1.44	−2.47, −0.40	0.007	0.24	0.08, 0.67
Watering site					
Site 1[b]	0	—	—	—	—
Site 2	−1.50	−2.59, −0.42	0.007	0.22	0.08, 0.66
Site 3	−1.28	−2.27, −0.29	0.01	0.28	0.10, 0.75
Site 4	−0.41	−1.14, 0.32	0.27	0.67	0.32, 1.38
Time period					
Time period 1 (0800−1100 h)[b]	0	—	—	—	—
Time period 2 (1101−1500 h)	2.07	1.01, 3.13	<0.001	7.94	2.74, 23.0
Time period 3 (1501−1700 h)	−1.22	−3.43, 0.99	0.28	0.29	0.03, 2.7
Maximum air temperature (°F)	0.04	−0.003, 0.08	0.07	1.04	1.0, 1.08
Day	0.07	−0.007, 0.15	0.07	1.07	0.99, 1.16
Day^2	−0.002	−0.003, −0.0003	0.02	0.998	0.996, 0.999
Horse × watering site					
Horses present × site 1[b]	0	—	—	—	—
Horses present × site 2	1.97	0.42, 3.53	0.01	7.2	1.5, 34.1
Horses present × site 3	1.62	0.10, 3.13	0.04	5.04	1.1, 23.0
Horses present × site 4	1.74	0.51, 2.97	0.005	5.7	1.7, 19.4
Constant	−8.52	−12.5, −4.54	<0.001	—	—

[a] Incidence rate ratios (IRRs) are the ratios of the rate of sheep visits per hour for the indicated factor, over the rate for the referent condition (no horses, site 1, period 1). For example, the IRR for horses present is 0.24, meaning that all other things being equal, having horses present results in a significant reduction to just 24% of the hourly visit rate at site 1 compared to when horses were absent (or a 76% reduction in the watering rate). For continuous variables the interpretation is for a single unit change; for example, as maximum air temperature increases by 1°F, the sheep visitation rate at site 1 increased by about 4%. 95% *CI* = 95% confidence interval.

[b] Referent condition for Poisson regression model.

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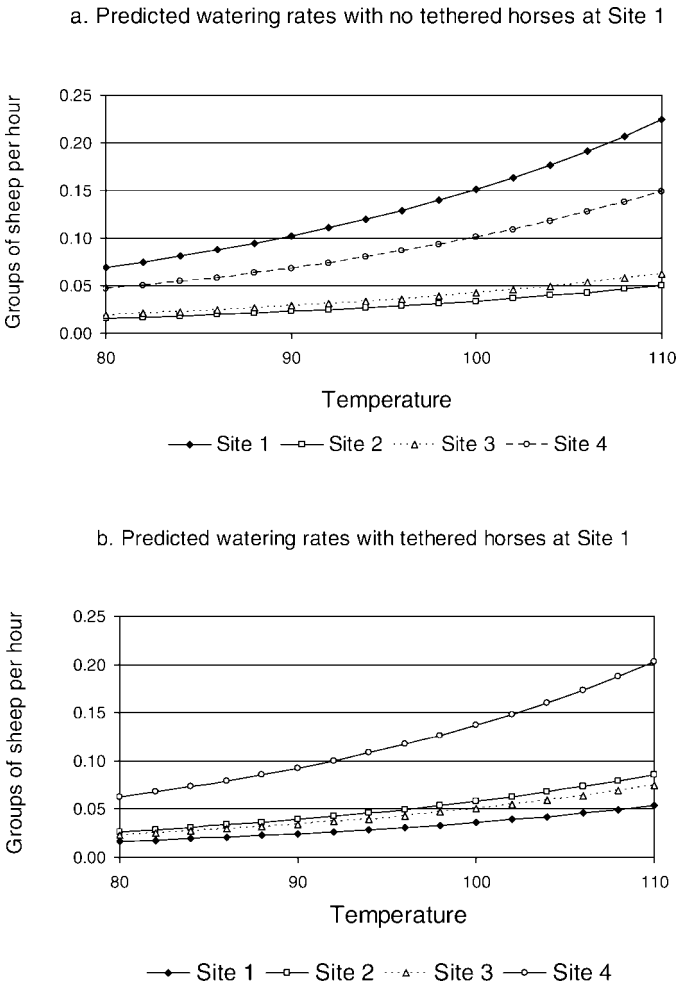

FIG. 1.—Comparison of watering rates by bighorn sheep (*Ovis canadensis*; groups of sheep per hour) per watering site when tethered horses (*Equus caballus*) were a) absent and b) present at site 1. Curves were plotted on the fitted relationship (Poisson regression model; Table 3) between watering rate and temperature (°F) during time period 2 (midday, 1100–1500 h) at Lower Willows in Coyote Canyon, Anza-Borrego Desert State Park, California, during summer 2003.

associated with spatial or temporal partitioning of watering sites, nor the overall rate of visits by bighorn sheep to Lower Willows.

DISCUSSION

In contrast to the study by Berger (1986) and other studies (Anonymous 1997; Beever and Brussard 2000; Bureau of Land Management 1996; Ganskopp and Vavra 1987), we found clear spatial overlap in habitats used by desert bighorn sheep and feral horses, particularly near water. Data from field observations and transect surveys showed that feral horses and bighorn sheep both used the same watering sources and occasionally interacted with each other near water (Table 1). Where use by feral horses was highest in terms of hours of use per day (Upper Willows), use by bighorn sheep was lowest.

Our finding that feral horses frequently spent several hours per day in or near riparian areas corroborates the findings of Crane et al. (1997) and Menard et al. (2002), who reported that feral horses preferred streamside or marsh–bog–meadow habitats during warm seasons. In contrast, Ganskopp and Vavra (1987) reported that feral horses in Oregon typically moved rapidly to and from water, with few feeding or loafing activities in the immediate vicinity of drinking areas. Ganskopp and Vavra (1987) suggested their finding may be explained by the plentiful water sources in their study area.

Although feral horses and bighorn sheep used all 3 Willow areas, both species rarely used these areas at the same time. On the 4 occasions when both species were present simultaneously, we saw no evidence of aggressive interactions and therefore we concluded that feral horses did not directly interfere or compete with bighorn sheep at water. This conclusion also was supported by the observations of Berger (1986) and Ganskopp and Vavra (1987).

Our field experiment demonstrated that bighorn sheep avoided water sources when horses were present nearby (Table 2; Fig. 1). Controls built into the experiment showed that this response was due to the presence of horses and was not influenced by the presence of horse handlers or equipment. This spatial partitioning of water resources is evidence of indirect interference competition, and warrants further investigation.

Temperature and day of the study also significantly influenced watering rates of bighorn sheep. The significant negative polynomial variable for day suggests that visitation rates by bighorn sheep initially increased, but then gradually decreased during the study period. This decrease may reflect the heavy rain and flash flooding that occurred within the study area beginning on day 28 of the 55-day study. The variables related to rain (precipitation within 24 h and precipitation within the last 3 days) were not significantly related to use of watering sites by bighorn sheep. Categorical variables for rain 1 and 3 days previously may not have been sufficiently sensitive to indicate when rain was an important influence on watering by bighorn sheep. A continuous variable that quantified precipitation would have more accurately accounted for any variation in watering by bighorn sheep due to rain; however, these data were not available. Rainfall in the desert is highly variable and patchy, making accurate quantification of rain in the study area difficult. The variable day^2 appeared to best account for the effect of rainfall.

Temporal partitioning of water resources by populations of desert bighorn sheep in Nevada and Arizona has been documented in response to human disturbance (Campbell and Remington 1981; Leslie and Douglas 1980). Perhaps we detected only spatial partitioning because there was an abundance of nearby watering sites available where horses were not present. In our study area, spatial partitioning was apparently less costly in terms of energy and predation risk than temporal resource partitioning. The avoidance behavior we documented likely underestimated the potential impact of feral horses because the 2 or 3 horses in our experiment were restrained and band sizes of feral horses in Coyote Canyon ranged from 4 to 16 horses. Larger numbers of free-ranging horses in and near water sources would be expected to have a greater effect on behavior of bighorn sheep.

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An experimental approach to studying competition between large mammals has been problematic (Stewart et al. 2002) and to our knowledge our study constitutes the 1st manipulative field experiment to study potential competitive interactions between feral horses and bighorn sheep. Our study clearly showed that bighorn sheep avoided watering sites when horses were nearby, which constitutes evidence of indirect interference competition (Diamond 1978; Loft et al. 1991). Inference from our study would have been strengthened by having replicates of the experiment involving tethering domestic horses near watering sites used by bighorn sheep. Although further research is clearly needed, our study demonstrates that the presence of horses has the potential to negatively impact bighorn sheep by causing them to avoid watering sites during the hot summer months.

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APPENDIX I

Numbers of feral horses and bighorn sheep groups observed at Lower, Middle, and Upper Willows in Coyote Canyon, Anza-Borrego Desert State Park, California; summer 2002. Numbers in parentheses indicate the number of groups seen. NR = not recorded.

Date	Day no.	High temperature	Low temperature	No. horses	No. sheep
Lower Willows					
23 July	1	101	76	0	7 (1)
24 July	2	102	81	5 (1)	4 (2)
19 September	3	95	73	0	0
21 September	4	100	79	0	7 (1)
23 September	5	106	81	0	14 (3)
24 September	6	106	89	0	8 (3)
26 September	7	105	89	0	6 (1)
27 September	8	94	74	5 (1)	0
1 October	9	80	63	0	0
2 October	10	79	58	0	0
				2/10 days	6/10 days
Middle Willows					
30 July	1	NR	NR	17 (2)	18 (1)
11 August	2	102	86	0	9 (1)
12 August	3	103	NR	5 (1)	15 (3)
13 August[a]	4	103	84	5 (1)	13 (2)
14 August[a]	5	102	83	5 (1)	21 (4)
19 August	6	92	89	13 (1)	0
20 August[a]	7	96	74	16 (2)	16 (2)
21 August	8	92	68	0	25 (2)
22 August	9	98	68	0	16 (2)
26 August	10	104	88	5 (1)	5 (1)
				7/10 days	9/10 days
Upper Willows					
5 July[a]	1	94	86	5	14 (1)
6 July	2	95	82	13	0
17 July	3	98	80	9 (2)	12 (1)
18 July	4	97	76	11 (3)	9 (1)
4 September	5	100	80	8 (3)	0
5 September	6	89	81	7 (1)	8 (1)
9 September	7	90	67	11 (3)	0
10 September	8	89	72	8 (2)	0
11 September	9	90	71	6 (2)	0
12 September	10	92	72	8 (2)	0
				10/10 days	4/10 days

[a] Days on which horses and sheep were in view at the same time.

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Impacts of feral horses on a desert environment

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Abstract

Background: Free-ranging horses (*Equus caballus*) in North America are considered to be feral animals since they are descendents of non-native domestic horses introduced to the continent. We conducted a study in a southern California desert to understand how feral horse movements and horse feces impacted this arid ecosystem. We evaluated five parameters susceptible to horse trampling: soil strength, vegetation cover, percent of nonnative vegetation, plant species diversity, and macroinvertebrate abundance. We also tested whether or not plant cover and species diversity were affected by the presence of horse feces.

Results: Horse trailing resulted in reduced vegetation cover, compacted soils, and in cases of intermediate intensity disturbance, increased plant species diversity. The presence of horse feces did not affect plant cover, but it did increase native plant diversity.

Conclusion: Adverse impacts, such as soil compaction and increased erosion potential, were limited to established horse trails. In contrast, increased native plant diversity near trails and feces could be viewed as positive outcomes. Extensive trailing can result in a surprisingly large impact area: we estimate that < 30 horses used > 25 km^2 of trails in our study area.

Background

Zoogeomorphology, the study of the geomorphologic impacts of animals [1], is a relatively new field of research. Ecologists and geomorphologists are placing increasing emphasis on understanding the fundamental role of animals as agents of erosion, transportation, and deposition of sediment [2,3]. Zoogeomorphologic data may be useful to wildlife managers who need to quantify, predict, and manage impacts from feral species on native ecosystems.

Zoogeomorphology may be particularly helpful in understanding the controversial role of feral horses (*Equus caballus*) in native ecosystems [4-8]. Feral horses have a wide geographic range across the southwestern United States and may potentially affect many species through seemingly small changes to the ecosystems they inhabit. For instance, the tendency for feral horses to use landscapes heterogeneously results in the creation of multiple trails [5]. We documented an extensive complex of trails that were used and maintained by feral horses in southern Cal-

ifornia and similar trail complexes have been documented in Nevada [5]. Horse feces and trails may visually impair the landscape and detract from the experience of some wilderness users. Natural animal trails from a variety of species are well documented, primarily through casual mention in the literature, but little quantitative information on the impacts of animal trails in natural environments exists [3,9]

Trampling, which leads to the formation of trails, is one of the most influential geomorphologic effects of large mammals such as feral horses [3]. Through a variety of mechanisms, trampling may lead directly or indirectly to erosion [7]. It is a direct agent of erosion when hoof chiseling leads directly to erosion. Trampling is an indirect agent of erosion when it prepares the soil for erosion through other geomorphic processes; for example, when trampling removes vegetative cover or increases soil bulk density (i.e., causes soil compaction). Soil compaction is problematic because it increases soil strength, reduces both rainwater infiltration rates and soil pore volume [3], and affects plant root growth through increased mechanical impedance and elevated soil temperatures [10]. Reducing vegetative cover increases the likelihood of soil erosion.

Erosion is of special concern for desert soils because nutrients are often concentrated in the surface soil [11]. Even the loss of a few centimeters of surface soil may substantially reduce available nutrients for plants and disrupt community structure [12]. Microbiotic soil crusts serve important functions in soil stabilization, nitrogen fixation, and water conservation. These crusts are concentrated in the top 1-4 mm of soil and are particularly sensitive to trampling [11].

Erosion, soil compaction, and vegetation loss from trampling can ultimately alter the structure of local soil, plant, macroinvertebrate, bird, or small mammal communities [3,6,7,11,13]. Soil disturbance and compaction have been associated with decreased plant germination [11]. Decreases in plant cover have been associated with decreases in the diversity and abundance of lizards [11] and increased predation rates on bird eggs [14]. Because geomorphic changes may have cascading effects that potentially extend to multiple species, it is important to quantify the geomorphic impacts of large, wide-ranging mammals such as feral horses. The impacts of cattle trampling and grazing on native plant and animal species have been relatively well-studied. However, because of behavioral, morphological and evolutionary differences, it is not appropriate to assume that impacts from feral horses are similar to those of domestic livestock [5,15].

In this study our first objective was to quantify, at varying distances from trails used by horses, five parameters susceptible to horse trampling: soil strength, vegetation cover, percent of nonnative vegetation, plant species diversity, and macroinvertebrate abundance. Another potentially important effect of feral horses in an arid environment is their role, via feces, in redistributing seeds, nutrients, and moisture, as well as increasing soil pH [16]. An adult horse deposits an estimated 9145 kg of feces per year [17], and the extra nutrients and moisture provided by horse feces may provide a more favorable environment for both native and nonnative plant species. Our second objective in this study was to quantify changes in plant cover and species diversity near feral horse feces.

Methods

Study Area

We sampled upland habitat near Upper Willows and Alder Canyon at the northwest end of Coyote Canyon in Anza-Borrego Desert State Park (ABDSP), California, USA. Coordinates for the approximate center of our study area are latitude 33.438, longitude -116.523. Coyote Canyon is within the Colorado subdivision of the Sonoran Desert. This area was chosen for sampling because it was a high use area for feral horses and it contained a dense complex of visible trails used by feral horses.

Soils in the study area are of granitic origin and range in texture and composition from course sand to fine sandy loam, and in some cases, fine silt. Vegetation in Coyote Canyon is dominated by chaparral at elevations above approximately 1500 m and by pinyon pine (*Pinus monophylla*)-juniper (*Juniperus californica*) above approximately 1200 m. At lower elevations, vegetation is dominated by agave (*Agave deserti*), ocotillo (*Fouquieria splendens*), cholla (*Opuntia* spp.), palo verde (*Cercidium floridum*), creosote (*Larrea tridentata*), and palo verde-mesquite (*Prosopis* spp.) associations. Annual species comprise over half the flora in the Colorado subdivision of the Sonoran Desert and are mostly winter growing species that flourish only in wet years.

Climate is characterized by hot summers, cool wet winters, and a bimodal precipitation pattern, with most precipitation occurring during November - February and a smaller amount occurring during July - September. Between 1948 and 2003, annual precipitation averaged 149.1 mm, but was only 29.7 mm and 118.6 mm in 2002 and 2003, respectively (Western Regional Climate Center, Borrego Desert Park Station). This area of the Sonoran Desert is classified as arid [18].

Historically, Coyote Canyon was home to several bands of Native Americans, followed by a small number of cattlemen and homesteaders between the 1880s and 1960s. Feral cattle were introduced into the canyon during the Anza Expeditions beginning in 1773. Cattle ranchers and the Los Coyotes Indians maintained horses and cattle in

Coyote Canyon beginning in the mid-1800s and into the early 1900s. Small numbers of feral cattle roamed the canyon until they were captured and removed in 1987.

A population of approximately 20-40 feral horses inhabited Coyote Canyon from circa-1920 until March 2003. Anecdotal accounts suggested the horses were released from a nearby ranch in the 1920s, but the actual origin and date of introduction of these horses is unknown. In March 2003, California State Parks removed all feral horses (n = 29) from the canyon due to poor range conditions. Young and female horses were translocated to a wild horse sanctuary and the males were transferred to a Bureau of Land Management holding facility.

It is important to note that our study area was subject to cattle grazing for approximately 100 years. One of the more difficult aspects of researching feral horse impacts on arid environments is finding a study site that was not previously grazed by cattle. The rarity of ungrazed land in the southwestern U.S. effectively forces researchers to use previously grazed lands in studies of other land impacts [6,7,11]. While cattle were removed from Coyote Canyon >15 years before our study, 15 years is probably insufficient time to allow complete recovery of vegetation to pre-grazing conditions [11]. Therefore, although we defined horse trails as those trails apparently used and maintained by feral horses in the 15 years prior to our study, it is possible that many of these trails were originally created or used by cattle. The feral horse trails sampled in this study are distinct and separate from the equestrian riding trail in Coyote Canyon that is maintained by California State Parks. Wild burros (*Equus asinus*) are found in a few locations in southern California but were absent from our site.

Field sampling

Using ARCVIEW 3.2 (Environmental Systems Research Institute, Inc., Redlands, California), we created a study area polygon within Coyote Canyon that encompassed approximately 10 km^2 of upland habitat used frequently by feral horses. We chose this area to provide a relatively homogeneous study area that did not include riparian vegetation. Using ARCVIEW, we generated 120 randomly placed potential starting points within the polygon. From each of our starting points, we walked a spiral circle outward to the first encountered horse trail. We considered only obvious paths ≥ 30 cm wide containing <25% vegetation cover for a linear distance of >10 m, and/or linear paths showing clear incision as starting points for sampling. Once a clear trail was identified, whenever possible, we added three additional sampling points along the trail, spaced 120 paces (approximately 50 m) apart. In these cases, trails may not have measured >30 cm in width where sampling occurred.

At each trail sampling point, we recorded the trail width and depth (measured as the difference between the center of the trail and a meter stick placed perpendicular to the trail, resting on the edges of the trail). Two 6.4 m transects were established perpendicular to each side of the trail. We placed 30 cm^2 quadrat frames in the center of the trail and at 0, 0.40, 1.40, and 6.40 m from each side of the trail, along the transect, resulting in nine quadrats per trail sampling site. Quadrats at 0 m from the trail were immediately adjacent to the edge of the trail. Quadrats at 6.40 m from the edge of the trail were designated as the referent or control plots because we expected trail impacts to be minimal >6 m from the trail. If a referent plot fell on or near (within a 5-m radius) a horse trail, the quadrat was relocated to a nearby area (within 10 m) not having feral horse trailing. The exact placement of the quadrat at the relocated site was determined by tossing the quadrat frame in the designated area. Horse fecal piles were selected for sampling by searching a 15-m diameter area near referent quadrats. Only feces estimated to be <1-year-old based on moisture content and color were sampled. A 30-cm^2 quadrat was placed immediately adjacent to the feces in one of the four, systematically-altered cardinal directions.

For all 1080 quadrats, we estimated the total percent cover and the percent cover of each plant species. Cover was estimated as the actual percentage of the quadrat covered by vegetation rooted within the quadrat, without rounding or filling in areas between leaves or vegetative parts. Plant species were identified and classified as native or non-native [19]. For each quadrat, we also recorded whether the referent quadrat was moved (described above), the percentage of the quadrat under the dripline of a shrub, and the presence or absence of horse feces.

We counted all live macroinvertebrates (e.g., Araneae, Coleoptera, Hemiptera, Hymenoptera) within a quadrat during a 10-s scan within quadrats at the trail center, and at 0, 0.40 and 6.40 m from the trail. Vegetation was manipulated when necessary to improve visibility. We also measured soil strength eight times per quadrat in quadrats at the trail center, and at 0, 0.40, and 6.40 m. Soil strength is a measure used to characterize soil compaction. We measured soil strength in kg/cm^2 using a hand-held pocket penetrometer (ELE International Pocket Penetrometer Model 29-3729, Pelham, AL, USA). For consistency, all soil measurements were made by one person using the same penetrometer. Macroinvertebrate and soil data were not collected from quadrats at 1.40 m from the trail or for those adjacent to horse feces, in order to improve data collection efficiency and facilitate a two-person field team. Soil strength data was not collected during the first week of fieldwork because the equipment was not available.

We estimated the total length of trails used by feral horses in the greater Coyote Canyon area by viewing aerial photographs of Coyote Canyon http://terraserver-usa.com/ and measuring visible trails using TOPO 2.3.2 (Digital Data Services, Inc., Lakewood, CO, USA). We also recorded some of the less-visible trails via GPS during field surveys and later displayed and measured these trails using TOPO. As a result of our methodology and incomplete survey of the canyon, our estimate of the trails used by feral horses in Coyote Canyon represents a minimum estimate.

Data Analysis

Data were analyzed using S-PLUS 2000 Professional Release 2 (MathSoft, Inc). We used linear mixed-effects models [20] for continuous outcome variables and Poisson regression models [21] for discrete outcome variables. Outcome variables included percent total plant cover, percent cover of nonnative plant species, number of native plant species, soil strength, and number of macroinvertebrates. Continuous covariates were distance from the trail (QUADRAT), percent of the quadrat under a shrub dripline (DRIPLINE), day of data collection (DAY), trail area (width × depth in mm; TRAILAREA), and average soil strength (SOIL). Categorical covariates were presence or absence of precipitation within the preceding 48 hrs (RAIN), presence or absence of horse feces or tracks within the quadrat (HORSESIGN), and whether or not the referent quadrat was moved to avoid a trail (MOVED). The referent conditions, to which all models were compared, included no rain in the preceding 48 hours, absence of horse feces and tracks, and "not moved" for the referent quadrat. Because one of our primary objectives was to test the significance of "distance from the trail" for each outcome variable, the covariate QUADRAT was included in all models.

We began our data analysis with univariate regression models for all covariates and two-way interactions for each outcome variable. Data from referent quadrats (located 6.4 m from the edge of the trail) were always used as the referent values. Significant differences between quadrats on or adjacent to the trail and the referent quadrat were indicated by a significant ($P \leq 0.05$) coefficient for the corresponding QUADRAT (on the trail, 0 m, 0.1 m, or 1.4 m from the trail) in the regression model. Similarly, significant relationships between outcome variables and covariates were indicated by significant coefficients for covariates.

For linear mixed-effect models, quadrats were grouped by transect number to test for significant random effects (i.e., unexplained, but correlated data between quadrats within a transect). Quadrats near feces were compared to the nearest referent quadrats. We Arcsin transformed (2* [Arcsin $\sqrt{Y}$]) all outcomes that were percentages to make them more suitable for regression analysis. We used an exponential variance function for all linear mixed-effect models in order to control for heteroscedacity. Alpha was set at 0.05 for all analyses. For Poisson regression models, we calculated *p*-values for the *t*-values calculated by S-PLUS by using an online probability calculator (J. Pezzullo; http://davidmlane.com/hyperstat/t-table.html).

Results

Between 7 April and 5 May 2003, we sampled 120 transects (1080 quadrats) and 64 fecal piles within the Alder Canyon and Upper Willows area of Coyote Canyon. Trails ranged from 36-980 mm wide (μ = 407 mm, SD = 110) and 0-113 mm deep (μ = 48 mm, SD = 18), with a maximum trail area (width × depth) of 56 500 mm^2. We estimated that the feral horse population in Coyote Canyon regularly used ≥ 21 km of trails within Coyote Canyon.

A total of 79 plant species were identified (14 perennial and 65 annual species; see Additional File 1), including three nonnative species: red brome grass (*Bromus madritensis spp. rubens*), red stem filaree (*Erodium circutarium*), and Mediterranean grass (*Schismus barbatus*). Overall, the most common species encountered was the exotic *S. barbatus*, followed by the native annual, desert pincushion (*Chaenactis fremontii*). On or along trails, the number of native species per quadrat ranged from 0-13, percent total plant cover ranged from 0-100%, and percent nonnative plant cover ranged from 0-78% (Table 1). Soil strength varied from 0-4.6 kg/cm^2 (4.6 kg/cm^2 was the maximum reading of the penetrometer; μ = 0.1.74; SD = 1.1). Near horse feces, the number of native plant species per quadrat ranged from 2-12, percent cover ranged from 10-80%, and percent nonnative cover ranged from 0-27% (Table 1).

Percent total vegetation cover was lower than referent quadrats on the trail and at 0.40 m from the trail (Table 2; Fig. 1). Our model for percent total vegetation cover accounted for significant random effects and showed that vegetation cover increased with soil strength and dripline (Table 2). Percent nonnative cover differed from the referent quadrats only on trail quadrats. Overall, our regression model showed that percent nonnative cover had a positive association with dripline and a curvilinear relationship with soil strength, with the highest percentages of nonnative cover obtained at intermediate soil strengths (Table 2). The number of native plant species per quadrat was significantly lower than referent quadrats on the trail and significantly higher than referent quadrats at 0 and 0.40 m from the trail (Table 3; Fig. 2). The number of native species per quadrat declined as dripline increased and changed curvilinearly with soil strength, again with

Table 1: Summary of species composition and soil strength data from 120 transects centered on and adjacent to horse trails in Coyote Canyon, Anza-Borrego Desert State Park, California, USA; Spring 2003.

Location of quadrat	N	Mean percent plant cover	Mean percent nonnative plant cover	Mean number of total species	Mean number of native species	Mean number of nonnative species	Mean soil strength (kg/cm^2)	Mean number of macro-invertebrates
Quadrat 1 (Trail)	120	13.7 (10.1)	5.7 (7.5)	4.0 (2.0)	3.0 (1.9)	1.0 (0)	2.2 (1.3)	0.63 (1.4)
Quadrat 2 (0 m)	240	31.6 (15.0)	10.4 (11.1)	5.9 (2.3)	5.0 (2.3)	1.0 (0)	1.6 (1.0)	0.52 (1.1)
Quadrat 3 (0.4 m)	240	29.0 (14.4)	10.3 (10.8)	5.7 (2.4)	4.7 (2.4)	1.0 (0)	1.7 (1.1)	0.61 (1.3)
Quadrat 4 (1.4 m)	240	30.3 (15.2)	10.9 (12.7)	5.2 (2.1)	4.3 (2.1)	1.0 (0)	NA	NA
Adjacent to feces	64	30.8 (13.7)	7.1 (6.9)	6.4 (2.2)	5.4 (2.3)	1.0 (0)	NA	NA
Quadrat 5 (Referent)	240	31.7 (15.9)	11.9 (13.5)	4.9 (2.1)	4.0 (2.1)	1.0 (0)	1.66 (1.0)	0.43 (0.8)

Standard deviations are given in parentheses. Soil strength data was not collected for quadrats at 1.4 m from the trail or adjacent to feces.

the highest number of native species occurring at intermediate soil strengths.

Trails had higher soil strength than referent quadrats, while quadrats at 0.0 and 0.4 m had lower soil strength than referent quadrats (Table 2). Our model for soil strength accounted for random effects among transects and showed that soil strength decreased with rain, trail area, dripline, and horse sign (i.e., hoof prints or horse feces). In quadrats near horse feces, we found higher native plant diversity (number of native plant species) than at nearby referent quadrats (Table 4). Neither total percent vegetation cover nor percent nonnative vegetation cover differed near horse feces. We found higher numbers of macroinvertebrates on the trail and at 0.40 m from the trail than at referent quadrats (Table 3). The number of macroinvertebrates found per quadrat decreased with increasing soil strength and varied significantly among days.

Trail quadrats differed significantly from referent quadrats for all five parameters examined (Table 5). Immediately adjacent to the trail, the only significant differences from referent quadrats were the number of native plant species and soil strength. Quadrats located 0.4 m from the edge of the trail differed relative to referent quadrats for four parameters (i.e., decreased total vegetation cover, higher species diversity, more macroinvertebrates, and reduced soil strength). There was no evidence of differences in vegetation characteristics at 1.4 m from the trail, compared to referent quadrats. Assuming an average trail width of approximately 40 cm, the total area impacted along horse trails is estimated to be approximately 1.2 m in width.

Discussion

One of the most interesting results from this study is an estimate of the area subjected to indirect biotic impacts associated with feral horse trail use. If all trails were similarly impacted, at least 25 km^2 (1.2 m × 21 000 m) of habitat within greater Coyote Canyon was affected by feral horse trail use. In areas inhabited by large feral horse populations across the western U.S., the geomorphologic impact of feral horses through erosion and reduced plant cover may be substantial.

The impacts of feral horses on trails were much different than impacts to areas adjacent to trails. Trails were characterized as having significantly compacted soil, low plant cover, a high percentage of bare ground, and low species diversity (Table 5). In contrast, areas adjacent to trails (0-0.4 m) had increased plant diversity and lower soil strength. Overall, our findings on and along trails used by feral horses are consistent with the anticipated outcome of large mammal trampling in an arid environment: reduced vegetation cover, compacted soils, and in cases of intermediate intensity disturbance, increased plant species diversity [3,22].

High plant diversity near trails used by feral horses is consistent with the intermediate disturbance hypothesis [23] and the model presented by Milchunas et al. [22]. Increases in plant species diversity with low-density livestock use is a well-documented phenomenon, although the effect is predicted to be smallest in arid and semiarid environments [9,22,24]. Our results corroborate the pattern of increased plant diversity at small spatial scales with light to moderate levels of disturbance in an arid environment.

Table 2: Linear mixed-effects regression model results from testing for differences between treatment and referent quadrats in vegetation cover, percent nonnative vegetation cover, and soil strength for horse trails at Coyote Canyon, Anza-Borrego Desert State Park, California, USA; Spring 2003.

Covariate	Coefficient (95% CI)	Back-Transformed coefficient	P-value
Percent Total Vegetative Cover[a]			
Intercept	1.14 (1.08, 1.20)	29.03 (26.21, 31.93)	<0.01
Soil strength	0.03 (0.01, 0.05)	0.022 (0.002, 0.06)	<0.01
Dripline	0.003 (0.0004, 0.005)	0.002 (3.9×10^{-6}, 0.0006)	0.02
Quadrat[b]	---	---	<0.01[b]
Quadrat 1 (trail)	-0.55 (-0.61, -0.49)	-7.35 (9.08, 5.77)	<0.01
Quadrat 2 (0 m)	-0.03 (-0.09, 0.03)	-0.02 (0.22, 0.02)	0.32
Quadrat 3 (0.4 m)	-0.09 (-0.15, -0.03)	-0.19 (0.53, 0.02)	<0.01
Quadrat 4 (1.4 m)	-0.09 (-0.27, 0.10)	-0.19 (1.85, 0.24)	0.35
Quadrat 5 (Referent)	---	--	---
Random effects	0.12 (0.09, 0.15)	0.12 (0.21, 0.59)	<0.01
Percent nonnative cover[a]			
Intercept	0.38 (0.30, 0.47)	3.60 (2.23, 5.31)	<0.01
Soil strength	0.15 (0.08, 0.21)	0.53 (0.16, 1.13)	<0.01
Soil strength^2	-0.03 (-0.04, 0.21)	-0.02 (0.04, 1.13)	0.01
Dripline	0.003 (0.0002, 0.005)	0.0002 (1.0×10^{-6}, 0.0006)	0.03
Quadrat[b]	---	---	<0.01[b]
Quadrat 1 (trail)	-0.17 (-0.23, -0.11)	-0.72 (1.32, 0.30)	<0.01
Quadrat 2 (0 m)	-0.02 (-0.07, 0.04)	-0.01 (0.14, 0.03)	0.51
Quadrat 3 (0.4 m)	-0.04 (-0.09, 0.02)	-0.03 (0.20, 0.01)	0.20
Quadrat 4 (1.4 m)	-0.09 (-0.23, 0.06)	-0.19 (1.35, 0.09)	0.25
Quadrat 5 (Referent)	---	--	---
Random effects	0.18 (0.15, 0.22)	0.79 (0.53, 1.16)	<0.01
Soil strength			
Intercept	2.44 (2.148, 2.727)	88.19 (77.37, 95.82)	<0.01
Rain	-0.73 (-0.95, -0.51)	12.74 (6.36, 20.92)	<0.01
Trail Area	-2.1×10^{-5} (-3.2×10^{-5}, -0.0010)	-1.0×10^{-5} (3.0×10^{-10}, 3.0×10^{-9})	<0.01
Dripline	-0.0045 (-0.0081, -0.0010)	-0.0005 (3.0×10^{-5}, 0.002)	0.01
Horse sign (present)	-0.15 (-0.29, -0.01)	-0.56 (0.002, 0.02)	0.04
Horse sign (Referent)	---	---	---
Quadrat[b]	---	---	<0.01[b]
Quadrat 1 (trail)	0.48 (0.27, 0.68)	0.24 (1.81, 11.12)	<0.01
Quadrat 2 (0 m)	-0.15 (-0.28, -0.01)	-0.56 (0.002, 1.95)	0.03
Quadrat 3 (0.4 m)	-0.15 (-0.28, -0.02)	-0.56 (0.01, 1.95)	0.02
Quadrat 4 (1.4 m)	NA	NA	NA
Quadrat 5 (Referent)	---	---	---
Random effects	0.48 (0.45, 0.64)	0.48 (0.45, 0.64)	<0.01

[a] Arcsin transformed; [b] Likelihood ratio test to determine the significance of the overall covariate.

The deposition of horse feces (which contain seeds, moisture, and nutrients) is another potential mechanism that may enhance plant diversity and cover in habitat used by feral horses. The role of herbivores in dispersing seeds is well established [25], and several studies have shown that horses pass large numbers of seeds through their digestive tract [26,27]. We found that quadrats near feces had significantly higher plant diversity than all other locations (Table 5). Although we hypothesized that feral horse feces may improve conditions for nonnative species, we found the least amount of nonnative plant cover near feces (Table 1).

Our results suggest that feral horse trampling in an arid environment contributes to both soil compaction and erosion. Hendee and Dawson [28] found that controlled amounts of use by horses on trails caused increased soil compaction. In contrast, DeLuca et al. [29] reported that horse use loosened soil and made it more susceptible to erosion. In our study, soil often appeared to have been chiseled (by hooves), washed, and/or blown from the trail and collected along the edges of the trail, which could explain the significantly looser soil we found at quadrats 0 and 0.4 m from the trail relative to referent quadrats (Table 5).

Table 3: Results from Poisson regression models used to test for differences between treatment and referent quadrats in variables related to feral horse impacts at Coyote Canyon, Anza-Borrego Desert State Park, California, USA; Spring 2003.

Covariate	Coefficient (95% CI)	Back-Transformed Coefficient (95% CI)	P-value
Number of native species			
Intercept	1.20 (1.07, 1.33)	3.29 (2.91, 3.78)	<0.01
Soil strength	0.22 (0.10, 0.33)	1.24 (1.11, 1.39)	<0.01
Soil strength^2	-0.03 (-0.06, -0.01)	-0.97 (0.94, 0.99)	<0.01
Dripline	-0.01 (-0.01, -0.00)	-0.99 (0.99, 1.0)	<0.01
Quadrat[b]	---	---	<0.01
Quadrat 1 (trail)	-0.36 (-0.49, -0.23)	-0.96 (0.61, 0.80)	<0.01
Quadrat 2 (0 m)	0.21 (0.12, 0.30)	1.23 (1.12, 1.35)	<0.01
Quadrat 3 (0.10 m)	0.16 (0.07, 0.26)	1.18 (1.07, 1.29)	<0.01
Quadrat 4 (1.4 m)	-0.01 (-0.30, 0.27)	-0.99 (0.74, 1.31)	0.93
Quadrat 5 (Referent)	---	---	---
Number of macroinvertebrates			
Intercept	-0.71 (-1.04, -0.38)	-0.49 (0.35, 0.68)	<0.01
Soil strength	-0.27 (-0.37, -0.17)	-0.76 (0.69, 0.98)	<0.01
Day	0.03 (0.01, 0.06)	1.03 (1.01, 1.06)	<0.01
Quadrat[a]	---	---	0.10[c]
Quadrat 1 (trail)	0.54 (0.24, 0.85)	1.72 (1.27, 2.33)	<0.01
Quadrat 2 (0.00 m)	0.24 (-0.03, 0.51)	1.27 (0.97, 1.67)	0.08
Quadrat 3 (0.40 m)	0.38 (0.12, 0.64)	1.46 (1.13, 1.90)	<0.01
Quadrat 4 (1.4 m)	NA	NA	NA
Quadrat 5 (Referent)	---	---	---

Regression models were also used to quantify associations between covariate and outcome variables.
[a]Likelihood ratio test to determine the significance of the overall covariate.

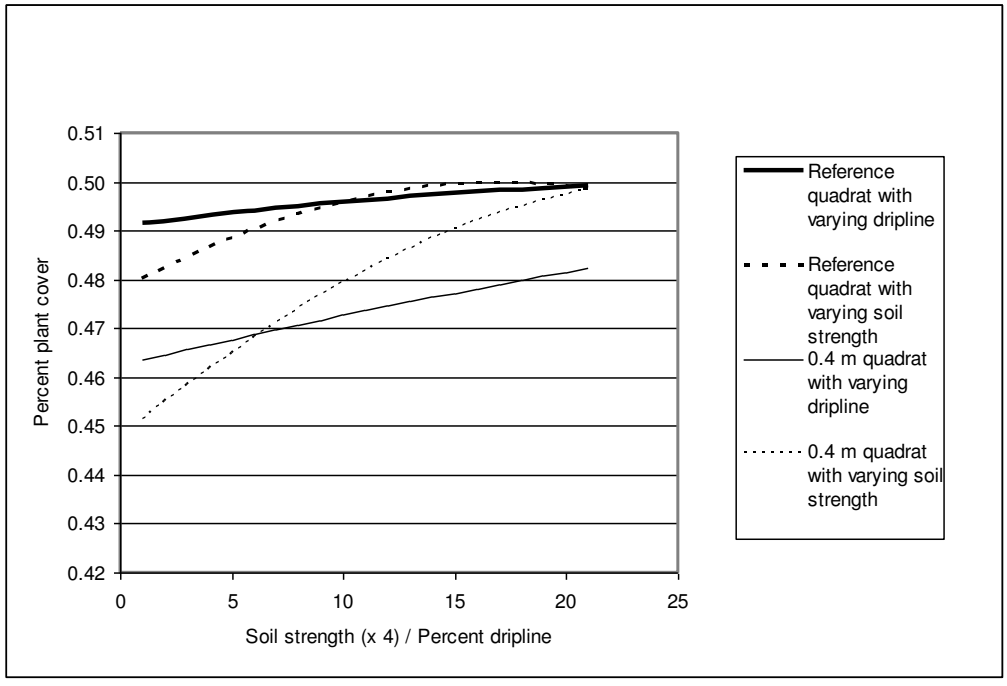

Figure 1
Results from a linear mixed-effects regression model of percent vegetation cover at 0.4 m from the edge of the trail and at referent quadrats. Graph illustrates the relationships between percent plant cover, soil strength, and dripline. After accounting for variation in dripline and soil strength, quadrats at 0.4 m from the trail had less vegetation cover than referent quadrats.

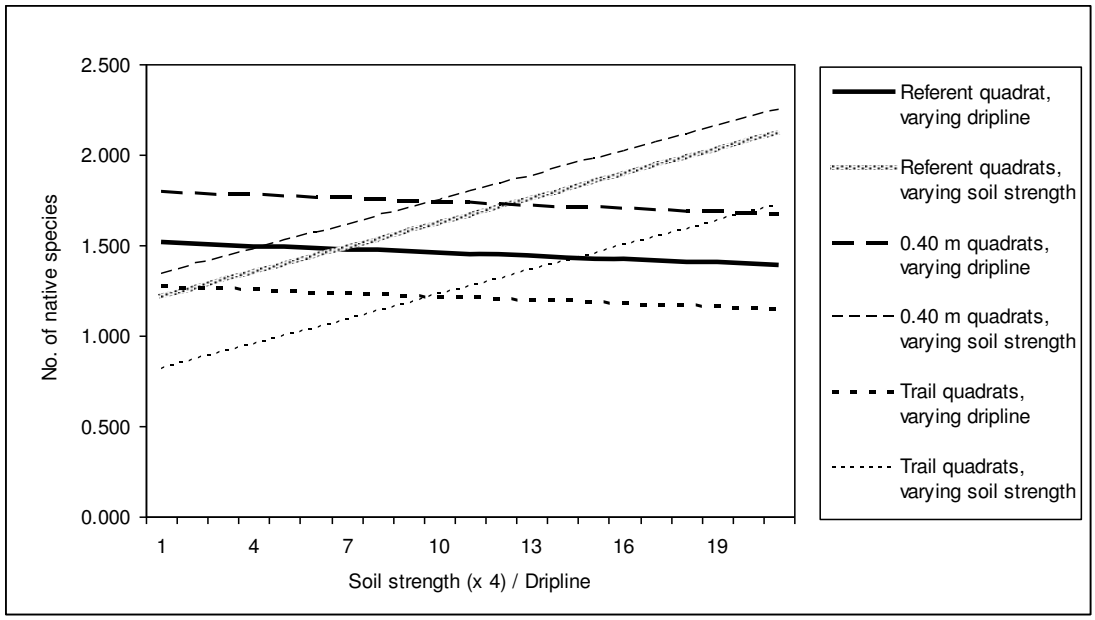

Figure 2
A comparison of results from Poisson regression models of the number of native plant species at the trail center, 0.4 m from the edge of the trail, and at referent quadrats. After accounting for differences in soil strength, plant species diversity was highest at quadrats 0.4 m from the trail.

While our study found compacted soils (relative to reference quadrats) only on trails and not adjacent to trails, an important caveat to our findings is that the referent quadrats in our study experienced some level of horse use and historic cattle grazing. Comparing our study area to a pristine, non-horse area may show that soils in nearly all areas used by feral horses were compacted. Beever [30] and Beever and Herrick [7] found that horse-grazed sites had greater soil strength than horse-excluded areas. Additionally, it is possible that grazing impacts were found throughout our study area and therefore minimized the differences between trails and referent quadrats for all five parameters we measured. In general, herbivory on a large scale ultimately selects for more grazing-tolerant species [31]; therefore, grazing-sensitive plant species in Coyote Canyon may have been eliminated from the local plant assemblage during a past period of cattle grazing. This idea of long-term and widespread impacts is consistent with the nonnative grass *S. barbatus*, which is often associated with disturbed areas [19], being the most abundant plant in our study area.

Table 4: Results from linear mixed-effects or Poisson regression models used to test for and quantify differences in total vegetation cover, percent nonnative cover, and number of native species between quadrats near horse feces and referent quadrats at horse trails in Coyote Canyon, Anza-Borrego Desert State Park, California, USA; Spring 2003.

Outcome variable	Covariate	Coefficient (CI)	P-value
Percent total vegetative cover			
	Intercept	1.07 (0.99, 1.16)	<0.01
	Referent quadrat	--	--
	Quadrat near feces	0.07 (0.0, 0.17)	0.23
Percent nonnative cover			
	Intercept	0.53 (0.44, 0.62)	<0.01
	Referent quadrat	--	--
	Quadrat near feces	-0.07 (-0.16, 0.02)	0.13
Number of native species			
	Intercept	1.49 (1.38,1.61)	<0.01
	Referent quadrat	--	--
	Quadrat near feces	0.20 (0.04, 0.35)	<0.01

Table 5: Summary of significant differences in parameters between sampling quadrats and referent quadrats.

	Trail Quadrat	0.0 m Quadrat	0.4 m Quadrat	1.4 m Quadrat	Quadrat near feces
Percent plant cover	↓	-	↓	-	-
Percent nonnative cover	↓	-	-	-	-
No. of native plant species	↓	↑	↑	-	↑
No. of macroinvertebreates	↑	-	↑	NA	NA
Soil strength	↑	↓	↓	NA	NA

Arrows indicate significant increases or decreases relative to referent quadrats and dashes indicate no difference from referent quadrats. Referent quadrats were located at 6.4 m from the edge of trails used by feral horses in Coyote Canyon, Anza-Borrego Desert State Park, California, USA; Spring 2003.

Our finding of greater macroinvertebrate abundance on the trail and at 0.4 m from the trail (where vegetation cover was also reduced) could be interpreted at least two ways. First, greater macroinvertebrate abundance may reflect superior habitat conditions for the species we observed. An alternative interpretation of our macroinvertebrate data is that visibility was higher in areas having less vegetation, hence the correlation between reduced vegetation cover and greater macroinvertebrate abundance. We recommend that future studies that incorporate macroinvertebrate monitoring focus on specific taxa, with known habitat requirements. For example, Beever and Herrick [7] reported that ant mounds were more abundant at sites where feral horses had been removed.

Conclusion

Our results show that feral horses may cause substantial indirect geomorphic changes. This finding is consistent with the idea of using feral horses as "ecosystem engineers" in highly-managed conservation areas [15]. Understanding and quantifying the impacts of feral horses on their environment will help wildlife managers to maintain the biotic integrity of habitat used by feral horses, as required by the Wild Free-Roaming Horse and Burro Act of 1971. If feral horse populations are maintained within habitat of threatened or endangered species known to be sensitive to loss of vegetative cover (e.g., lizards, grassland birds, and some small mammals), precautions should be taken to avoid impacts to these species. The results from our study should be extrapolated carefully because the impacts of grazing on arid environments are highly influenced by animal density and abiotic factors [22,32]. Also, this study was conducted in upland areas, and the impacts of horses in riparian areas may have much more significant impacts [33].

Authors' contributions

SO designed the study, drafted the manuscript, and conducted the fieldwork with LH. EA and ER assisted with study design, analyses and manuscript review. WB conceived the idea, supervised the research and revised the manuscript. All authors have approved the final manuscript.

Additional material

Additional file 1

Plant species identified in and adjacent to transects during Spring 2003 in Upper Willows and Alder Canyon within Coyote Canyon, Anza-Borrego Desert State Park, California, USA.

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DOMINANCE OF A NATURAL WATER SOURCE BY FERAL HORSES

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Abstract—We used a motion-triggered camera to document and qualify the nature of interspecific interactions between elk (*Cervus elaphus*) and feral horses (*Equus caballus*) at an isolated, natural water source

Fig. 1—Short series (1-s intervals) of photos depicting a cow elk (*Cervus elaphus*) approaching and being deterred by horses (*Equis caballus*) from an isolated spring at Mesa Verde National Park. This cow did not acquire water at any point during the day these photos were taken.

in Mesa Verde National Park, Colorado. The camera was active for at least 110 of 145 potential trap-nights between 24 April 2012 and 16 September 2012. Elk and horse interactions were observed 51 times, and elk were averted from accessing water 42 times (82%). Feral horses exhibited dominant behavior over native elk during the driest time of the year (May–June), often preventing acquisition of water by elk.

Resumen—Utilizamos una cámara sensible a movimientos para documentar y calificar la naturaleza de interacciones interespecíficas entre el uapití (*Cervus elaphus*) y caballos silvestres (*Equus caballus*) en una fuente de agua natural aislada en el parque Nacional de Mesa Verde en Colorado. La cámara estaba activa por lo menos 110 de 145 trampas-noches entre el 24 de abril y el 16 de setiembre del 2012. Las interacciones del uapití y del caballo silvestre se observaron 51 veces, y los caballos evitaron que los uapitís tomaran agua 42 veces (82%). Los caballos silvestres demostraron un comportamiento dominante sobre los uapitís nativos durante los tiempos de más sequía en los meses de mayo y junio, muchas veces previniendo la adquisición de agua por el uapití.

For land managers throughout the western United States, feral and free-roaming horses (*Equis caballus*) create a myriad of management challenges and can incur significant damage to natural ecosystems (Boyles, 1986; Bastian et al., 1999; Beever et al., 2008). Many feral horses in the western United States exist outside of designated management areas as identified by the Wild and Free-Roaming Horses and Burros Act of 1971, including Mesa Verde National Park (Mesa Verde NP), Colorado. Feral horse populations have occurred periodically in Mesa Verde NP since its establishment in 1906. Historically, feral horses were trapped and sold by neighboring land

Table 1—Summary of time feral horses (*Equis caballus*), elk (*Cervus elaphus*), and deer (*Odocoileus hemionus*) occupied a small, isolated spring in Mesa Verde National Park, Colorado, during 110 camera trap-nights in 2012. Times are depicted in hhh:mm.

Species	Days recorded at spring	Total time at spring	Average daily time at spring	Maximum time at spring during one 24-h day
Horse	106	366:53	3:27	18:11
Elk	76	71:13	0:56	3:26
Deer	42	12:43	0:18	2:46

mangers (e.g., Ute Mountain Ute tribe). In recent years, however, the value of horses has plummeted, and trapping efforts subsequently have declined (D. Tozier, pers. comm.). Informal, observational estimates of horse numbers in the 1980s and 1990s ranged from 10 to 40 animals (M. Colyer, in litt.) within Mesa Verde NP. Lacking natural limiting factors and human management, the horse population in the greater Mesa Verde area has grown during the past decade (Wolfe et al., 1989; Garrot et al., 1991). A 2011 aerial mark–recapture survey of horses, using natural horse markings (Lubow and Ransom, 2009), at Mesa Verde NP estimated the population at 100–117 horses (95% confidence interval).

Water is a primary limiting factor for many species of wildlife, as well as feral horses, in and around Mesa Verde NP. Recent drought has exacerbated the importance of rare, natural water sources in dry regions such as Mesa Verde. During the dry spring, premonsoonal months of May and June in 2011, we noted almost constant horse presence near some springs. Negative impacts from congregating horses to vegetation and prehistoric archaeological resources near these water sources have been observed (S. Travis, pers. comm). Less apparent is the potential for water resource competition between feral horses and native wildlife, and potential exclusion of native wildlife resulting from an interspecific behavioral hierarchy (Berger, 1985; Ostermann-Kelm et al., 2008). In an effort to better understand the intraspecific behavioral dynamic of horses and native wildlife at water sources, we used a motion-triggered camera to qualify the general nature of horse presence at one isolated spring in Morefield Canyon, Mesa Verde NP.

The spring in Morefield Canyon is best characterized as a seep; its flow rate is variable and augmented by precipitation events. During dry spells, the minimal spring flow creates a pool as small as 15 cm in diameter and 5–7 cm in depth. The spring occurs along the base of a shallow canyon wall. Vegetation near and above the spring is characterized by a mix of pinyon pine (*Pinus edulis*), Utah juniper (*Juniperus osteosperma*), gambel oak (*Quercus gamblii*), and other mountain shrub species (*Rosacea* and *Hydrangeacea* families). The canyon bottom is an expansive meadow system, characterized by a mix of native bunch grasses, smooth brome (*Bromus inermis*), and a diversity of weedy forbs. The landscape within 100 m of the spring location is heavily trampled, largely denuded of vegetation and contains no examples of wetland indicator species.

A motion-triggered camera (model PC800, Reconyx, Holmen, Wisconsin) was placed approximately 15 m from the spring on a tree, elevated approximately 3 m above the spring (Fig. 1). The camera was set with the highest possible sensitivity and recorded 10 consecutive digital images each time it was triggered. There was no lag time between motion triggering events. The camera recorded events 24 h/day for approximately 110 days of 142 deployment days (the camera memory was unexpectedly filled multiple times, preventing photo records).

The camera recorded each approach to the spring by mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), and horses. A gap of more than 20 min between photos of animals at the spring was tallied as a new event. This allowed for identification of discrete visits to the spring and facilitated comparisons of time spent at the spring. Events were also differentiated by the species present. For example, if horses were present and remained present as elk approached, the first photo with an elk would be recorded as a new event. Interspecific interactions were recorded as either 1) horse averted native wildlife away from water, 2) native wildlife averted horse away from water, and 3) no dominance observed. To be captured by the camera's motion detector animals had to be within approximately 5 m of the spring pool.

Between 24 April and 16 September 2012, 1,090 animal visit events in total were identified (100,406 animal photos) during approximately 110 trap-nights. Of these, 782 events (71.7%) included horses, 249 (22.8%) events included elk, and 56 (5.1%) events included mule deer. Horses spent significantly more time at the spring than elk and deer combined (Table 1).

Between 29 June and 3 July, horses were on the spring an average of 14 h 10 min per day. This time period was associated with particularly hot temperature (highs ranging from 29 to 32°C) and was preceded by approximately 1 month with no measurable precipitation (Morefield Canyon, Interagency Remote Automatic Weather Station 55706).

Elk and horses were recorded together at the spring 51 times in total. Horses deterred elk from accessing water during 41 (83%) of those 51 interaction events (Fig. 1). Bull elk were recorded deterring horses from the spring twice on 8 and 11 September (4%); during the rut and after monsoonal rain events had occurred. One cow elk was recorded deterring horses from the spring on 11 September. On 16 May, one interaction between elk and horses was nonaggressive. On five occasions the photo data was inconclusive. Deer and horses only shared the spring area twice, and there were no obvious interactions.

Our trail camera data indicate there might be behavioral dominance occurring at small natural water

sources by feral horses over elk. This is likely exacerbated by horse persistence in proximity to the spring. Elk visits to the spring were rare during the driest period, preceding the summer monsoon season. Based on our data, this lack of attendance is possibly due to an avoidance of negative interactions with horses. Elk and deer are likely forced to find water at other sources, the nearest known being over 5 km away. Because of the few water sources in this area, this could negatively affect elk by reducing water access during the dry summer, a critical time for young of the year animals. The extended periods of time horses spend in proximity to springs impacts native vegetation and archaeological resources associated with the springs (Beever and Brussard, 2000; Ostermann-Kelm et al., 2009; Glowacki et al., in litt.). Such impacts would likely be diminished if the spring was being utilized by wider ranging native wildlife. Removal or exclusion of feral horses would help restore the ecological character of this site and protect important archaeological resources.

Our data are limited; one spring was observed with one camera. However, despite a lack of rigorous study design and analysis, our data reveal an apparent species hierarchy in which a large, nonnative ungulate is restricting the availability of limited water resources to native wildlife species. A larger study might provide insight into the nature of horse–native wildlife interactions and competition for scarce resources.

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evolved as a means of escape from herbivory. Others argue that it is the differences in developmental phenology, resulting from trade-offs associated with male versus female function, that cause plants to be differentially susceptible and/or responsive to herbivory. Too little work is available to discriminate between these alternatives. Studying the effects of herbivory in male versus female morphs of facultatively sex-changing species may prove useful in this regard.

Whatever the case, differences in the developmental phenology appear crucial for determining plants' overall responses to herbivory (overcompensation, compensation, undercompensation), as well as the likelihood of and pattern of response to sex-biased herbivory in dioecious plant species. Study of the evolution, maintenance and importance of patterns of developmental phenology in plants is proving to be an exciting and productive area of research, one which may give rise to predictive theories in areas formerly resistant to generalization. Already, these studies are yielding important insights into the limits of plant plasticity as an adaptive strategy and the importance of developmental constraints in regulating plants' responses to their environments.

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The Keystone cops meet in Hilo

'Keystone species', a term coined by Paine[1] more than 25 years ago, has proven a powerful metaphor for the investigation of forces that organize ecological communities. Increasingly, the concept influences the thinking of managers and policy makers who must set priorities in their efforts to conserve species and habitats. The meaning of the term, however, has been blurred by overly expansive usage and for this reason, its application poses real dangers of misuse in decision making[2].

On the other hand, the term is too charismatic, too entrenched and too useful to be abandoned. Based on these concerns, Hal Mooney (Stanford University, CA, USA) and Jane Lubchenco (Oregon State University, Corvallis, USA) organized a workshop on the Keystone Species Concept on December 8–11, 1994 in rainy Hilo, Hawaii, USA, as part of the Global Biodiversity Assessment (GBA) sponsored by the United Nations Environmental Programme (UNEP). At the heart of the workshop was a belief that conservationists and managers have too few ecological tools to predict and prevent loss of biodiversity and ecosystem function, and that a refined keystone concept would be an important addition. The workshop had two goals: to seek consensus on a definition of keystone, and to explore whether potential keystone species could be identified *a priori* (before experimental confirmation, or their loss due to local extinction) by any distinguishing traits. The GBA team – Mooney, Lubchenco, Tony Janetos (NASA, Washington, DC, USA), Osvaldo Sala (Universidad de Buenos Aires, Argentina), Hall Cushman (Sonoma State University, CA, USA) and Rodolfo Dirzo (UNAM, Mexico) – met with nine ecologists who have investigated keystone species to address these and other questions about keystone species. What are keystones, how can they be identified? How many systems have them? How vulnerable are they to human impacts? What ecosystem functions and services would disappear if they were lost?

Mooney and Lubchenco launched the workshop, challenging the group to achieve consensus on a definition that followed either historical (Paine's original usage) or functional criteria (can we arrive at an expanded definition that remains clear and heuristic?) The need is immediate. According to Janetos, the Science and Technology Panel of the World Bank (a group that makes decisions about funding projects with impacts on biodiversity) has found no body of comprehensive statements in which ecologists express any consensus on such issues.

In short, ecologists need to make their science more useful for conservation and biodiversity practitioners. With this mandate, the nine workshop participants initiated discussion with brief synopses of their previous and current views on keystones. Bob Paine (University of Washington, Seattle, USA) began by reviewing his original definition. 'Keystone' in Paine[1] originally referred to a species that preferentially consumed and held in check another species that would otherwise dominate the system. This suppressed target species could be a competitive dominant (e.g. the mussels suppressed by a starfish in Paine's rocky intertidal system) or coupled to a trophic cascade (e.g. sea urchins, suppressed by sea otters[3]). The interaction had to be of sufficient strength to mediate observable indirect effects in the community. Traits suggesting a potential keystone role for a consumer were preference for prey of high competitive ability, and the ability to control this prey at all sizes (so the prey had no escape in size).

David Tilman (University of Minnesota, Minneapolis, USA) defined keystone in terms of the effect of a change in one species on some characteristic of its community or ecosystem, such as species richness, productivity or nutrient availability. He stressed that the measure should reflect per capita or per unit biomass effects of the species, and the total, not the partial, derivative of the change in the community, characteristic with change in the species, because the total derivative reflects indirect as well as direct effects. The change should be measured after all important feedbacks have had time to occur. These feedbacks may be more rapid in aquatic systems, but can take longer in terrestrial systems such as the deserts in which Jim Brown and colleagues found more unexpected results as the experiment aged[4]. Tilman also argued that the term keystone should not be restricted to animals or a particular trophic level, although consumers at higher trophic levels would, *a priori*, seem more likely to have larger per capita effects than plants, which commonly have larger biomass.

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Jim Estes (University of California, Santa Cruz, USA) drew upon his classic studies of sea otters and their role in trophic cascades that can completely alter the structure of subtidal and even adjacent intertidal communities. These studies have led to three questions of broad relevance to other systems containing keystones: (1) How general are the direct and indirect interactions? (2) What is the breadth of effects on other members of the community? (3) What are the evolutionary consequences? Since the vast majority of systems in nature either have not been or cannot be studied in comparable detail, it is important to evaluate whether or not keystone species and interactions can be predicted *a priori* based on some aspect of the predator, prey or ecosystem. In the sea otter–kelp forest system, the keystone predator is much larger and more mobile than its primary prey. Estes argued for increased use of 'natural experiments' and 'adaptive management' in evaluating the potential importance of other large, mobile consumers. His comparative surveys of otter–urchin interactions throughout the northeast Pacific have shown that prey properties (e.g. whether urchins graze attached or drift kelp) can also influence the strength of these interactions and the breadth of the cascading effects that they generate.

The theme of prey influence on keystones was continued by Juan Carlos Castilla (Pontificia Universidad Católica de Chile, Santiago, Chile), who reviewed his studies of the keystone carnivorous gastropod, *Concholepas*, on the rocky shores of Chile. In his studies, the snail's keystone status depended on whether its prey could be both eaten and bulldozed off the substrate. Mussels and barnacles were susceptible, hence *Concholepas* plays a keystone role where these prey are dominants. Other intertidal communities are dominated by a tunicate, which cannot be bulldozed, and in these, the snail is not a keystone. Castilla also reviewed results from studies of *Homo sapiens*, which feeds heavily on *Concholepas*, with consequences that ripple through the intertidal food web.

Mary Power (University of California, Berkeley, USA) emphasized that keystones have been distinguished from other types of strong interactors by having effects that are much greater than would be expected from their relative abundance. She also pointed out that the original metaphor has had a second useful connotation: keystone species, if experimentally perturbed, can be keys to understanding the forces that organize communities. Although it would be useful to discover traits that identify keystones *a priori*, she was skeptical that a 'field guide to strong interactors', as Steve Carpenter (pers. commun.) has called it, could be compiled until we have a better understanding of the context dependencies of interaction strength. She illustrated this point by reviewing her studies in northern California rivers, in which the keystone role of fish as top predators depends on whether or not scouring floods have occurred.

Bruce Menge (Oregon State University, Corvallis, USA) supported the argument that keystone species are context dependent, citing a variety of studies from marine habitats including his own recent work. He further noted that detecting keystone species can be difficult, particularly when several similar species are candidates for potentially controlling a system. Removing a single suspected keystone from a multispecies group of consumers could lead to no change in the community for one of three reasons: (1) the removed species had no impact; (2) control was imposed not by a single species but by the entire group, the remaining members of which compensated for the absent species; or (3) none of the consumers had an effect. To distinguish among these, Menge advocated, where feasible and appropriate, a combination of experiments that would estimate both the collective trophic impact of all consumers, and the isolated impacts of single species (or individual trophic groups). As yet, no species or system traits reliably distinguish keystones from non-keystones. Examples from a wide variety of habitats are available, however, which could be mined for comparative guidelines in efforts to identify the most likely strong interactors in unstudied systems or systems being considered for management.

Scott Mills (University of Idaho, Moscow, USA) raised the question of whether keystone characteristics are dichotomous (some species are keystones, the rest are wimps), or whether the effects of species on their communities were in fact more continuously distributed. Presumably, a community with keystone species would have 'community importance' or interaction strength values distributed very differently from communities that are traditionally modeled. He warned of the dangers of the lack of an operational, repeatable criterion for designating keystone status if this term is to be used by decision makers. He stressed, however, that the keystone phenomenon is real and the need for application is great, so that

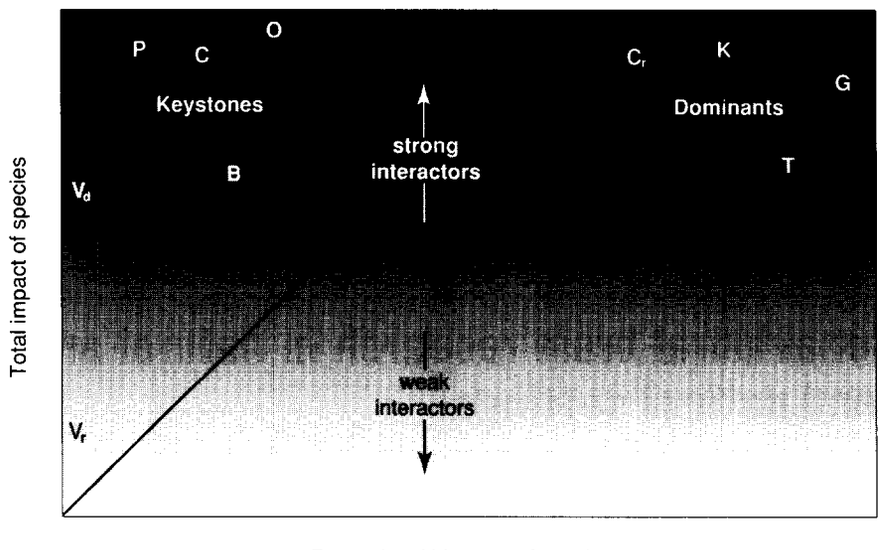

Fig. 1. Total (collective) impact of species versus its proportional abundance. A point representing a species whose total impact is proportional to its abundance would fall along the diagonal line $x = y$. Keystones have effects that exceed their proportional abundances by some large factor. They also have a total effect whose magnitude exceeds some absolute threshold. Therefore, although a rhinovirus that made wildebeests sneeze (V_r) might have a total effect that far exceeded that expected from its very low biomass, it would not be a keystone if the total effect fell below the threshold. On the other hand, a distemper virus (V_d) that killed lions or wild dogs might have a collective effect of sufficient magnitude for keystone designation. *Pisaster* (P), sea otters (O), the predatory snail *Concholepas* (C) and freshwater bass (B) have disproportionately large impacts on their communities. Trees (T), giant kelp (K), prairie grasses (G) and reef-building corals (C_r), which dominate community biomass, have total impacts that are large, but not disproportionate to their biomass. Quantitative values that should be prescribed for thresholds of absolute total collective impact (vertical position) and factors by which keystone effects should exceed a species' proportional abundance (distance left of the line $x = y$ required for keystone status) may vary with the community trait (e.g. species richness, biomass of other species or guilds, primary productivity, nutrient or soil retention, albedo) under consideration. In addition, interaction strengths, and therefore status as keystones or dominants, may change for given species under different environmental circumstances. Impacts of succession, changes in productivity, or deletions of other species on the status of a species could be represented by families of points representing the same species in different contexts.

steps towards a clearer operational definition would be welcome.

Gretchen Daily (University of California, Berkeley, USA) described how determining the consequences of a species deletion requires overcoming some of the greatest challenges in ecology: starting with a flash of naturalists' intuition; bridging across spatial scales to detect the influence of individual behavior on characteristics of communities and ecosystems; working over potentially formidable timescales and with a daunting diversity of taxa; and all the while persevering with knowledge that similar consequences may not manifest themselves in seemingly similar systems. She argued that, nonetheless, it is imperative to incorporate the potentially dramatic role of subtle, indirect species interactions when depicting communities in conservation and management models.

This point was emphasized by William Bond (University of Cape Town, Cape Town, South Africa), who decried the lack of contribution by ecologists of protocols that would allow conservation priorities to be set on the basis of interactions. Keystone, he pointed out, was the only single name widely associated with interactions that can conform to database formats ('species *i* is a keystone, and it's here'). A keystone can be pragmatically defined as a species whose loss from or addition to a system would change community composition, structure or function enough to arouse concern. Keystones are best demonstrated by experiments, which, unfortunately, are slow, particularly in terrestrial systems. Consequently, we do not yet know whether deletions of possible keystone mutualists (pollinators, seed dispersers) would in fact alter population dynamics to produce large effects on the rest of their communities. In general, we lack and need a protocol for evaluating probable keystone interactions for biodiversity conservation, so that we can flag those species involved and the species or key processes that would be vulnerable to their loss.

During the subsequent days, the group hammered out a verbal, and a potentially operational, definition of keystone. The verbal definition, which expands the original definition to include interactions other than trophic ones, was: '*A keystone species is a species whose impacts on its community or ecosystem are large, and much larger than would be expected from its abundance*'. This verbal definition distinguishes keystones from other strong interactors whose effects are due to their dominance of ecosystem biomass. The potentially operational definition takes a step towards quantifying 'large, and larger than expected' by formally defining the community importance of a species, deriving from this species' total (collective) impact, and relating this impact to its proportional biomass in the community (Fig. 1). This definition distinguishes keystones from dominants and other species. Its potential for examining the context dependence of species interaction strengths and keystone status (for example, how these change with the gain or loss of other members of interaction webs, or over the course of succession) will be explored in a paper by this group in preparation for *BioScience*.

By developing a more operational definition, the workshop participants hope to refocus the term keystone for ecological research, and to make it more useful for policy makers concerned with preserving biodiversity. All agreed that it was premature to prescribe 'magic numbers' (specified quantitative thresholds above which species would be designated as keystones). Nevertheless, there was growing excitement over research questions that emerged or were clarified during discussion, and a general optimism that the keystone concept was evolving towards a form that could take an important place in the conservation biologist's tool box.

Acknowledgements
We thank Adrian Sun for help in preparing Fig. 1.

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Behavioural brain research in natural and semi-natural settings

In the 'decade of the brain', the goals of neuroscience have become very ambitious. Why should we not find the genes of memory, describe the neural basis of consciousness or of reason? These goals, however, demand explicit solutions, and it is not at all clear whether we are prepared for such reduction. In general, scientists agree that a reductionist approach is merely a convenient way to design feasible experimental studies. But in this case, the main problem is defining relevant functions within an evolutionary perspective, whether at the cognitive or the cellular and infracellular levels. Moreover, linking different levels of description requires exceptional research competence as well as effective communication among scientists in different fields.

The first aim of Enrico Alleva (Istituto Superiore di Sanita, Rome, Italy), Hans-Peter Lipp (Anatomy Institute, University of Zürich, Switzerland) and Lynn Nadel (University of Arizona at Tucson, USA) – the organizers of a recent NATO ASI workshop in Maratea, Italy – was therefore to bring together behavioural ecologists and neurobiologists. Presentations and discussions were aimed at understanding the evolution of the nervous system as an adaptive process in relation to specific ecological niches. Four very active discussion groups were concerned with the major underlying theoretical issues, that is, (1) the conditions in which a reductionist study of brain structures might be acceptable, (2) the process of assessing the adaptive value of behavioural or cognitive abilities, (3) the limit and complementarity of laboratory and field approaches, and (4) the functions of the hippocampus. Neuroanatomy methods were taught by specialists with the aim of helping researchers to do in one week what might take a year in the absence of supervision. Behavioural techniques were demonstrated, from homing pigeon (Fig. 1) tracking with sophisticated radiotelemetry devices, to bat detection or satellite tracking. In general, there was an ideal complementarity between theoretical and practical topics.

The definite neodarwinian bias of the meeting, '*le comportement moteur de l'évolution*'[1], was introduced in the opening lecture on microphrenology, in which Lipp discussed the mechanisms by which mutations are more likely to be buffered or to appear as behavioural traits that have been submitted to natural selection. Changes in brain structure in the course of evolution were related to specialized digit capacity (Randolph Nudo, University of Texas, Houston, USA) or to nutritional regime (Gerd Rehkamper, Heinrich Heine

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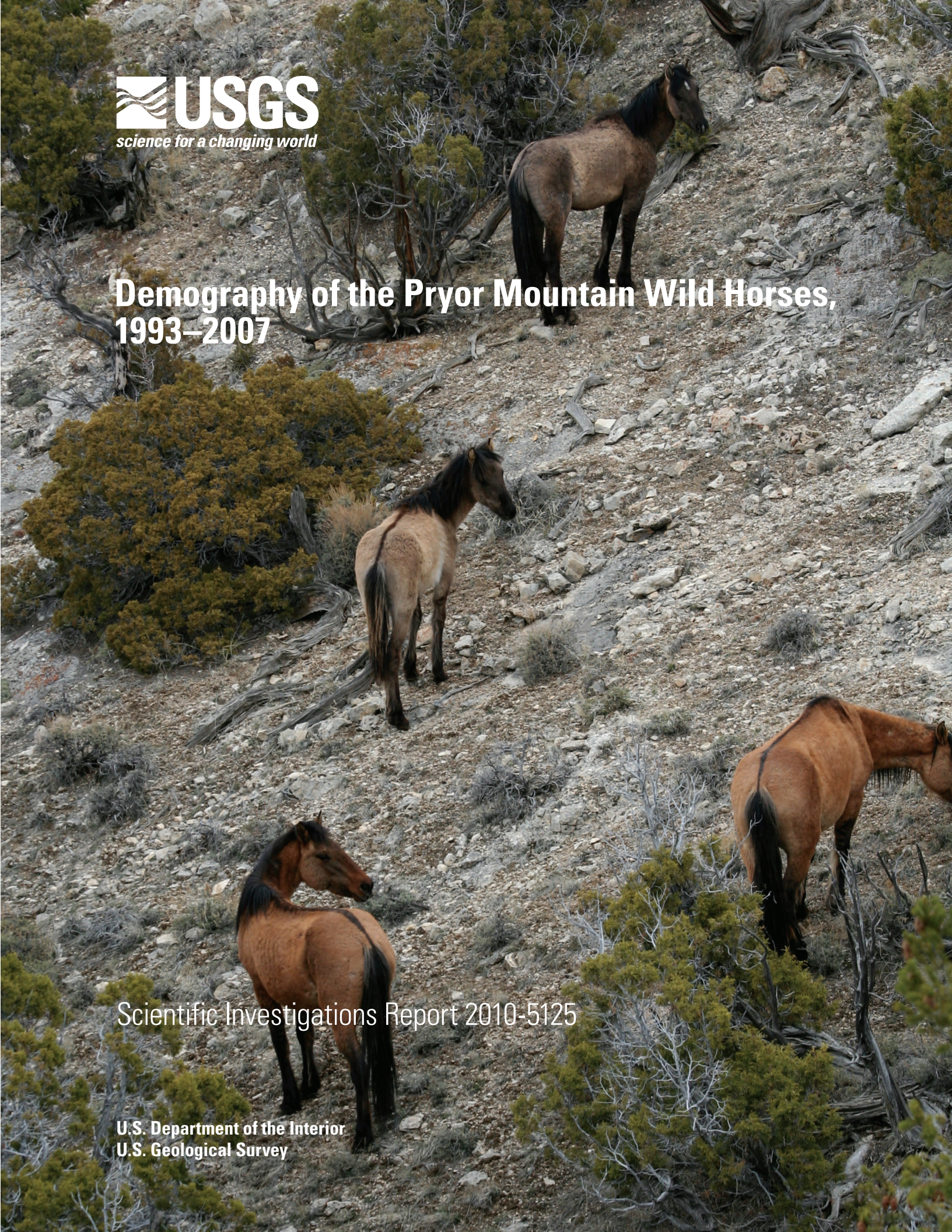

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Demography of the Pryor Mountain Wild Horses, 1993–2007

Scientific Investigations Report 2010-5125

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
yard (yd)	0.9144	meter (m)
	Area	
acre	0.4047	hectare (ha)
square mile (mi^2)	259.0	hectare (ha)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8×°C)+32$$

Acronyms Used in Report

AML	Appropriate Management Level
APHIS	Animal and Plant Health Inspection Service
BLM	Bureau of Land Management
FS	Forest Service
HMA	Herd Management Area
NCDC	National Climatic Data Center
NPS	National Park Service
PMWHR	Pryor Mountain Wild Horse Range
RAWS	Remote Automated Weather Station
USGS	U.S. Geological Survey

Demography of the Pryor Mountain Wild Horses, 1993–2007

By James E. Roelle,[1] Francis J. Singer,[1,2] Linda C. Zeigenfuss,[1] Jason I. Ransom,[1] Linda Coates-Markle,[3] and Kathryn A. Schoenecker[1]

Abstract

Wild horses (*Equus caballus*) at Pryor Mountain were studied by direct observation from 1993 through 2007. All horses present were individually identifiable on the basis of coat coloration, head and leg markings, gender, and band associations. Of the 609 horses either present prior to foaling in 1993 or born since, ages were precisely known for 491 (observed as a foal). Ages for 52 horses were estimated through tooth eruption and wear patterns, and for the remaining 66 horses through body size, morphology, and anecdotal evidence concerning when they were present on the range. At varying intensities, never less than 30 days per year, all horses were inventoried and their band associations noted. Foals were paired with dams based on observations of attachment during the early days and weeks of life. Year of death was determined by identification of the carcass where possible. In the absence of finding a carcass, an animal that was not observed for 2 years was considered to have died in the year that it went missing. Animals that were removed from the herd and mares that were part of a contraception study were excluded from calculations of survival and foaling rates, respectively, as appropriate.

The average prefoaling population over the 15 years of the study was 148.8 animals (range = 120–187), and the annual foal crop averaged 32.1 (range = 23–40). Large removals (19–60 animals) in four years helped maintain the herd at this level; apparent growth rate (calculated as though removals had not occurred) was 9.6 percent annually ($\lambda = 1.096$, range = 0.977–1.220). This annual growth rate is relatively low compared to that for many western horse herds, at least in part because of a decline in foal survival. Sex ratio of the foal crop varied widely among years, but pooled across years did not differ from 50:50. Sex ratio in the herd changed mostly as a result of removals. The average age of both males and females in the herd increased during the course of the study. Annual survival of males did not differ from that of females, nor did gender affect annual survival of foals. Pooled across years, ages, and sexes, the annual survival rate was 0.899. Annual foal survival rate was 0.697 and declined through time, with a tendency toward recovery in 2005–2007. Foal survival was higher in larger bands, but did not differ between foals born to primiparous and multiparous mares. A few 2-year-old mares produced foals; foaling rate (excluding contracepted mares and foals they produced) increased through age 10, remained high through age 15, and declined thereafter. Overall foaling rate for mares ≥3 years of age was 0.576 foals per mare, with no apparent trend during the period of our study. Foaling rate in years following gathers was somewhat lower than in other years. There was a positive relation between foaling rate and band size. Primiparous mares were somewhat less likely to foal in the following year than were multiparous mares. Most stallions that acquired a harem did so at age 5 or 6, and the average age of harem stallions increased during our study. Most harems had 1–3 mares ≥2 years of age, but harem size varied with age of the stallion, increasing through about age 11 and declining thereafter. About 6 percent of bands had a satellite stallion (≥5 years of age), but the mean number of mares did not differ between single- and multistallion bands. Most stallions left their natal band at age 2 or 3, but 17 percent remained with their natal band until age 4 or 5.

Foal survival rate was positively related to precipitation, suggesting a possible link to forage production and availability mediated through mare fitness. There also was evidence for density-dependent population regulation, as both population growth rate and survival rate were negatively correlated with population size from the previous year. These and other factors were not sufficient to stabilize the population during our period of study, however, as evidenced by the necessity for large removals in several years.

Introduction

The Pryor Mountain Wild Horse Range was created in 1968 by order of the Secretary, U.S. Department of the Interior, who directed that wild horses (*Equus caballus*) be managed in "a balanced program which considers all public values and without impairment of the productivity of the land" (Federal Register, Document 68-11056, Sept. 11, 1969;

[1] U.S. Geological Survey, Fort Collins, Colorado.

[2] Deceased.

[3] Bureau of Land Management, Wheat Ridge, Colorado.

Bureau of Land Management, 2006, p. 5). The Bureau of Land Management (BLM) was designated as the lead agency for management of wild horses, though the range also contains lands administered by the U.S. Forest Service (FS; Custer National Forest) and the National Park Service (NPS; Bighorn Canyon National Recreation Area). The Wild Free-Roaming Horses and Burros Act of 1971 (P.L. 92-195) further directed the FS and BLM to manage wild horses at Pryor Mountain and wild horses and burros (*Equus asinus*) wherever they occur "in a manner that is designed to achieve a thriving natural ecological balance on the public lands."

While laudable as general management goals, the conditions implied by phrases such as "a balanced program which considers all public values without impairment of the productivity of the land" and "a thriving natural ecological balance" have proven difficult to achieve for many wild horse herds. With the protection afforded by the Act and a dearth of natural predators, many wild horse herds can increase at annual rates of 15–25 percent (Eberhardt and others, 1982; Garrott and Taylor, 1990; Garrott and others, 1991b; Singer and others, 2000), thus threatening to exceed the carrying capacity of their ranges. BLM has addressed this problem largely through a gather and removal program in which excess horses are removed from the range and offered to the general public for adoption or sale to good homes. While hugely successful by some measures (BLM has adopted out more than 220,000 horses since 1971; *http://www.blm.gov/wo/st/en/prog/wild_horse_and_burro/wh_b_information_center/Fact_Sheet.html*), supply has exceeded demand, leaving nearly 32,000 horses in BLM corrals and long-term holding pastures. This approach is not embraced by all members of the public. Wild horse advocacy groups often favor a policy of minimum disturbance and intervention, arguing that there are too few, rather than too many, wild horses and that the gather and removal process is detrimental to horse health and well-being. On the other hand, ranchers and conservationists often see wild horses as competing with domestic cattle (*Bos taurus*) and native wildlife for forage, and would thus prefer that BLM reduce the size of many horse herds.

Given the contentious nature of the issues involved, BLM has a continuing need for the best scientific information available on the ecology and demography of wild horse herds. Since creation of the range in 1968, information on wild horses has been gathered nearly continuously by trained investigators and volunteers, making the Pryor Mountain horses perhaps the most studied herd in the Western United States. Furthermore, all of the horses at Pryor Mountain are individually identifiable (unique color markings), and many are of known (observed as a foal) or closely estimated (tooth eruption and wear patterns) age, making the resulting data dependable. The first study of horses at Pryor Mountain was initiated in 1970 by J.D. Feist, who focused largely on behavior (Feist, 1971), but also gathered some information on demography of the population (Feist and McCullough, 1975). Shortly thereafter, Hall (1972) performed an assessment of the herd and possible management alternatives. Perkins and others (1979) studied population dynamics, age distribution, and band composition in the Pryor Mountain herd from 1974 through 1978. Garrott and Taylor (1990), using information gathered by BLM personnel, reported on many aspects of herd demography from 1972 through 1986. F.J. Singer and several colleagues began studies at Pryor Mountain in the early 1990s, broadening their scope to include vegetation dynamics and conservation genetics as well as demography (Singer and Schoenecker, 2000). Prior to his untimely death in 2005, Singer also participated in work at Pryor Mountain on contraception and population estimation.

Here we report on the demographics of the Pryor Mountain wild horse herd from 1993 to 2007. The results contained herein represent a more detailed analysis of the data presented by Singer and others (2000) and an extension covering the next decade. While specific to the Pryor Mountain herd, and thus not necessarily representative of the other 180 Herd Management Areas (HMAs) overseen by BLM, we hope that our results will provide wild horse managers with useful insights as they continue to meet the challenges of managing wild horse herds in the Western United States.

Study Area

During the period of our study, horses actually used an area larger than the Pryor Mountain Wild Horse Range as originally designated. The northwestern and northern boundaries of our study area are not well defined, as there are no natural or manmade barriers to horse movement in that direction. As shown in figure 1, however, the study area encompasses about 22,300 hectares (ha). The following description of the area largely follows Singer and others (2000) and Ricketts (2004).

The study area lies along the Montana-Wyoming border at approximately latitude 45°4'N and longitude 108°19'W, 76 kilometers (km) south of Billings, Mont., and 14 km north of Lovell, Wyo. (fig. 1). The area is topographically diverse, dominated by narrow canyons and steep cliff faces. Elevations range approximately from 1,175 to 2,670 meters (m), with corresponding variation in climate and vegetation. Temperatures range from 40 ºC in the summer to -34 ºC in the winter. Mean annual precipitation ranges from 15 centimeters (cm) at lower elevations to nearly 70 cm at higher elevations, with much of the annual total falling in April–June. Midelevation ridges and plateaus often remain snow free or accumulate <10 cm of snow as a result of winds and southern and western exposures. Higher elevations often have winter snow accumulations of 1 m or more. In water years 1993–1998 (water year 1993, for example, runs from October 1992 through September 1993), mean annual precipitation at Lovell, Wyo. (*http://www.wrcc.dri.edu/summary/climsmwy.html*), was 17.2 cm, essentially identical to the 30-year average (Bureau of Land Management and others, 2008). From 1999 to 2004, however, severe drought conditions prevailed (mean annual precipitation = 12.3 cm). Prolonged drought can decrease plant health

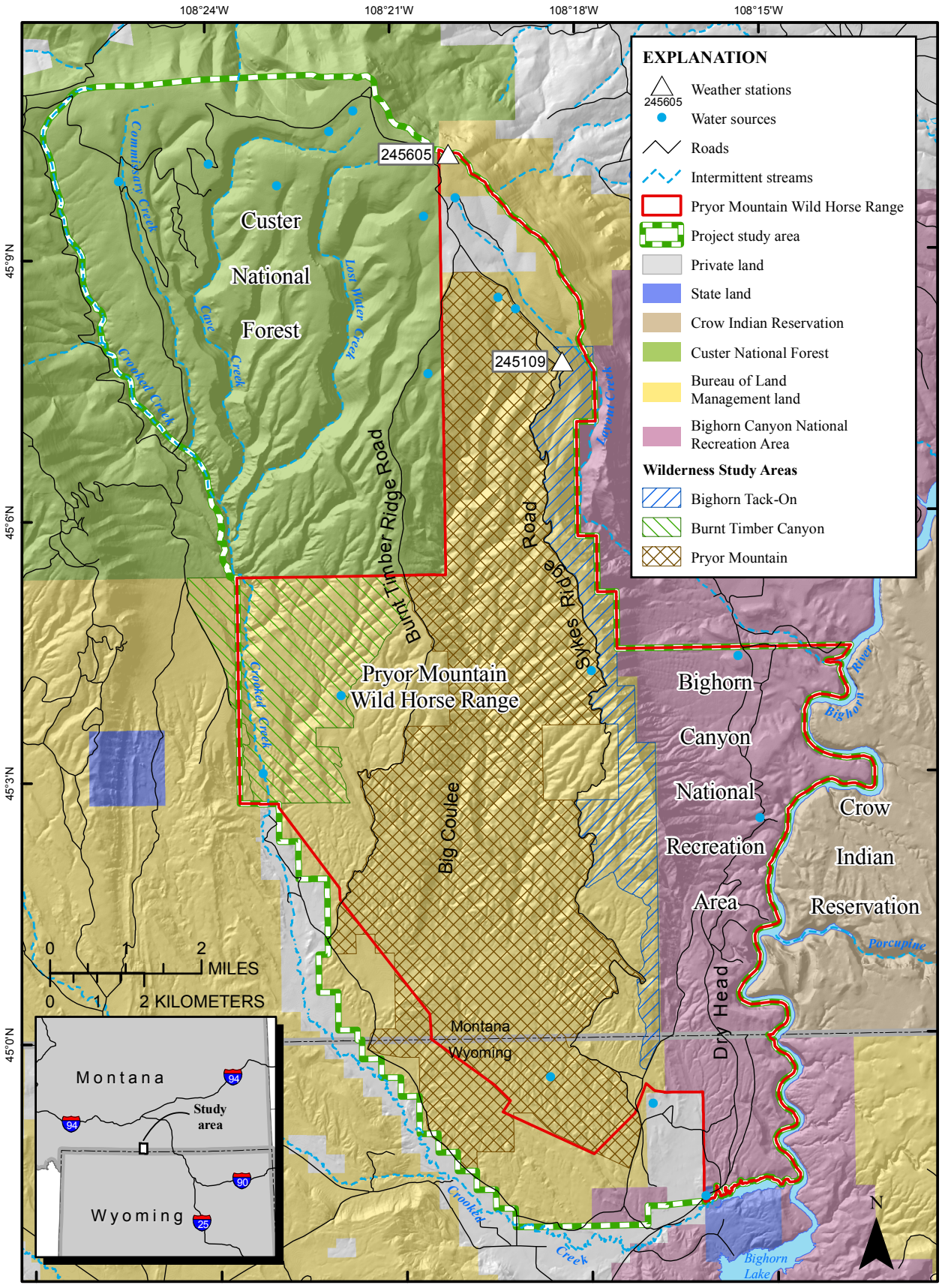

Figure 1. Location of the Pryor Mountain Wild Horse Range and study area.

and vigor and forage production. Temporary relief from the drought occurred in 2005 (annual precipitation = 21.2 cm) and 2007 (annual precipitation = 14.3 cm for 11 months, data missing for June) At least in 2005, greater precipitation probably resulted in improved forage production (Bureau of Land Management, 2006).

Vegetation in the study area changes dramatically with elevation. At the highest elevations, subalpine meadows (Idaho fescue, *Festuca idahoensis*; alpine timothy, *Phleum alpinum*; alpine bluegrass, *Poa alpina*; Ross sedge, *Carex rossii*; silky lupine, *Lupinus sericeus*) are interspersed with stands of subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*). At somewhat lower elevations, Douglas fir (*Pseudotsuga menziesii*) occurs with an understory of snowberry (*Symphoricarpos* spp.). Still lower is a shrub community dominated by big sagebrush (*Artemisia tridentata*), rubber rabbitbrush (*Ericameria nauseosus*), shrubby cinquefoil (*Dasiphora fruticosa*), Utah juniper (*Juniperus osteosperma*), and curl-leaf mountain mahogany (*Cercocarpus ledifolius*) and a variety of grasses and forbs such as bluebunch wheatgrass (*Pseudoroegnaria spicata*), threeawn (*Aristida purpurea*), needle-and-thread (*Hesperostipa comata*), and blue grama (*Bouteloua gracilis*). For a more complete description of vegetation communities on the Pryor Mountain Wild Horse Range, see Ricketts (2004).

Herd Behavior and Management

The social structure of the Pryor Mountain wild horse population consists of bands that include a harem stallion, occasionally along with a satellite stallion, plus adult mares and yearlings and foals of both sexes. In general, we use the term band to refer to all members of the group and harem to refer to mares ≥2 years of age. Males older than yearlings that have not acquired a band usually are found in bachelor groups. Distribution and movements of the bands largely are restricted by topography to the west (Crooked Creek drainage) and east (Bighorn Canyon), and fences of varying integrity to the north and south (fig. 1). The wild horses occur in three more or less discrete subpopulations (Burnt Timber Ridge, Sykes Ridge, and Dryhead). These areas are separated by Big Coulee (a deep canyon) and a long, nearly vertical cliff face. However, the horses are able to move between these areas at high elevations and below Big Coulee, as well as occasionally by way of trails on the cliff face. Varying numbers of horses also use U.S. Forest Service land to the north and west of the original horse range boundary. Interchange of horses between subpopulations occurs regularly, but not with high frequency. The horses move with the seasons, spending winters at low and middle elevations where snow is less deep and summering at higher elevations. Distribution is restricted by available water in summer, when the horses tend to congregate near water sources. Water has less effect on distribution in winter, when the horses use snow to meet their water needs.

In the past, the herd has been managed consistent with national selective removal policy for the BLM Wild Horse and Burro Program, removing mostly young animals and conserving the core breeding component of the population. In general, BLM defines Appropriate Management Level (AML) as the number of adult wild horses (6 months and older) determined through the agency planning process to be consistent with the objective of achieving and maintaining a thriving natural ecological balance and multiple-use relation (Bureau of Land Management, 2006). Initially, the AML for the Pryor Mountain herd was set at 115–127, but was revised to 85–105 horses in 1992. However, based on genetic research (Cothran and Singer, 2000; Gross, 2000a,b), from 1996 to 2006 BLM attempted to manage the herd at an average of 140 adult horses to help conserve genetic diversity (Bureau of Land Management, 2006). More recently, BLM has determined that management at an AML of 90–120 adult horses is necessary to protect and improve rangeland health (Bureau of Land Management, 2009).

The BLM has managed the size of the Pryor Mountain herd primarily through a gather, removal, and adoption program. In 1994, wranglers on horseback attempted to capture the entire herd by moving horses into corral traps. In 1997 and 2001, a helicopter was used to move most of the family bands (individual bachelors typically were not gathered) into corral traps; approximately 125 animals were gathered in each of these years. Smaller gathers aimed at removing excess bachelor stallions and yearling females were conducted in 2003 and 2006. The 2003 gather involved a helicopter to move groups containing target horses into a corral trap. The 2006 gather was conducted using bait trapping to lure the horses into a trap, after which they were transported by vehicle to a holding corral.

Since 2001, some mares in the Pryor Mountain herd have received fertility control treatments using the contraceptive porcine zona pellucida [PZP; see Kirkpatrick and Frank (2005) for a recent review of contraception in equids and other free-ranging animals] as part of a cooperative research project between BLM, the U.S. Geological Survey (USGS), and the U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS). In 2001, six mares (age 1–2) that had not yet reached breeding status were treated with PZP by hand injection during the gather. A booster inoculation was administered to three of these females in August 2002; the remainder had either died or could not be located to deliver the booster. Fertility control was subsequently applied to younger mares (age 1–2, 2002–2004) and older mares (>14 years, 2002–2004; >10 years after 2004) that had already contributed to the genetics of the population. After 2001, all inoculations (both primers and boosters) were delivered remotely by darting. Because of the timing of booster inoculations relative to the breeding season, the first contraceptive effects were expected in 2004. From 2004 through 2007, 20.0, 29.0, 10.8, and 30.8 percent of the mares (≥3 years old) in the herd were presumptively contracepted.

BLM also has attempted to manage the herd to adjust the sex ratio in favor of males (Bureau of Land Management, 2006) and occasionally has introduced a limited number of horses (both mares and stallions) from outside herds in order to supplement the herd genetically. Introduction of outside horses was discontinued in 1994.

Methods

Field Data Collection

All data reported in this study were gathered through direct observations of the herd by trained BLM and USGS employees and volunteers. From 1995 to 1997, efforts were focused on the peak foaling season, May 1 to June 30. From 1998 to 2007, daily observations were made during the peak foaling and breeding period, May 1 to August 30. This effort totaled approximately 100 hours of observation per week during 1995–1997 and 100–150 hours per week during 1998–2007. Semi-weekly to weekly observations were made March–April and September–November. Fewer observations were made during midwinter, and they were limited to accessible areas of the range, which varied from year to year. Observations were made from the ground during systematic surveys along roads and trails that traverse the study area. Ground observations were augmented with two helicopter flights each fall or winter, 1995–2001, and one flight in late 2006, as well as 20–25 days of horseback surveys throughout each year, 1995–2005.

Greater than 90 percent of the bands were located at least twice per week during the May–July period, and all bands usually were located at least once per week from April to mid-May and August to mid-October. Reduced effort in the remainder of the year resulted in less than one observation per week per band. Observers collaborated during the peak observation season to develop a weekly list of band composition and foal presence.

Wild horses were approached within 100–250 m and could be observed for periods of 2–6 hours with no apparent effect on their behaviors. All horses were identified individually based on color, markings, gender, and band associations since 1993. All stallions, mares, yearlings, and foals observed in bands, bachelor groups, or alone were recorded. Lead harem stallions were identified based on behavior as described in Feist and McCullough (1975), Oom and Santos-Reis (1986), and Berger (1986). Interchanges between bands by mares and stallions were recorded, as were returns to the original band.

Each horse in the population was assigned a unique number during data compilation. Of the 609 animals in the population from 1993 to 2007, horses whose birth year was known from foal records included 480 of the 481 foals born during 1993–2007 and 11 horses born prior to 1993. Ages of an additional 52 animals were estimated by a veterinarian based on tooth eruption and wear patterns (American Association of Equine Practitioners, 2002). Ages of the remaining 66 animals were based on body size and morphology and anecdotal evidence of years the animals were on the range. Death year was determined by identification of the carcass of the deceased individual or, if an individual was not observed for two consecutive years, the animal was considered to have died in the year it went missing. Number of foals produced was determined by observation as described above. It is possible that some foals were born and died without being seen; however, given the intensity of the observations, we believe that this was rare. Identification of an individual's dam was based on observations of attachment of foal to mare during the early days and weeks of the foal's life.

Analysis

We conducted all of our analyses on the basis of biological years, which we defined as just prior to foaling in one year to the same time the next year. Thus, the biological year 1993 encompasses the period from spring 1993 to spring 1994. Because we defined the biological year in this way, because we made no attempt to pinpoint when during a year a horse was born or died, and because we have the benefit of hindsight (other reported data were often projections), our data will in some cases not match exactly those presented elsewhere (for example, various Environmental Assessments prepared by BLM).

We calculated annual population growth using the expression $\lambda_t = N_t / (N_{t-1} - R_{t-1})$, where λ_t is the growth multiplier from year $t-1$ to year t, N is the population size, and R_{t-1} is the number of animals removed in the period $t-1$ to t. In this formulation, λ represents the apparent growth rate of the population had horses not been removed (Garrott and Taylor, 1990).

Survival rates were calculated as the number of animals present at the end of a year divided by the number present at the beginning of that year. Animals that were removed from the herd were excluded from survival calculations in the year they were removed. Foaling rates were calculated as the number of foals born (regardless of how long they lived) divided by the number of mares present. Mares that were presumptively contracepted and foals that they produced were excluded from calculations of foaling rate.

Band composition has been recorded on "horse lists" regularly (usually weekly) since 1996. These are lists of all the harem stallions present and all the members of their bands, plus lists of bachelor males and animals in transit between bands. To derive information on harem stallions and band composition, we used two of these lists for each year from 1996 through 2007, one from the breeding season (usually early June) and one from fall (September–November, usually the last list available for the calendar year). For each harem stallion present, we calculated the number of mares ≥2 years of age in the band for each of the two time periods and then

took the maximum of those two values as the number of mares held in the harem in that year. We calculated total band size in an analogous manner, and we used these same lists to derive information on bachelors and satellite stallions, which we defined as ≥5 years of age. We defined a satellite stallion in this way in an effort to distinguish true multistallion bands from cases in which a male simply remained with his natal band longer than usual.

We looked for evidence of density dependence in foaling rate, herd survival, foal survival, and population growth rate in the Pryor Mountain wild horse population using stepwise multiple regression with the current year's postfoaling population and the previous year's postfoaling population as independent variables. For these analyses, we used data from Garrott and Taylor (1990) for 1976–1986 (foaling rate, herd survival, and population growth rate), as well as data from our study for 1993–2007. We excluded data from the winter of 1977–1978, during which 51 percent of the population died as a result of heavy snow and ice accumulations (Garrott and Taylor, 1990), from the analyses of density dependence in herd survival and growth rate. We also excluded data from 2004, when 96 percent of the foal crop was lost, from the analysis of foal survival. Foal losses in 2004 are suspected to have been the result of predation by mountain lions (*Puma concolor*). We believe that these exclusions are justified because the biological processes operating in these years were clearly different from those operating in other years.

It would be desirable to have consistent, long-term data on annual forage production for comparison with demographic parameters, but we are unaware of such data for the study area. As a possible surrogate, we examined weather records from a number of stations in the area, reasoning that forage production in this semiarid environment likely is related to precipitation, even though large elevation differences across the study area make it unlikely that any single station will be representative of the entire area. In terms of location, the best available data are from a Remote Automated Weather Station (RAWS; Wild Horse Montana, NWS ID #245605, elevation 2,675 m), which was operated in the study area from October 1991 to July 1997 (*http://raws.dri.edu/wraws/emtF.html*) (fig. 1). Unfortunately, overlap between this period of record and the period of our study is minimal. A National Climatic Data Center Station (NCDC #484770, elevation 1,170 m) at Lovell, Wyo., has a much longer period of record (1948–present; *http://www.wrcc.dri.edu/summary/climsmwy.html*), but its lower elevation caused us to question its relevance to higher elevations in the study area. For the 7 years of data in common, however, there was a strong correlation between the two stations for both total annual precipitation ($R^2 = 0.921$, $P = 0.0006$) and the minimum of the monthly average minimum temperatures ($R^2 = 0.763$, $P = 0.01$). We therefore used data from the Lovell station and stepwise multiple linear regression to analyze relations between weather and herd survival rate, foal survival rate, and foaling rate (mares ≥3 years of age). Data on annual herd survival and foaling rate were available from both our study and the work of Garrott and Taylor (1990), but data on annual foal survival were available only from our study. For the reasons cited above, we again excluded 2004 from the analysis of foal survival.

Other investigators (Heitschmidt and others, 2005; Smart, 2005) showed that spring precipitation (April–June) is related to annual forage production in the Great Plains. We therefore divided precipitation data into spring (April–June), summer (July–September), and winter (October–March). For each year, we also calculated the mean of the monthly average minimum temperatures (December–February) and the mean of the monthly average maximum temperatures (April–September) as indices of winter cold and summer heat.

For herd survival, we used the covariates winter precipitation in the previous year, spring precipitation in the current year, and summer precipitation in the current year (hypothesizing that all might have a positive relation with forage production in the current year), winter precipitation in the current year (potential negative effect of snow accumulation on forage availability in the current year), and average monthly minimum temperature in the current year (potential negative effect on ability to meet energy demands). For foal survival, we used the same set of covariates and added average monthly maximum temperature (possible effect of heat stress on more susceptible foals). For foaling rate, we used the covariates summer precipitation in the previous year (potential positive relation with forage production during early pregnancy), winter precipitation in the previous year (potential negative effect of snow accumulation on forage availability), average monthly minimum temperature (potential negative effect on ability to meet energy demands), and spring precipitation in the current year (possible positive relation with forage production during late pregnancy).

All data were entered into Microsoft Excel® spreadsheets (Microsoft Corporation, Redmond, Wash.). Analyses were conducted in SAS® v. 9.1 (SAS Institute, Cary, N.C.) using standard statistical techniques as noted in the Results section.

Results

Population Size and Growth

Prior to foaling in spring 1993, there were 128 horses ≥1 year of age in the study area. From 1993 to 2007, 481 horses were born; thus, our study encompasses 609 individual animals. During the period of study, the prefoaling population averaged 148.8 animals (range = 120–187), the foal crop (number born) averaged 32.1 (range = 23–40), and the postfoaling population averaged 180.9 animals (range = 149–227) (table 1). As we calculated it, the postfoaling population represents the maximum number of animals that could have been present at any time during the year, as it assumes no mortality of foals or adults during the foaling period. The number of deaths per year apparently increased during 1999–2006, while the foal crop remained relatively constant throughout

Table 1. Size and growth rate of the Pryor Mountain wild horse (*Equus caballus*) herd, 1993–2007.

[Growth rate (λ) is calculated based on the postfoaling population. —, not applicable; SE, standard error of the mean.]

Year	Prefoaling population	Foals born	Postfoaling population	Deaths	Removals	λ
1993	128	23	151	1	1	—
1994	149	34	183	3	60	1.220
1995	120	29	149	7	0	1.211
1996	142	32	174	7	2	1.168
1997	165	35	200	15	46	1.163
1998	139	23	162	7	1	1.052
1999	154	38	192	27	0	1.193
2000	165	37	202	15	0	1.052
2001	187	40	227	31	46	1.124
2002	150	32	182	28	0	1.006
2003	154	30	184	32	7	1.011
2004	145	28	173	38	0	0.977
2005	135	36	171	19	0	0.988
2006	152	30	182	16	19	1.064
2007	147	34	181	9	0	1.110
Total	2,232	481	2,713	255	182	—
Mean	148.8	32.1	180.9	17.0	12.1	1.096
SE	4.18	1.30	5.14	3.02	5.36	0.0228

the period of study. The mean annual apparent growth rate, calculated as though removals had not occurred, was 9.6 percent (λ = 1.096, range = 0.977–1.220), or 10.5 percent if the year (2004) of heavy foal loss is excluded. Although the growth rate rebounded somewhat in 2006 and 2007, there was a significant (R^2 = 0.514, P = 0.004) overall decline during the period of study as determined by linear least squares regression (fig. 2).

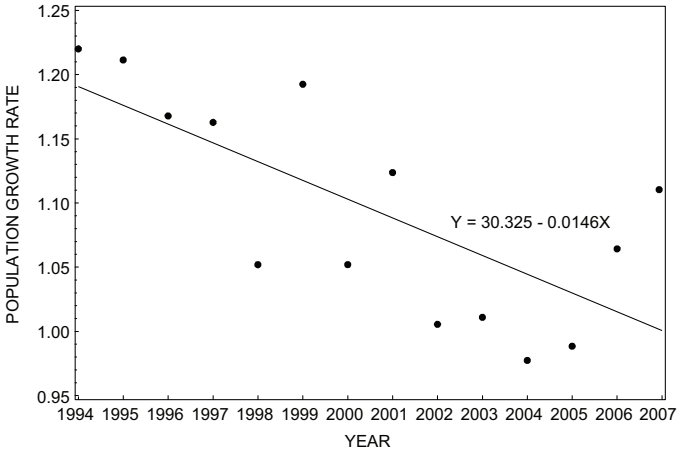

Figure 2. Trend in growth rate of the Pryor Mountain wild horse (*Equus caballus*) population, 1993–2007.

Removals

Major removals of wild horses occurred in 1994, 1997, 2001, and 2006, with smaller numbers of horses removed in four other years (table 2). For the entire period, adults (≥2 years of age) were removed most often (62.6 percent; n = 182), followed by yearlings (28.6 percent) and foals (8.8 percent). Across all age classes, slightly more males (56.6 percent; n = 182) were removed than females.

Sex and Age Structure

During the period 1993–2007, 477 foals of known sex were born; four foals disappeared before sex could be ascertained. Slightly more males (243) were born than females (234), but this difference was not statistically significant (χ^2 = 0.170, P = 0.68). On an annual basis, however, the proportion of males in the foal crop varied widely (range = 34.8–71.9 percent) (fig. 3). The proportion of males produced also varied by age of mare, declining from age 3 through about age 10, and then increasing in older mares (fig. 4).

The sex ratio of animals ≥1 year of age varied only moderately during the period of study, ranging from a high of 55.2 percent males in 1997 to a low of 44.2 percent males in 2000 and 2007 (fig. 5). The largest interannual changes in sex ratio occurred as a result of removals in 1994 (27 males, 33 females

Table 2. Removals of wild horses (*Equus caballus*) from the Pryor Mountain herd, 1993–2007.

	Foals		Yearlings		Adults		
Year	Males	Females	Males	Females	Males	Females	Total
1993	0	0	0	0	1	0	1
1994	8	6	7	7	12	20	60
1996	0	0	0	0	2	0	2
1997	2	0	11	1	20	12	46
1998	0	0	0	0	1	0	1
2001	0	0	10	6	8	22	46
2003	0	0	1	0	6	0	7
2006	0	0	4	5	10	0	19
Total	10	6	33	19	60	54	182

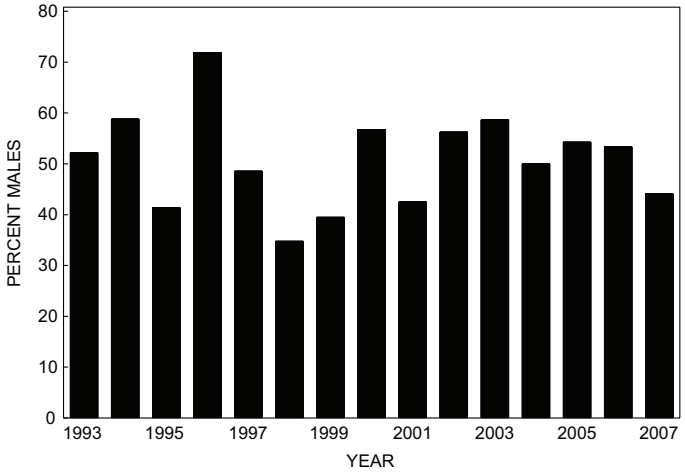

Figure 3. Sex ratio of wild horse (*Equus caballus*) foals born in the Pryor Mountain herd, 1993–2007.

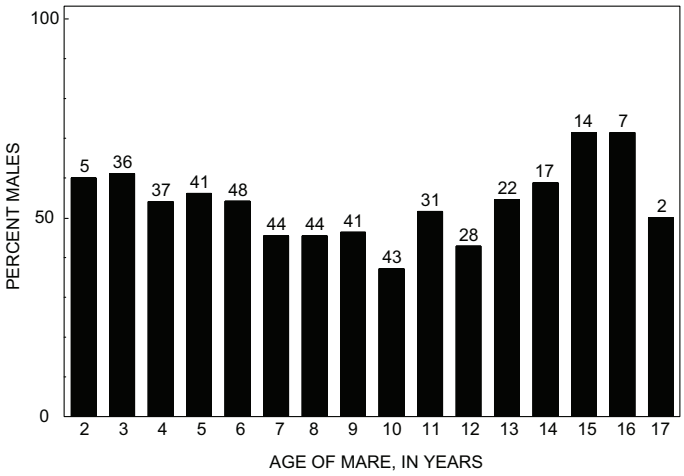

Figure 4. Variation in the sex ratio of wild horse (*Equus caballus*) foals by age of dam in the Pryor Mountain herd, 1993–2007. Values above the bars are number of foals born.

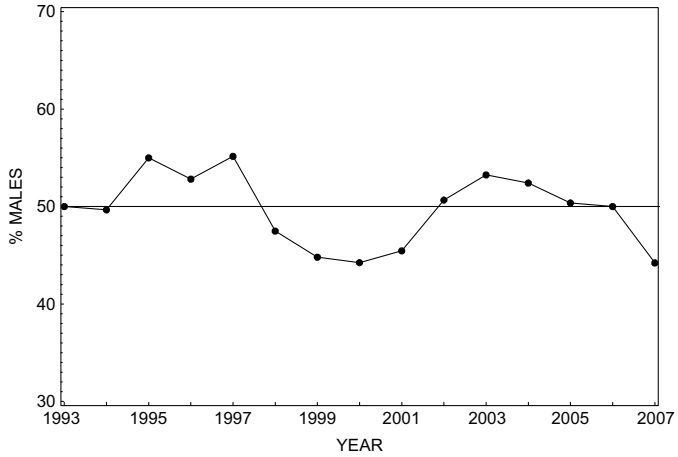

Figure 5. Annual sex ratio of adult (≥1 year old) wild horses (*Equus caballus*) in the Pryor Mountain herd, 1993–2007.

removed), 1997 (33 males, 13 females), 2001 (18 males, 28 females), and 2006 (14 males, 5 females).

The age structure of the Pryor Mountain wild horse herd, on the other hand, changed markedly between 1993 and 2007 (fig. 6*A*,*B*). In 1993, males in the herd averaged 4.4 years of age and females averaged 4.2 years. In 2007, the comparable values were 8.1 and 6.8 years, respectively. Both of these trends are statistically significant as judged by linear least squares regression (males, $P < 0.0001$, $R^2 = 0.911$; females, $P < 0.0001$, $R^2 = 0.832$).

Survival

Pooled across years, ages, and sexes ($n = 2{,}531$), the annual survival rate of horses on the study area was 0.899. Excluding four foals that disappeared before sex could be ascertained, survival of males (0.896, $n = 1{,}246$) did not differ from that of females (0.905, $n = 1{,}281$) ($\chi^2 = 0.486$,

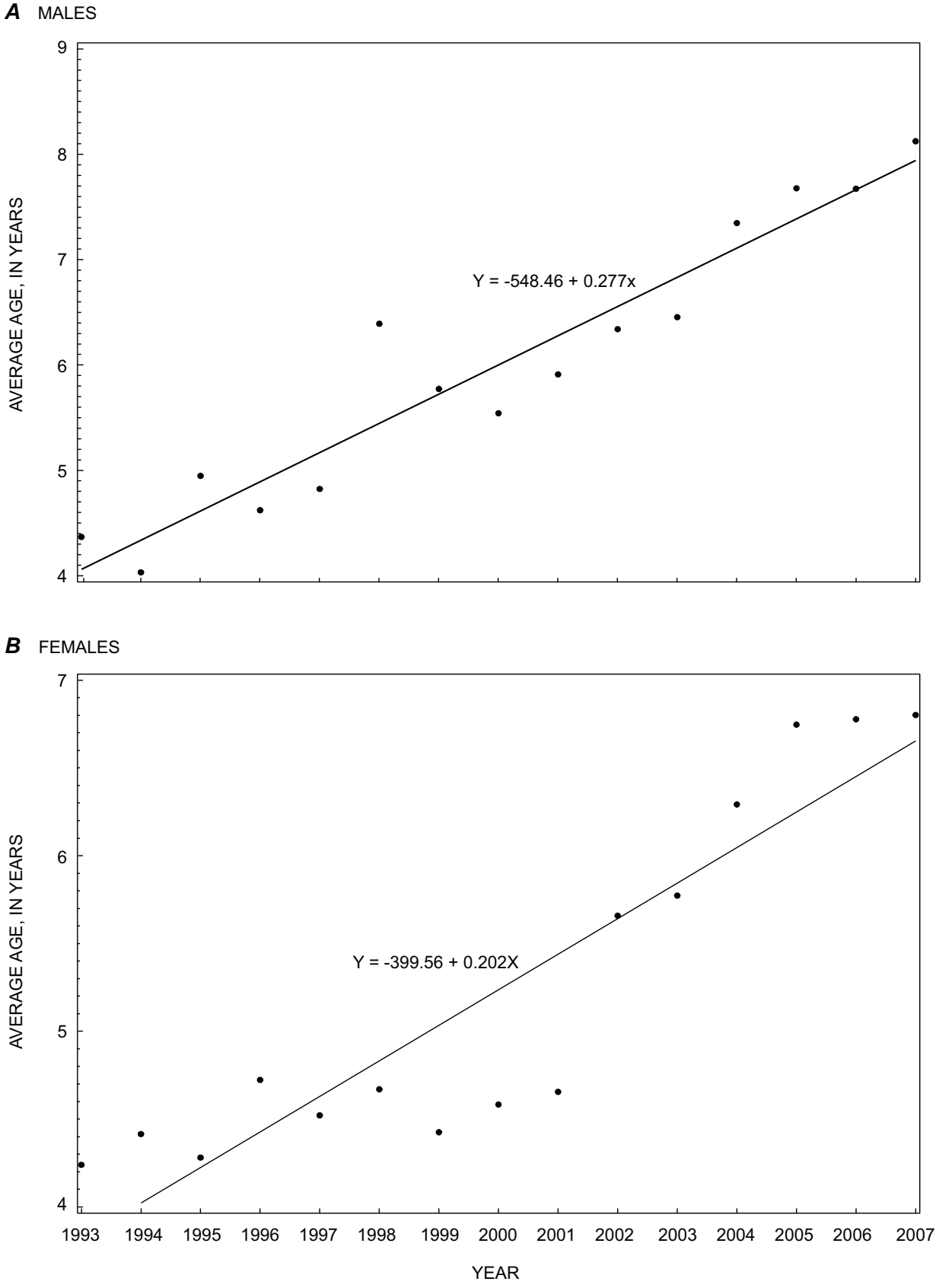

Figure 6. Average age of (*A*) male and (*B*) female wild horses (*Equus caballus*) in the Pryor Mountain herd, 1993–2007.

$P = 0.486$), nor was the difference between the sexes significant for foals ($\chi^2 = 2.500$, $P = 0.114$, $n = 461$). Data from both sexes were therefore pooled for calculations of survival by year.

Survival by year varied from a high of 0.993 in 1993 to a low of 0.780 in 2004 (table 3), when 27 of 28 foals were lost, with predation by mountain lions suspected as the cause (Bureau of Land Management, 2006). For the period of our study, there was a trend toward decreasing foal survival (fig. 7; $P = 0.020$, $R^2 = 0.353$), but there was no trend in survival of animals ≥1 year old ($P = 0.282$, $R^2 = 0.088$). Foal survival increased in the most recent three years of our study, however.

More than one half of the horses that died from 1993 to 2007 were foals, and annual foal survival pooled across years was 0.697 (table 4). Survival increased gradually from age 0 to age 3, remained high through age 15, and then declined gradually. Horses ≥18 years of age were pooled for this analysis because of small sample sizes in these age classes. The oldest animal recorded during the period of study was a male that died at age 26 in 2005. Nine horses lived to be 20 years of age or older, seven of which were males. Four horses (3 males, 1 female) age 20 and 21 were present on the range at the end of our study.

As judged by logistic regression, there was a positive relation between the probability of a foal surviving and the mean (average of summer and fall in a given year) number of members in the band ($n = 393$ foals in 1996–2007; Wald $\chi^2 = 14.964$, odds ratio = 1.244 with 95 percent CI = 1.114–1.390, $P = 0.0001$). Thus, for example, the regression yields a predicted foal survival rate of 0.457 (95 percent CI = 0.351–0.567) for a band size of two, and a predicted survival rate of 0.757 (95 percent CI = 0.688–0.815) for a band size of eight.

We also examined survival of foals in relation to parity of their dams—primiparous (those giving birth to their first foal) compared to multiparous (those that had given birth one or more times). For this analysis, we excluded all mares born before 1993 (since parity could not be determined with certainty) and any foals they produced. We also excluded mares that were presumptively contracepted or were present postcontraception (hereafter referred to as treated and posttreated) and foals that they produced. For the remaining subset of foals, there was no difference in survival based on parity of the dam ($n = 189$, $\chi^2 = 0.957$, $P = 0.328$).

Table 3. Annual survival rates of Pryor Mountain wild horses (*Equus caballus*), 1993–2007.

[Horses that were removed were excluded from survival calculations in the year of their removal.]

Year	n	Deaths	Survival
1993	150	1	0.993
1994	123	3	0.976
1995	149	7	0.953
1996	172	7	0.959
1997	154	15	0.903
1998	161	7	0.957
1999	192	27	0.859
2000	202	15	0.926
2001	181	31	0.829
2002	182	28	0.846
2003	177	32	0.819
2004	173	38	0.780
2005	171	19	0.889
2006	163	16	0.902
2007	181	9	0.950
Total	2,531	255	0.899

Foaling Rates

For ease of comparison with other studies, we calculated foaling rates of mares ≥2 years of age, ≥3 years of age, and ≥4 years of age. Treated and posttreated mares were excluded from these calculations, as were foals born to unknown dams. Pooled across years, productivity was 0.501 foals/mare (range = 0.254–0.705) for mares ≥2 years of age, 0.576 foals/mare (range = 0.300–0.795) for mares ≥3 years of age, and 0.597 foals/mare (range = 0.311–0.795) for mares ≥4 years of age (table 5). Regression analysis showed a slight increase in foaling rate of mares over time (for mares ≥3 years of age, $P = 0.088$), but variability was high ($R^2 = 0.208$).

From 1993 to 2007, 464 of the 481 foals produced in the study area were born to 118 known or highly probable dams (table 6), an average of 3.93 foals per mare. Many of the dams represented in table 6 are still producing foals; thus, the data represent only a single point in time. Twenty-seven dams that each produced seven or more foals accounted for a total of 237 foals, or 51.1 percent of the production by known dams. Of the 54 dams that have been monitored since birth (that is, those born in 1993 or later) and have not been contracepted, 6 (11.1 percent) first produced a foal at age 2, 29 (53.7 percent) at age 3, 14 (25.9 percent) at age 4, 3 (5.6 percent) at age 5, and 2 (3.7 percent) at age 7. The average age at first foaling for these dams was 3.4 years. Age-specific fecundity was 0.048 foals per mare for 2-year-old mares, increased nearly monotonically through age 10, remained high through age 15, and dropped rapidly thereafter (table 7). The maximum age at which any mare gave birth during the study period was 17 years, although that mare was presumptively contracepted and thus is not represented in table 7. A single set of twin foals (both females) was born during the period of our study, to a 6-year-old mare in 1994.

We used logistic regression to examine the probability of foaling in years following a gather as compared to other years for three age groups of mares: 2 years old, 3 years old, and ≥4 years old. Foal production (yes or no) was the dependent variable and year was the independent variable, and we used a specific hypothesis test (or contrast) to compare the mean probabilities of foaling. For this analysis we considered

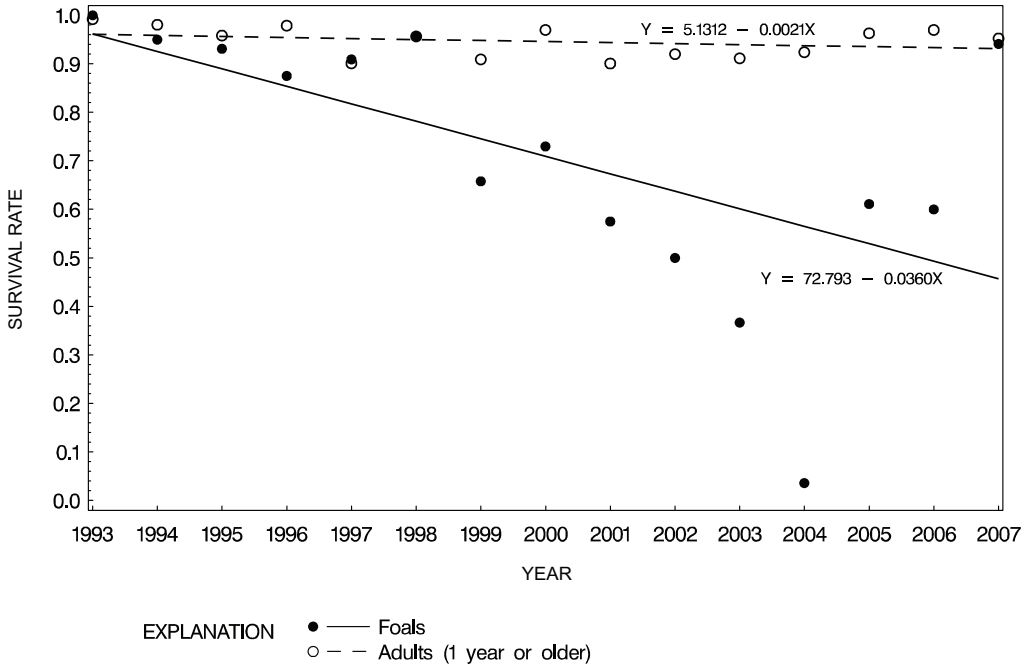

Figure 7. Trend in annual survival of Pryor Mountain wild horses (*Equus caballus*) for adults and foals, 1993–2007.

Table 4. Age-specific survival rates of Pryor Mountain wild horses (*Equus caballus*), 1993–2007.

[Horses that were removed were excluded from survival calculations in the year of their removal.]

Age	Males			Females			Total		
	n	Deaths	Survival	*n*	Deaths	Survival	*n*	Deaths	Survival
0	233	77	0.670	228	60	0.737	[1]465	141	0.697
1	115	9	0.922	137	12	0.912	252	21	0.917
2	91	5	0.945	108	9	0.917	199	14	0.930
3	77	3	0.961	89	2	0.978	166	5	0.970
4	72	1	0.986	84	5	0.941	156	6	0.962
5	70	1	0.986	87	4	0.954	157	5	0.968
6	67	4	0.940	76	3	0.961	143	7	0.951
7	60	2	0.967	73	0	1.000	133	2	0.985
8	60	1	0.983	69	0	1.000	129	1	0.992
9	56	1	0.982	65	1	0.985	121	2	0.984
10	53	0	1.000	57	4	0.930	110	4	0.964
11	49	3	0.939	48	3	0.938	97	6	0.938
12	38	2	0.947	40	5	0.875	78	7	0.910
13	34	1	0.971	32	4	0.875	66	5	0.924
14	33	1	0.970	27	1	0.963	60	2	0.967
15	30	1	0.967	22	2	0.909	52	3	0.942
16	30	1	0.967	18	4	0.778	48	5	0.896
17	26	4	0.846	9	2	0.778	35	6	0.829
≥18	52	12	0.769	12	1	0.917	64	13	0.797
Total	1,246	129	0.896	1,281	122	0.905	[1]2,531	255	0.899

[1] Includes four foals that disappeared before sex could be ascertained.

Table 5. Annual foaling rates of Pryor Mountain wild horse (*Equus caballus*) mares, 1993–2007.

[Treated and posttreated mares in 2004–2007 and foals that they produced were excluded, as were foals born to unknown dams.]

Year	Mares ≥ 2 years old			Mares ≥ 3 years old			Mares ≥ 4 years old		
	Foals	Mares	Foals/mare	Foals	Mares	Foals/mare	Foals	Mares	Foals/mare
1993	15	59	0.254	15	50	0.300	14	45	0.311
1994	32	64	0.500	32	59	0.542	30	50	0.600
1995	23	46	0.500	23	42	0.548	20	38	0.526
1996	32	51	0.627	30	44	0.682	27	40	0.675
1997	34	66	0.515	33	50	0.660	29	43	0.674
1998	23	55	0.418	23	48	0.479	22	43	0.512
1999	38	70	0.543	37	52	0.712	34	46	0.739
2000	37	76	0.487	36	61	0.590	27	44	0.614
2001	40	88	0.455	40	75	0.533	34	60	0.567
2002	32	63	0.508	32	57	0.561	28	53	0.528
2003	30	65	0.462	29	56	0.518	29	50	0.580
2004	28	52	0.538	28	48	0.583	28	48	0.583
2005	31	44	0.705	31	39	0.795	31	39	0.795
2006	23	42	0.548	23	42	0.548	23	37	0.622
2007	21	35	0.600	21	29	0.724	21	29	0.724
Total	439	876	0.501	433	752	0.576	397	665	0.597

Table 6. Total foals born to Pryor Mountain wild horse (*Equus caballus*) mares, 1993–2007.

[Includes only foals born to known dams. Many of the mares represented are still producing foals.]

Foals / Mare	Number of mares	Total foals	Percent of total foals
1	43	43	9.3
2	12	24	5.2
3	10	30	6.5
4	5	20	4.3
5	16	80	17.2
6	5	30	6.5
7	9	63	13.6
8	6	48	10.3
9	4	36	7.8
10	2	20	4.3
11	4	44	9.5
12	1	12	2.6
14	1	14	3.0
Total	118	464	100

only the gathers conducted in 1994, 1997, and 2001 in which most of the family bands were gathered; in 2003, only groups containing animals targeted for removal were gathered, and in 2006 a subset of the herd was captured by bait trapping. For mares 2 or 3 years old, the data were too sparse to allow calculation of the maximum likelihood estimate in the logistic regression (for example, in some years no mares in these age groups produced foals). For mares ≥4 years old the probability of foaling was lower in years following a gather than in other years ($P = 0.03$). The absolute value of this difference was small, however. The mean predicted foaling rate in years following a gather was 0.522 ($n = 3$ years, 134 mares) as opposed to 0.622 ($n = 12$ years, 531 mares) in other years.

We also used logistic regression to examine the probability of a mare foaling as a function of number of members in the band in summer and found a positive relation ($n = 577$ mare-years, Wald $\chi^2 = 24.122$, odds ratio = 1.254 with 95 percent CI = 1.146–1.372, $P < 0.0001$). As an example, the regression yields a predicted probability of foaling of 0.427 (95 percent CI = 0.347–0.511) with a band size of two, as compared to a probability of foaling of 0.743 (95 percent CI = 0.682–0.797) with a band size of eight.

Table 7. Age-specific fecundity of Pryor Mountain wild horse (*Equus caballus*) mares, 1993–2007.

[Treated and posttreated mares in 2004–2007 and foals that they produced were excluded, as were foals born to unknown dams. —, not applicable.]

Age	Number of foals	Number of mares	Foals/mare
0	0	234	0.000
1	0	156	0.000
2	6	124	0.048
3	36	87	0.414
4	34	81	0.420
5	37	72	0.514
6	43	69	0.623
7	41	68	0.603
8	44	70	0.629
9	42	69	0.609
10	43	59	0.729
11	31	48	0.646
12	28	40	0.700
13	22	30	0.733
14	14	23	0.609
15	14	20	0.700
16	4	9	0.444
17	0	4	0.000
≥18	0	3	0.000
Total	439	1,266	—

In addition, we compared the probability of foaling in the next year for primiparous and multiparous mares. Primiparous females were less likely to foal ($\chi^2 = 27.29$, $P < 0.0001$) in the year following their first foal (proportion foaling = 0.26, n = 43) than were multiparous females (proportion foaling = 0.72, n = 110). On the other hand, multiparous females were somewhat more likely to foal ($\chi^2 = 2.60$, $P = 0.107$) if they foaled in the previous year (proportion foaling = 0.72, n = 110) than if they did not foal in the previous year (proportion foaling = 0.61, n = 76).

Harem Stallions and Band Composition

During the 12 years (1996–2007) for which information was available, the number of bands varied from 29 to 38 (table 8), with an increasing trend through time (least squares regression, $P = 0.012$, $R^2 = 0.48$). There was no relation, however, between number of bands and band size (least squares regression, $P = 0.88$); that is, band size did not decline significantly as the number of bands increased. Bands were held by 64 different stallions during this period, the youngest being age 3 and the oldest being age 23 (fig. 8). The vast majority of bands, however, were held by stallions aged 5–17 (fig. 8; n = 399). A single stallion gained his first harem at age 3, but 18 of the 29 harem stallions (62.1 percent) for which we have records since birth (born in 1993 or later) acquired their first harem at age 5 or 6 (fig. 9). As might be expected from the increasing age of all males in the herd (fig. 6A), the average age of harem stallions also increased through time (table 8) (least squares regression, $P < 0.0001$, $R^2 = 0.82$).

Harems with as many as six breeding-age females (≥2 years old) were recorded occasionally, but more than 86 percent of the harems contained 1–3 breeding-age females (fig. 10; n = 399). Harem size varied by age of stallion, increasing from age 3 to about age 11 and declining thereafter (fig. 11; n = 399). There were four somewhat anomalous cases in which a male was listed as a harem stallion but the harem size was zero (fig. 10). In two of these cases there were no harem members at all when the observations were recorded. These represent harems in flux, with one or more mares sometimes with the stallion and sometimes not. In the other two cases the only band members were the harem stallion and a yearling female, and we counted only females ≥2 years old in our calculations of harem size.

Of 399 band-year combinations for which we have observations, only 25 (6.3 percent) involved satellite stallions, which we defined as a male ≥5 years old that was associated with a harem stallion. Three pairs of stallions that lived in the same band for 6, 6, and 5 years accounted for 17 of these 25 associations. The remaining eight associations lasted only 1 or 2 years. In only one case were three stallions involved, and that association was maintained for a year or less. Two of the long-term associations (≥5 years) involved stallions that were the same age (7 through 12 years of age) or 1 year apart (harem stallion 5 through 9 years of age; satellite stallion 6 through 10 years of age). The third long-term association included a harem stallion 17 through 22 years of age and a satellite stallion 7 through 12 years of age. The mean number of mares (≥2 years old) did not differ between single- and multistallion bands (2.2 mares in both cases), although 5 of the 25 multistallion bands had 4–6 mares.

Of the 180 male foals born from 1993 through 2003 (those born after 2003 would have been only 3 years old or younger at the end of our study), 124 died or were removed before reaching age 4 and thus had virtually no chance of becoming a harem stallion. An additional 17 died or were removed at age 4 or 5 and thus had a much reduced chance of becoming a harem stallion. Three died at age 6, and two were removed at age 7 without having held a harem. Of the original 180 male foals born, 29 became harem stallions. Of the remaining five animals, two were still bachelors at the end of our study (ages 4 and 6 in 2007), two briefly held harems (at ages 4 and 8) but reverted to bachelor status, and one was a satellite stallion in his natal band (at age 5).

Table 8. Number of wild horse (*Equus caballus*) bands, mean age of harem stallions, mean harem size (mares ≥2 years old), and mean band size (all members) in the Pryor Mountain herd, 1996–2007.

[—, not applicable.]

Year	Number of bands	Mean age of harem stallions	Mean harem size	Mean band size
1996	29	8.76	1.90	5.14
1997	31	9.68	2.06	5.23
1998	31	10.26	1.87	4.90
1999	31	10.71	2.68	5.74
2000	31	11.10	2.68	5.87
2001	38	10.71	2.39	5.24
2002	34	11.06	1.94	4.59
2003	36	10.89	2.06	4.53
2004	34	11.21	2.06	4.03
2005	35	12.11	2.11	4.20
2006	35	13.00	2.20	4.66
2007	34	11.97	2.38	5.18
Total	399	—	—	—

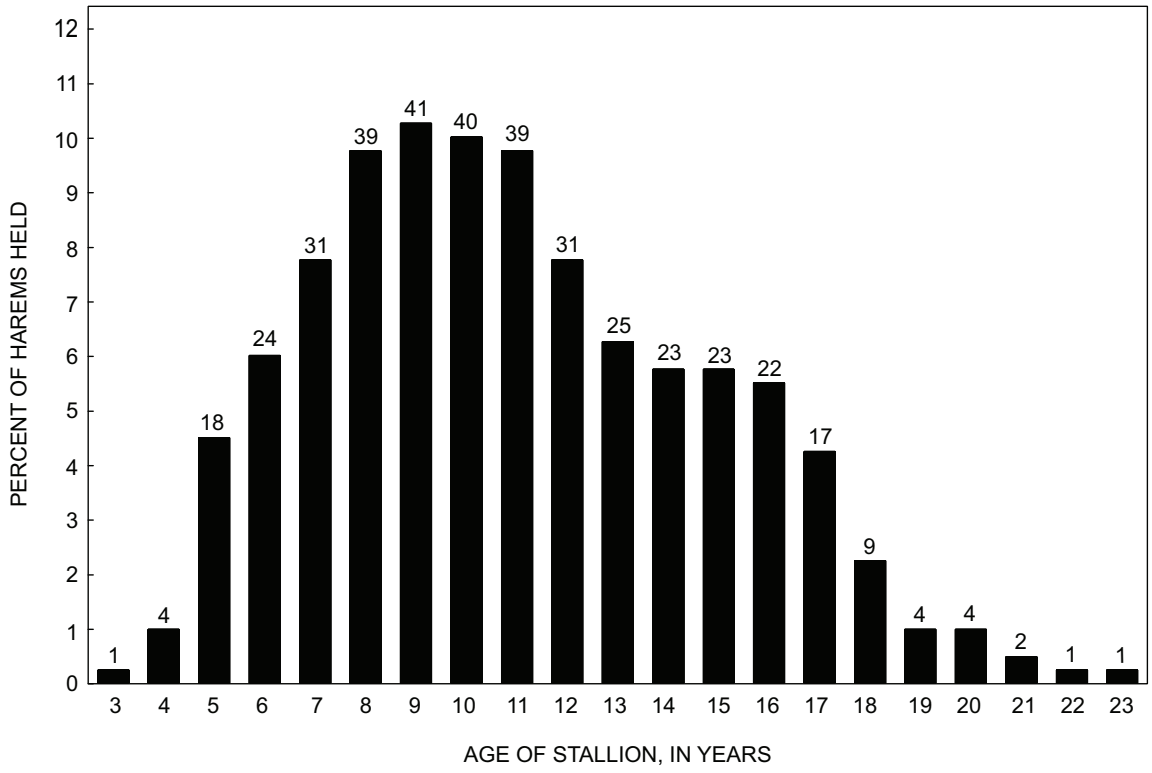

Figure 8. Age of wild horse (*Equus caballus*) stallions holding harems in the Pryor Mountain herd, 1996–2007. Values above the bars are number of harems.

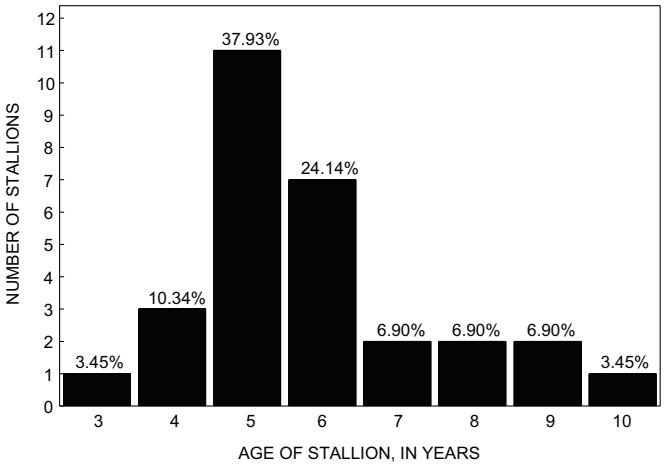

Figure 9. Age at which wild horse (*Equus caballus*) stallions first held a harem in the Pryor Mountain herd, 1996–2007. Values above the bars are percent of the total stallions represented on the chart.

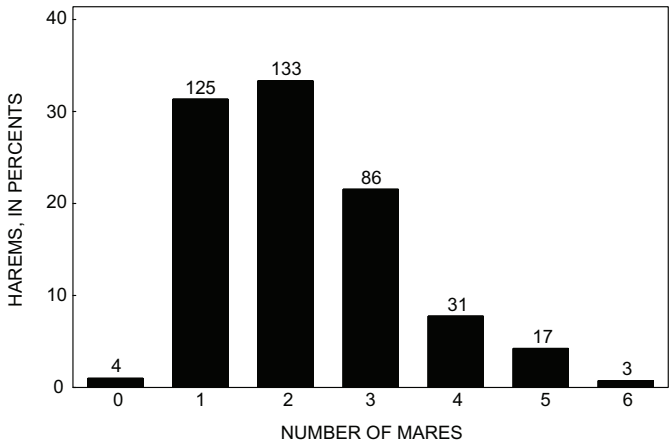

Figure 10. Frequency distribution of wild horse (*Equus caballus*) harem size in the Pryor Mountain herd, 1996–2007. Values above the bars are number of harems.

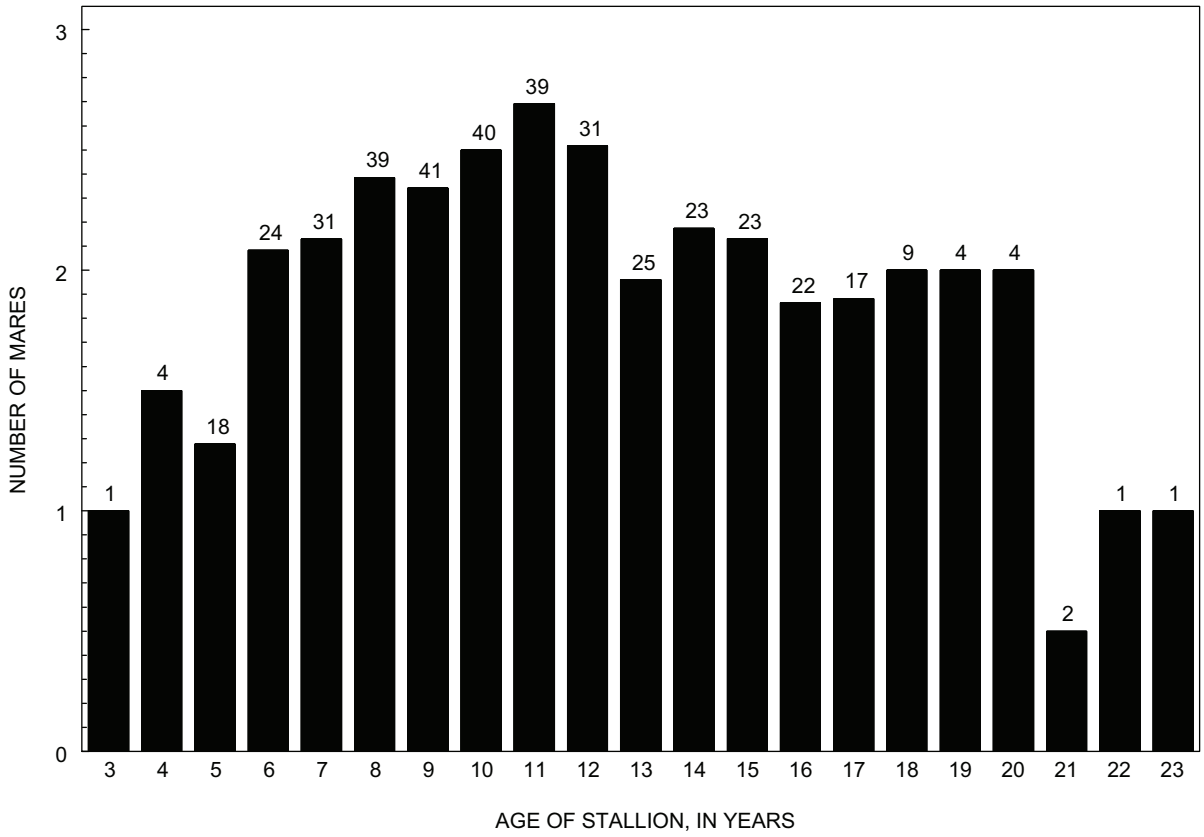

Figure 11. Mean number of wild horse (*Equus caballus*) mares held relative to age of harem stallions in the Pryor Mountain herd, 1996–2007. Values above the bars are number of harems.

Bachelors

The number of bachelor males in a wild horse herd changes through the course of a year, as young males are expelled from or leave bands, middle-aged males (formerly bachelors) gain bands, and older males gain and lose bands. In the Pryor Mountain herd, the number of bachelor males in summer (early to mid-June) varied between 16 and 36 during the period of study (fig. 12). The largest interannual change occurred between 1997 and 1998, in part because of the removal of 18 bachelors in fall 1997. In total, 40 bachelors were removed from the herd from 1996 through 2007. Pooled across years, 188 of 328 bachelors (57.3 percent) were 2 through 5 years of age (fig. 13).

To examine the question of when young stallions leave their natal bands and become bachelors, we used a subset of our data that included all males born in 1996 or later (thus ensuring that we had complete information on their band associations since birth). Of the 59 males that were born in 1996 or later and reached bachelor status (many died or were removed before becoming bachelors, others were born too late in the study period to have an opportunity to become bachelors), 4 (6.8 percent) became bachelors at age 1 (though one subsequently returned to his natal band), 32 (54.2 percent) at age 2, 13 (22.0 percent) at age 3, 7 (11.9 percent) at age 4, and 3 (5.1 percent) at age 5.

Population Regulation

Density Dependence

Regression analyses showed no relation between the foaling rate of mares ≥3 years of age and population size in either the current year or the previous year ($P \geq 0.143$). Foaling rate of 2-year-old mares may have declined somewhat with larger population in the previous year ($n = 13$ years, $P = 0.090$), but variability was high ($R^2 = 0.239$). Other young age classes (3–5 years) did not show similar relations, nor did combinations of these age classes.

Overall herd survival was related negatively to the previous year's postfoaling population (fig. 14A) ($n = 23$ years, $P = 0.006$), but there was a great deal of variability ($R^2 = 0.305$). Foal survival, however, was unrelated to population size ($n = 13$ years, $P > 0.15$). There also was a relation between population growth rate and the previous year's postfoaling population (fig. 14B) ($n = 23$ years, $P = 0.002$, $R^2 = 0.382$). This is perhaps not surprising, because survival rate is an important component of population growth rate.

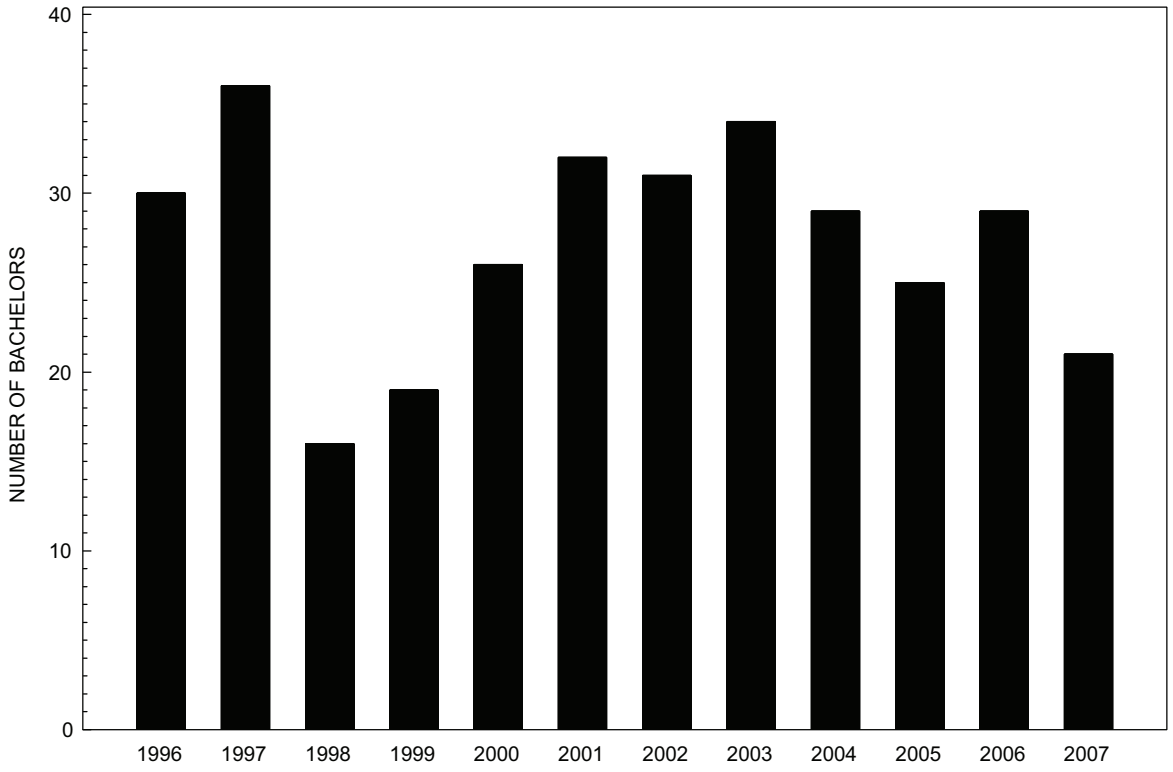

Figure 12. Number of bachelor wild horses (*Equus caballus*) in the Pryor Mountain herd, 1996–2007.

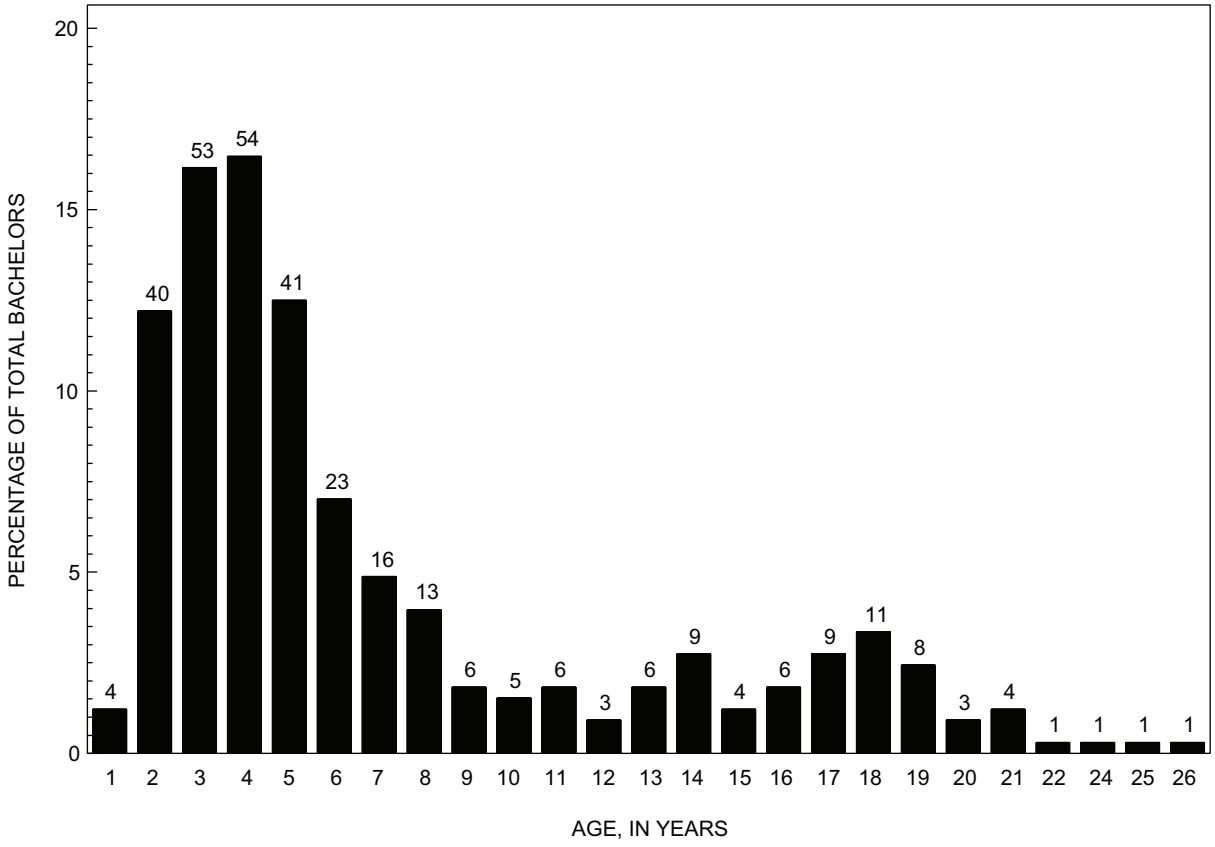

Figure 13. Age distribution of bachelor wild horses (*Equus caballus*) in the Pryor Mountain herd, 1996–2007. Values above the bars are number of bachelors.

Weather

None of the covariates that we used entered the stepwise multiple regression model for herd survival ($P > 0.15$; table 9). For foal survival, both summer and winter precipitation in the current year met the criterion for entry in the model ($P < 0.15$), and both were related positively to foal survival. In the case of winter precipitation in the current year, the positive relation was contradictory to our hypothesis. In combination, these parameters accounted for about 81 percent of the variability in foal survival. In terms of mare foaling rate, only the mean of the monthly average minimum temperature in the previous winter entered the model, and the relation accounted for only about 15 percent of the variability.

Discussion

Population Size and Growth

From 1993 to 2007, the prefoaling (adult) population averaged about 149 animals, only slightly more than the target population of ≈140 adults established on the basis of genetic considerations (Bureau of Land Management, 2006). Removals and a declining survival rate for foals appear to have been the primary factors keeping the population at this level. Contraception also may have played a role if it prevented the birth of any foals. However, it seems likely that the effect of the contraceptive program on population growth was small, given that relatively few mares were treated and that those mares were not in the most productive age classes.

The subject of population growth in wild horse populations has been controversial since early reports (for example, Cook, 1975) of rates as high as 30 percent annually. Other investigators challenged the accuracy of such estimates, and several used simulation modeling in combination with the scant data then available for wild horses and extrapolation of data from other ungulates to show that growth rates of 20–30 percent seemed highly unlikely given apparently reasonable assumptions about model parameters (Conley, 1979; Wolfe, 1980). Frei and others (1979) suggested that the apparently inflated growth rates might be an artifact of improved aerial census techniques and greater experience of observers.

As additional data were accumulated, however, it became apparent that initial assumptions regarding population parameters, particularly survival rates and age of mares at first reproduction, were probably conservative for many wild horse herds (Wolfe, 1986). Eberhardt and others (1982) calculated rates of increase of 20 and 22 percent for two herds

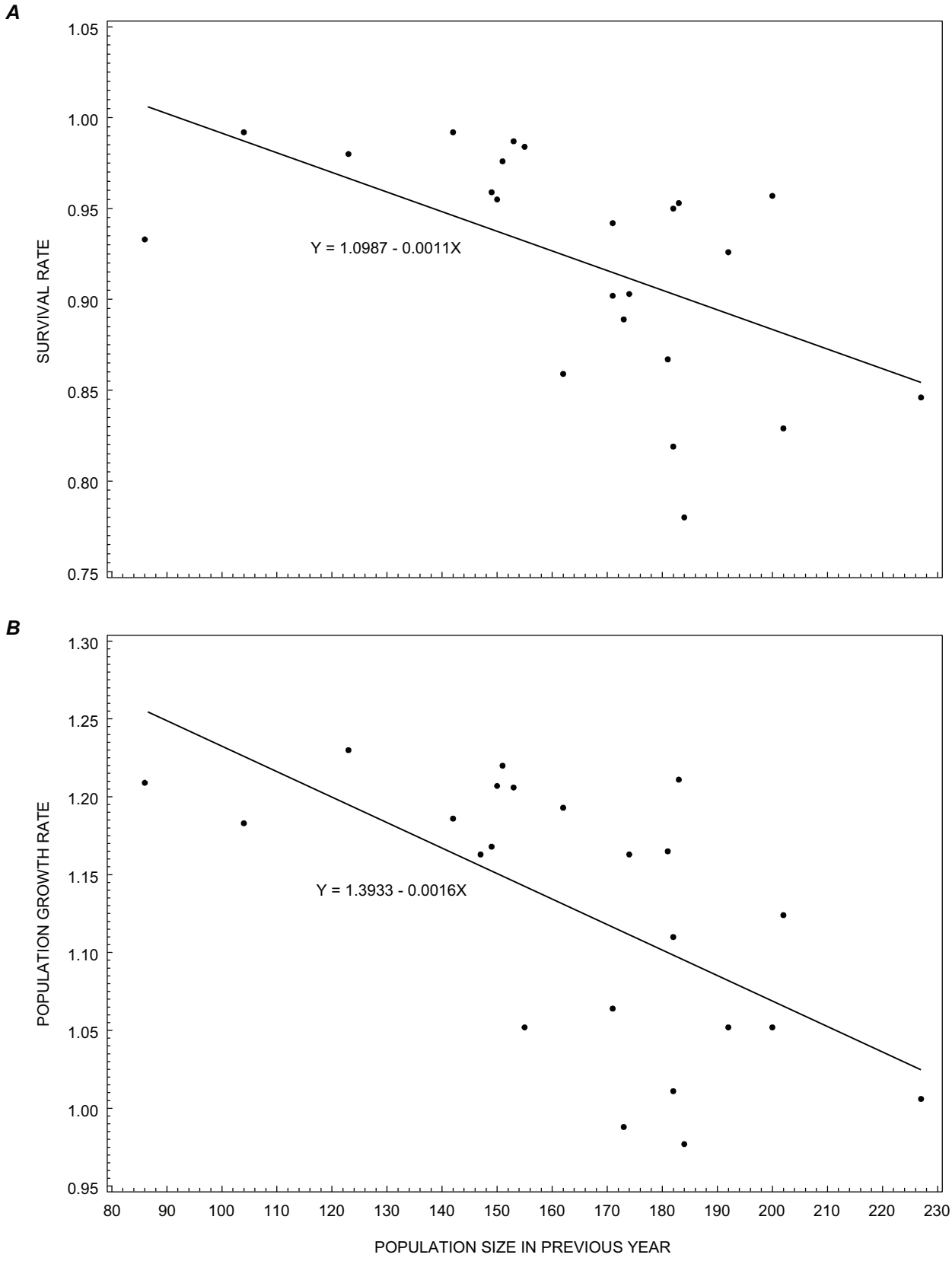

Figure 14. Relation of (*A*) survival and (*B*) population growth rate to the previous year's population for wild horses (*Equus caballus*) in the Pryor Mountain herd. Includes data from this study and from Garrott and Taylor (1990), excepting the abnormally severe winter of 1977–1978.

Table 9. Results of stepwise multiple regressions between wild horse (*Equus caballus*) herd survival, foal survival, and foaling rate (mares ≥3 years of age) and various weather parameters for the Pryor Mountain herd.

[Includes data from Garrott and Taylor (1990) and this study for herd survival and mare foaling rate, but only from this study for foal survival. *n*, sample size; SE, standard error of the estimate; R^2, coefficient of determination; *P*, probability; —, no variables entered the model; SUMP, summer precipitation in the current year; WINP, winter precipitation in the current year; LMNT, average monthly minimum temperature (December–February) in the previous year.]

Population parameter	*n* (years)	Covariate	Parameter estimate	SE	Partial R^2	Model R^2	*P*
Herd survival	19	—	—	—	—	—	—
Foal survival	10	SUMP	0.164	0.041	0.71	0.71	0.002
		WINP	0.117	0.059	0.10	0.81	0.090
Foaling rate	19	LMNT	0.008	0.005	0.15	0.15	0.105

in Oregon and, by comparing pre- and postremoval populations with known removals, showed that the aerial counts used to derive the growth rates must have been reasonably accurate. Berger (1986, p. 76), based on a 5-year study of horses in the Granite Range of Nevada, reported an average annual growth rate of 31 percent. [Note, however, that Berger (1986, p. 77) also reported an exponential growth rate of 0.188, which is equivalent to a finite growth rate of only 20.7 percent annually.] Wolfe (1986), using data from an unspecified number of BLM herds (>40,000 animals), calculated an annual growth rate of 14 percent for the period 1981–1983 and 15 percent for 1983–1985. Garrott and others (1991b) reported an unweighted mean growth rate of 21 percent (range = 15–27 percent) for 12 western herds. High rates of population growth are not limited to western horse populations. Franke Stevens (1990), for example, reported that the horse population at Rachel Carson National Estuary, made up of four small islands off the coast of North Carolina, increased from 44 animals in 1984 to 68 animals in 1986, from which we calculated an annual growth rate of 24.3 percent.

Reported growth rates of wild horse herds have not been universally high, however. Keiper and Houpt (1984), for example, stated that the horse population on Assateague Island National Seashore grew from 42 to 80 animals during the period 1975 to 1982, which represents an average annual growth rate of 9.6 percent. Goodloe and others (2000) found an average annual growth rate of 4.3 percent (range = 3.0–6.8 percent) for horses on Cumberland Island, Georgia, from 1986 to 1990 and suggested that the low rates likely were the result of density-dependent response to limited forage. Greger and Romney (1999), studying a horse population at the Nevada Test Site (now the Nevada Wild Horse Range), found an average growth rate of -7.0 percent, which they attributed to very low foal survival as a result of predation by mountain lions.

The first multiyear study of horses at Pryor Mountain was that of Perkins and others (1979). While they did not calculate population growth rates, they presented information sufficient to do so for two years. Based on information in their table 1, we calculated growth rates of 7.5 and 16.0 percent for 1976 and 1977, respectively, for the postfoaling population. Garrott and Taylor (1990) reported growth rates at Pryor Mountain for 1977–1986 with a mean of 11.9 percent, but 17.8 percent if a year with heavy winter mortality (51 percent of the population died) was excluded. Singer and others (2000) found a mean growth rate of 17.6 percent at Pryor Mountain from 1992–1997.

Our mean annual growth rate (9.6 percent; 10.5 percent if the year of heavy foal loss is excluded) for the period 1993–2007 is thus toward the lower end of the range reported for the Pryor Mountain and other herds. The declining trend in growth rate through time appears to be a result of decreasing survival of foals, though both foal survival (2005–2007) and growth rate (2006–2007) increased in recent years. Contraception also may have played a small role in reducing the average growth rate, though it is difficult to separate the effects of multiple factors.

Sex and Age Ratios

Studies at Pryor Mountain and elsewhere have found foal sex ratios favoring both males and females, with the pattern sometimes switching for the same herd in different time periods. At Pryor Mountain, for example, Feist and McCullough (1975) reported that 54.3 percent of 35 foals were males, Singer and others (2000) found that 58.3 percent of "surviving" foals were males (sample size not given), but Perkins and others (1979) found 48.5 percent males among 103 foals. Similarly, Keiper (1979) reported 52.6 percent males among 190 foals on Assateague Island, but Keiper and Houpt (1984) found 46.6 percent males in 103 foals born at the same location. In many of these studies with relatively small sample sizes, of course, the results did not differ significantly from parity, which also is true of most studies with larger samples, including ours. Speelman and others (1944), for example, found 49.4 percent males in 568 foals born to domestic mares raised under range conditions in Montana. Garrott (1991), who

studied the sex ratio of more than 10,000 foals removed from 74 BLM herds, found no significant difference from parity in 65 of those herds; the foal sex ratio favored females in seven herds and males in two herds. Interestingly, one exception to this pattern is found in the study by Garrott and Taylor (1990) at Pryor Mountain, who reported a sex ratio of 39.7 percent males ($P < 0.001$) in a sample of 330 foals from 1972 to 1986. Garrott and Taylor offered no explanation for this result, but they did comment that other data from their study might suggest low forage availability. Other investigators have hypothesized that females in poor condition (as through low forage availability) should produce fewer male offspring (Trivers and Willard, 1973).

The foal sex ratio did not differ from parity during the course of our study, and there was no overall difference in survival between the sexes. Thus, apart from minor variations resulting from each foal crop entering the population, consistent departures from a 50:50 sex ratio are the result of removals. This is evidenced by the fact that the largest interannual changes in sex ratio occurred following the larger removals. The drop in the proportion of males in the herd in 2007 was because of the removal of 14 males and 5 females in 2006, but also because natural mortality in 2006 consisted of 13 males and only 3 females. The increasing age of the herd also is mostly explained by removals; for all animals removed during the period of study, the average age was 3.2 years for females and 2.7 years for males. This is in keeping with BLM's management strategy of retaining harem stallions and core breeding-age mares (6–10 years) on the range (Bureau of Land Management, 2006). Low survival of foals in 2003 (36.7 percent) and 2004 (3.6 percent) also reduced the proportion of young animals in the herd and thus increased the average age. To the extent that it prevented any mares from foaling, the contraceptive program also would have contributed to increasing age of the herd, but the magnitude of any such effect is unknown.

Survival

The most striking feature of the survival data from our study is the general decline in foal survival in 1993–2004, followed by an apparent increase in the next 3 years. It would be tempting to attribute at least the declining part of this pattern to increased observational effort and hence increased detection of neonatal loss. We do not believe this to be the case, however, because there was no trend in the number of foals produced through time (linear least squares regression, $R^2 = 0.06$, $P = 0.38$), and because all animals present in the herd in 1993 and all foals born since then have been accounted for. Predation by mountain lions is suspected as the cause of low foal survival in 2004 and perhaps in 2003, though only four foals were confirmed to have been taken by mountain lions (Bureau of Land Management, 2006). Three mountain lions were removed from the area by hunters in winter 2004–2005 (Bureau of Land Management, 2006), which might in part explain the increase in foal survival observed in 2005–2007. It also seems possible that predation began on a smaller scale much earlier than 2003, but we know of no evidence to support this hypothesis. Predation by mountain lions has been shown to be an important factor in foal mortality in at least one herd (Turner and Morrison, 2001) and has been implicated in others (Salter, 1979; Greger and Romney, 1999). Wolves (*Canis lupus*), when present, are also suspected of preying on wild horses (Salter, 1979; Oom and Santos-Reis, 1986). Another possible contributor to the observed pattern in foal survival is drought. The drought began in 1999, the same year as the first real drop in foal survival, and was somewhat ameliorated in 2005 and 2007, at which time foal survival increased. The results of our regression analyses between precipitation and foal survival would seem to support this explanation. On the other hand, the initial response to reduced forage availability would likely be a decline in body condition of mares and foals, and such a decline was not observed during the early years of the drought (LC-M).

Overall, survival rates from our study for 1993–2007 are similar to those reported by Perkins and others (1979), but lower than those reported by Garrott and Taylor (1990) and Singer and others (2000) for the same study area (table 10). The foal survival rate reported by Garrott and Taylor, however, probably is an overestimate because it covers the period from midsummer to midsummer; neonatal mortality, which often constitutes the majority of foal mortality (Boyd, 1979; Keiper, 1979; Berger, 1986; Monard and others, 1997; Goodloe and others, 2000), likely was missed. Age of the herd also may account for some of the difference between our survival rate and that calculated by Garrott and Taylor (1990). At the end of their study in 1986, about 22 percent of the herd was ≥11 years of age, whereas the comparable number for 2007 was 39 percent. Perkins and others (1979) and Singer and others (2000) did not provide sufficiently detailed age data to make similar comparisons. Survival rates from our study were also moderate compared to those reported previously for other horse herds in North America (table 10).

Relations between foal survival and band size have not often been reported in the literature on wild horses, and the few available results are equivocal. We found that foals from larger bands tended to survive better than those from smaller bands. Working on Camargue horses in France, Feh (1999) found that there was less foal mortality in bands with an alliance of two stallions (3.2 percent), than in single-stallion bands (22.0 percent). Multiple stallions often are associated with larger bands. Cameron and others (2003), on the other hand, found that among Kaimanawa horses in New Zealand more foals died in multistallion bands (survival = 80 percent, $n = 30$) than in single-stallion bands (survival = 94 percent, $n = 50$), but the difference was not quite significant ($P = 0.056$). Similarly, evidence for a relation between mare age or parity and foal survival is equivocal. We found no relation between foal survival and parity of the mare. Keiper and Houpt (1984) reached the same conclusion, but only 10 foals died in the course of their study. In contrast, Cameron and

Table 10. Survival rates reported for North American wild horse (*Equus caballus*) herds.

[Data are arranged in order of increasing foal survival. Sample size (*n*), when available, is given in parentheses. NA, data not available; PMWHR, Pryor Mountain Wild Horse Range.]

Source and location	Survival rate (*n*)				Comments
	Foals	Yearlings	Adults	Herd	
Greger and Romney (1999), NV	0.12	NA	NA	NA	Foal survival is a mean for 8 years and is a maximum estimate because some neonatal mortality probably went undetected.
Turner and Morrison (2001), CA and NV	0.32	0.88	0.92	NA	All data represent means for 10 years.
Goodloe and others (2000), GA	0.600 (105)	NA	0.923 (263)	NA	Adult rate is for mares only, probably ≥3 years old.
This study, (PMWHR)	0.697 (465)	0.917 (252)	0.949 (1,814)	0.899 (2,531)	
Perkins and others (1979), PMWHR	0.75	NA	NA	0.903 (579)	Foal survival is a mean for 4 years. Herd survival is a weighted mean calculated from Table 1, Perkins and others (1979).
Boyd (1979), WY	0.824 (51)	NA	NA	NA	Data for 1978 only.
Singer and others (2000), PMWHR	0.87	NA	NA	Males, 0.965 Females, 0.975	Not clear that data reported for the herd actually includes all animals.
Siniff and others (1986), Pine Nut, NV	0.875 (40)	NA	0.972 (72)	NA	Adult rate is a weighted mean for 2 years representing only mares, probably ≥2 years old
Siniff and others (1986), Pah Rah, NV	0.877 (73)	NA	0.975 (81)	NA	Adult rate is a weighted mean for 2 years representing only mares, probably ≥2 years old
Keiper and Houpt (1984), MD and VA	0.883 (86)	NA	NA	NA	Foal rate is a weighted mean for 8 years.
Pellegrini (1971), NV	0.905 (21)	NA	NA	NA	Data are for 1969. However, in 1968 no foals were observed, and in 1970 only one foal was observed.
Berger (1986), NV	0.917 (120)	0.969 (64)	0.951 (329)	0.945 (513)	Herd rate calculated from data on the three age groups.
Garrott and Taylor (1990), PMWHR	0.968 (249)	0.977 (173)	0.962 (865)	0.965 (1,287)	Excludes data from a severe winter. Adult and herd rates calculated from Table 2, Garrott and Taylor (1990). Foal rate measured from midsummer to midsummer and may be an overestimate.

others (2000) found significant differences in mortality of foals born to mares 3–5 years old (18 percent mortality), 6–8 years old (3 percent), and ≥9 years old (9 percent).

Foaling Rates

Foaling rates of mares at Pryor Mountain most often have been low to moderate when compared to those reported for other North American herds (table 11). In fact, the rate of 0.432 foals/mare for mares ≥4 years of age calculated from Feist and McCullough (1975) is among the lowest for any herd, although their study was primarily behavioral and lasted only 1 year. In addition, they attempted to classify mares aged 1, 2–3, and ≥4 years without the benefit of examining tooth eruption and wear, and they admit that some classification errors probably occurred. If there was a tendency to misclassify 3-year-old mares as being ≥4 years old, the resulting foaling rate would be biased low. Garrott and Taylor (1990), however, reported similarly low rates, and mares in their study were aged by dental characteristics. As noted above, Garrott and Taylor (1990) reported on foals present in midsummer; some neonatal loss likely was missed, which would tend to bias foaling rates low. Perkins and others (1979) did not report age-specific foaling rates of mares, but for the three years of their study for which data are complete (1975–1977), the foal crop was 15.1 percent of the prefoaling population (weighted average, $n = 411$ animals ≥1 year of age). The comparable value during our study was 21.6 percent (table 1, $n = 2{,}232$ animals). These values, of course, are affected by the sex and age structure of the herd. Similarly, Singer and others (2000) did not report age-specific foaling rates in sufficient detail to be included in table 11. They did, however, show rates of 0.107 foals/mare for mares of age 2, 0.54 for age 3, 0.67 for ages 4–11, and 0.46 for ages ≥12 in the period 1992–1997. Comparable values from our study (1993–2007) were 0.048, 0.414, 0.588, and 0.636, respectively. Thus, it appears that foaling rates at Pryor Mountain have varied considerably through time, with those from our study being intermediate.

Several investigators have suggested that forage availability can affect the condition of feral mares and thus foaling rates (Green and Green, 1977: Nelson, 1978; Berger, 1986; Siniff and others, 1986; Garrott and Taylor, 1990). Hall (1972) described range conditions at Pryor Mountain as being poor to extremely poor through much of the area. Feist and McCullough (1975) reported a low foaling rate in 1971, as did Garrott and Taylor (1990) in the first 3 years (1976–1978) of their study. Furthermore, Garrott and Taylor (1990) suggested that low foaling rates likely were a result of poor forage, also noting that the foaling rate increased markedly in 1979 following loss of 51 percent of the herd in the severe winter of 1977–1978. Singer and others (2000) reported somewhat higher foaling rates than were observed in the earlier studies and also noted that former managers who visited Pryor Mountain in 1997 remarked about the overall improvement in "plant condition." Again, our values for foaling rate appear to be intermediate. It also may be relevant that mean annual precipitation in the biological years covered by the study of Singer and others (17.55 cm; 1992–1997, all years included regardless of missing data) was greater than that for the remainder of our study (13.79 cm; 1998–2007).

In addition to its effects on foaling rates of adult animals, forage availability may affect age of first reproduction by mares. Feist and McCullough (1975), Perkins and others (1979), and Garrott and Taylor (1990) all worked at times when forage production may have been poor at Pryor Mountain and all found that mares first foaled at age 3. Singer and others (2000), on the other hand, at a time when forage production may have been somewhat better, found that 10.7 percent of 2-year-old mares produced foals; the comparable value from our study was 4.8 percent. First foaling at age 2 (Salter and Hudson, 1982; Berger, 1986; Lucas and others, 1991) and age 3 (Boyd, 1979; Keiper and Houpt, 1984; Goodloe and others, 2000) has been reported for other herds, with the rate for 2-year-olds varying both among herds and within herds in different years (Garrott and others, 1991a). In at least two studies, low foaling rates in young mares have been attributed to high rates of fetal and neonatal loss (Lucas and others, 1991; Linklater and others, 2004).

Other factors that have been shown or hypothesized to affect foaling rate include gathers, band stability, and parturition history of the mare. In the case of gathers, we found a small but statistically significant effect, with foaling rate being lower in years following gathers. It must be remembered, however, that we did not design an experiment specifically to test a hypothesis about the effect of gathers. In particular, we had to assume that the majority of mares were affected by the gather (either actually moved into a trap or significantly disturbed by helicopter activity) in each of the three years that we considered to be gather years. Given the nature of the gathers in those three years, we believe that such an assumption is reasonable. Other evidence for an effect of gathers on foaling rate is equivocal. Hansen and Mosley (2000) studied two herds, one in Idaho and one in Wyoming, and found no difference in foaling rate between mares ungathered, gathered and released, or gathered and adopted. The ungathered samples were small, however, consisting of only 14 mares in each herd. Ashley and Holcombe (2001), on the other hand, found that in one of the two years of their study, ungathered mares foaled at a higher rate than did those that were gathered and released or gathered and removed. They found no evidence for an effect of a gather in the other year.

Evidence for an effect of band stability on mare foaling rate is more consistent. Berger (1983) found that mares in bands with resident stallions produced foals at a higher rate than those in bands taken over by a new stallion. Kaseda and others (1995), working on Misaki horses in Japan, reported that mares in "stable consort relationships" had higher reproductive success than those that changed stallions. Similarly, Goodloe and others (2000) found that mares that changed bands had a lower probability of foaling than those that did

Table 11. Foaling rates reported for North American wild horse (*Equus caballus*) herds.

[To the extent possible, data are arranged in order of increasing production by mares ≥3 years old. Sample size (*n*), when available, is given in parentheses. NA, data not available; PMWHR, Pryor Mountain Wild Horse Range.]

Source and location	Foals/mare (*n*)			Comments
	Mares ≥2 years old	Mares ≥3 years old	Mares ≥4 years old	
Siniff and others (1986), Pine Nut, NV	0.385 (104)	NA	NA	Combined data for 2 years. Age of mares inferred from other information.
Feist and McCullough (1975), PMWHR	NA	NA	0.432 (81)	Some animals may have been aged incorrectly. Includes two foals born to 3-year-old mares.
Greger and Romney (1999), NV	NA	0.360	NA	Unweighted mean for 5 years.
Garrott and Taylor (1990), PMWHR	NA	0.488 (600)	NA	Calculated from Table 3, Garrott and Taylor (1990).
Wolfe and others (1989), NV	0.432 (206)	NA	NA	Calculated from Table 5, Wolf and others (1989), for lactating mares.
Boyd (1979), WY, 1979	NA	0.526	0.545	Sample sizes not given.
Turner and others (1992), CA and NV	NA	0.537	NA	Unweighted mean for 6 years.
Keiper and Houpt (1984), MD	NA	0.571	NA	Unweighted mean for 8 years.
Nelson, (1978), NM	NA	NA	0.553 (38)	
This study, PMWHR	0.501 (876)	0.576 (752)	0.597 (665)	
Keiper (1979), MD	NA	0.614	NA	Unweighted mean for 5 years.
Salter and Hudson (1982), Alberta	0.521 (71)	0.621 (58)	NA	Calculated from Table I, Salter and Hudson (1982).
Seal and Plotka (1983), OR	NA	0.626 (99)	NA	Foaling rate based on lactating mares from Table 4, Ashley and Holcombe (2001).
Ashley and Holcombe (2001), Granite Range, NV, 1994	NA	NA	0.714 (28)	Calculated only for ungathered horses.
Ashley and Holcombe (2001), Granite Range, NV, 1997	NA	NA	0.741 (54)	Calculated only for ungathered horses. Age of mares inferred from other information.
Wolfe and others (1989), WY	0.535 (172)	NA	NA	Calculated from Table 5, Wolfe and others (1989), for lactating mares.
Garrott and others (1991a), NV	0.584 (901)	NA	NA	Foaling rate based on lactating mares gathered in June. Calculated from Table 1, Garrott and others (1991a).
Keiper (1979), VA	NA	0.744	NA	Unweighted mean for 4 years.
Ashley and Holcombe (2001), Garfield Flat, NV, 1997	NA	NA	0.824 (17)	Calculated only for ungathered horses. Age of mares inferred from other information.
Boyd (1979), WY, 1978	NA	0.781	0.863	Sample sizes not given.
Siniff and others (1986), Pah Rah, NV	0.670 (109)	NA	NA	Combined data for 2 years. Age of mares inferred from other information.

not. Data on mare interchanges are available from the Pryor Mountain herd, but have not yet been analyzed.

The question of whether parturition history of the mare affects foaling rate has been of interest since early investigators reported what they perceived to be a tendency to foal in alternate years (Green and Green, 1977; Nelson, 1978). This question has been addressed in a number of ways and results have varied. Seal and Plotka (1983) found that 68.4 percent (n = 76) of pregnant mares also had a foal at their side or were lactating, and Wolfe and others (1989) found no difference in pregnancy rates for lactating and nonlactating mares in six different populations. Neither of these studies, however, addressed the question of whether lactating and nonlactating mares are equally successful in bringing their pregnancies to term. On Assateague Island, 10.2 percent of 49 mares followed for 4 years foaled in alternate years, whereas 55.1 percent foaled in either 3 or 4 years (Keiper, 1979). Similarly, Keiper and Houpt (1984) could not see any tendency to foal in alternate years among 14 mares followed for 8 years. At Pryor Mountain, in both our study and that of Garrott and Taylor (1990), primiparous mares were less likely to foal in the next year than were multiparous mares. Cameron and Linklater (2000), on the other hand, found that the probability of foaling in a given year was reduced significantly if the mare had a foal in the previous year. Thus, while not universal, it appears that foaling in one year can sometimes reduce the probability of foaling in the subsequent year, particularly in primiparous mares.

Harem Stallions and Band Composition

Comparisons among band or harem sizes reported by various investigators are hampered by inconsistencies in defining what constitutes a harem member, or failure to do so at all. We defined harem members as mares ≥2 years of age, and found that the mean harem size was 2.2 mares with a range of 1.9 to 2.7 over 12 years; the number of bands ranged from 29 to 38. In other studies at Pryor Mountain, Feist and McCullough (1975) reported only average band size (5.0 including all members, not just mares), but they found 44 bands and 106 females ≥2 years of age, so the average harem size was likely somewhere near 2.4 mares. Note that the total population during the single summer of their study was about 225 animals, which probably explains the somewhat larger number of bands. Perkins and others (1979), working on a population that ranged from 95 to 168 animals (1974–1978), found 19–27 bands with a mean size of 4.9 (total animals), but did not report harem size in terms of number of mares. During a period (1992–1997) when the mean population was 161 animals, Singer and others (2000) reported an increase in the number of bands (18 to 31) and a decline in the number of mares (age unspecified) per harem from four to two. They attributed these trends to an increasing proportion of males in the population, death or waning vigor of a number of older males, and removal of members from the bands of several stallions aged 10–15 years. Investigators working on other herds have found similar or perhaps slightly larger average harem sizes. Mean harem size on Cumberland Island was 1.8 mares (Goodloe and others, 2000); the authors did not specify the age of mares included, but only mares ≥3 years old produced foals. Greger and Romney (1999) reported an average harem size of 2.4, which included all females ≥1 year of age, excluding daughters. Berger (1986, p. 130) found an average harem size of 3.1 mares with a range of 2.73–3.67 across years; age of mares was not specified but, because 2-year-old females reproduced, mares ≥2 years old may have been included. In Misaki horses (Japan), the annual average harem size ranged from 1.8 to 5.3 mares ≥2 years old; one stallion in one year had a harem of nine mares, and 55.0 percent of 60 harems (14 harem stallions) observed from 1979 to 1994 had four or more mares (Kaseda and Khalil, 1996).

In our study, 62.1 percent of harem stallions first acquired a harem at age 5 or 6. Other investigators have found comparable results: Berger (1986, p. 142), age 5–6; Kaseda and Khalil (1996), age 4–6; Asa (1999), age 5; Singer and others (2000), mean age = 6 years. In the last two years of our study, the mean age of harem stallions was 13 and 12 years, which is remarkably similar to the mean of 12.8 years reported at Pryor Mountain by Perkins and others (1979). Hall (1972), however, reported a mean age of 7.8 years, which is more similar to the data from the early years of our study. Age structure of removals is undoubtedly an important determinant of such results.

During our study, 6.3 percent of bands had multiple stallions. Feist and McCullough (1975) did not mention whether any of the 44 bands present during their study had multiple stallions. Perkins and others (1979) found only two multistallion bands in the 19–27 bands present during the 4 years of their study; if the mean number of bands present was, say, 23 per year, multistallion bands would have made up about 2.2 percent of the total. These percentages are lower than those reported for other herds: Goodloe and others (2000), 10.7 percent, n = 177; Nelson (1978), 11.8 percent, n = 17; Berger (1986, p. 129), 12 percent, sample size not given; Salter and Hudson (1982), 17.4 percent, n = 23; Asa (1999), 28 percent and 33 percent in 2 years, n = 18 and 9; Miller (1979), 23–45 percent for 3 years, n = 12–18; Bowling and Touchberry (1990), 39.1 percent, n = 69; Franke Stevens (1990), 50 percent, n = 12; Green and Green (1977), 45 percent and 54 percent in 2 years, n = 53 and 67, respectively. Kirkpatrick and Turner (1986) suggested that differences in proportions of bands with multiple stallions may be related to population density and sex ratio, with a greater ratio of males to females tending to lead to multistallion bands, and noted that some of the reported proportions may be high as a result of inaccurate aging of the animals based on body size [for example, Green and Green (1977)].

Bachelors

We have information on the total number of bachelors, but not on individual groups, which makes comparisons with other studies at Pryor Mountain difficult. Hall (1972) reported that the average size of bachelor groups was three, with individuals ranging in age from 1 to 5 years, and that older stallions usually lived alone after losing their harems. Feist and McCullough (1975) found 23 bachelor groups with a mean of 1.8 animals per group. Perkins and others (1979) found six bachelor groups, all with 2–3 individuals ranging in age from 3 to 8 years, as well as six older stallions that lived alone. With allowances for varying population size, our results do not appear to be greatly different from those found at other times at Pryor Mountain.

Most evidence suggests that males leave or are expelled from their natal band when they reach sexual maturity, which usually occurs at age 3 and occasionally at age 2 (Angle and others, 1979; Kirkpatrick and Turner, 1986). Our data show a somewhat different pattern. A few males left their natal band at age 1, most (54.2 percent) left at age 2, but 17 percent remained with their natal band until age 4 or 5. Of the three individuals that remained in their natal bands until age 5, two subsequently acquired harems and one was still a bachelor (6 years old) at the end of our study. Interestingly, one of these stallions took over his natal band, at which point his dam left the band for another. It seems possible that instances of stallions remaining with their natal band until age 4 or 5 account for some of the reports in other studies of a high proportion of multistallion bands.

Population Regulation

Several investigators have suggested a relation between forage availability and foaling rate, but few studies have been long enough and had sufficient variation in population size to allow detection of density-dependent effects. Berger (1986, p. 97) found little evidence for density dependence in his data from the Granite Range and suggested that the confounding effects of weather were responsible. He did, however, find some evidence for a decline in foaling rate with increasing population size in data from Keiper and Houpt (1984). Singer and others (2000) found that population growth rate at Pryor Mountain declined with increasing population size, but this result was clearly dominated by data from a single year [Singer and others (2000), fig. 5]. They did not find evidence for a density-dependent effect on either foaling rate or survival rate. Jenkins (2000) examined data from the Granite Range and Pryor Mountain herds, both having individually identified animals, as well as five additional herds where population size was estimated using aerial surveys. In all seven cases, he found that population growth rate decreased with increasing population size, but only one was statistically significant ($P \leq 0.05$). However, his meta-analysis of the entire data set indicated that the probability of the same result through chance alone was only 0.001.

Our results are similar to those of both Singer and others (2000) and Jenkins (2000) in that we also found that population growth rate declined with increasing population size, albeit population size from the preceding year, which suggests that lag effects may be important. Furthermore, we found similar evidence for a negative relation between overall herd survival and population size, and perhaps some weaker evidence that the foaling rate of 2-year-old mares is affected by population size. We did not, however, find evidence for a density-dependent effect on foal survival, perhaps in part because Garrott and Taylor (1990), whose study encompassed a range of population sizes, did not provide annual foal survival rates.

We used population size as a surrogate for population density in these analyses, as did all of the authors cited in this section. In doing so, we made the implicit assumption that the area used by horses did not change significantly through the course of the study. In the case of the Pryor Mountain herd, however, horses probably made increasing seasonal use of Forest Service lands north and west of the original wild horse range. It seems likely that any density-dependent effects would have been more pronounced had this increase in use of Forest Service land not occurred.

In all cases where we found evidence for density dependence, variability was high, suggesting that other factors also may be important in regulating the Pryor Mountain wild horse herd. Assuming that the cause of mortality was correctly identified, mountain lion predation may have had a dramatic effect on foal survival in at least one year. In the latter years of our study, contraception also may have had some effect on foaling rate, though it seems likely that this effect was small given that relatively few mares were treated and that they were not in the most productive age classes. One of the most important regulatory mechanisms appears to be precipitation, which we found to be strongly related to foal survival. Both density dependence and precipitation effects are consistent with an interpretation of forage availability per individual as an important parameter. All of these factors combined, however, were not sufficient to stabilize the population during our period of study, as evidenced by the necessity for large removals in several years.

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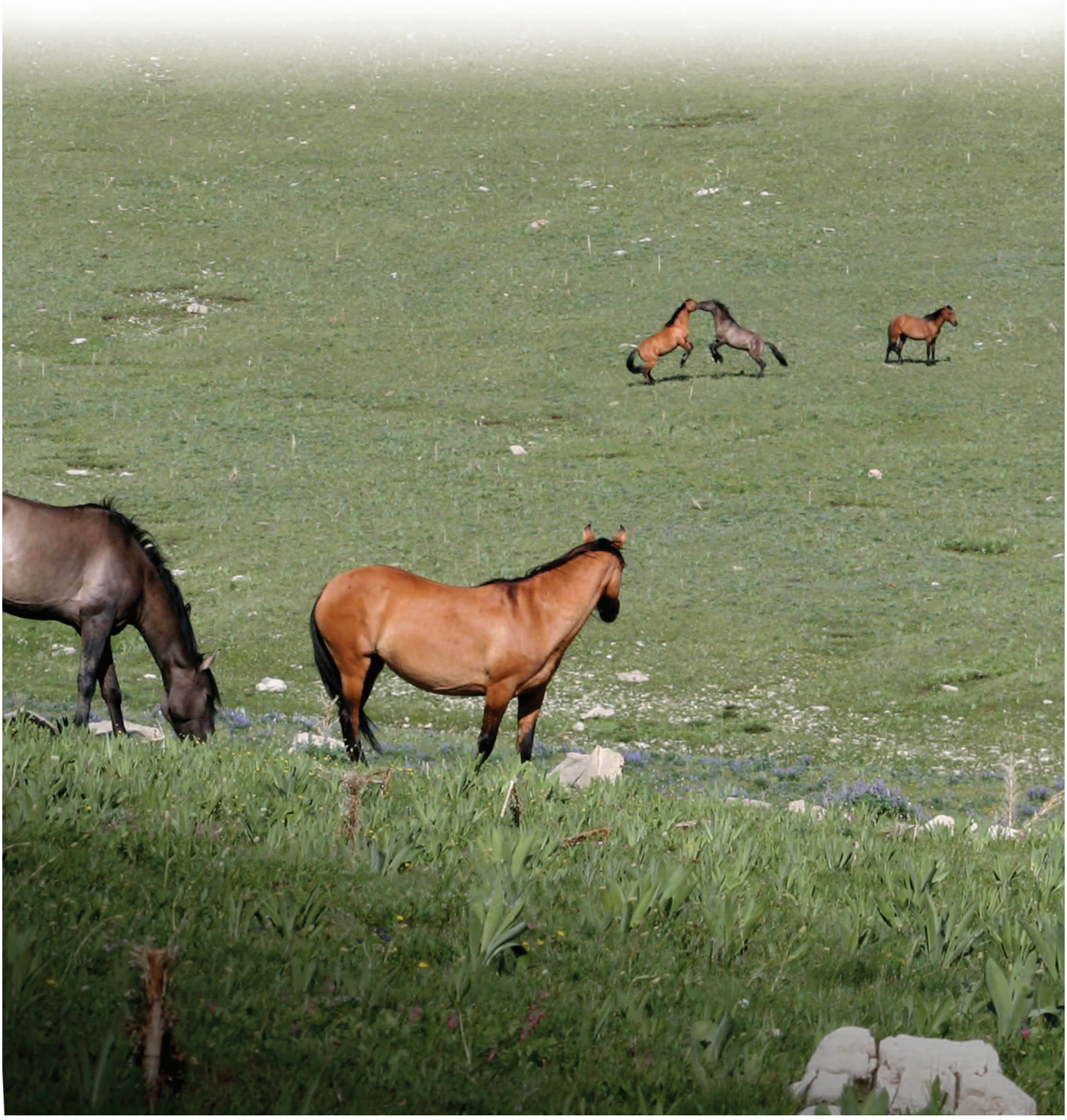

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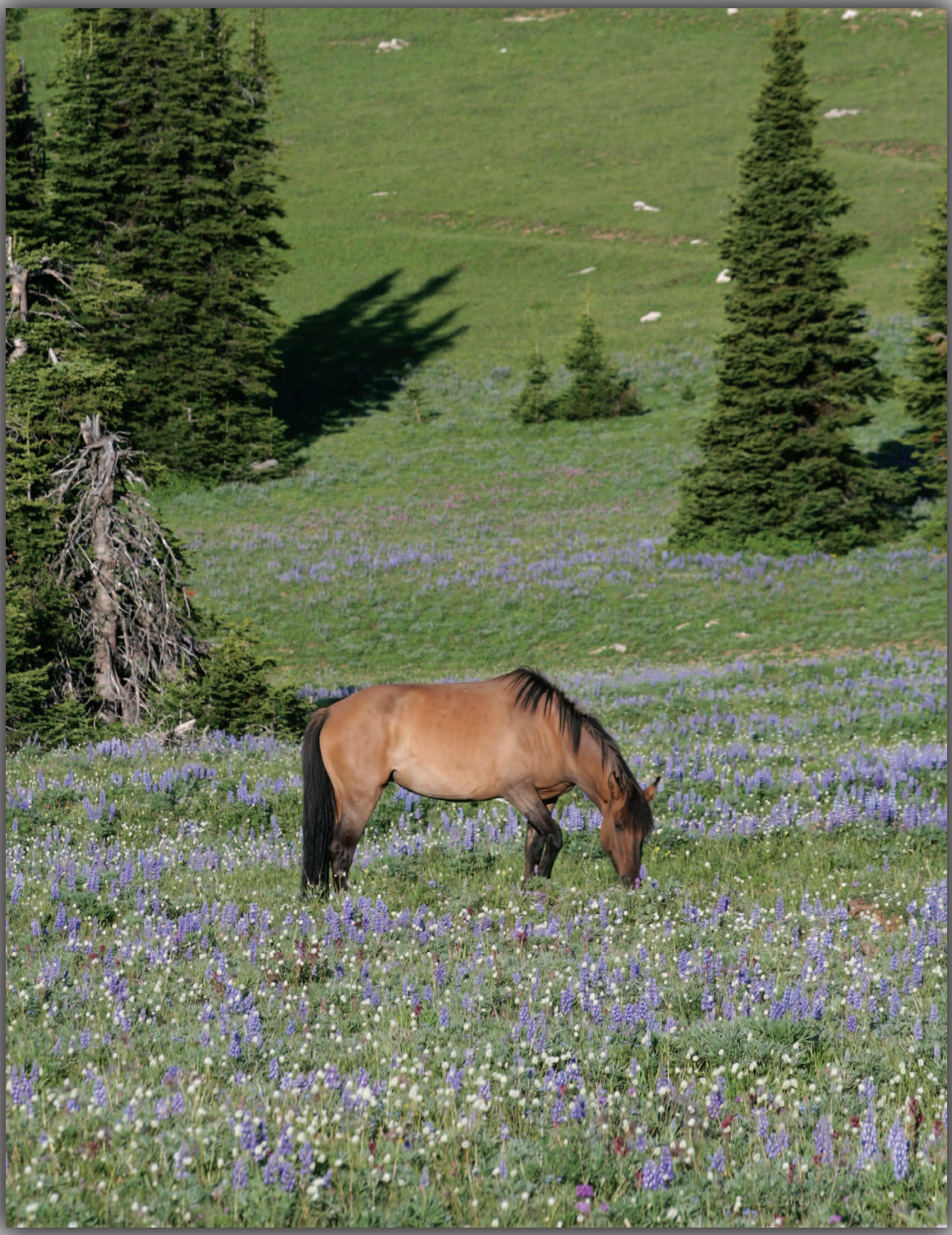

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Roelle and others— **Demography of the Pryor Mountain Wild Horses, 1993–2007**—Scientific Investigations Report 2010–5125

Feral equids, such as these donkeys in the US Mojave desert, affect desert ecosystems by digging wells to access water.

PHOTO: MICHAEL ALFUSO

Edited by **Jennifer Sills**

Feral equids' varied effects on ecosystems

In their Report "Equids engineer desert water availability" (30 April, p. 491), E. J. Lundgren and coauthors present observations of feral burros digging shallow wells and suggest that these wells may benefit native wildlife and ecosystems by increasing the number of water sites. The authors consider feral equids (horses and burros) to be beneficial but fail to acknowledge substantial research establishing the many negative effects that feral equids have on arid ecosystems. The positive view presented by Lundgren *et al.* is troubling because growing feral equid populations in the western United States are a serious concern for natural resource managers (*1*).

Feral equids compete with native wildlife for food and water and displace native ungulates from water (*2*–*5*). Their presence has been associated with decreased diversity of native species at water, and native species have been observed to visit water less frequently and spend less time at water when equids are present (*6*). Reduced access to water is particularly detrimental in arid landscapes, especially during drought.

The addition of a small number of shallow wells does not benefit native wildlife when their overall access to water is reduced by equids. Lundgren *et al.* present no data to demonstrate an overall benefit to wildlife. We urge caution in speculating that the addition of a few localized wells benefits native species. Feral equids have also altered plant composition, reduced plant diversity and cover, and increased soil compaction and erosion (*7*–*9*), thereby putting native habitats at risk. This, together with poorly controlled equid population growth, results in degraded habitats with decreased carrying capacities. Effective management of feral equids will benefit from the public's accurate understanding of their overall effects on ecosystems.

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Response

Rubin *et al.* rightly point out that feral equids have diverse effects on ecosystems, including exerting strong herbivory pressure and dominating water sources. These effects are common to all large herbivores [e.g., (*1*–*3*)]. If we did not already know that feral equids were introduced, would we be able to tell from their actual effects? Just as elephants can dominate water sources in Africa (*4*), most animal communities show dominance hierarchies at limiting resources [e.g., (*5*)]. Preliminary evidence indicates that this is true for feral donkeys, but only where cougars are absent (*6*).

The effects of organisms depend on the ecological context of the population. Feral equids can be the primary prey of cougars (*7*). Yet predation, as well as the near-ubiquitous persecution of predators, has been overlooked in nearly all research regarding the effects of feral equids—including in the studies cited by Rubin *et al.* Much as the return of wolves to Yellowstone National Park changed the behavior and thus the effects of elk (*8*), the effects of feral equids would likely change if we protected their predators.

The effects of organisms are also scale-dependent and diverse, and they may appear contradictory. For example, beaver herbivory can deforest ecologically important riparian woodlands, yet beavers can also create ecologically important wetlands (*9*). Elephant disturbance can create

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essential habitat for small vertebrates at the patch scale but appear to suppress their diversity and abundance at broader scales (*3*, *10*). Likewise, while feral equids can have all the effects that Rubin *et al.* describe, our Report shows that they can also dig wells up to 2 m in depth—at times providing the only water available. Feral donkey disturbance also appears important to maintaining open-water habitat at desert springs; several endemic and endangered freshwater fish populations in both North America and Australia went extinct following feral donkey eradications (*11*). Describing feral equids as either ecological heroes or as invasive pests oversimplifies complexity and moralizes ecology.

Feral equids, like other introduced species, can change ecosystems in ways that alarm us. However, our desire to fight these changes can hinder our ability to study them with openness and curiosity, and in light of Earth's dynamic history (*12*).

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Academic bullying: How to be an ally

Academic bullying and harassment are all too common, and institutional reactions are often inadequate (*1*, *2*). Although reports often focus on what the targets of bullying can do to protect themselves [e.g., (*3*)], it is important to acknowledge that all members of the scientific community can and must address academic bullying. If witnesses to harassment, members of investigative committees, journal editors, other gatekeepers, and individuals at every level of the scientific community all leverage their knowledge and power to combat bullying, we can create a safer and more civil scientific environment.

Witnesses of academic bullying can report the incident to trustworthy resources at the relevant institution and funding agency. For example, in the United States, one could report unacceptable behavior to a university ombudsman or submit a bullying report to the US National Institutes of Health (NIH) (*4*). The NIH has removed more than 70 lab leaders from their grants (*5*), demonstrating that such reports by witnesses can be effective. The UK Wellcome Trust also invites such reports (*6*) and has withdrawn funding from scientists accordingly [e.g., (*7*)]. Actions by funding agencies can prevent decisions that just pass the harasser (*8*) to a different environment where they can focus on new targets.

Members of institutional academic bullying investigation committees can take steps to get unbiased and comprehensive reports of the bullying behavior. To do so, they should ask former lab members about the perpetrator, given that their feedback is likely to be more accurate, honest, and informative than that of current lab members, whose serious reservations might include fear of retaliation. Committee members can support targets during the course of investigation by putting in place a constant monitoring system to prevent retaliation against the target. They can also avoid unnecessary delays in the investigation process, while making sure not to sacrifice quality for speed. Efficient investigations show respect for the target and minimize visa issues for international students. To increase transparency, committees should make available at least one example of the outcome of a previous investigation, including discipline and punishment of the perpetrator and support for the target.

Journal editors can be open to submissions about sexual harassment, academic bullying, and imbalances in diversity (*9*), regardless of the main scope of the journal. The publication's readership, regardless of discipline, has a right to be aware of these issues. Publishing such information empowers readers to contribute to the global efforts to address these issues.

Members of gatekeeping organizations for scientific metrics (such as institution and hospital rankings) and clubs (such as national academies of sciences) can consider academic bullying in their criteria. The US National Academy of Sciences, for example, ejected members in response to validated sexual harassment allegations (*10*). In 2018, AAAS (the publisher of *Science*) established a new policy for ejecting harassers among AAAS fellows (*11*).

Individuals in all positions in the scientific community, regardless of their seniority or whether they have witnessed offensive behavior, can help address inequities, harassment, bullying, and discrimination in STEM by refusing to remain neutral about these issues. They can demand more accountability and more transparency about expectations, consequences, and reporting guidelines. They can also work to increase awareness about academic bullying and harassment by sharing studies, reports, and their own experiences.

Evidence shows that incidents of sexual harassment do not decrease simply as a result of strong policies and legal recourse (*12*). Diminishing academic harassment in science requires attention and collaborative action by all members of the scientific workforce (*8*).

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COMPETING INTERESTS

M.M. is a co-founder and director of the Academic Parity Movement (www.paritymovement.org), a nonprofit organization dedicated to addressing academic discrimination, violence, and incivility, and receives royalties/honoraria for his published books, plenary lectures, and licensed patents.

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Feral equids' varied effects on ecosystems—Response

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Meta-Analysis of Diet Composition and Potential Conflict of Wild Horses with Livestock and Wild Ungulates on Western Rangelands of North America☆

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ABSTRACT

Wild horse *(Equus ferus caballus)* management in western North America is an escalating concern for ecological integrity on these landscapes. Identifying potential diet overlap among horses, livestock, and wildlife will inform management decisions to optimize multiple interests. To understand dietary relationships, we conducted a quantitative synthesis of microhistological fecal studies for wild horse, beef cattle (*Bos* spp.), domestic sheep *(Ovis aries)*, elk *(Cervus elaphus)*, pronghorn *(Antilocapra americana)*, and mule deer *(Odocoileus hemionus)* diet composition on western rangelands of North America. Our search yielded 60 studies from 14 states, 1 Canadian province, and 2 Mexican states with 392 unique species-season samples. We summarized plant species into graminoid, forb, and browse functional groups. For wild horses, seasonal diet composition means for graminoids (77−89%), forbs (4−15%), and browse (3−10%) did not vary seasonally for any plant group ($P \leq 0.05$). Univariate analyses and the calculation of effect sizes corroborated our finding that graminoid composition explained the potential overlap of wild horses with cattle regardless of season, with sheep and elk in the spring, with sheep in the summer, and with elk in the fall and winter. Although data indicate wild horse diets are primarily composed of graminoids, several studies reported unusual, regionally specific shifts in response to winter snow that limited graminoid accessibility, leading to higher browse composition. Season, plant composition, and ungulate assemblage may all influence dietary competition between wild horses and other large ungulate sharing western North American rangelands; however, the low and nonsignificant heterogeneity values at alpha 0.01 for cattle:horse effect size comparisons suggest that cattle and horses respond to regional and seasonal variation similarly—a result not observed for other ungulate:horse comparisons. Our meta-analysis provides a robust data set for evaluations of diet composition for wild horses, livestock, and wildlife, whereas no empirical studies have assessed all species together.

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Introduction

Management of wild horses *(Equus ferus caballus)* is an ecological and sociological issue of escalating concern on western North American rangelands and other areas of the world such as eastern North American salt marshes, Africa, Asia, Argentina, Australia, and New Zealand (Turner, 1988; Linklater et al., 2004; Zalba and Cozzani, 2004; Mallon and Zhigang, 2009; Hampson et al., 2010; Odadi et al., 2011). In North America, wild equids became extinct about 10 000 years ago, and extant wild horse populations are the result of introductions of domesticated horses by Spaniards in the 1500s, repeated escapes from domestic herds, and successive commingling with present free-roaming herds (Haines, 1938; Wagner, 1983; Beever, 2003). The Wild Free-Roaming Horses and Burros Act of 1971 directs the federal management of these wild equids as part of the natural system (Public Law 92-195). More recently, the Federal Land Policy and Management Act of 1976 (Public Law 94-579) and the Public Rangelands Improvement Act of 1978 (Public Law 95-514) have further established the enforcement authority of the Bureau of Land Management (BLM) to remove excess wild horses, from both public and private lands, when populations exceed appropriate management levels to maintain the ecological integrity of western rangelands.

Since 1971, the BLM has removed 195 000 wild horses from western rangelands and offered many of these horses to the public for adoption (Garrott and Oli, 2013). However, a struggling adoption program coupled with annual population growth rates that can exceed 20% has

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relegated many horses to temporary holding facilities (Eberhardt et al., 1982; Garrott and Taylor, 1990; Garrott et al., 1991). Removal of horses alone is not anticipated to effectively meet population objectives, and more recent strategies have included fertility control (Gross, 2000; Bartholow, 2010). As of March of 2015, there were approximately 47 329 wild horses and 10 821 wild burros roaming western rangelands, more than twice the national appropriate management levels of 26 715 wild horses and burros. Furthermore, there are currently 46 298 in temporary holding corrals or long-term pastures—as many that are currently free roaming (BLM, 2015). Federal expenditures for the adoption and relocation program in FY 2013 were $76 million, with $51 million accounting for holding, gathering, and removal costs. The annual cost of managing horses in temporary holding facilities is expected to exceed $1 billion by 2030 (Garrot and Oli, 2013).

Management of the escalating wild horse population in the United States is critical because federal lands are mandated to be managed for multiple uses, including livestock grazing and providing habitat for native wildlife species (Bastian et al., 1991). Many studies have quantified diet composition of wild horses, but not all studies have compared wild horse diet composition with livestock and/or wildlife; they have only measured overlaps for a certain season of the year or for only a subset of co-occurring ungulates (Hansen, 1976; Hansen et al., 1977; Salter and Hudson, 1980; Krysl et al., 1984; Stephenson et al., 1985a). Further complicating wild horse management in some areas is the movement of horses across the largely unfenced matrix of public-private land ownership known as "checkerboard," a relic of the Union Pacific Railroad (Calef, 1952). Evidence also suggests that wild horses may disproportionately use features of the landscape, such as riparian areas and wet meadows, more than other areas, thus having negative effects on riparian function (Crane et al., 1997; Hampson et al., 2010).

Given the burgeoning wild horse population, a federal mandate to manage for multiple uses, variation in diet compositional comparisons of wild horses with other ungulate across regions and seasons, and the inevitable seasonal diet overlap between wild horses and livestock and native wildlife, we sought to quantify diet overlap of the most common large rangeland ungulate in western North America. The primary objective of our study was to identify potential dietary overlap between wild horses and livestock and wild ungulates across seasons, geographical boundaries, and limitations of prior studies. We systematically reviewed and synthesized microhistological fecal studies for wild horse, beef cattle (*Bos* spp.), domestic sheep *(Ovis aries),* elk *(Cervus elaphus),* mule deer *(Odocoileus hemionus),* and pronghorn *(Antilocapra americana)* diet composition on western rangelands of North America. To understand broad ecological interactions on western rangelands, we used univariate and meta-analytic effect size calculations to compare functional group diet composition of these six ungulate in spring, summer, fall, and winter and on an annual basis.

Materials and Methods

Literature Search Criteria

We searched the peer-refereed and gray literature (theses, dissertations, reports, and proceedings) using Google Scholar and Web of Science scholastic search engines for wild horse diet studies based on the following combinations of search terms: Animal species searched individually for "wild horse" (or "feral horse," "horse," or "equid" singularly), "cattle" (or "cow"), "sheep" (or "livestock"), "elk" (or "wapiti" or "Cervus"), "pronghorn" (or "antelope" or "Antilocapra"), "mule deer" (or "deer" or "Odocoileus"), and "ungulate" or "herbivore." Each individual animal species term was also used in combination with "diet composition" and "microhistological," and searches were conducted with and without the term "'rangeland." We also searched the bibliographies of relevant papers for other potential sources of data that might have been missed with the initial search protocol. To be included, studies must have presented percentage diet composition or availability data for graminoid, forb, and browse plant functional groups and presented data for at least one season (spring, summer, fall, winter). We only considered studies from the western United States; Alberta and British Columbia, Canada; and northern Mexico. The literature search and data extraction process were conducted between August 2014 and August 2015.

We intentionally restricted our search to studies that used the microhistological fecal analysis technique, thus removing studies that solely evaluated diets through bite counts, forage use (e.g., visual observations of feeding sites and plant selection), ingesta samples, and rumen content analysis. Restricting our study to this single technique was important because studies have shown disagreements with other techniques, particularly esophageal fistula sampling and forb estimates (McInnis, 1977; Vavra et al., 1978). Microhistological studies use a microscopic comparison of fecal plant fragments to reference specimens to determine botanical diet composition, especially for dominant plant species across western North America since the 1930s (Johnson, 1982). Microhistological procedures are advantageous because they are practical for free-roaming animals, are less intrusive than esophageal-fistulation for in vitro estimation, are less subject to observer error than forage use estimates, do not disrupt behavior of grazing animals, and are ideal for comparing multiple ungulate using the same rangeland (Crocker, 1959; Anthony and Smith, 1974; Smith and Shandruk, 1979; Mayes and Dove, 2000).

From a practical standpoint, fecal microhistological analysis has been suggested to be one of the best techniques for quantifying dietary composition of large ungulate on rangelands (Holechek et al., 1982b; Mohammad et al., 1995). However, this technique is not without its limitations including that a portion of plant fragments may remain unidentifiable, differential digestion of different fragments by species may be influenced by maturity, observer skill and bias can influence accuracy, and some studies have demonstrated disagreement between fecal analyses with the analyses of stomach contents (Holechek et al., 1982b, 1982c; Mayes and Dove, 2000). However, Mayes and Dove (2000) concluded in a detailed review that microhistological fecal analysis can be used for both ruminants and nonruminants as the limitations to the technique apply regardless of digestive strategy. Furthermore, a recent study concluded that microhistological fecal analyses can be a useful tool to determine the botanical diet composition of horses (Morrison, 2008). We did not censor cattle dietary information by animal age or class because the fecal samples from wild horses and native ungulates were not censored in such a way. Thus, we included mature cows, yearling stocker cattle, heifers, and/or calves from beef cattle studies.

Data Analyses

Our statistical analyses were designed to answer three specific questions: 1) Do wild horse, livestock, and native wildlife diets fluctuate seasonally? 2) Are seasonal mean plant functional group components for wild horse, livestock, and native wildlife diets similar? 3) What is the magnitude of the diet comparison effect on an annual basis for livestock and native wildlife that potentially share rangelands with wild horses?

We pooled plant species data from scientific studies that met our search criteria by plant functional groups to make generalizations about animal species diet composition across different plant communities. Specifically, we grouped grasses and grasslike plants inclusive of grasses (Poaceae), sedges (Cyperaceae), and rushes (Juncaceae) as graminoids; herbaceous, broad-leaved flowering plants as forbs; and woody plants and cacti (Cactaceae) as browse (including all woody deciduous and coniferous shrub and tree species). Because some studies reported total diets with plant functional group components that did not equal 100% due to the lack of reporting rare or uncommon food species, we corrected percentages as the percent of the total diet accounted for following Christianson and Creel (2007). This correction results in all diets summing to 100% but assumes that unreported portions of the diet were composed of equal proportions of graminoids, forbs, or browse.

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We first compared seasonal plant functional group means by ungulate species diet for each season using analysis of variance (ANOVA) to determine if diets were influenced by season (SAS Institute, 2011). Seasonal designations were based on either sample study definitions or the following categorization of months into seasons (winter—December, January, February; spring—March, April, May; summer—June, July, August; fall—September, October, November). If multiple months were presented, we took the average of the months to indicate the season. In separate analyses, we used graminoid, forb, and browse means as the dependent response variable and ungulate species as the fixed main effect. We then conducted an ANOVA to compare means for all pairwise comparisons between horses and each of the other five ungulate species and grouped each analysis by season. For each pairwise comparison we noted the level of significance at $P \leq 0.001$, $P \leq 0.05$, or $P > 0.05$. For each ANOVA, we used a generalized linear model assuming negative binomial distribution in PROC GENMOD (SAS Institute, 2011) to account for the non-normal distribution and nonindependence due to the unit sum constraint of diet components inherent in the plant functional group diet data (White and Bennetts, 1996; Ver Hoef and Rohlf, 2007; O'Hara and Kotze, 2010). Adjusted standard errors to correct for overdispersion were used to separate means, but we also present unadjusted standard errors and raw means.

Before calculating effect sizes, we transformed plant functional group diet data using the arcsine transformation because percentage data are non-normally distributed and asymptotic (i.e., cannot be lower than 0 or exceed 100; Cohen, 1988; Prendergast et al., 2002; Nakagawa and Cuthill, 2007). We calculated effect sizes using Hedges' d ($\bar{E}$; Gurevitch and Hedges, 1993; Osenberg et al., 1997) for potentially co-occurring ungulate annual diets and potential direct overlap with wild horses by making comparisons for each potential wild horse and livestock or wild ungulate species combination (*other*) for the three plant functional groups by:

$$Hedges' \; d = \frac{\left(\bar{x}^{horse} - \bar{x}^{other}\right)}{S} J \tag{1}$$

where $\bar{x}^{horse}$ was the mean diet for a given plant functional group for wild horses and $\bar{x}^{other}$ was the mean diet for the given plant functional group for each other livestock or wildlife species. Effect sizes used an estimate of the pooled sampling variance by calculating the pooled standard deviation (S) as

$$S = \sqrt{\frac{\left(N^{horse}-1\right)\left(S^{horse}\right)^2 + \left(N^{other}-1\right)\left(S^{other}\right)^2}{\left(N^{horse} + N^{other} - 2\right)}} \tag{2}$$

where S^{horse} was the standard deviation of each plant functional group diet mean for wild horses, S^{other} was the standard deviation of each plant functional group diet mean for each other livestock or wildlife species, N^{other} was the total number of studies for each other livestock or wildlife species, and N^{horse} was the total number of studies for wild horses. We chose Hedges' d over Hedges' g, in part, because it includes a correction term for small sample sizes (J) calculated as:

$$J = 1 - \frac{3}{4\left(N^{other} - N^{horse} - 2\right) - 1} \tag{3}$$

where N^{other} was the total number of studies for each other livestock or wildlife species and N^{horse} was the total number of studies for wild horses. To compare effect sizes and for evaluating the magnitude of the effect size, we calculated the variance (v) in the effect as:

$$v = \frac{N^{other} + N^{horse}}{\left(N^{other}\right)\left(N^{horse}\right)} + \frac{d^2}{2\left(N^{other} + N^{horse}\right)} \tag{4}$$

We calculated 95% confidence intervals for each comparison to assess significance of dietary overlap (at $P \leq 0.05$). If confidence interval bars overlapped zero, the effect size was considered insignificant and reflected potential dietary overlap with wild horses for that plant functional group during a specific season. If the confidence interval bars did not overlap zero, the effect size was significant and reflected no potential dietary overlap with wild horses for that plant functional group. All effect size analyses and calculations were computed in MetaWin v 2.0 (Rosenberg et al., 1999).

To assess variability of effect sizes we used Q statistics as a measure of heterogeneity (Hedges and Olkin, 1985). Total heterogeneity (Q_T), a weighted sum of squares similar to the calculation of the total sum of squares used in ANOVA, was calculated as an indication of effect size homogeneity (tested against a χ^2 distribution) and as an indicator of additional structure in the data (Rosenberg et al., 1999). Within-group heterogeneity (Q_W) was calculated for each categorical group (in this case for each ungulate species compared with wild horses) to determine if diet comparisons were homogenous or confounded by other external factors.

Results

Our literature search yielded 60 peer-refereed studies with 392 unique diet composition samples (combinations of animals species and season considered as cases) from 14 states (Arizona, California, Colorado, Idaho, Montana, North Dakota, New Mexico, Nevada, Oregon, South Dakota, Texas, Utah, Washington, Wyoming), Alberta, Canada, and 2 states in Mexico (Fig. 1; Table 1). On average, only two animal species were assessed per study, and none of the studies assessed all six ungulate together—further justification for our study.

We found no difference in seasonal diet composition for horses ($P \leq 0.05$). Seasonal diet means ($\pm$ SE) ranged from 77 $\pm$ 7% to 89 $\pm$ 5% for graminoids, 4 $\pm$ 1% to 15 $\pm$ 6% for forbs, and 3 $\pm$ 1% to 10 $\pm$ 4% for browse (Table 2). In all seasons, wild horse diets always included a similar proportion of graminoids as cattle and significantly more than mule deer or pronghorn (see Table 2). In the spring, wild horse diets were composed of a similar proportion of forbs as elk but less than livestock or other wildlife species (see Table 2). In summer, wild horse diets were composed of lower proportions of forbs than livestock or wildlife species. In the fall and winter, wild horse diets were composed of a similar proportion of forbs as all herbivore species except for pronghorn in winter, which included a significantly higher proportion of forbs in their diets as compared with wild horses. Wild horse diets were composed of a lower proportion of browse than livestock or wildlife species in the spring, a similar proportion of browse as cattle and sheep in the summer and winter, a similar proportion to cattle in the fall, and always a smaller proportion than elk, mule deer, or pronghorn regardless of season (see Table 2).

When we analyzed the variance of diets for each herbivore species individually, there were no differences in the seasonality of plant functional group diet composition for wild horses, mule deer, pronghorn, or sheep. However, cattle diets were composed of a higher proportion of graminoids in the summer (79 $\pm$ 3%) than in the winter (64 $\pm$ 6%) ($P = 0.046$) but there were no seasonal differences for forbs or browse. Furthermore, elk diets included three times more forbs in the summer (31 $\pm$ 6%) than in the winter (9 $\pm$ 2%) ($P = 0.009$) (see Table 2).

Effect sizes across all comparisons ranged from −5.1 to +2.6 depending on the animal species and plant functional group comparison to wild horses (Fig. 2). Total heterogeneity was high and significant ($Q_T = 604.1$, df = 59, $P < 0.001$), rejecting the null hypothesis that all

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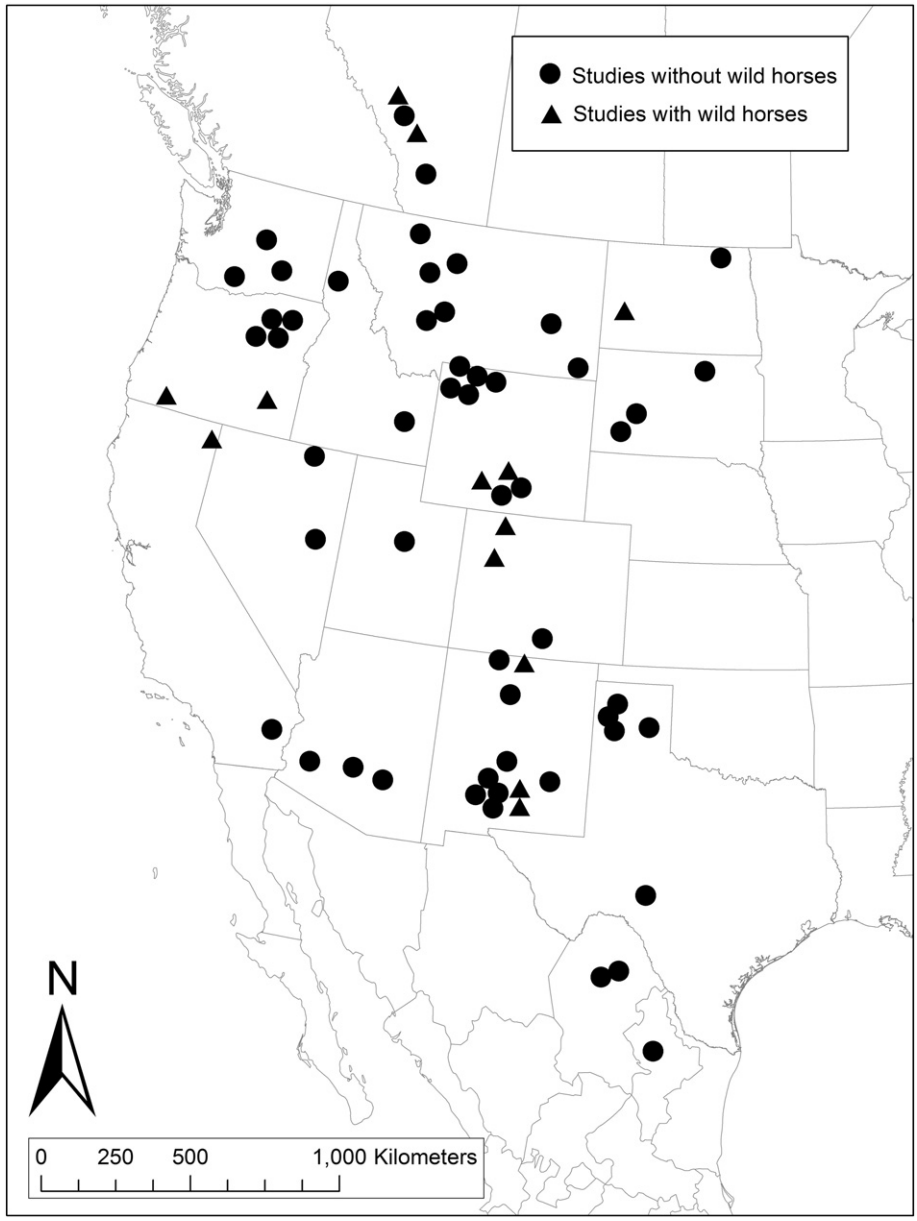

Figure 1. Study locations assessing wild horse ($n = 12$) or domestic livestock or native wildlife ($n = 100$) diet composition with microhistological analyses on rangelands of western North America. Each symbol represents a single study with the exception of the two triangles in Wyoming, which denote two different locations within a single study from Krysl et al. (1984).

diet overlaps between horses and other ungulates were equal and further justifying the calculation of individual effect sizes for each species relative to wild horses (i.e., a categorical meta-analysis). When wild horses were compared with cattle, effect sizes overlapped zero for all plant functional groups (graminoid $\overline{\overline{E}} = -0.63$; 95% CI: –1.26 to 0.002; forb $\overline{\overline{E}} = 0.42$; 95% CI: –0.21 to 1.05; browse $\overline{\overline{E}} = 0.28$; 95% CI: –0.34 to 0.91) (see Fig. 2). The weighted mean effect size for cows ($\overline{\overline{E}} = 0.03$; 95% CI: –0.22 to 0.28) indicated diet overlap between cattle and horses for all plant functional group types and similar diet composition on an annual basis. Heterogeneity for cattle:horse comparisons was the lowest for all ungulate:horse comparisons and the only one that was nonsignificant at alpha = 0.01 ($Q_W = 21.4$, df = 11, $P = 0.03$), suggesting that all diet comparisons between cattle and horses were similar and likely did not vary by season or location.

When wild horses were compared with domestic sheep, effect sizes overlapped zero for browse ($\overline{\overline{E}} = 0.68$; 95% CI: –0.09 to 1.45) but not for graminoids ($\overline{\overline{E}} = -1.33$; 95% CI: –2.16 to –0.49) or forbs ($\overline{\overline{E}} = 0.87$; 95% CI: 0.09–1.65; see Fig. 2). Horse diet composition was equal for browse but included more graminoids and fewer forbs than sheep (see Fig. 2). The weighted mean effect size for sheep ($\overline{\overline{E}} = 0.14$; 95% CI: –0.18 to 0.45) overlapped zero, indicating overlap between domestic sheep and horses for diet composition on an annual basis. Heterogeneity for sheep:horse comparisons was low but significant ($Q_W = 49.5$, df = 11, $P < 0.001$), suggesting that not all diet comparisons between wild horses and sheep were similar and varied by season or region.

When wild horses were compared with elk, effect sizes overlapped zero for forbs ($\overline{\overline{E}} = 0.0.44$; 95% CI: –0.22 to 1.10) but not for graminoids ($\overline{\overline{E}} = -1.46$; 95% CI: –2.16 to –0.75) or browse ($\overline{\overline{E}} = 1.03$; 95% CI: 0.36–1.70; see Fig. 2). The effect size was negative for graminoids, indicating that wild horses ate more grass than elk but the effect size was positive for browse, indicating that wild horses ate less browse than elk. The weighted mean effect size for elk ($\overline{\overline{E}} = 0.06$; 95% CI: –0.21 to 0.33) indicated diet overlap between elk and horses for diet composition in general on an annual basis, and the primary function of that overlap appeared to be for forbs. Heterogeneity for elk:horse comparisons was moderate and significant ($Q_W = 86.0$, df = 11, $P < 0.001$),

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Table 1
Summary of studies with suitable diet composition data using microhistological fecal analyses of wild horses, livestock, and wildlife on western rangelands of North America. Please see Literature Cited for full citations

Author and yr	Location	Data type	Horse	Cattle	Sheep	Elk	Prong-horn	Mule deer
Morgantini and Hudson, 1985	Alberta	winter	–	–	–	x	–	–
Salter and Hudson, 1979	Alberta	all seasons	x	–	–	–	–	–
Salter and Hudson, 1980	Alberta	winter (horse/elk), summer (horse/cattle)	x	x	–	x	–	–
Telfer, 1994	Alberta	winter	–	x	–	x	–	x
Krausman et al., 1997	AZ	all seasons	–	–	–	–	–	x
Hanley, 1982	CA/NV	all seasons	x	x	x	–	x	x
Marshal et al., 2004	CA	all seasons	–	–	–	–	–	x
Hansen and Reid, 1975	CO	all seasons (mule deer/elk), summer/fall (cattle)	–	x	–	x	–	x
Hansen et al., 1977	CO	summer	x	x	–	–	–	x
Hubbard and Hansen, 1976	CO	summer	x	x	–	–	–	x
Johnson, 1979	ID	summer (cattle/sheep/pronghorn), winter (pronghorn)	–	x	x	–	x	–
Mitchell and Rodgers, 1985	ID	spring, summer, fall	–	x	–	–	–	–
Mellado et al., 2005a	Coahuila	all seasons	–	–	x	–	–	–
Mellado et al., 2005b	Coahuila	all seasons	–	x	–	–	–	–
Ramirez et al., 1996	Nuevo Leon	all seasons	–	–	–	–	–	x
Alexander et al., 1983	MT	summer	–	–	x	–	–	–
Canfield, 1984	MT	winter	–	–	–	x	–	–
Daneke, 1980	MT	all seasons	–	–	–	x	–	–
Frisina et al., 2008	MT	winter	–	–	–	–	–	x
Grings et al., 2001	MT	spring, summer, fall	–	x	–	–	–	–
Jenkins and Wright, 1987	MT	winter	–	–	–	x	–	–
Kasworm et al., 1984	MT	winter and spring (mule deer/elk), summer (cattle)	–	x	–	x	–	x
Beasom et al., 1982	NM	fall, winter	–	–	x	–	x	–
Hamadeh et al., 1990	NM	spring, fall, winter	–	–	x	–	–	–
Hansen, 1976	NM	all seasons	x	–	–	–	–	–
Hulet et al., 1992	NM	summer	–	x	x	–	–	–
Mofareh et al., 1997	NM	all seasons	–	x	–	–	–	–
Mohammad et al., 1996	NM	all seasons	–	x	–	–	–	–
Rosiere et al., 1975	NM	all seasons	–	x	–	–	–	–
Sandoval et al., 2005	NM	all seasons	–	–	–	x	–	x
Smith et al., 1998	NM	all seasons	x	–	–	–	x	–
Stephenson et al., 1985a	NM	winter	x	–	–	x	x	x
Stephenson et al., 1985b	NM	spring, winter	–	x	x	–	x	–
Osborn et al., 1997	ND	fall, winter	–	–		x	–	–
Sullivan, 1988	ND	all seasons	x	–	–	x	–	x
Beck and Peek, 2005	NV	spring and summer (elk), summer (mule deer/ cattle/sheep)	–	x	x	x	–	x
Kolada, 2011	NV	summer	–	x	–	x	–	x
Clark et al., 2013	OR	summer	–	x	–	–	–	–
Darambayar et al., 2013	OR	summer	–	x	–	–	–	–
Holechek et al., 1982a	OR	spring, summer, fall	–	x	–	–	–	–
Hosten et al., 2007	OR	all seasons	x	x	–	x	–	x
McInnis and Vavra, 1987	OR	all seasons	x	x	–	–	x	–
Stewart et al., 2003	OR	summer	–	x	–	x	–	x
Plumb and Dodd, 1993	SD	summer and fall	–	x	–	–	–	–
Jacques et al., 2006	SD	all seasons	–	–	–	–	x	–
Uresk ,1984	SD	spring, summer, fall	–	x	–	–	–	–
Koerth et al., 1984	TX	all seasons	–	–	–	–	x	–
Sowell et al., 1985	TX	all seasons	–	–	–	–	–	x
Warren et al., 1984	TX	all seasons	–	–	x	–	–	–
Mower and Smith, 1989	UT	winter	–	–	–	x	–	x
Jenkins and Starkey, 1993	WA	spring, fall, winter	–	–	–	x	–	–
McArthur, 1977	WA	all seasons	–	–	–	x	–	–
McCorquodale, 1993	WA	spring, fall, winter	–	–	–	x	–	–
Compton, 1974	WY	all seasons	–	–	–	x	–	x
Delgiudice et al., 2001	WY	winter	–	–	–	x	–	–
Krysl et al., 1984	WY	summer	x	x	–	–	–	–
Ngugi et al., 1992	WY	all seasons	–	x	x	x	x	x
Singer and Norland, 1994	WY	winter	–	–	–	x	x	x
Torstenson et al., 2006	WY	all seasons	–	x	–	x	–	x
Vales and Peek, 1993	WY	all seasons	–	–	–	x	–	–
		TOTAL STUDIES	**12**	**29**	**11**	**26**	**11**	**23**

suggesting that not all diet comparisons between wild horses and elk were similar and varied by season or region. Furthermore, heterogeneity for elk:horse comparisons, specifically for forbs, was the highest and significant ($Q_W = 86.0$, df = 11, $P < 0.05$), the only time this occurred for any of the specific plant functional group comparisons to wild horses for any of the other ungulate. This indicates that elk respond to environmental factors that dictate forb abundance differently than other ungulate species.

When wild horses were compared with mule deer, effect sizes did not overlap zero for any plant functional group; graminoids ($\overline{\overline{E}} = -5.08$; 95% CI: –6.31 to –3.85), forbs ($\overline{\overline{E}} = 0.71$; 95% CI: 0.07–1.36), browse ($\overline{\overline{E}} = 2.62$; 95% CI: 1.78–3.45) (see Fig. 2). The relative magnitude between elk and mule deer effects compared with wild horses was an order of magnitude greater for mule deer for graminoids and browse (see Fig. 2). The weighted mean effect size for mule deer ($\overline{\overline{E}} = 0.47$; 95% CI: 0.14–0.80) indicated no overlap between mule deer and

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Table 2
Pair-wise mean comparisons (±1 standard error; n = number of cases) for plant functional group diets by livestock and wild ungulates compared with wild horses in western rangelands of North America. Values in parentheses after standard errors are adjusted standard errors calculated in a generalized linear model assuming a negative binomial distribution to correct for overdispersion and to separate means. Mean comparisons based on least-squares output from analysis of variance with statistical differences between herbivore species noted within season and plant functional groups

Season Herbivore species	n	% Graminoid	% Forb	% Browse
Spring				
Horse	7	89 ± 5 (20)	8 ± 4 (3)	3 ± 1 (1)
Cattle	26	70 ± 4 (8)[1]	17 ± 4 (3)[2]	13 ± 3 (2)[3]
Domestic sheep	8	56 ± 8 (12)[1]	29 ± 9 (10)[2]	15 ± 4 (4)[2]
Elk	22	54 ± 6 (7)[1]	15 ± 3 (3)[1]	31 ± 5 (5)[3]
Mule deer	18	8 ± 2 (1)[3]	22 ± 4 (5)[2]	70 ± 4 (13)[3]
Pronghorn	7	9 ± 3 (2)[3]	32 ± 9 (12)[2]	59 ± 11 (17)[2]
Summer				
Horse	12	88 ± 4 (18)	4 ± 1 (1)	8 ± 3 (2)
Cattle	48	79 ± 3 (8)[1]	13 ± 3 (2)[2]	7 ± 1 (1)[1]
Domestic sheep	13	66 ± 6 (13)[1]	21 ± 5 (7)[2]	13 ± 4 (4)[1]
Elk	11	41 ± 7 (8)[2]	31 ± 6 (10)[2]	28 ± 6 (8)[2]
Mule deer	25	9 ± 3 (1)[3]	24 ± 5 (6)[2]	67 ± 6 (14)[3]
Pronghorn	8	10 ± 4 (3)[3]	46 ± 9 (19)[2]	44 ± 9 (16)[2]
Fall				
Horse	7	84 ± 8 (13)	8 ± 4 (4)	8 ± 4 (3)
Cattle	25	78 ± 4 (7)[1]	9 ± 3 (2)[1]	13 ± 3 (2)[1]
Domestic sheep	7	47 ± 8 (8)[2]	27 ± 12 (12)[1]	25 ± 8 (8)[2]
Elk	14	54 ± 6 (6)[1]	18 ± 4 (5)[1]	28 ± 6 (6)[2]
Mule deer	16	4 ± 1 (1)[3]	15 ± 4 (5)[1]	81 ± 5 (16)[3]
Pronghorn	6	8 ± 3 (2)[3]	35 ± 11 (17)[1]	57 ± 12 (19)[2]
Winter				
Horse	11	77 ± 7 (17)	15 ± 6 (6)	10 ± 4 (2)
Cattle	12	64 ± 6 (13)[1]	21 ± 4 (6)[1]	15 ± 4 (3)[1]
Domestic sheep	8	57 ± 9 (15)[1]	25 ± 9 (9)[1]	18 ± 5 (4)[1]
Elk	31	52 ± 5 (7)[1]	9 ± 2 (2)[1]	39 ± 5 (5)[3]
Mule deer	24	6 ± 2 (1)[3]	20 ± 3 (4)[1]	74 ± 4 (10)[3]
Pronghorn	12	13 ± 4 (3)[2]	34 ± 9 (1) 0[2]	53 ± 9 (10)[3]

[1] NS (nonsignificant) = $P > 0.05$.
[2] $P \leq 0.05$.
[3] $P \leq 0.001$.

horses for diet composition on an annual basis. Heterogeneity for mule deer:horse comparisons was the highest for all animal:horse comparisons and significant ($Q_W = 284.9$, df = 11, $P < 0.001$), suggesting that not all diet comparisons between wild horses and mule deer were similar and varied by season or region.

None of the plant functional group effect sizes overlapped zero for the pronghorn comparisons (graminoids $\overline{\overline{E}} = -3.8$; 95% CI: −5.12 to −2.52; forbs $\overline{\overline{E}} = 1.33$; 95% CI: 0.48– 2.19; browse $\overline{\overline{E}} = 1.82$; 95% CI: 0.91–2.73) (see Fig. 2). The weighted mean effect size for pronghorn ($\overline{\overline{E}} = 0.55$; 95% CI: 0.16–0.94) indicated no overlap between pronghorn and horses for diet composition in general on an annual basis, similar to the pattern for elk and mule deer. Heterogeneity for pronghorn:horse comparisons was high and significant ($Q_W = 155.4$, df = 11, $P < 0.001$), suggesting that not all diet comparisons between wild horses and pronghorn were similar and varied by season or region.

Discussion

We compiled diet composition data to develop broad comparisons of wild horses with domestic and wild ungulates that share western North American rangelands. Results from our statistical analyses considered season and study location and provide strong support that wild horse and cattle diets overlapped in plant functional group composition, primarily for graminoids (Smith, 1986). The low and nonsignificant Q_W heterogeneity values at alpha = 0.01 for cattle:horse effect size comparisons suggest cattle and horses were similar in diets and likely responded to regional and seasonal variation similarly, a result that was not the case for other comparisons of livestock and native wild ungulates to wild horses. Rather, diet overlap between wild horses

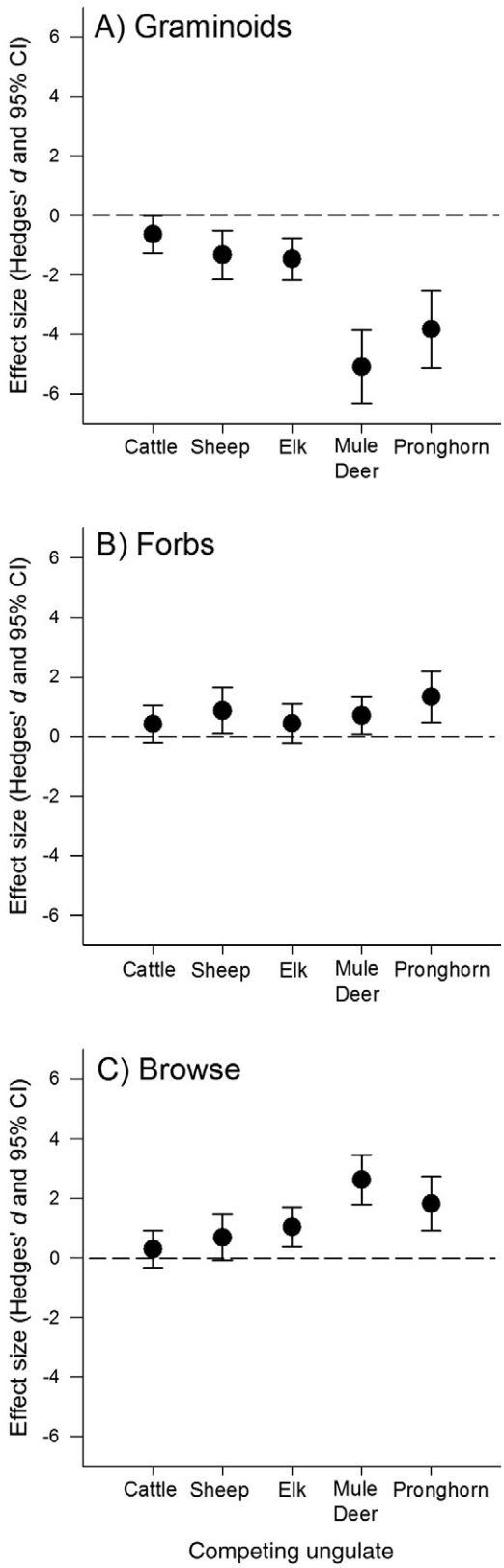

Figure 2. Effect sizes using Hedges' d and 95% confidence intervals for potentially co-occurring ungulate annual diets and potential direct overlap with wild horses for **A,** graminoids, **B,** forbs, and **C,** browse. If confidence interval bars overlap zero, the effect size is insignificant, reflecting potential diet overlap with wild horses for that plant functional group. If the confidence interval bars do not overlap zero, the effect size is significant, reflecting no potential diet overlap with wild horses for that plant functional group.

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and domestic sheep and elk was more related to similarities in seasonal diet composition for specific plant functional groups. The effect size pattern when comparing wild horses with all native wild ungulates was similar for all species with negative effect sizes for graminoids and positive effect sizes for browse and forbs, indicating that wild horses ate more grass but less browse and forbs than elk, pronghorn, or mule deer. Furthermore, our results are corroborated by studies that we did not consider because they lacked specific data that met our search criteria, but that also report substantial diet overlap between wild horses and cattle (e.g., Olsen and Hansen, 1977; Crane et al., 1997).

Although we employed systematic search criteria to include microhistological studies from western North America, our results have limitations inherent in the assumptions that all species within a plant functional group were similar in quantity and quality, that all regions had similar plant functional groups available to ungulate, and that all seasonal designations represented similar phenological expression of various plant functional groups and plant species comprising those groups. Despite these assumptions, we compiled data in a robust and interpretable manner, and we also demonstrated that the variation in descriptions of wild horse diet composition were influenced more by regionally specific weather or plant species availability than general seasonal shifts. The application of meta-analytic techniques and effect sizes to data from existing studies is a well-accepted tool used to provide information to answer important questions for organisms with different traits that occur across ecological gradients by identifying fundamental processes while minimizing extraneous factors (Osenberg et al., 1997, 1999).

Wild horses are not necessarily ecologically comparable with cattle or other ungulates due to different mouth structures (incisor presence/absence and prehensile ability of the lips) and digestive system (rumen fermentation or foregut in true ruminants versus cecal fermentation or hindgut in horses; Beever, 2003). This different digestive strategy places a greater time-energy constraint and limits the use of low-quality forage by horses (Hanley and Hanley, 1982). These anatomical and physical adaptations in horses results in a high-intake foraging strategy of 20−65% greater consumption by volume of plant herbage than a domestic cow of equivalent size (Hanley, 1982; Menard et al., 2002). Consequently, horses consume small, frequent meals with daily estimates of time spent grazing ranging from 10–17 hours (Fleurance et al., 2001). A review of comparative anatomy suggests that digestive tracts in true ruminants comprise a greater proportion of total body weight at 40% compared with 15% in horses, and that horses only achieve 70% efficiency in comparison (i.e., a tradeoff; Janis, 1976). These physiological differences result in a more rapid passage time in horses compared with cattle−14 to 50 h for horses versus 57 to 90 h for cattle or, more approximately, 1.6× greater mean retention time for ruminants than hindgut fermenters (Janis, 1976; Illius and Gordon, 1992; Huhtanen and Kukkonen, 1995; Van Weyenberg et al., 2006). However, our results indicate that these differences may not result in differences between wild horses and cattle in the high graminoid composition of their diets relative to forbs or browse.

Although our findings indicate mean browse composition of wild horse diets did not exceed 10%, several studies have reported unusually high composition of browse by wild horses with seasonal variation. In northern New Mexico, Stephenson et al. (1985a) reported 43% browse composition in wild horse winter diets, whereas Smith et al. (1998) reported 2% browse composition from January to March (cool/dry period) and 28% browse composition from July to November (warm/wet period) in southern New Mexico. The increase of browse composition of horse diets in northern New Mexico in winter was attributed to the low volatile oil content of common winter fat *(Krascheninnikovia lanata)* and fourwing saltbush *(Atriplex canescens)*, as well as the inaccessibility of graminoids due to snow cover for half of the winter (Stephenson et al., 1985a). Krysl et al. (1984) reported a similar increase of browse composition due to winter conditions for both wild horses and cattle in Wyoming, ranging from 33−39% browse composition. However, in the winter wild horses consumed equal amounts of the two preferred winter browse, common winter fat and gray horsebrush *(Tetradymia canescens)*, whereas cattle consumed ~ 1.5× more common winter fat than gray horsebrush, and in the summer neither ungulate diet was composed of more than 2% gray horsebrush (Krysl et al., 1984). However, in southern New Mexico the increase of browse composition in the late summer/early fall was attributed to the use of mesquite beans (*Prosopis* spp.) by wild horses, a legume that contains 9−14% protein and serves as an important part of ruminant diets in arid and semiarid regions of the southwest (Fagg and Steward, 1994; Smith et al., 1998). Thus, horses are strong grazers of graminoids but may employ regionally specific shifts in response to winter stress and limited graminoid accessibility or use of leguminous browse resulting in greater browse composition in diets. Furthermore, severe winters may increase selection by all rangeland ungulates for sites with reduced wind and snow, thus increasing potential for diet overlap (Miller, 1983). These types of unusual scenarios lead to overdispersion of horse diet estimates and large adjustments of standard errors under the generalized linear model and negative binomial distribution assumptions (see Table 2).

Dietary overlap by plant functional groups is just one aspect of overlap among wild horses, livestock, and wild ungulates. A less understood aspect of overlap that influences foraging and diet composition is the spatial competition for optimum habitat and site selection. For example, Salter and Hudson (1980) reported 66% overlap in summer diets between wild horses and cattle but low contemporaneous spatial overlap in western Alberta. However, others have reported that wild horse occupancy of sites may physically displace other ungulates (Miller, 1983). Several studies have also demonstrated that the availability of water affects horse distribution, and when water becomes scarce, interspecific aggression occurs and wild horses may force both cattle and pronghorn off watering sites (Miller, 1983).

The temporal effects of wild horse grazing year-round on federal allotments before turning livestock out on allotments in the spring, as well as the potential grazing effects that may have occurred before livestock grazing is initiated, are areas that need additional research. This issue is an ongoing concern for public-lands ranchers (personal communication). Producers and managers should note that wild horses are not ecologically synonymous with livestock or native wild ungulates due to physiological and morphological differences (Beever, 2003), but our results demonstrate that they may target graminoid components of the plant community before cattle have been turned out (Beever et al., 2008). The effects of horse social behavior, interspecific and intraspecific aggression in site selection and dominance, and how site occupancy influences site selection by wildlife species are also not well understood. Given the burgeoning wild horse population and recent negative population trends of mule deer and pronghorn (Pojar and Bowden, 2004; Ellenberger and Byrne, 2011), this is an area that needs additional research. Finally, the importance of water to the distribution of all rangeland ungulate in the context of escalating warming and drought cycles, trends that may be especially acute in western North America, may increase wild horse overlaps with livestock and native wildlife (Beever and Brussard, 2000; Meehl and Tebaldi, 2004; Westerling et al., 2006; Burke and Brown, 2008).

Management Implications

Our results suggest that potential diet overlap between wild horses and co-occurring rangeland ungulates is greatest for cattle, domestic sheep, and elk—a concerning result relative to managing allotments for multiple use. Finally, adjustments in stocking rates should be considered in areas dually grazed by wild horses and livestock or wild ungulates because wild horses appear to prefer graminoids and the hindgut fermentation physiology and relative digestive inefficiency of horses compared with other ungulates increases intake of herbage relative to body mass in wild horses (Hanley, 1982; Menard et al., 2002). Furthermore, the potential negative effects of concentrated horse use in areas

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composed of perennial grasses and sagebrush should be considered in the management of sage-grouse (*Centrocercus spp.*) (Beever and Aldridge, 2011; Davies et al., 2014). This meta-analysis provides a robust data set for modeling diet composition of wild horses, cattle, domestic sheep, elk, mule deer, and pronghorn, whereas no empirical studies have assessed all species together.

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4

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Habitat and Diet of Equids

The subgenus *Equus* (order Perissodactyla; Groves 1974) appeared ~4.5 million years ago in North America (Orlando *et al.* 2013) and successfully colonized North America, Asia, Europe, and Africa (see chap. 8). Equids were once the most abundant medium-sized grazing animals of the world's grasslands and steppes (Duncan 1992). During the Late Pleistocene and Holocene, all North American equids went extinct for reasons that are not well understood (Berger 1986); however, the evolution of ruminant digestion is thought to have led to competition and reduction in diversity of perissodactyls coincident with the radiation of artiodactyls (Van Soest 1994). Modern equid species inhabit, and have adapted to, a wide range of habitats. From arid hot and cold deserts to temperate forests, and from the hottest, driest landscapes to subzero cold temperatures, they survive and thrive in some of the harshest terrestrial habitats on earth.

Today's wild and feral equids are predominantly grazers. Their digestive system is specialized to consume large quantities of low-quality foliage as compared to ruminant mammals. They can extract nutrients out of most types of vegetation, even consuming it twice in the practice of coprophagy, or the consumption of feces (fig. 4.1). Equids have an enlarged colon and cecum to accommodate their cellulose-rich diet, allowing the indigestible material to remain in contact with a commensal microbial population for digestion (called "cecal digesters," or "hind-gut fermenters"; Van Soest 1994). The jaw, high-crowned (hypsodont) teeth, and flexible lips of equids are well adapted for processing tough (cellulose and silica-rich) plant material. Being fairly nonselective (roughage) feeders on grasses that are low in protein:fiber ratios, these nonruminants sustain faster rates of food passage and higher intake rates than ruminants. Ruminants of equivalent sizes that feed on the same low-quality diet as equids are at a disadvantage compared with cecal digesters because lignified food requires energy for ruminating and time for processing (Van Soest 1994).

In this chapter, we present information from studies of equids and their habitat use across various habitat types. We provide a synthesis of the scientific literature on equid habitat selection, home range and movements, water needs, and diet.

Fig. 4.1 A feral horse in the Pryor Mountains, Montana, USA, consumes feces as a food supplement during winter. Coprophagy can help equids gain more nutrients per effort when forage is minimal. Dung of feral horses in the Namib Desert, Namibia, for example, contains almost three times more fat (1.99%) than the area's dry grass (*Stipagrostis obtuse*, 0.7%) and almost twice as much protein (6.1% vs. 3.1%) (Greyling *et al.* 2007). Photo by Jason I. Ransom

Habitat Selection

Resource selection in arid-adapted equids is primarily influenced by forage availability and also quality (Henley *et al.* 2007; Sundaresan *et al.* 2007*b*). The best predictor of equid habitat use is abundance of forage (King and Gurnell 2005; St-Louis and Côté 2014). Przewalski's horses (*Equus ferus przewalskii*) show a preference for the most productive communities in their habitats in Mongolia, which are riparian communities and areas of high biomass production in the Great Gobi B Strictly Protected Area (SPA) and lowland vegetation in Hustai National Park (King and Gurnell 2005; Kaczensky *et al.* 2008). Plant community is the strongest predictor for resource selection for Przewalski's horses in the Gobi, with slope, biomass, distance to water, and elevation having only limited predictive ability (Kaczensky *et al.* 2008). In free-ranging Przewalski's horses in Kalamaili, China, plant community, forage abundance, slope, and soil types determine species distributions in spring, summer, and fall (in winter they are in an enclosure; Chen 2008). Liu (2012) reported that Przewalski's horses in Kalamaili prefer lower, gentle slopes, facing east or west, with 10–30% vegetation cover and short distance to water. Daily use of habitat for Przewalski's horses consists of movements between preferred grazing areas, watering areas, and refuges from weather or flies (Bahloul *et al.* 2001; King and Gurnell 2005; Kaczensky *et al.* 2008).

Kiangs (*E. kiang*) select for forage abundance, but more so in summer when plants are greener (St-Louis and Côté 2014). Kiangs inhabit high-altitude rangelands, specifically the steppes of the Tibetan Plateau, where harsh climatic conditions prevail and overall plant production is low (Schaller 1998). They occur from 3,500 to 6,000 m, but at slopes <15° (Shah 1994, 1996; Sharma *et al.* 2004; St-Louis and Côté 2009). Kiangs in Pakistan are found along river and stream basins in patches of *Myricaria*, willow, and *Hippophe* (Rasool 1992), and occur in largest numbers in xeric south-facing basins (Harris and Miller 1995). In India, kiangs are commonly found around high-altitude lakes and along the Indus and Hanley Rivers (Shah 1996). They are nonmigratory but have large local movements (Schaller 1998).

Grevy's zebra (*E. grevyi*) select areas with higher Normalized Difference Vegetation Index values (NDVI, otherwise known as "greenness") and highest biomass of food, regardless of quality, as they need to consume more bulk compared to ruminants (Williams 1998, 2002; Hostens 2009). Grevy's zebra are found in Kenya and Ethiopia in stony semideserts (Mungall 1979; Churcher 1993; Williams 2002), and like plains zebra (*E. quagga*) tend to avoid forest, instead preferring habitat with open shrub cover and herbaceous vegetation (Williams 2002; Hostens 2009; Mwazo 2012).

Plains zebra are found in open savanna with an abundance of grass and the presence of some trees or open woodland (Hirst 1975; Mungall 1979; Mwangi and Western 1998; Traill and Bigalke 2006; Averbeck *et al.* 2009; Thaker *et al.* 2010; Arsenault and Owen-Smith 2011; Kleynhans *et al.* 2011; Macandza *et al.* 2012), and they avoid habitat where they have an increased risk of predation, especially at night (Fischhoff *et al.* 2007; Valeix *et al.* 2009; Burkepile *et al.* 2013). Plains zebra are found in midproductive grasslands in areas where there is the highest green standing crop (McNaughton 1985), selecting areas of the highest grass biomass regardless of quality (Brooks 2005; Groom and Harris 2010).

Research on plains zebra habitat use has largely focused on their role within the herbivore community (Arsenault and Owen-Smith 2011), examining competition and facilitation among grazers resulting from their high overlap in habitat use (Dekker 1997). Zebra mitigate competition with ruminants through their bulk diet and tend to consume a greater proportion of low-palatability species in the dry season (McNaughton 1985). Zebra have the highest overlap in diet and habitat use with species of a similar body weight early in the wet season, and least during the height of the wet season (Shem *et al.* 2013). Plains zebra are most often associated with wildebeest (*Connochaetes taurinus*), a species of similar size (Hirst 1975; McNaughton 1985; de Boer and Prins 1990; Kgathi and Kalikawe 1993; Dekker *et al.* 1996; Groom and Harris 2010; Hopcraft *et al.* 2010; Kleynhans *et al.* 2011). They occur together more often than would be expected by chance (de Boer and Prins 1990), particularly during the wet season (McNaughton 1985; Voeten and Prins 1999; Kleynhans *et al.* 2011). But they avoid competition by using different movement cues for migration (Hopcraft *et al.* 2010), spatial and temporal separation within a habitat (Hirst 1975; McNaughton 1985), and use of a different sward height (de Boer and Prins 1990).

Plains zebra track resource abundance across seasons (Young *et al.* 2005). At a large scale, zebra follow the long grass that grows after the rains (Bell 1971). At a finer scale, they move to maximize intake of food of sufficient quality while minimizing time spent in habitats where they may encounter predators (Hopcraft *et al.* 2010). Not all zebra herds migrate (Stelfox *et al.* 1986; Georgiadis *et al.* 2003), however, and different herds respond differently to changing conditions (Owen-Smith 2013). In the Okavango Delta of Botswana, only 55% of zebra make the 588-km round trip migration (Bartlam-Brooks *et al.* 2011). Migration allows zebra to optimize their nutrition by moving to prime grasslands during the wet season (Bartlam-Brooks *et al.* 2013), selecting higher-quality resources rather than absolute abundance of grass (Bartlam-Brooks *et al.* 2011).

Mountain zebra (*E. zebra*) are adapted to mountainous habitat in southern Africa (Joubert 1973), with the two subspecies (Cape mountain zebra and Hartmann's mountain zebra) historically being separated by a low plain with less suitable or marginal habitat (Novellie *et al.* 2002). Mountain zebra are found in grassland vegetation communities, or in shrub communities that contain a high biomass of grass (Winkler and Owen-Smith 1995). Mountain zebra select habitat types with >50% grass cover, with the best habitat found in low-lying areas that have nutrient-rich soils and a high abundance of palatable grasses, and they prefer burned over unburned veld (Watson *et al.* 2005, 2011; Watson and Chadwick 2007; Kraaij and Novellie 2010).

Asiatic wild ass (*E. hemionus*) in India (referred to as khur) inhabit the Little Rann of Kutch, Gujarat, India. The habitat is a saline desert with extremely sparse vegetation cover and very specific flora. Monsoon rains from July to September drop an average of 517.8 mm, transforming the habitat into grassy meadows with saline pools (Smielowski and Raval 1988). Asiatic wild ass in the southwest part of the Mongolian Gobi (referred to as khulan) do not appear to have a strong preference for any particular plant species but use plant communities almost relative to their availability (Kaczensky *et al.* 2008). Regression analyses of khulan abundance as a function of slope, elevation, distance to water, vegetation type, and NDVI did not reveal evidence that khulan select habitat on the basis of these factors (Ransom *et al.* 2012). Habitat use analysis suggests that khulan are well adapted to cope with unpredictable resource distribution, covering long distances in search of water and pasture (Kaczensky *et al.* 2008), and they track patches of green-up, similar to zebras and other large ungulates in semiarid and arid ecosystems of Africa and Asia. When snow cover is higher (20–550 cm), khulan in Mongolia use lower-elevation mountain slopes, and when snow partly melts, they move to the plains (Feh *et al.* 2001).

African wild ass (*E. africanus*) are found in arid and semiarid bushland and grassland (Mungall 1979; Moehlman *et al.* 2008) and are thought to be predominantly grazers. They often cover large distances to fulfill resource requirements (Mungall 1979; Moehlman 2002) and are arid adapted, moderating their temperature through efficient water use (Moehlman 2002; Grinder *et al.* 2006) and use of terrain (Mungall 1979).

By far the most numerous and widespread present-day equids are feral horses (*E. caballus*) and feral asses (*E. asinus*), also called "feral burros." Their distribution is tied to, and has been facilitated by, the spread of human culture (see chap. 8). Today, feral equids are found in a diverse range of habitats and environmental conditions in North America, South America, Europe, Asia, Africa, New Zealand, and Australia. The term "feral" describes equids that escaped or were released by humans and reverted to a wild condition. Feral equids are well adapted to harsh climatic and habitat conditions and thus are coincidently often found where human density is low.

The availability of preferred forage for feral horses is the primary determinant of habitat use in all seasons

(Salter and Hudson 1979). In Wyoming, USA, feral horses select for streamsides, bogs, or meadows that have high standing crop, and mountain sagebrush, whereas lowland sagebrush is avoided and no selection is shown for grassland or coniferous forest (Crane *et al.* 1997). Feral horses in northern sagebrush steppe exhibit no preference for a particular plant community, instead making use of the most prevalent habitat type (Ganskopp and Vavra 1986). Other studies also indicate that feral horses utilize certain meadow types on a yearlong basis in proportion to their availability (Salter 1978; Berger 1986; Crane *et al.* 1997). Likewise, feral horses in Alberta, Canada, select for habitats covering 14% of a study area while avoiding 42% of habitats, and the largest percentage of areas (44%) are used in proportion to their availability (Girard *et al.* 2013).

Like equids elsewhere, feral horses adapt seasonally to utilize what forage is available, accessible, and of suitable quality within the limits of their range (Girard *et al.* 2013). In a coniferous forest ecosystem, feral horses select for lowland grasslands across all seasons, with shrublands increasingly selected in spring and summer (Girard *et al.* 2013). During fall, they select grasslands, but at a lower level than summer, and avoid conifer forests. In Alberta winters, feral horses select for conifer patches because of warmer ambient temperatures and available forage in early winter. Shrublands are selected in spring because feral horses can access these areas as snow melts, with taller shrubs being some of the only forage available after winter and prior to spring green-up (Girard *et al.* 2013). In Wyoming, feral horses select high elevations, areas close to water, flatter slopes, south-facing aspects, low forest canopies, and open nonforested vegetation types in summer, whereas in winter they select flatter slopes, lower forest canopies, and riparian vegetation (Wockner *et al.* 2004). Conversely, in New Zealand, feral horses are more likely to occupy north-facing aspects, steeper slopes in exotic and red tussock grasslands, and flush zones in winter, but in spring and summer they occupy lower altitudes on gentler slopes (Linklater *et al.* 2000). Feral horses shift to river basin and stream valley floors in spring and higher altitudes in autumn and winter, coinciding with the beginning of foaling and mating in spring and formation of frost inversion layers in winter (Linklater *et al.* 2000).

Snow limits feral horse habitat use in some temperate zones, despite their aptitude for obtaining forage beneath snow (Salter and Hudson 1979). In winter, feral horses in the Australian Alps are limited in distribution by deep snow at higher elevations (Walter 2002), and in Wyoming, feral horses use drier habitats of low elevation with less snow cover (Wockner *et al.* 2004).

In a desert ecosystem in California, feral burros spend 60–78.8% of their time in interfluves (a region between valleys of adjacent watercourses, typically in a dissected upland) in winter (Woodward and Ohmart 1976). In spring, burro habitat use is predominantly in washes, and in summer, when temperatures approach 48°C, much of their time is spent in densely shaded pockets of vegetation (Woodward and Ohmart 1976). Feral burros spend little time foraging in arroyos and use washes almost strictly as travel paths to the Colorado River for water. After drinking, feral burros often remain briefly near water to consume the salt-encrusted soil beneath salt cedars.

Insect pests influence habitat selection by equids. In Mongolia, bloodsucking insects such as tabanids and mosquitoes influence habitat use by khulan (Feh *et al.* 2001). In the Xihu semireserve, where habitat is predominantly sand dunes and oases, Wang *et al.* (2012) found that from late spring to early fall, Przewalski's horses stay away from wetlands to avoid mosquitoes and instead graze on higher ground.

Other factors that influence habitat selection include human settlement and pastoralism. Areas closer than 5 km to human settlement are assumed unsuitable for kiang because of their intolerance of human disturbance (Sharma *et al.* 2004), and onager (*E. hemionus onager*) reside far from roads in all seasons to avoid humans (Nowzari *et al.* 2012). As human activities develop across their range, Grevy's zebra are increasingly constrained by the presence of livestock, especially as their movements often take them outside protected areas (Hostens 2009; see chap. 13). During the wet season, Grevy's zebra have less available habitat owing to the presence of livestock, which can spatially exclude them and cause zebra to eat a less nutritious diet (Kleine 2010; Kebede *et al.* 2012). Grevy's zebra avoid areas with high livestock density (Sundaresan *et al.* 2007*b*; Hostens 2009; Kebede *et al.* 2012), yet they overlap spatially and temporally: 40–50% of daylight observations were in association with livestock (Low *et al.* 2009). Lactating females are particularly observed in proximity of livestock owing to their need for access to water (Low *et al.* 2009).

Habitat use is influenced by forage quality and water availability but also differs by sex and reproductive class. For example, female onager with juveniles in Iran are found closer to water points and use plains with high-quality vegetation, whereas females without young and solitary males use intermediate-quality vegetation farther from water (Nowzari *et al.* 2013). Lactating Grevy's zebra females require access to the most nutritious vegetation, even if it is accompanied by a higher predation risk, whereas nonreproductive individuals can moderate their risk with less nutritious forage. All reproductive classes of Grevy's zebra prefer shorter and greener grass, but lactating females and bachelors use areas with greener, shorter grass and medium-dense bush more than nonlactating females or territorial males, which are found in areas of deeper grass and more open habitats (Sundaresan *et al.* 2007*b*).

Home Range and Movements

Home range size of equids is highly dependent on resource availability. Przewalski's horses in Mongolia have smaller home ranges in the mesic steppe grassland of Hustai National Park, with a kernel home range of 0.75–12 km^2 (King 2002) and 2.84–78 km^2 (Nandintsetseg and Boldgiv 2007), compared to the arid Great Gobi B SPA, with a minimum convex polygon home range of 152–826 km^2 (Kaczensky *et al.* 2008) and 290–1,357 km^2 (Lugauer 2010), and arid Kalamaili in China, with a home range of 120–660 km^2 (Chen 2008). In China, home range sizes increased over time since release (Chen 2008); this was not seen in Hustai National Park, although home ranges gradually moved farther from release sites (King 2002). In Hustai, there was no difference in home range size of harems across seasons, although they tended to be slightly larger in winter (King and Gurnell 2005; Nandintsetseg and Boldgiv 2007). While there is little spatial overlap between bands, there is no evidence of exclusive range use in Hustai (King and Gurnell 2005) or the Great Gobi B SPA (Kaczensky *et al.* 2008). Home ranges of Przewalski's horses are centered on the most productive habitat types but are only about a tenth of the size of sympatric Asiatic wild ass (Kaczensky *et al.* 2008). Home ranges of Asiatic wild asses are from 18,186 to 69,988 km^2 in southeast Gobi and 4,889 to 7,368 km^2 in southwest Gobi (Great Gobi B SPA; Kaczensky *et al.* 2011). They show an almost linear relationship between travel distance and time interval between successive locations, suggesting they are highly mobile, with mean daily traveled distance of 8,451 m (Lugauer 2010).

Resources determine space use and movements of zebras (Williams 1998): when conditions are severe, Grevy's zebra can move >80 km and have home ranges of 10,000 km^2 (Moehlman *et al.* 2013). Home range of plains zebra varies across the continent, determined by seasonal vegetation (Smuts 1975), and varies by group composition (Klingel 1969; Rubenstein 2010). In East Africa, plains zebra home ranges in Ngorongoro range from 80 km^2 to 250 km^2 in different parts of the crater (Klingel 1969). In the Serengeti, range size varies by season; 300–400 km^2 in the wet season and 400–600 km^2 in the dry season (Klingel 1969). Combined with a migration route of 100–150 km in each direction, Serengeti zebra cover at least 1,000 km^2 in a year, compared with annual home ranges of 49–566 km^2 in Kruger National Park (Smuts 1975). Plains zebra subpopulations cover areas from 28–136 km^2 in Zululand (Brooks 1982) to 1,530–1,560 km^2 in Kruger National Park (Smuts 1974).

Seasonal movements are associated with changes in food quality. Mountain zebra summer on the plateau, where they have a high selectivity of vegetation communities, and winter on hillsides, where they use a wider range of vegetation communities (Novellie *et al.* 1988; Winkler and Owen-Smith 1995). Home ranges of Cape mountain zebra breeding herds are 3–16 km^2 in Mountain Zebra National Park, and core areas change with seasonal movements (Penzhorn 1982*b*). Hartmann's zebra in southwest Africa and Namibia have winter grazing areas of 6–20 km^2 and smaller ranges in the summer; winter and summer areas at one site were separated by 120 km (Penzhorn 1988). Like migratory plains zebra that track resource abundance across seasons (Young *et al.* 2005), Hartmann's zebra do not appear to select for specific areas for a home range, as their distribution is associated with rainfall pattern (Penzhorn 1982*b*). In Ethiopia, Grevy's zebra have a larger area of optimal habitat in the dry season than in the wet season, whereas like other equids they use a smaller geographic area when forage quantity and quality are high (Kebede *et al.* 2012).

Home range size of feral horses varies considerably within and among populations (McCort 1984), and feral horse bands generally show high fidelity to home ranges (Berger 1986). In coniferous forest habitat, home ranges average 48 km^2 (Girard *et al.* 2013), which is 33 km^2 larger than that reported by Salter and Hudson (1982) in similar habitat. In Oregon, USA, home range size of feral horses averages 12–27 km^2, and in similar Great Basin habitat, their low-altitude (fall/winter) home ranges average 6.7 km^2, whereas high-altitude (summer) home ranges average 25.1 km^2 (Berger 1986). Home range of feral horse bands in the Red Desert of Wyoming, USA, varies from 73 to 303 km^2, and six bands overlapped home range areas during that study (Miller 1983). Band home ranges in New Zealand are smaller than those reported by Berger (1977) in Grand Canyon, USA, and Miller (1983) in the Red Desert but are comparable to those recorded by Berger (1986) in the Granite Range, USA, and Salter and Hudson (1982) in Alberta. Band sizes were correlated to home range size, indicating home range size is likely related to resource demand (Linklater *et al.* 2000). Information on

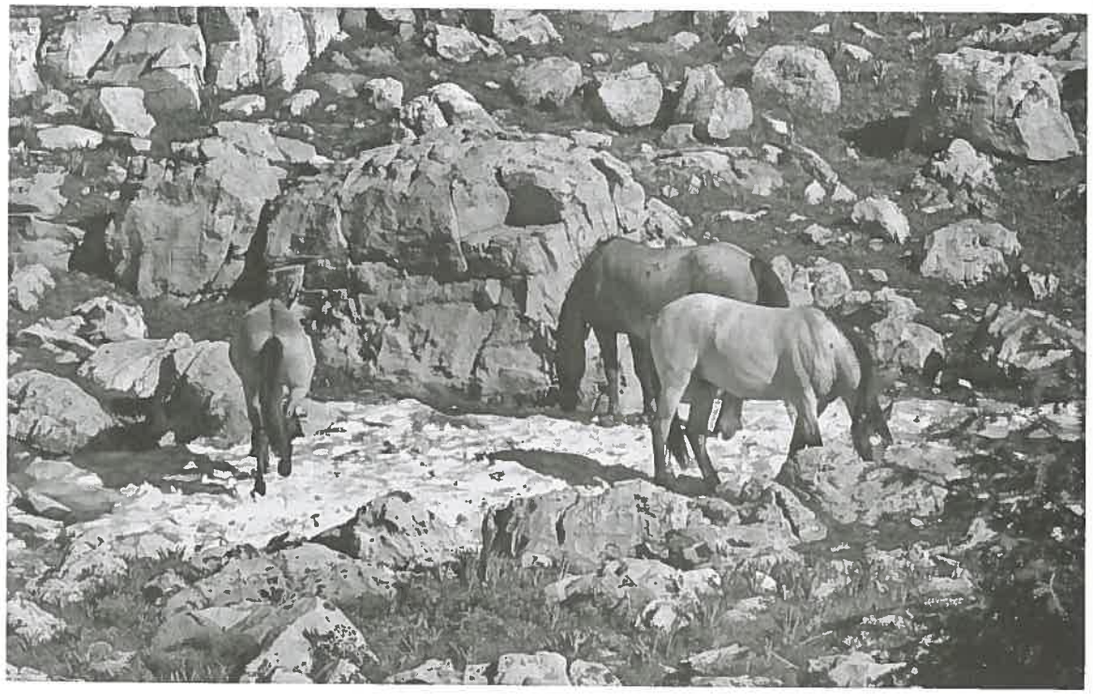

Fig. 4.2 Feral horses seek out a subalpine snow patch for hydration in the high elevations of the Pryor Mountains, Montana, USA. Photo by Jason I. Ransom

feral bachelor home range size is rarely reported, but Linklater *et al.* (2000) reported relatively small home ranges for bachelors compared to bands, whereas other studies have reported larger home ranges for bachelors than bands (Berger 1986). Almost no information on home range size is available for feral burros: Moehlman (1974) reported that female home ranges are 1.3–18.6 km^2 and male home ranges are 2.3–40.7 km^2.

Water

Equids are dependent on water sources in warm seasons; thus the distribution of water strongly influences distribution, space use, and movement patterns of equid species. In winter, equids are able to eat snow for hydration, allowing them to forage farther from water (Feh *et al.* 2002; Kaczensky *et al.* 2010) (fig. 4.2).

Przewalski's horses in Kalamaili drink twice a day, in the early afternoon and early evening (Wang *et al.* 2012). Free-ranging Przewalski's horses drank less frequently postrelease than when in captivity (reintroduced, mean 1.3 ± 0.5 times per day; captive, 4.8 ± 1.5; Chen 2008; Zhang 2010), suggesting that drinking frequency depends on availability. In Great Gobi B SPA, Przewalski's horses drink once daily in spring and autumn and every other day in summer, when vegetation is green and rich in water content (Ganbaatar 2003). Although water is not limiting in winter, forage availability can be problematic in deep snow.

Watering sites strongly determine summer ranges of equids, particularly wild asses. In spring, with high water content in plants, Asiatic wild asses can go without watering, but when water content drops below 50–55%, they remain within 10–19 km of water (Bannikov 1971). During summer, African wild asses subsist on dry and hard grass, but in winter there is enough moisture in forage that they can go two to three days without drinking (Mungall 1979). In Ethiopia, they are generally found within 30 km of known water sources (Moehlman 2002). Khulan will also dig holes as deep as 60 cm in dry riverbeds to access water in summer (Feh *et al.* 2002) (fig. 4.3). Kiang feed on green patches to fulfill their water requirements because they do not appear to drink frequently from running water (Schaller 1998; St-Louis and Côté 2009). Onager use areas farther from water and roads in the cold season, but in the hot season they use higher slopes and areas closer to water (Nowzari *et al.* 2012). Although more arid adapted than plains zebra (Rubenstein 2010), Grevy's zebra tend to remain <10 km from water and are not

observed >18 km from nearest water source (de Leeuw *et al.* 2001; Hostens 2009; Mwazo 2012).

Frequency of drinking varies by sex, reproductive status, and species. Mountain zebra are physiologically dependent on almost daily access to drinking water (Joubert 1973; Joubert and Louw 1976). The species' range in the more desert areas of Namibia was able to expand when artificial water sources were established (Novellie *et al.* 2002). Lactating plains zebra females stay within 2 km of water, drinking every one or two days, twice as often as nonlactating females, which may move up to 4.5 km away and only drink every two to five days (Becker and Ginsberg 1990; Sundaresan *et al.* 2007*a*,*b*). In a study of a single khulan mare, she did not drink daily but rather every 1.5–2.2 days during summer and on average every 2.3–3.8 days in spring and autumn (Kaczensky *et al.* 2010). Khulan drink at least every third day during the hot season. They have maximal intervals of five to six days between drinking events during the cooler and dry months such as April, May, and September, and do not visit water points between the middle of December and the end of February because there is ample snow. Lone khulan or small groups visit water sites during all 24 hours of the day without an apparent diurnal pattern in the southwest Gobi (Kaczensky *et al.* 2010), but different diurnal patterns have been described from other areas (e.g., China; see chap. 3). Average distance to nearest water source for khulan in the southwest Gobi Mongolia is 9.0 ± 2.9 km, and there are seasonal differences (Kaczensky *et al.* 2008). Mean watering frequency of feral horses in the Australian outback is 2.67 days (range 1–4 days; Hampson *et al.* 2010). Feral horses have been recorded up to 55 km from their watering points, and some horses walk for 12 hours to water from feeding grounds (Hampson *et al.* 2010). Watering activities in a feral horse population in Oregon are most intense during the first and last periods of daylight (Ganskopp and Vavra 1986). Feral horses remain closer to water during hot, dry summer months compared to spring, when additional sources and seeps are available (Ganskopp and Vavra 1986). Feral burros drink once every 24 hours during hot, dry summers, and females with young foals drink several times per day in Death Valley, California, USA (Moehlman 1974).

There is evidence that equids compete for water with domestic livestock and sympatric wildlife. In arid and semiarid ecosystems, water is a scarce resource, and potential for competition is high. In Africa, zebra are increasingly constrained by the presence of livestock,

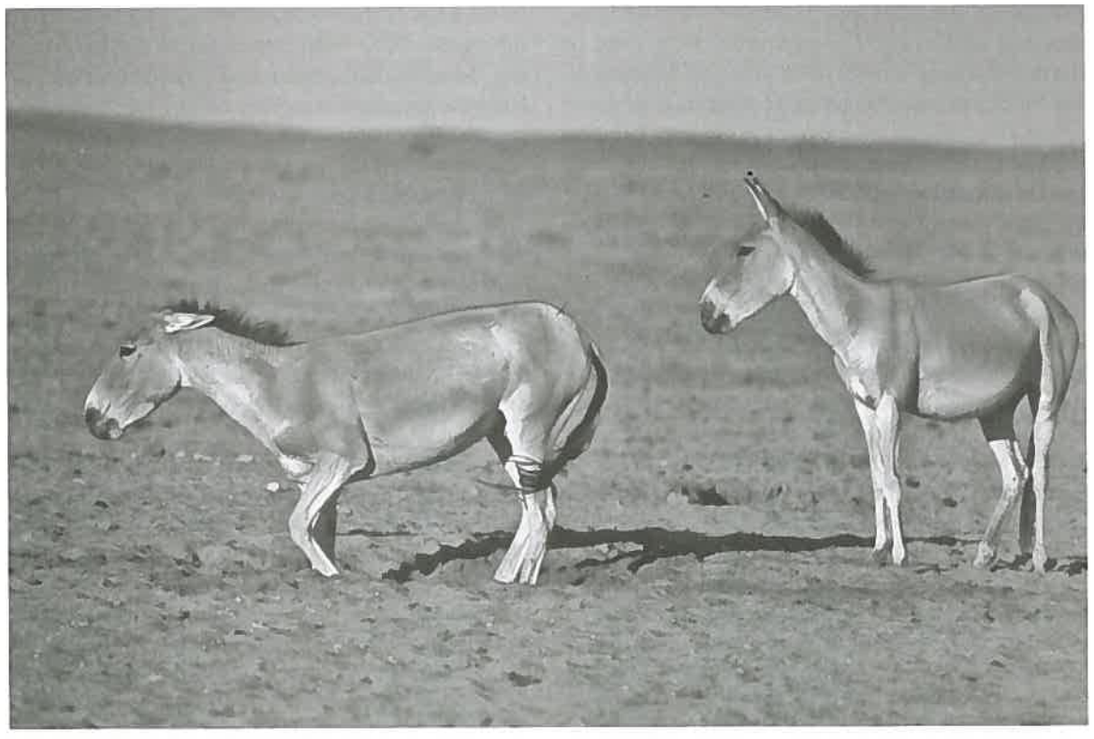

Fig. 4.3 A group of Asiatic wild asses digging for water in the arid southeast Gobi Desert, Mongolia. Photo by Petra Kaczensky

especially as their movements often take them outside protected areas (Hostens 2009). They avoid areas with high livestock density (Sundaresan *et al.* 2007*b*; Hostens 2009; Kebede *et al.* 2012) but are forced in proximity of livestock because of their need to access water sources (Low *et al.* 2009). In the western United States, equids compete and prevail over smaller-bodied ruminants. For example, feral horses in the Great Basin have little dietary overlap with pronghorn (*Antilocapra americana*) (Meeker 1979; McInnis and Vavra 1987), yet pronghorn spend more time in vigilance behavior when horses are present, and in pronghorn–feral horse interactions, pronghorn are excluded from water almost 50% of the time (Gooch 2014).

Diet

Equids are primarily grazers and typically select graminoids over other species when available (table 4.1). Diet of Przewalski's horses in Hustai National Park consists primarily of grasses, making up 75–83% even in winter (Siestes *et al.* 2009), and in Great Gobi B SPA, Przewalski's horses move from pastures with dry grasses to pastures with woody plants in winter (Ganbaatar 2003), likely resulting in decreased graminoids in winter diet compared to summer. Harris and Miller (1995) determined that *Stipa* spp. constitutes ~95% of kiang diet, and Schaller (1998) reported that 84.3–100% of the diet of kiangs is made up of graminoids. Kiang select for higher plant biomass and percentage of green foliage compared to random sites in the same habitats, while at the plant level, grasses are selected over forbs and shrubs, and sedges are used in proportion to their availability during all seasons (St-Louis and Côté 2014) (fig. 4.4).

Plains zebra diet consists almost entirely of grasses (Dekker 1997; Bodenstein *et al.* 2000), with occasional browse to maintain protein levels (Berry and Louw 1982). During the dry season, plains zebra spend more time foraging (Okello *et al.* 2002; Owen-Smith and Goodall 2014) and graze longer grasses than in the wet season (Stelfox *et al.* 1986; Awiti 1997; Arsenault and Owen-Smith 2011; Kleynhans *et al.* 2011), select sites with a lower level of fiber than wildebeest or cattle (Voeten and Prins 1999), and even eat dry leaves (McNaughton 1985). They eat a broader range of species during the dry season than in wet season, depending on availability (Owen-Smith *et al.* 2013). Mountain zebra are also tall-grass grazers (Novellie 1990; Novellie and Winkler 1993; Kraaij and Novellie 2010), only including browse in their diet as quality and quantity of grass decline in winter (Penzhorn 1982*a*; Novellie *et al.* 1988; Penzhorn and Novellie 1991). They select greener grass with a high leaf:stalk ratio at a height of 40–150 mm in Mountain Zebra National Park (Grobler 1983; Novellie 1990; Penzhorn and Novellie 1991; Novellie and Winkler 1993). Grevy's zebra are predominantly grazers, although browse can comprise up to 30% of their diet during drought, and there is significant variation in diet between individuals (Churcher 1993; Williams 2002; Kleine 2010).

Major constituents of feral horse diets are graminoids, while forbs and shrubs play a more limited—although sometimes still significant—role particularly in winter (Hansen 1976; Krysl *et al.* 1984*a*,*b*; Crane *et al.* 1997). Several studies report grass species remaining at or above 83% of feral horse diet in all seasons (Salter and Hudson 1979; McInnis and Vavra 1987; Smith *et al.* 1998), with sedges (*Carex* spp.) being important dietary components in bogs / meadows and stream sides (Salter and Hudson 1979; Crane *et al.* 1997). Smith *et al.* (1998) reported that feral horse diets consist of 91% grasses, 8% shrubs, and 1% forbs and unknowns. Salter and Hudson (1979) and Hubbard and Hansen (1976) indicate *Carices* as the major dietary constituent of feral horses. Grasses comprise 66–76% of summer feral burro diets in the Cottonwood Mountains of Death Valley National Park (five times more than predicted on the basis of their availability), but burros switch to shrubs (50–81%) from September to April (Ginnett and Douglas 1982). Jordan *et al.* (1979) reported that *Muhlenbergia porteri* comprises 24% of July burro diets but is a minor component of plant communities.

Equids likely do not have the capacity to detoxify plant phenolic compounds (Janis 1976; Duncan 1992); thus high amounts of phenolics in forbs and shrubs may deter equids from feeding on them. The minimum protein content required to meet metabolic functions in herbivores is around 6–7% (Owen-Smith 2002). Protein content is generally lower for grasses and sedges than forbs and shrubs, so in fall and winter, forbs and shrubs can meet metabolic requirements better than graminoids.

Seasonal differences in equid diets are due to changes in forage availability across seasons (Salter and Hudson 1979; Crane *et al.* 1997; Hanley and Hanley 1982; McInnis and Vavra 1987). Smith *et al.* (1998) reported that feral horse diet is consistent throughout the year; however, other authors have observed seasonal differences in specific grasses consumed or changes in use of forbs during spring. In Hustai National Park, Przewalski's horses select a greater variety of vegetation classes in spring and autumn, less in summer, and only few in winter (King and Gurnell 2005). Bannikov

Table 4.1. **Percentage of total diet of wild and feral equids**

Species	Location	Season	Grasses	Forbs	Browse	Forbs and Browse Combined
E. caballus (feral)	North America[1]	spring	91.03 ± 3.58 (85.6–99.0)	7.66 ± 4.41 (0–33.0)	4.50 ± 0.94 (trace–8.7)	3.0 ± 2.0 (1.0–5.0)
		summer	84.32 ± 2.76 (58.0–100)	9.18 ± 2.18 (0–27.0)	12.38 ± 3.36 (1.0–33.4)	7.4 ± 3.34 (trace–18.0)
		autumn	76.05 ± 8.55 (8.0–100)	11.28 ± 3.98 (0–37.0)	6.98 ± 2.05 (2.0–22.0)	0.50 ± 0.50 (0–1.0)
		winter	97.17 ± 5.53 (36.0–100)	16.75 ± 6.34 (0–52.0)	5.77 ± 1.65 (1.0–12.1)	11.25 ± 8.09 (0–23.0)
E. f. przewalskii	Mongolia,[2] China[3]	spring	~50 (—)			
		summer	72.0 ± 22 (50–94)	4.4 (—)	1.6 (—)	
		autumn		primary		
		winter	78.53 ± 2.07 (75.8–82.6)	15.87 ± 2.63 (10.7–primary)	5.60 ± 0.56 (4.9–6.7)	
E. asinus (feral)	India,[4] Arizona,[5] California[6]	spring	8.24 ± 5.62 (0.2–30.1)	64.0 ± 10.92 (34.5–98.0)	24.62 ± 6.67 (1.0–38.1)	
		summer	30.84 ± 9.49 (0–66.0)	19.13 ± 3.31 (11.2–37.2)	46.03 ± 9.77 (9.0–82.3)	
		autumn	12.73 ± 6.06 (2.3–23.3)	8.83 ± 0.64 (8.0–10.1)	74.00 ± 5.66 (64.2–83.8)	
		winter	17.70 ± 13.82 (0–86.0)	27.03 ± 8.09 (10.9–46.9)	50.90 ± 12.89 (0–82.9)	
E. hemionus	Mongolia[7]	spring		primary		
		summer	primary			
		autumn	35.0 (—)	65.0 (65–primary)	—	
		winter	primary			
E. kiang	India[8]	summer	92.88 ± 2.10 (86.8–98.0)	3.28 ± 0.65 (1.6–4.9)	1.02 ± 0.45 (0–2.5)	
		autumn	92.63 ± 1.56 (90.0–95.4)	3.37 ± 1.01 (1.7–5.2)	2.27 ± 1.50 (0–5.1)	
E. zebra	South Africa[9]	summer	primary			
		winter	primary		some use	
E. quagga	South Africa[10]	annual	81.92 ± 2.40 (76.0–100)	7.0 (—)	1.5 (—)	

Sources:

[1]Hansen 1976, Hubbard and Hansen 1976, Hansen and Clark 1977, Hansen *et al.* 1977, Vavra and Sneva 1978, Salter and Hudson 1979, Hanley and Hanley 1982, Krysl *et al.* 1984*b*, McInnis and Vavra 1987, Kissell *et al.* 1996, Crane *et al.* 1997, Smith *et al.* 1998, Nordquist 2011.

[2]Siestes *et al.* 2009.

[3]Meng 2007.

[4]Mishra *et al.* 2004.

[5]Jordan *et al.* 1979, Potter and Hansen 1979, Seegmiller and Ohmart 1981.

[6]Mohelman 1974, Woodward and Ohmart 1976.

[7]Lengger *et al.* 2007, Horacek *et al.* 2012.

[8]St-Louis and Côté 2014.

[9]Penzhorn 1982*a*, Novellie *et al.* 1988.

[10]Landman and Kerley 2001, Arsenault and Owen-Smith 2011.

Note: The mean value across studies per season ± standard error is shown. The range of individual study means is given in parentheses after the point estimate unless data are from only one study. The word "primary" indicates that these plants were the dominant food source. Jordan *et al.* (1979) used microhistological analysis of stomach contents; Horacek *et al.* (2012) used gas chromatography; and Arsenault and Owen-Smith (2011) used relative use of grass species. All other studies used microhistological analysis of fecal samples to determine diet constituents (box 4.1).

Fig. 4.4 Kiang persist on minimal forage at 4,550–6,000 m elevation in the Tso Kar basin of eastern Ladakh, India, where they seek out meadows with the highest forage biomass (St-Louis and Côté 2014). Photo by Antoine St-Louis

(1971) reported the diet of Asiatic wild asses across their range to include cereals and wormwood in summer, with proportions varying according to locale, conditions, and time of year, whereas in spring they feed on *Ephemerae*, such as *Poa* and *Bromus*. Ongoing work using isotope analyses (box 4.1) suggests khulan switch between the grass-dominated diet of a typical grazer in summer to a mixed grass / shrub diet in winter (M. Burnik-Sturm, personal communication).

Studies demonstrate that equids select and are also able to subsist on nongraminoids. Khur in India have been observed eating seedpods (Shah 1993) and use hooves to break up woody vegetation to obtain succulent forbs at the base of woody plants. They feed mostly on a mixed diet of forbs and grasses like *Cyperus capillaris*, *Andropogon* spp., *Dichanthium annulatum*, *Aristida alscansiouis*, and *Iseilema prostratum* (Jadhav 1979). Khur also feed on tree leaves of *Salvadora oleoides* and *Salvadora persica*, and leaves and pods of *Prosopis juliflora* (Smielowski and Raval 1988). Grevy's zebras are predominantly grazers, although browse can comprise up to 30% of their diet during drought, and there is significant variation in diet between individuals (Churcher 1993; Williams 2002; Kleine 2010). Feral horse diets in New Mexico contain a lower percentage of grasses (50%) than studies of feral horse diet in other habitat types have found (Hansen 1976), and feral burros are primarily browsers in Death Valley, California (Moehlman 1974). In a review of feral burro diets in the Mojave Desert, USA, Abella (2008) reported that a native annual forb constituted the greatest proportion (11%) of burro diets in three of seven annual diet studies. Other studies report shrubs as the major component (58–84%; Woodward and Omart 1976) of feral burro diets in all seasons except spring, when they focus on forbs (Moehlman 1974; Woodward and Omart 1976). In the Chemehuevi Mountains of California, USA, feral burros were reported to feed on 39 different plant species, with *Plantago insularis* and *Cercidium floridum* being most common. These two species combined with *Prosopis* spp. and *Pluchea sericea* make up over 50% of the annual diet of feral burros (Woodward and Ohmart 1976).

Although feral burros, like other equids, can forage on a variety of plant species, they forage selectively when given the opportunity (Smith 1969; Douglas and

BOX 4.1 TOOLS FOR DIET ANALYSES

Microhistology

The most common method to determine diet of ungulates has been microhistological analysis of feces (Hubbard and Hansen 1976; Hansen and Clark 1977; Hansen *et al.* 1977; Olsen and Hansen 1977; Salter and Hudson 1979; Hanley and Hanley 1982; Krysl *et al.* 1984*b*; McInnis and Vavra 1987; Crane *et al.* 1997; Smith *et al.* 1998). Fresh fecal samples are prepared with an alcohol solution and analyzed with a binocular compound microscope. The frequency of occurrence of individual plant species is recorded in 100 microscope fields. Histological characteristics are used to determine plant species. Size and shape of epidermal hairs, cell shapes, and crystals within epidermal cells are used to determine forbs species. Presence and position of cork cells, silica cells, silicosuberose couples / asperities, and size and shape of guard and subsidiary cells of the stomata are used to identify graminoids (Storr 1961; Sparks and Malechek 1968; Williams 1969).

Observational Studies

Observational studies are used to determine forages consumed (Krysl *et al.* 1984*a*; Mayes and Duncan 1986; Menard *et al.* 2002) by using scan sampling at a predetermined rate (e.g., every two minutes) for a discrete time period. Activity is recorded and plants consumed. The method allows the potential to directly measure nutrients consumed, but the presence of observers could alter behavior and influence forage consumption.

Stable Isotopic Analysis

Isotopic analysis has been used for several decades (Deniro and Epstein 1978; Tiezen *et al.* 1983; Ambrose and Deniro 1986). Hair has been used in to extract $\delta^{13}C$ and $\delta^{15}N$ signatures, which are used to characterize diet (Schoeninger *et al.* 1998; Macko *et al.* 1999; O'Connell and Hedges 1999; Chambers and Doucett 2008). Hair or tissue—such as muscle, blood, or feces—is collected in the field, cleaned, weighed, and placed in a mass spectrometer, which burns the sample, ionizes it, and separates the ionized particles by mass, quantifying atoms with different masses. Forage samples are also collected, dried, ground, and weighed. Once isotopic values are obtained for the tissue and forage samples, an analysis program (IsoSource) tests all possible combinations for the forage samples. If there is a possibility of the sources adding up to the tissue value, the possible combination value is stored. IsoSource gives ranges that indicate all possibilities of source contributions to the tissue sample (Nordquist 2011). With isotopic analysis, one tail hair can provide several years of chronological data; however, IsoSource is limited in the number of sources that can be put into the program.

Plant DNA Barcoding

A recently developed method is plant deoxyribonucleic acid (DNA) barcoding. When ungulates consume plants, not all of the plant DNA is digested before defecation. Thus plant DNA can be isolated from ungulate feces and used to reconstruct diet (Valentini *et al.* 2009; Kowalczyk *et al.* 2011). Total plant DNA is extracted from the sample, DNA is amplified using primers that capture all possible plant taxa, and the polymerase chain reaction–amplified DNA is sequenced. A reference database is then used to match resulting sequences to given plant taxa. Calibration studies have suggested the percent of all sequences identified to a given taxa is proportional to the relative amount of biomass in the diet (Willerslev *et al.* 2014), yet more research is needed to calibrate the technique for factors such as chloroplast density in tissues or preferential digestion. Over 1,000 sequences per sample can often be recovered, providing high-resolution information on the diversity of plants consumed.

Photo by M. Dumbleton

Hiatt 1987). Within a habitat type, mountain zebra are highly selective, using only 7 of 17 grass species at feeding sites and 26% of plants available (Grobler 1983; Penzhorn and Novellie 1991). Out of 20 plant communities available in Mountain Zebra National Park, breeding herds preferred 9 in summer, 7 in winter, and 3 in both seasons; bachelors had no preference (Penzhorn and Novellie 1991). In Kenya, plains zebra eat 6.2–7 species of grasses on average (Stewart and Stewart 1970), with zebra in South Africa eating 19 (Landman and Kerley 2001) to 27 (Boyers 2011) species, depending on the area, and displaying a seasonal change in species preference: 6 of 13 species preferred in the early dry season and 9 of 17 in the late dry season (Owen-Smith *et al.* 2013).

Conclusion

Resource selection by equids is driven mostly by forage availability. Studies have shown that Przewalski's horses select the most productive communities, kiangs select for forage abundance, Grevy's zebra and plains zebra track resource abundance across seasons selecting areas with high grass biomass, and mountain zebra select habitat with >50% grass cover. Some equids, such as Asiatic wild ass and some feral horse herds, use habitat relative to its availability. Feral horses and feral burros are found on almost all continents, their distribution assisted by the spread of human culture, but today they are mostly in habitats of low human value and use. All equids are dependent on water in warm months and can eat snow for hydration in winter. Wild asses in particular are highly arid adapted and survive several days without drinking water, instead obtaining hydration from plants. Equids can dig for water in dry seasons, and dig through snow for forage in winter if necessary. Pests influence habitat selection and daily habitat use in most equids, particularly Przewalski's horses, khulan, and some herds of feral horses. Equids are ubiquitous in their avoidance of people and human settlement, and most equid species compete with pastoralism or livestock for access to water and forage.

Equids are primarily grazers and select graminoids over other species when available, relying on browse as quality and quantity of grass declines. The exception is wild asses and feral burros, for which browsing is common. Equids are bulk or roughage feeders, selecting quantity over quality. Their digestion is less efficient than ruminants; they can re-ingest semidigested food via coprophagy. Equids consume large quantities of low-quality forage, and they survive and thrive in some of the harshest environmental conditions and extreme terrestrial habitats on earth. The breadth of ecosystems they inhabit is truly astounding.

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IMPACT OF GRAZING MANAGEMENT ON THE CARBON AND NITROGEN BALANCE OF A MIXED-GRASS RANGELAND

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Abstract. Rangeland grazing management strategies have been developed in an effort to sustain efficient use of forage resources by livestock. However, the effects of grazing on the redistribution and cycling of carbon (C) and nitrogen (N) within the plant–soil system are not well understood. We examined the plant–soil C and N balances of a mixed-grass rangeland under three livestock stocking rates using an area that had not been grazed by domestic livestock for more than 40 years. We established nongrazed exclosures and pastures subjected to continuous season-long grazing at either a light stocking rate (20 steer-days/ha) or a heavy stocking rate (59 steer-days/ha, ~50% utilization of annual production). Twelve years of grazing under these stocking rates did not change the total masses of C and N in the plant–soil (0–60 cm) system but did change the distribution of C and N among the system components, primarily via a significant increase in the masses of C and N in the root zone (0–30 cm) of the soil profile. The mass of soil C (0–60 cm) under heavy grazing was comparable to that of the light grazing treatment. Grazing at the heavy stocking rate resulted in a decrease in peak standing crop (PSC) of aboveground live phytomass, an increase in blue grama (*Bouteloua gracilis* [H.B.K.] Lag. Ex Steud.), and a decrease in western wheatgrass (*Pascopyrum smithii* [Rydb.] A. Love) compared to the light grazing treatment. The dominant species under light grazing was western wheatgrass, whereas in the nongrazed exclosures, forbs were dominant and appeared to have increased at the expense of western wheatgrass. The observed increase of soil C and N in the surface soil where roots dominate indicates a greater opportunity for nutrient availability and cycling, and hence enhanced grazing quality.

Key words: C and N balance; carbon; mixed-grass prairie; nitrogen; rangelands.

INTRODUCTION

Rangeland grazing management strategies have been developed in an effort to sustain efficient use of the forage resource by livestock. However, these management practices affect many ecosystem components besides livestock and forage production. Grazing can also influence plant community structure, soil chemical and physical properties, and the distribution and cycling of nutrients within the plant–soil system. This paper examines the effects of grazing on C and N distribution within a semiarid, mixed-grass plant–soil system.

Historically, most grazing studies have focused on the effects of management practices on forage production and animal response, although a few researchers have evaluated the effects of grazing on soil C and N (Smoliak et al. 1972, Bauer et al. 1987, Frank et al. 1995). Grazing of the northern mixed prairie reduces canopy biomass by depressing the vigor of cool-season grasses and causing the replacement of mid-grasses by warm-season short grasses (Coupland et al. 1960, Dormaar and Willms 1990). The degree to which this shift in species composition occurs depends on the density and duration of stocking (Coupland 1992). Grazing also partially controls the quantity and chemical composition of soil organic matter and the distribution of C and N in the soil profile (Rosswall 1976, Smoliak et al. 1972, Dormaar and Willms 1990, Dormaar et al. 1990, Frank et al. 1995), thus influencing the largest reservoir of N and C in the perennial grass plant–soil system. Since plant-available N is usually the limiting nutrient to grass production in the semiarid Great Plains (Power 1977), the quantity and chemical composition of soil organic matter is of critical importance to N and C cycling and primary productivity (Power 1994), and thus to overall ecosystem function. Aboveground plant productivity and composition also influence C and N inputs. Grazing has been shown to influence litter accumulation and depletion (Christie 1979, Hart et al. 1988, Naeth et al. 1991), its rate of decomposition (Shariff et al. 1994), and its subsequent effects on herbage production (Willms et al. 1993).

Milchunas and Lauenroth (1993) reviewed a worldwide 236-site data set and found no clear relationship between species composition, root biomass, soil organic C, or soil N of grazed vs. ungrazed grasslands. These cited studies clearly indicate the variance of findings on the effects of grazing on soil organic C and N. We believe that much of the variance noted in earlier

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research results from soil variations within the studies, differences in the depth of the soil profile being evaluated, and a lack of thorough evaluation of the C and N distribution within the system. For example, a significant number of past studies only evaluated the surface 5–10 cm of the soil profile. We feel that careful evaluation of the effects of grazing on ecosystem C and N balance can be a useful indicator of the effects of grazing management on rangeland health (National Research Council 1994). Therefore, the objective of this research was to quantify the effects of 12 yr of livestock grazing at three stocking rates on plant biomass, plant community composition, and the C and N balance of a mixed-grass prairie.

METHODS

Study sites

The research was conducted at the High Plains Grasslands Research Station near Cheyenne, Wyoming, on a native mixed-grass rangeland with rolling topography and elevations ranging from 1910 to 1950 m. The climate is semiarid, with an annual frost-free period of 127 d, and average annual precipitation (1971–1994) of 384 mm, of which 70% occurs from 1 April through 30 September (National Oceanic and Atmospheric Administration 1994). Dominant soil series are Ascalon and Altvan sandy loams (mixed, mesic, Aridic Argiustoll; Stevenson et al. 1984).

Vegetation is predominantly grasses (55% cool-season species and 23% warm-season species), forbs, sedges, and half-shrubs. Dominant cool-season species are western wheatgrass (*Pascopyrum smithii* (Rydb.) A. Love) and needleandthread (*Stipa comata* Trin & Rupr.), and the dominant warm-season species is blue grama (*Bouteloua gracilis* (H.B.K) Lag. Ex Steud.). Legumes comprised <2% of the plant community of this mixed-grass ecosystem. Prior to establishment of the grazing management and stocking rate phase of this research, the area had not been grazed by domestic livestock for >40 yr.

Treatment pastures were established in 1982 in a randomized block design with two replicate blocks (pastures) for each of seven grazing strategy–stocking rate treatment combinations. Three of the treatments were evaluated in this study: (1) EX, nongrazed exclosures, (2) CL, pastures with continuous season-long grazing at a light stocking rate of 0.16 to 0.23 steers/ha (mean of 20 steer-days/ha), and (3) CH, pastures with continuous season-long grazing at a heavy stocking rate of 0.56 steers/ha (mean of 59 steer-days/ha). The light stocking rate was ~35% below the stocking rate recommended by the Natural Resources Conservation Service (NRCS, formerly the Soil Conservation Service) for the condition of the site, whereas the heavy stocking rate, which utilized slightly <50% of annual production, was ~33% higher than the NRCS recommended rate (Hart et al. 1988). Further details of the grazing treatments and pasture design are given in Hart et al. (1988) and Manley et al. (1995).

Field sampling

In 1982, prior to initiation of grazing treatments, a 50-m permanent transect was established in each replicate pasture on near-level sites on the Ascalon soil series. The A horizon and solum (A + B horizons) of the Ascalon soil have mean (±1 SD) depths of 15 ± 2 cm and 100 ± 7 cm, respectively. The soil ranges from 6.4 to 7.3 pH. In July 1993, soil and plant samples were collected to measure the C and N content in the various components of the plant–soil system. Five sample locations were established at 10-m intervals along the 50-m transect in each pasture. Soil samples (4.6 cm diameter) were collected to 90-cm depth with a hydraulic soil sampling machine. All plant litter was removed from the soil surface before the samples were taken. Soil samples were segregated into 0–3.8, 3.8–7.6, 7.6–15, 15–30, 30–45, 45–60, and 60–90 cm increments. The first three segments, 0–15 cm, encompass the soil A horizon; the 15–90 cm segments represent the various components of the soil B horizon. Because the soil profile was extremely dry below 60 cm, we were unable to collect a complete set of soil samples at the 60–90 cm depth; therefore, soil C and N and root biomass were only assessed to the 60-cm depth. Two cores were taken at each sample site and composited by depth increment to provide adequate sample for analyses. Samples were placed in sealed plastic bags and transported to the laboratory in coolers. Separate soil cores were collected at the second and fourth sampling sites along each transect to assess bulk density as described by Blake and Hartge (1986). The bulk density data were used to convert soil C and N concentrations (in milligrams per kilogram) to C and N mass (in kilograms per hectare) in the soil. These soils contain <1% fine gravels that are generally found in the C horizon; therefore, no adjustment of the bulk density was necessary.

Five additional cores were collected at 10-m intervals along each transect to assess root biomass and root C and N. The surface 30 cm were sampled with a 9.9 cm diameter core, and the 30–60 cm depth was sampled with a 4.6 cm diameter core. Soil cores were separated into 0–15, 15–30, and 30–60 cm increments. The smaller diameter core was required to obtain the lower depth samples because of low soil moisture levels. Root core increments were placed in sealed plastic bags and stored at 5°C until roots could be washed from the soil.

Surface litter and standing dead plant biomass were estimated along each transect with five 0.18-m^2 quadrats, spaced at 10-m intervals. Estimates of annual aboveground biomass production were obtained at peak standing crop from three 1.5 × 1.5 m temporary exclosures randomly located throughout each treatment pasture; two 0.18-m^2 quadrats were sampled within each of the temporary exclosures. In the nongrazed

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TABLE 1. Comparison of total biomass of vegetation components as affected by stocking rate (NS = not statistically significant).

System components	Exclosure (kg/ha)	Continuous light grazing (kg/ha)	Continuous heavy grazing (kg/ha)	Least significant differences	
				$P = 0.10$	$P = 0.05$
Above ground					
Live biomass	1 330	1 224	816	270	325
Standing dead	472	492	0	155	187
Litter	2 872	1 647	1 271	1018	1227
Total above ground dead	3 344	2 139	1 271	1054	1270
Total above ground biomass	4 674	3 363	2 087	1176	1418
Roots					
0–15 cm	31 474	21 695	27 319	6500	NS
15–30cm	5 516	6 971	5 289	NS	NS
30–60cm	1 618	1 779	1 162	NS	NS
Total roots:	38 608	30 445	33 770	NS	NS
Root : shoot ratio	28.4	26.9	41.6	10.4	12.5
Total plant biomass	43 282	33 808	35 857	NS	NS

permanent exclosures (EX), five 0.18-m^2 quadrats were sampled at 10-m intervals along the 50-m transect for all aboveground plant components.

Laboratory analysis

Soil samples intended for C and N analysis were passed through a 2-mm screen to remove plant crowns and visible roots and root fragments. Each sample was mixed and a 10-g field-moist subsample removed for NH_4^+ and NO_3^- extraction; the remaining soil was air-dried and stored at 4°C until analyses for total C and N were completed. Root separation from root cores was accomplished by hand with the washing method described by Laurenroth and Whitman (1971). Vegetation components were dried at 60°C, weighed, and the final biomass estimates converted to a kilogram per hectare basis using the area of the sample quadrat, or in the case of the roots, the surface area of the root core. Ash content of all components of the vegetation was used to calculate/adjust the C and N masses.

Plant samples were analyzed for organic C and N with a Carlo-Erba automated combustion analyzer. Organic N concentrations of soil samples were determined with a modified micro-Kjeldahl procedure (Schuman et al. 1973). Soil organic C was determined with the Walkley-Black dichromate oxidation procedure (Nelson and Sommers 1982). Soil NH_4^+ and NO_3^- were extracted from field moist soils with 1 mol/L KCl at a 1:10 soil : solution ratio; extracts were filtered and analyzed with a Technicon autoanalyzer (Environmental Protection Agency 1983).

Statistical analysis

Analysis of variance was used to test stocking rate effects on soil and plant component C and N masses and on plant component biomass data using a randomized complete block design with two blocks. Individual system components (litter, standing dead, live biomass, root by depth, and soil by depth) were each tested with a separate analysis of variance with replicate pastures treated as blocks. Least-significant-differences (LSD) procedures were used for treatment mean separation (Steel and Torrie 1980). All statistical evaluations and discussion are based upon $P \leq 0.10$. While we believe that the 10% probability level is very appropriate to test and evaluate the effects of management alternatives on grassland C and N balance, we present LSD values for both the 5 and 10% probability levels in each table. Only 20% of the statistical test accomplished did not meet the 5% probability.

RESULTS

Vegetation components

Twelve years of grazing at the heavy stocking rate resulted in decreased peak standing crop (PSC) of aboveground live phytomass (Table 1), as well as shifts in the plant composition of the PSC (Table 2). Western wheatgrass declined from 45 to 21% of PSC (mass

TABLE 2. Proportional botanical composition of peak standing crop biomass as affected by stocking rate (NS = not significant).

Taxon	Exclosure	Continuous light grazing	Continuous heavy grazing	Least significant differences	
				$P = 0.10$	$P = 0.05$
Blue grama	0.165	0.170	0.272	0.092	NS
Western wheatgrass	0.290	0.448	0.214	0.124	0.149
Needleandthread	0.129	0.068	0.111	NS	NS
Other grasses	0.026	0.046	0.116	0.046	0.068
Sedges	0.060	0.105	0.071	NS	NS
Forbs	0.330	0.163	0.216	0.124	NS

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TABLE 3. Mass of C from vegetation components and soil (0–60 cm profile) as affected by stocking rate (NS = not statistically significant).

System components	Exclosure (kg/ha)	Continuous light grazing (kg/ha)	Continuous heavy grazing (kg/ha)	Least significant differences	
				$P = 0.10$	$P = 0.05$
Above ground					
Live biomass	587	535	355	119	143
Standing dead	206	209	0	65	79
Litter	809	533	394	240	29
Total aboveground dead C	1 015	742	394	255	307
Total aboveground C	1 602	1 277	749	252	371
Roots					
0–15 cm	7 166	6 011	5 763	1 073	NS
15–30 cm	1 244	1 646	1 312	NS	NS
30–60	379	504	346	NS	NS
Total root C	8 789	8 161	7 421	NS	NS
Total plant C	10 391	9 438	8 170	1 259	1517
Soil profile					
0–3.8 cm	9 595	12 675	12 000	1 309	1929
3.8–7.6 cm	5 906	7 457	8 478	660	793
7.6–15 cm	12 662	15 009	15 472	1 573	1896
Total soil C (0–15 cm)	28 163	35 141	35 950	2 188	3224
15–30 cm	19 761	22 847	22 348	2 485	NS
Total soil C (0–30 cm)	47 924	57 988	58 298	2 463	3629
30–45 cm	22 932	20 353	25 281	NS	NS
45–60 cm	17 291	13 595	17 689	NS	NS
Total soil C (0–60 cm)	88 147	91 936	101 268	11 853	NS
Total ecosystem C					
(to 30 cm)	58 315	67 426	66 468	4 334	6565
(to 60 cm)	98 538	101 374	109 438	NS	NS

basis), and blue grama increased from 17 to 27% of PSC, under CH compared to CL grazing (Manley et al. 1997). The PSC under CL grazing was comparable to that in the EX, but the plant compositions of the two treatments differed. The dominant species under CL grazing was western wheatgrass (45% of PSC), whereas in the EX, forbs were dominant. Surface litter biomass was significantly greater in the EX compared to both grazing treatments. Standing dead biomass was comparable in the EX and CL grazed pastures, but absent under CH grazing (Hart et al. 1988). Root biomass in the surface soil (0–15 cm) of the EX and CH grazed pasture was similar, and the EX had significantly greater root biomass than the CL grazing treatment (Table 1).

Trends in the distributions of C and N in the aboveground vegetation components (Tables 3 and 4) were similar to the trends seen for total aboveground biomass, i.e., decreasing masses of C and N with increasing grazing pressure. However, the masses of root C and N in the 0–15 cm depth were significantly higher in the EX than with either grazing treatment (Tables 3 and 4).

Soil response

Total organic C and N masses in the surface 30 cm of the soil profile were significantly lower in the EX than in either grazing treatment (Tables 3 and 4). In the 30–60 cm soil depth, soil organic C and N concentrations were low, and C and N masses were quite variable. The lower masses of C and N in the surface 30 cm of the soil profile of EX were due both to the significantly lower surface soil (0–7.5 cm) bulk density in the EX compared to the grazed pastures (1.00 vs. 1.14 and 1.17 g/cm^3 in the EX, CL, and CH treatments, respectively) and to lower concentrations (milligrams per kilogram) of C and N in the surface 15 cm of the soil profile in the EX than in the grazing treatments (data not shown). Mean bulk densities for the 7.5–30 cm depth were 1.37, 1.31, and 1.44 g/cm^3 in the EX, CL, and CH, respectively. Bulk densities for the 30–60 cm depth averaged 1.39, 1.26, and 1.47 g/cm^3 in the EX, CL, and CH, respectively.

The inorganic N content of the soil profile at the July sampling was low and did not vary significantly among treatments. Nitrate-N concentrations were consistently <1 mg/kg in the soil profile, while NH_4-N concentration were <5 mg/kg. While these data represent a single measurement in time, they are consistent with past studies that have demonstrated that nitrate and ammonium levels in unfertilized grassland soils are almost universally very low (Richardson 1938, Walker 1956, Woodmansee et al. 1978).

Total C and N masses of the system

An evaluation of total C and N masses in the surface 30 cm of plant–soil system, the depth that includes >90% of the root biomass, revealed that (1) total C and N were significantly lower in the EX than in either grazing treatment, and (2) total mass of C was comparable under the two grazing treatments, but total mass of N was significantly larger under CL grazing than

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TABLE 4. Mass of N from vegetation components and soil (0–60 cm profile) as affected by stocking rate (NS = not statistically significant).

System components	Exclosure (kg/ha)	Continuous light grazing (kg/ha)	Continuous heavy grazing (kg/ha)	Least significant differences	
				$P = 0.10$	$P = 0.05$
Above ground					
Live biomass	18	15	12	5	NS
Standing dead	5	4	0	1.4	1.6
Litter	33	20	15	7	11
Total above ground dead N	38	24	15	6	9
Total above ground N	56	39	27	8	13
Roots					
0–15 cm	308	237	233	50	60
15–30 cm	44	56	52	NS	NS
30–60 cm	10	14	11	NS	NS
Total root N	362	307	296	54	NS
Total plant N	418	346	323	59	71
Soil profile					
0–3.8 cm	684	939	840	26	39
3.8–7.6 cm	488	673	665	95	115
7.6–15 cm	1171	1460	1298	191	230
Total soil N (0–15 cm)	2343	3073	2802	488	636
15–30 cm	1936	2442	2005	233	329
Total soil N (0–30 cm)	4279	5515	4807	204	301
30–45 cm	1865	1736	1692	NS	NS
45–60 cm	1510	1091	1260	273	329
Total soil N, 0–60 cm	7654	8342	7760	NS	NS
Total ecosystem N					
(to 30 cm)	4697	5861	5130	254	362
(to 60 cm)	8072	8688	8083	NS	NS

under CH grazing (Tables 3 and 4). However, when the full 0–60 cm soil depth was evaluated, 89–93% of the system C and 95–96% of the N were stored in soil organic matter within the soil profile. Less than 10% of the C was found in the vegetation component, and 85–91% of vegetation C was in the root mass. Less than 5% of the system N was found in the vegetation component, with 87–92% of vegetation N in the roots. When the soil and plant components were combined for C and N accounting, statistically significant differences across grazing treatments were no longer evident, primarily because C and N concentrations were low and highly variable in the 30–60 cm depth of the soil profile.

DISCUSSION

We found that 12 yr of livestock grazing, after >40 yr of exclusion of both fire and livestock, resulted in a significant increase in the masses of soil C and N in the root zone (0–30 cm) of the soil profile. The surface 30 cm of the soil was 6000–9000 kg/ha higher in C and 450–700 kg/ha higher in N in the grazed treatments than in the EX (Tables 3 and 4). These increases in soil C and N with grazing are probably due to redistributions of C and N within the plant–soil (0–60 cm) system, increases in C and N cycling rates between system components, and reduced losses of C and N from the plant–soil system.

The heavy stocking rate, 135% of that recommended by the Natural Resources Conservation Service, could be expected to affect soil C negatively because of plant physiological responses to the increased grazing pressure. Grasses can respond to defoliation by increasing C allocation to new leaves while decreasing allocation to roots (Detling et al. 1979). Repeated and frequent grazing results in decreased root elongation and biomass (Schuster 1964, Davidson 1978), and hence lower C inputs into the soil from the roots (Holland and Detling 1990). Simulation models also have predicted decreasing soil C levels with increased grazing rates (Parton et al. 1987). In contrast, our data indicate that 12 yr of grazing increased the total mass of soil organic C in the 0–30 cm profile, but did not affect the total mass of C in the plant–soil system to 60 cm depth (Table 3). The heavy stocking rate altered plant composition, which may account for a portion of the change in the distribution of C among the system components. Blue grama, with a typically dense but shallow rooting system, increased under heavy grazing. This change is reflected in the higher root : shoot biomass ratio under the heavy grazing treatment (41:6) compared to the other treatments (Table 1), but it is not reflected in the root biomass or root C or N masses. Coupland and Van Dyne (1979) reported that blue grama-dominated grasslands transfer more of the energy contained in net primary production to underground plant parts than does mixed-grass prairie. Likewise, Frank et al. (1995), who reported similar findings on a North Dakota mixed-grass prairie, suggested that blue grama may partition more C belowground than other species in a mixed-grass ecosystem. Other research has shown that grazing stimulates greater aboveground phytomass production

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(Mutz and Drawe 1983, Dodd and Hopkins 1985), increased tillering (Floate 1981), and increased rhizome production (Schuman et al. 1990), and possibly stimulates root respiration and root exudation rates (Dyer and Bokhari 1976). Increased production rates and greater C allocation to the belowground portions of the system may explain the patterns we observed.

Although the mass of soil (0–30 cm) organic C under CH grazing was comparable to that under CL grazing, the mass of organic N was lower (Table 4). Carbon lost from the plant–soil system by herbivory can be replenished by increased photosynthesis and production, but N losses by defoliation are replaced primarily by increased atmospheric N_2 fixation; in our study nitrogen-fixing species represent an extremely small component (<2%) of the mixed-grass ecosystem and did not change with grazing. In the EX, 72% of the aboveground phytomass was in the form of litter and standing dead plant material. Bauer et al. (1987) found lower mass of soil N in relict (nongrazed) than in grazed grasslands and suggested that there is an increased potential for volatilization of NH_3 from plants, and increased opportunity for denitrification in the cooler and more moist conditions of the nongrazed soil profile. Coupland and Van Dyne (1979) reported that ~15% of net primary production of a Canadian mixed-grass prairie was not transferred to litter, but rather was lost via decomposition within the dead-shoot component of the canopy. They also reported losses in the litter layer from photochemical decomposition. Such C losses from the system should be greater in the exclosures where a large aboveground plant C pool exists.

Grazing stimulates C and N cycling from aboveground plant components to the soil. The apparent annual rate of turnover of shoots in the exclosures is 28% (PSC production of 1330 kg/ha divided by mean aboveground standing crop of 4673 kg/ha), compared to 36 and 39% with light and heavy grazing. Animal traffic in the grazed treatments may be enhancing physical breakdown, soil incorporation, and rate of decomposition of litter. Aboveground immobilization of C and N in standing dead plant materials in the EX treatment may also contribute to the lower soil C and N observed. Compared to the grazed treatments, ~275–675 kg/ha more C and 15–25 kg/ha more N are immobilized in the dead plant material of the exclosures instead of being recycled back into the surface soil. These levels of immobilized C and N account for 8% or less of the C deficit, and 6% or less of the N deficit in the surface 30 cm of the exclosure soil profiles. However, over a period of 12 yr of livestock grazing, the enhanced transfer of litter C and N into the soil has resulted in a significantly higher accrual of C and N in the soil of the grazed treatments than in the exclosures.

Grazing of these northern mixed-grass rangelands has not resulted in a reduction of soil C and N resources. In fact, grazing has led to increased levels of soil C and N through enhanced incorporation and decomposition of the litter and standing dead plant material. Transfer of net primary production to belowground plant parts may also account for a portion of the observed increase of soil C and N in the 0–30 cm soil depth, even though root biomass has not exhibited the significant increase typically observed when species composition is changed in response to grazing. The observed increases in soil C and N in the 0–30 cm soil zone have important implications in determining management strategies for these grasslands. Removing livestock from these lands could over the long term reduce soil C and N cycling and potentially the productivity of the systems. These ecosystems developed under grazing; the fact that soil resources are enhanced with grazing suggests that grazing is an important part of ensuring long-term sustainability of these grassland systems.

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Demography of feral horses (*Equus caballus*): a long-term study in Tornquist Park, Argentina

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Abstract

Context. All over the world, invasive alien mammals present conservation problems. Feral horses are invasive in many countries and their management is challenging.

Aims. To determine the demography of feral horses in Tornquist Park, Argentina, so as to develop a quantitative basis for their management.

Methods. Ground counts of individually identified female horses were conducted monthly from 1995 to 1997 and from 2000 to 2002, and seasonally in 1998 and 1999. We calculated the age structure, foaling and survival rates of mares and analysed the effects of adult density and rainfall on demographic parameters. The population trend was calculated by fitting a logistic equation to annual adult mare counts.

Key results. The foaling rate averaged 0.55 annually and the survival rate in females averaged 0.89 for adults, 0.91 for juveniles, 0.87 for yearlings and 0.94 for foals. We found adult density, rainfall and the previous year's rainfall to have a significant effect on fecundity but no effect on adult, juvenile and foal female survival rates. Adult density had a significant negative effect on female yearling survival; however, the effect is probably trivial. The logistic equation parameters gave $r = 0.327$ and carrying capacity (K) = 240 adult mares.

Conclusions. A density-dependent response is suggested. The population growth is mainly limited by low fecundity, with the reduced adult female survival probably also playing a minor role.

Implications. It is expected that the present long-term demographic study will contribute to the understanding of feral ungulate ecology and improve the management of feral populations.

Introduction

Invasive alien mammals are present worldwide and deemed by some sectors of society to be a serious biodiversity conservation problem (Lever 1994; Long 2003; White *et al*. 2008). Invasive feral ungulates constitute a highly successful group and the management of their populations has motivated considerable effort and investment in many countries, including Australia (Bradshaw *et al*. 2007), New Zealand (Parkes and Murphy 2003) and USA (Douglas and Leslie 1996; Witmer *et al*. 2007).

Feral horses (*Equus caballus*) are large herbivorous mammals considered invasive in many countries (Lever 1994; Long 2003). They are especially abundant in Australia and the western USA and at high population densities have an impact on the environment through overgrazing and trampling, although this has been poorly quantified (Dobbie *et al*. 1993; Beever and Brussard 2000; Dawson *et al*. 2006). Demographic data are crucial to the successful management of feral horse populations (National Research Council 1980; Eberhardt *et al*. 1982; Berger 1986; Duncan 1992) and has been collected since the 1970s. However, most existing studies are short-term and are based mainly on aerial counts (Feist and McCullough 1975; Welsh 1975; Frei *et al*. 1979; Wolfe 1980; Garrott *et al*. 1991). Some long-term studies based on aerial censuses do exist (Eberhardt *et al*. 1982). The literature covering individually identified horses over a period of five or more years is very sparse (e.g. Berger 1986; Garrott and Taylor 1990; Duncan 1992; Goodloe *et al*. 2000; Turner and Morrison 2001; Linklater *et al*. 2004; Grange *et al*. 2009; Tatin *et al*. 2009).

There are many feral horse populations in Argentina, especially in the Patagonia and Cuyo regions, although their size and precise geographic range have not been documented. The pampas region, known worldwide for its grasslands, is one of the most transformed ecosystems under the impact of anthropic activities, with natural protected areas being very few and relatively small. Tornquist Park, a hilly grassland reserve in south-western Buenos Aires province, has the largest known feral horse population in the country (Scorolli 1999), reaching a density as high as 22 horses km^{-2} in 1995. Although no official management strategy currently exists, the control of feral horses is considered to be an essential component of efforts to conserve the biodiversity of this extremely valuable grassland area and to minimise any eventual damage. The aim of the present study was to determine the long-term demography of the Tornquist Park feral horse population and explore the relationships among demographic parameters, population density and

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rainfall so as to develop a scientific basis for an adequate management program.

Materials and methods

Study area

Ernesto Tornquist Provincial Park (ETPP) is located in the south of the Province of Buenos Aires, Argentina, between 38°00′ and 38°07′S and 61°52′ and 62°03′W. This natural reserve was established in 1938 and covers 67 km^2 of hilly grassland, with heights ranging between 450 and 1175 m asl. The climate is temperate and humid (Burgos 1968), with a mean annual rainfall of 800 mm. Rains fall mainly in spring, with a second peak in autumn. Snowfalls are occasional and, in general, light. The typical vegetation is grassland steppe dominated by species of the genera *Stipa* and *Piptochaetium* (Cabrera 1976; Frangi and Bottino 1995).

This Natural Protected Area is very important for biodiversity conservation as it includes many endemic plant and animal species (Kristensen and Frangi 1995). In 1942, a small group of 5–10 horses was introduced into ETPP, eventually becoming feral. In 1995, the 450 descendents of the original group occupied a fenced-off sector of ~20 km^2 (Scorolli 2007). The horses were of Creole breed, similar to all other feral horse populations in Argentina, originating from Spanish and Andalusian horses of essentially African barb ancestry and brought to South America by colonisers during the XVI century (Cabrera 1945).

The feral horse population during the study period comprised between 40 and 66 harem-bands (Scorolli 2007) whose mean home-range area from 1995–1997 was 4.3 km^2 (Scorolli 1999). Their impact on biodiversity in Tornquist Park has not been fully quantified, although some research has suggested that feral horses have modified the composition of the plant and animal community in the area (Zalba and Cozzani 2004; Loydi and Zalba 2009). The convenience of implementing a feral horse management strategy emerged from discussions among rangers, biologists and government authorities.

Census protocol

The feral horses were observed with the aid of binoculars (×10), by walking a fixed path that covered almost the entire 20-km^2 study area over two consecutive days. Data were taken monthly from 1995 to 1997 and 2000 to 2002, and seasonally (four times a year) from 1998 to 1999.

In January–March 1995 female feral horses were individually identified on the basis of coat colour and face and leg markings (Berger 1986; Linklater *et al*. 2004). The individuals were assigned a numerical identification code and their data registered on cards.

The small size of the study area and hilly topography with grassland vegetation provided good visibility, thus facilitating total counts of the female segment of the population. The foals born were registered monthly between August and April and their individual marks recorded. Males in bachelor bands were not registered because these groups were highly unstable and usually located at the periphery and on hilltops.

For operational reasons, it was decided to study the female segment of the population. Mares were classified on the basis of their body size, length of tail and mane as adults (Ad: ≥3 years), juveniles (*j*: 2–3 years old), yearlings (*y*: 1–2 years old) and foals (*f*: 0–1 year old).

The exact adult sex ratio is unknown; however, a mean estimate based on data over 4 years is 0.9 males per female. Population density was calculated as twice the total female count divided by the total area (20 km^2); adult density was calculated in the same manner, but using adult female counts.

Demographic parameters

The foaling season in Tornquist Park extends from August to April, with most foals being born in October, November and December (Scorolli 1999). The biological year runs from the median birth date, 1 November of year t to 31 October of the year $t+1$. The foaling rate (F) was calculated by dividing the total number of foals by the number of adult mares (≥3 years old). Because it is possible that some foals were born and died without being registered, the foaling rates are taken as minimum estimates. The foals born between August and November were considered members of the cohort t.

The survival rate was calculated by dividing the total number of mares in every age class in the November census of year $t+1$ by the number in the census at year t. A horse was assumed to have died if it was registered in one census but not in the remaining censuses in a biological year. Taking into account undetected neonatal mortality, the actual foal survival rate is likely to be lower that the calculated rate. The estimated probability of 'recapture' for individual horses from one month to the next was high, with a minimum estimated value of 0.95 in 1995. Parameter estimates and factors are presented in the text as mean ± standard error. All tests were performed with a selected significance level of $\alpha = 0.05$.

The percentage of adult mares in the total female population and foaling and survival rates were compared with the chi-squared test of equal proportions with the R software package (Crawley 2005, 2007).

We explored the possible effects of adult population density and rainfall on foal, yearling and juvenile female survival by using generalised linear models (GLM) and on adult female survival and fecundity by using generalised linear mixed models (GLMM) (Zuur *et al*. 2009), including an identification code in the model as a random effect to take into account the fact that many individuals were measured repeatedly. The demographic data for survival and fecundity were coded as binary variables, as follows: '1' for survive and '0' for not survive and '1' for adult mare with a foal and '0' for adult mare without a foal. The selected level of significance for retaining a parameter in the model was $P < 0.05$ and models were selected on the basis of the Akaike information criteria (AIC) (Burnham and Anderson 2002). We also tested the possible correlation between factors by means of simple correlation.

The population trend was analysed by fitting the logistic equation to the adult mare count data by means of non-linear least-squares, as suggested by Eberhardt *et al*. (2008).

We used the following equation:

$$N(t) = \mathrm{K}/1 + ce^{-rt}, \quad c = \mathrm{K}/N_0 - 1,$$

where $N(t)$ is population size in year t, K is carrying capacity, r is maximum growth rate and c a constant that includes N_0, the initial population size. For comparative purposes we fitted the same equation to the 8-year data on the Camargue feral horse population reported by Grange *et al*. (2009).

All statistical analyses were performed with the R software package (http://cran.r-project.org, verified 9 April 2010). Rainfall data were obtained from a meteorological database owned by Tornquist Park administrators.

Results

The percentage of adult mares was constant from 1995 to 1998 at 48–55% ($\chi^2 = 2.702$, d.f. = 3, $P = 0.439$), increased up to 64% by 2002 ($\chi^2 = 3.918$, d.f. = 1, $P = 0.048$) and then decreased again to 60–65% ($\chi^2 = 2.231$, d.f. = 3, $P = 0.526$). Over the study period as a whole, foals, yearlings and juveniles together made up between 35 and 52% of the total mare population (Fig. 1).

In 1996, 1997, 2000 and 2001 foals were born between August and April, mostly (~80%) in October–December (Fig. 2), coinciding with late spring. The foaling rate showed no clear trend during the study period, with a mean of 0.55 (Table 1); it was above the mean in 1995 (0.81), then decreasing in 1996 (0.61; $\chi^2 = 9.563$, d.f. = 1, $P = 0.002$), remaining constant until 1998 ($\chi^2 = 2.438$, d.f. = 2, $P = 0.295$), decreasing again in 1999 (0.27; $\chi^2 = 23.413$, d.f. = 1, $P < 0.001$), increasing in 2000 (0.46; $\chi^2 = 15.144$, d.f. = 1, $P < 0.001$) and then remaining constant until 2002 ($\chi^2 = 5.007$, d.f. = 2, $P = 0.082$). The sex ratio of foals was 1 : 1 in all 8 years of the study ($\chi^2 = 5.261$, d.f. = 7, $P = 0.628$) ($n = 692$).

The survival rate of females averaged 0.886 ± 0.026 for adults ($\chi^2 = 7.689$, d.f. = 7, $P > 0.360$), 0.907 ± 0.003 for juveniles ($\chi^2 = 2.981$, d.f. = 7, $P > 0.880$), 0.866 ± 0.052 for yearlings ($\chi^2 = 7.023$, d.f. = 7, $P > 0.426$) and 0.936 ± 0.023 for foals ($\chi^2 = 2.351$, d.f. = 7, $P > 0.938$) (Fig. 3), with little variation among the years (χ^2, $P > 0.05$).

Effects on survival

The GLMM analysis carried out on the 1340 adult mares studied between 1995 and 2002 showed their survival to be unaffected by adult density (slope = 0.017 ± 0.035, $P = 0.614$) and rainfall (slope = -0.00004 ± 0.001, $P = 0.939$). The best-fit model corresponded to a constant adult mare survival of 0.886 ± 0.026

Similarly, GLM analysis of the 278 juvenile mares monitored over the same period showed adult density (slope = -0.019 ± 0.073, $P = 0.791$) and rainfall (slope = -0.001 ± 0.001, $P = 0.672$) to have no significant effect on survival. The selected model was that of constant juvenile female survival (0.907 ± 0.033).

In the case of the 321 yearling mares studied over this same period, however, the GLM analysis revealed highly

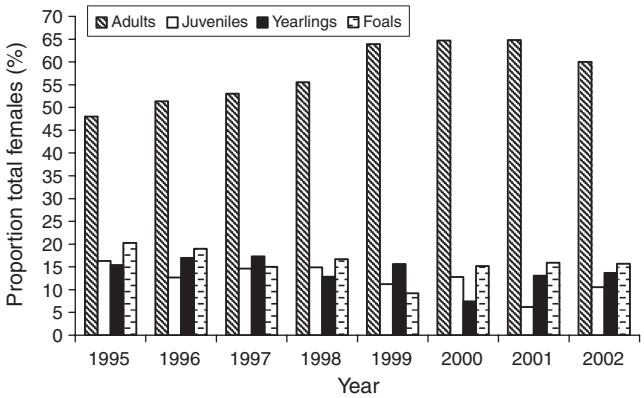

Fig. 1. Age structure as percentage frequency of the female population of feral horses in Tornquist Park during the 1995–2002 period.

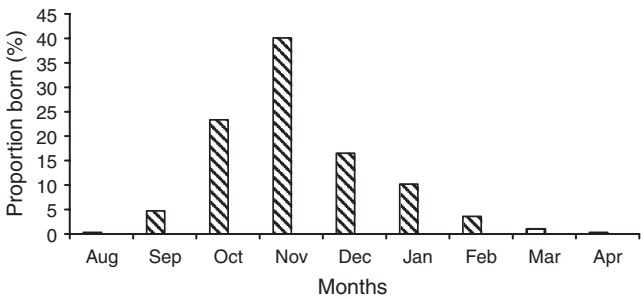

Fig. 2. Percentage of foals born by month in the feral horse population at Tornquist Park in the years 1996, 1997, 2001 and 2002.

Table 1. Total number of foals, adult mares, foaling rate, density and total annual rainfall at Tornquist Park during the 1995–2002 period

N, number of adult females; F, foaling rate

Year	Foals	*N*	F	Adult density (no. of horses km^{-2})	Rainfall (mm)
1995	88	109	0.81	10.9	725
1996	80	130	0.62	13.0	903
1997	78	141	0.55	14.1	1236
1998	98	160	0.61	16.0	847
1999	50	188	0.27	18.8	940
2000	89	192	0.46	19.2	914
2001	103	208	0.50	20.8	1480
2002	120	210	0.57	21.0	1244
Mean ± s.e.	86.5 ± 20.20	167 ± 37.90	0.55 ± 0.05	16.73 ± 3.79	1036 ± 90.10

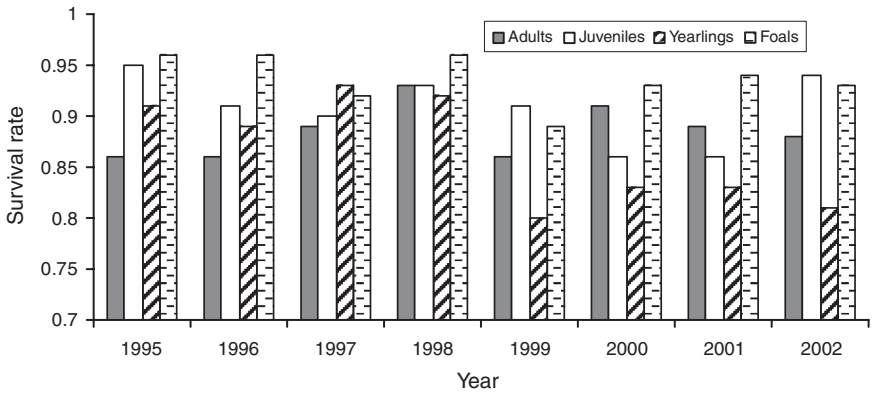

Fig. 3. Survival rate for the different age classes of females at Tornquist Park during the 1995–2002 period.

significant negative effects of adult density on survival (slope = –0.130 ± 0.049, $P = 0.008$) and no significant effect of rainfall (slope = 0.001 ± 0.001, $P = 0.429$). The selected model includes only adult density, and the explanatory power based on the proportion of deviance was 3%.

Adult density (slope = –0.047 ± 0.083, $P = 0.568$) and rainfall (slope = –0.00002 ± 0.001, $P = 0.987$) had no significant effect on survival according to the GLM analysis carried out on the 360 foals covered in the study. The best-fit model was that of constant foal female survival (0.936 ± 0.023).

Table 2. Estimated effect of adult density, rainfall and previous-year rainfall on adult fecundity calculated using generalised linear mixed models (GLMM) at Tornquist Park during the 1995–2002 period

*$P < 0.1$, **$P < 0.05$, ***$P < 0.001$

Parameter	GLMM estimate	s.e.	*Z*-value	*P*-value
Intercept	0.667	0.3952	1.688	0.0913
Adult density	–0.1680	0.0240	–6.974	3.08e–12***
Rainfall	0.0007	0.0003	2.524	0.0116*
Previous-year rainfall	0.0015	0.0002	5.854	4.79e–09***

Effects on fecundity

GLMM analysis of the data for 1340 adult mares showed adult density, rainfall and the previous year's rainfall to have a highly significant effect on fecundity (Table 2). Adult density was not significantly correlated with rainfall ($r = 0.654$, d.f. = 7, $P = 0.078$) or with the previous year's rainfall ($r = 0.472$, d.f. = 7, $P = 0.237$). The selected model includes adult density, rainfall and the previous year's rainfall.

Population trend

The size of the population, calculated on the basis of adult mare counts, increased steadily from 109 in 1995 to 210 in 2002 (Table 1). The logistic curve fitted the Tornquist Park and Camargue data well (Fig. 4). The parameters estimated for the Tornquist Park population were as follows: $r = 0.327 \pm 0.062$, carrying capacity K = 239.990 ± 17.406 and the constant $c = 1.699$; those for the Camargue population were calculated

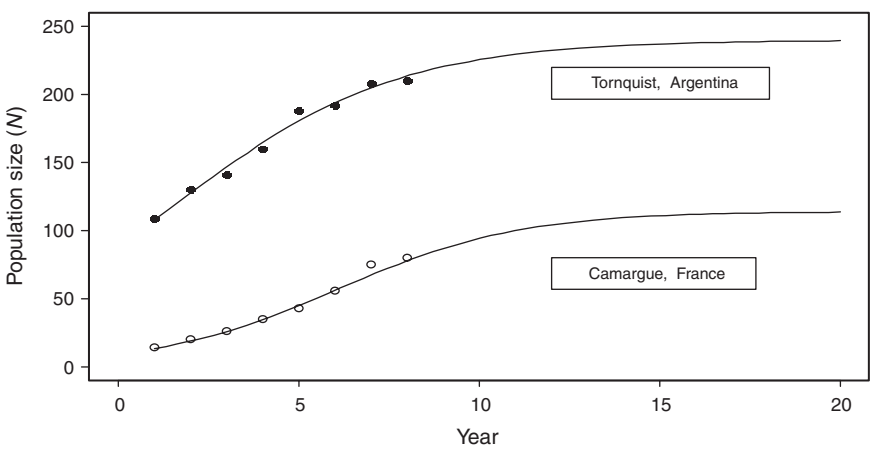

Fig. 4. Logistic curves for the feral horse population of Camargue, France, and Tornquist Park, Argentina. *N* = number of horses.

as $r = 0.399 \pm 0.033$, carrying capacity $K = 113.564 \pm 11.371$ and constant $c = 11.403$

Discussion

The current study is the first study presenting data on feral horse demography in Argentina and constitutes one of the few long-term (>5 years) studies of individually identified feral horses in the manner of the reports by Berger (1986), Garrott and Taylor (1990), Goodloe *et al*. (2000), Linklater *et al*. (2004) and Grange *et al*. (2009). Our results suggested that the feral horse population of Tornquist Park has probably approached carrying capacity and that fecundity and probably also adult survival are density-dependent. Our results were comparable to the values reported for non-managed feral horse populations whose growth is limited by lack of adequate food resources (Goodloe *et al*. (2000) in Cumberland Island, USA, Walter (2002) in the Australian Alps, Australia, Linklater *et al*. (2004) in Kaimanawa ranges, New Zealand, and Grange *et al*. (2009) in the Camargue, France). The observed age structure, with a relatively high and constant ratio of adult mares, suggested that population growth during the study period was slow, as reported by Cameron *et al*. (2001) for a slowly increasing population and Berman (1991) for a decreasing population.

Demographic parameters

Fecundity

All foals were born during the 9-month period from August to April, with a clear peak in late spring, in a pattern very similar to that recorded elsewhere in the southern hemisphere by Linklater *et al*. (2004) and Berman (1991) and in the northern hemisphere by Welsh (1975), Boyd (1979), Keiper and Houpt (1984), Berger (1986), Siniff *et al*. (1986) and Duncan (1992). The 1 : 1 sex ratio of foals observed during our study is congruent with the reports of Monard *et al*. (1997), Linklater *et al*. (2004) and Grange *et al*. (2009).

The foaling rate showed a wide range and no clear trend. However, the GLMM analysis revealed a negative effect of adult density on female fecundity and minor positive effects of rainfall, and previous year's rainfall, indicating a clear density-dependent response. The mean foaling rate was moderate (0.55) and similar to that reported for other non-managed or resource-limited feral horses (0.4–0.65) (Boyd 1979; Keiper and Houpt 1984; Siniff *et al*. 1986; Goodloe *et al*. 2000; Walter 2002; Linklater *et al*. 2004).

The highest value registered in 1995 (0.81) is similar to that reported for feral horses (0.7–0.9) by Salter and Hudson (1982), Keiper and Houpt (1984), Berger (1986) and Duncan (1992). The lowest (0.27) in 1999 is comparable to the lowest recorded value for the species (0.26–0.38) by Siniff *et al*. (1986), Kirkpatrick and Turner (1991), Garrott and Taylor (1990) and Greger and Romney (1999). However, we assume our results to be underestimated because the censuses in 1998 and 1999 were conducted seasonally.

We hypothesise that the moderate foaling rates recorded were caused by low pregnancies in mares with low body condition. Although the age classification we used, with all mares >3 years old being considered as adults, did not permit us to analyse this aspect, the low body condition values for adult mares during 2001 and 2002 (Scorolli 2007) lends indirect support to this hypothesis. Kirkpatrick and Turner (1991) found that low fecundity on Assateague Island, USA, was caused by lactational anoestrus. However, we do not consider this to be an important factor in the present study because many foals dispersed when between 1 and 2 years old, and a large number of mares foaled in consecutive years (A. Scorolli, pers. obs.). We cannot rule out the possibility that social factors such as those reported by Linklater *et al*. (2004) and Tatin *et al*. (2009) played a role in the low fecundity observed in the present study.

Survival

Foal female survival (0.94) was high and similar to that recorded by other authors for feral horses (Boyd 1979; Wolfe 1980; Berger 1986; Siniff *et al*. 1986; Duncan 1992; Cameron *et al*. 2001). The expected decrease in foal survival at high density (Eberhardt 1977, 2002; Fowler 1987) was not observed in Tornquist Park, in agreement with the results of Tatin *et al*. (2009) for Przewalski horses, but in contrast with those for the Camargue as reported by Grange *et al*. (2009). At this stage, we have no explanation for the constant and high foal survival rate; however, the moderate fecundity registered suggests that some mares could have traded their reproduction for survival, foaled only when environmental conditions were suitable and so increased the probability of foal survival.

The results of the GLM showed a significant effect of adult density on yearling female survival; however, the explanatory power of the best-fit model was very low (3%) and suggested a trivial effect. Yearlings could have been potentially more vulnerable to resource limitation than were other female age classes because most of them were already weaned, and still actively growing.

Adult density and rainfall were seen to have no effect on foal or juvenile (2 years old) female survival, as was the case in the study by Grange *et al*. (2009).

Adult female survival showed no clear response to density; values were high (0.86–0.89) and constant during the study period, as expected for large mammals (Gaillard *et al*. 1998). However, the observed values were unusual for feral horses and lower than those reported by Berger (1986) (0.95) ($\chi^2 = 11.334$, d.f. = 1, $P < 0.001$) and Garrott and Taylor (1990) (0.97) ($\chi^2 = 27.592$, d.f. = 1, $P < 0.001$), indicating that this parameter could have played some role in limiting population growth. We suspect that the adult female survival rate was already low before the present study commenced in 1995. Turner and Morrison (2001) reported similar adult survival values (0.80) but without mentioning any possible cause.

Grange *et al*. (2009) found that adult mare survival in the Camargue at high population densities decreased from high (0.9–1.0) to low (0.79–0.86) values, similar to our results, and proposed that feral horses trade survival for reproduction. The Camargue population was studied in its initial growth phase after being introduced into a new environment and, in contrast to our moderate rates, Grange *et al*. (2009) registered very high foaling rates (0.9), which they considered to be caused by artificial selection and the recent feralisation. Nevertheless, our

unusually low adult female survival rates indicate that perhaps some trade-off has occurred in Tornquist Park, and this parameter can be influenced by density dependence although the evidence is not conclusive.

Density dependence

In large mammals, evidence of density dependence was presented in reviews by Fowler (1987), Sinclair (1989) and Gaillard *et al*. (1998, 2000) although equids were poorly represented. Some authors reported food limitation in populations of feral horses (Welsh 1975; Walter 2002; Grange *et al*. 2009) whereas others proposed that social stress was the main limiting factor (Linklater *et al*. 2004; Tatin *et al*. 2009).

The feral horse population at Tornquist Park grew during the study period from a density of 10.9 to 21 adult horses km^{-2}, being one of the highest known densities for feral horses (23.2–35.4 horses km^{-2}) (Tyler 1972; Welsh 1975; Franke Stevens 1990; Duncan 1992).

The results of the present study showed, for the first time, a feral horse population probably approaching carrying capacity. The observed trend in adult mare counts fits well with a logistic model, suggesting that the Tornquist Park population was near the estimated asymptotic value for population size of 240 adult females, corresponding to a density value of 24 adult horses km^{-2}. Although it is recognised that the data series was shorter than desirable, the results nevertheless provided evidence of a density-dependent process.

The intrinsic estimated population growth rate ($r = 0.327$), the maximum attainable at very low densities, was higher than other results for feral horses ($r = 0.16$–0.30) (Garrott *et al*. 1991; Duncan 1992; Walter 2002; Linklater *et al*. 2004) but lower than the value obtained by fitting the logistic equation to the Camargue feral horse data (0.399). The Camargue population was studied during the initial phase of feralisation, and presented an unusually high fecundity rate (0.9–1.0) that could partly explain this very high intrinsic growth rate.

Growth of the Tornquist Park feral horse population appeared to be limited by low fecundity most likely caused by food availability. The role in the population limitation of the relatively low adult female survival observed remains unclear. Conclusions about this confined and relatively small population should not be extrapolated to feral horses under other conditions. The observed density-dependent response in vital rates, even in the absence of a reduced foal survival rate, is in general agreement with that proposed for large mammals by Eberhardt (1977).

Management implications

Our results suggest that the implementation of the management of feral horse population in Tornquist Park, reducing the population to densities similar to or lower than those recorded in 1995, will lead to an increase in demographic rates. The results of the present study could therefore help model the feral horse population demography under different management scenarios.

In the absence of adequate management, the survival rate of adult and yearling mares in the study area will probably fall, mainly as a result of under-nutrition. The welfare implications of this – certain sectors of society, especially animal rights groups, may find it unethical or unacceptable to let feral horses die from starvation – should be taken fully into account in the context of any eventual management strategy to be implemented by the pertinent authorities.

At the end of the study period in November 2002, a mass mortality occurred during a violent rainstorm in Tornquist Park (Scorolli *et al*. 2006). The number of dead horses registered was 193, and 115 of them were females. The proportions of dead females in each age class were 31% for adults, 58% for juveniles, 48% for yearlings and 41% for foals. Since that date, the population has slowly managed to recover somewhat. Between April 2006 and June 2007, the Tornquist Park authorities implemented a population control program and captured 220 feral horses, ~100 male and 120 female, in a mobile corral. The size of the population in 2007 was down to 200 horses, corresponding to a density of six adult horses per square kilometre, providing an opportunity to investigate demographic responses at lower densities.

Confined, non-managed populations of feral mammals with few or no predators can increase in size until they approach carrying capacity and become limited by low fecundity and survival. Many consider it undesirable to arrive at this point, placing responsibility on managers to take ethical and welfare aspects into account when planning management strategies. Long-term demographic studies, especially of individually identified animals, could contribute to a better understanding of the ecology of feral ungulates, allow more reliable population modelling and improve their management.

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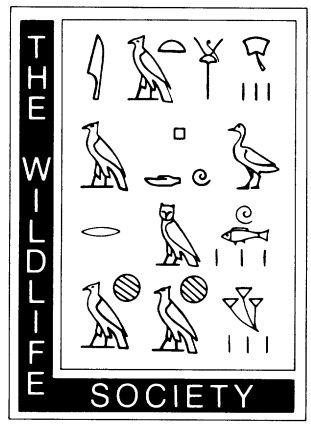

ECOLOGICAL RELATIONSHIPS OF FERAL BURROS AND DESERT BIGHORN SHEEP

by

RICK F. SEEGMILLER AND ROBERT D. OHMART

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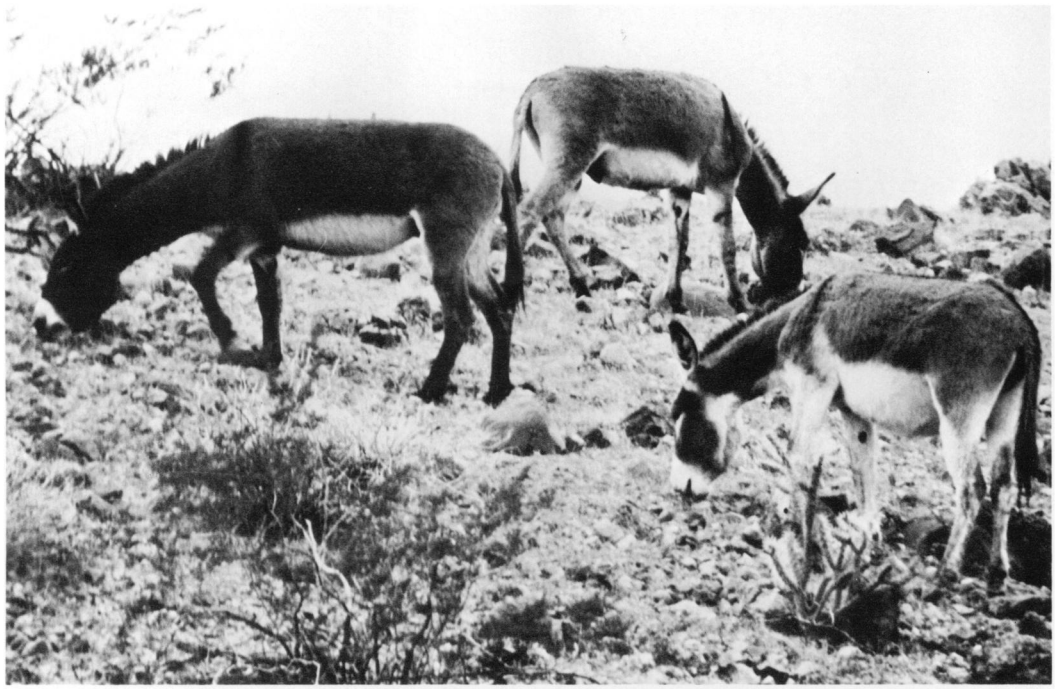

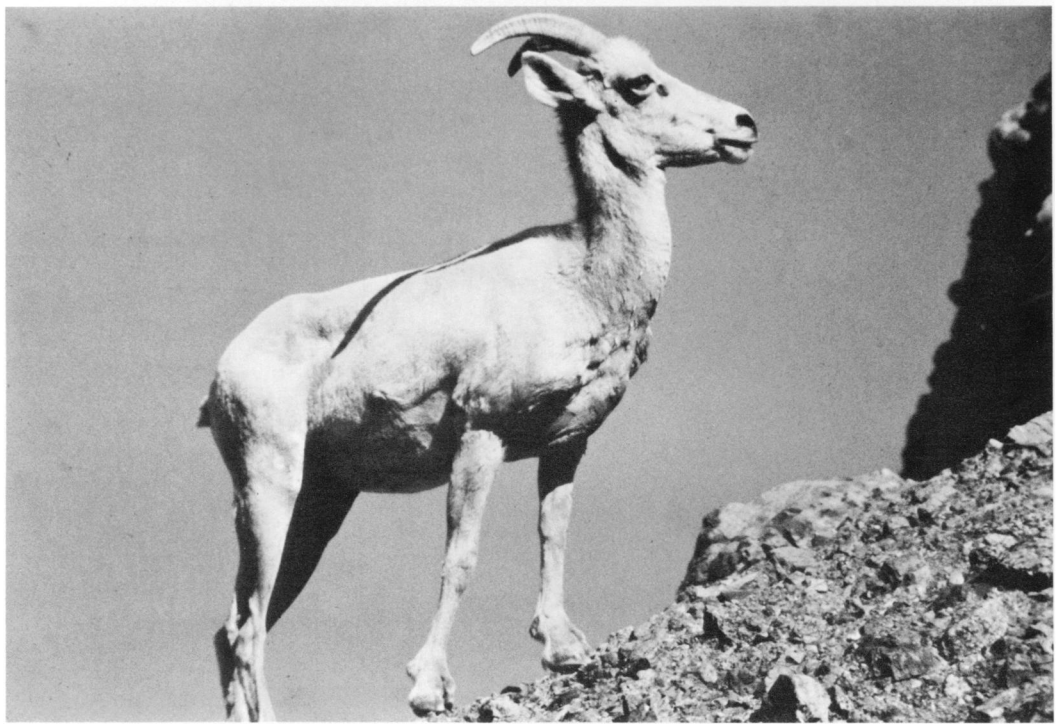

FRONTISPIECE. Group of feral burros foraging on the herbaceous layer (above). An adult ewe desert bighorn sheep (below). (Photos by Rick F. Seegmiller)

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ECOLOGICAL RELATIONSHIPS OF FERAL BURROS AND DESERT BIGHORN SHEEP

Rick F. Seegmiller[1,2] *and Robert D. Ohmart*[1]

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INTRODUCTION

Of the nearly 20 species of free-ranging exotic ungulates that inhabit North America, only a few have become widely distributed and abundant (Laycock 1966, Decker 1978). Among the most successful of those is the feral burro or donkey *Equus asinus*.

The burro is a descendant of the African wild ass of Ethiopia and Somalia. Fossil records indicate that wild asses in Africa were domesticated by approximately 4,000 B.C. (Protsch and Berger 1973).

The burro was first introduced into North America by the Spanish in the 1530s. It was probably not until the latter half of the nineteenth century that burros became widely dispersed in the southwestern United States, primarily through their use as pack animals by prospectors. Following the mining boom and with the advent of the railroad, the need for a hardy pack animal declined. Many burros were abandoned, became feral, and established themselves principally in the desert mountains along or near the Colorado River in Arizona, California, and Nevada (McKnight 1958; Woodward 1976, unpublished doctoral dissertation, University of California, Los Angeles, California).

The impact of feral burros on the native flora and fauna, especially desert bighorn sheep *Ovis canadensis mexicana* and *O. c. nelsoni* has been a source of controversy in the Southwest. One school of thought is that burros are disrupting the "natural balance" (the persistence of a community resulting from its tendency to compensate for perturbations; Slobodkin et al. 1967) of desert ecosystems. Implicit in that assumption is that the invasion of burros has or will induce unnatural and undesirable alterations of the coevolved biota. Those favoring such a viewpoint recommend strong control or elimination of burro populations, particularly where numbers are high or where they are sympatric with desert bighorn sheep. That group implicates the burro as having contributed to the decline of desert sheep numbers since the turn of the century (Russo 1956, Buechner 1960).

The other extreme feels that burros should be preserved in the Southwest because they are a part of our American heritage, a part of the pioneer spirit of the West, and have a significant aesthetic value. Still others take a paleoecological perspective in attempting to justify that burros are just as much a native species as bighorn sheep. The latter notion stems from the theory that burros have refilled a niche vacated by the extinction of the ass-like *Equus conversidens* during the late Pleistocene, approximately 11,000 years B.P. (Martin 1970). The vacant niche theory is a product of Martin's (1967, 1973) overkill hypothesis that postulates that early hominoid hunters from Asia crossed the Bering Platform into North America and moved across the continent in about 500 years, causing the extinction of 31 genera of large mammals, including the native *E. conversidens*. Vacant niches are presumed to have remained, because certain palynological records indicate that the plant species (and habitats) present in the Southwest during the late Pleistocene did not differ greatly from those of today (Martin 1963). However, several counterarguments to both the overkill hypothesis and the vacant niche theory have been advanced by various paleoecologists (e.g., Guilday 1967, Hester 1967, Flint 1971, Corbett 1973, Grayson 1977).

The controversy over burros was intensified with the passage of Public Law 92-195 in December 1971. It is known as the "Wild Free-Roaming Horse and Burro Act" which protects wild horses and burros from unauthorized "... capture, branding, harassment, or death." It eliminated shooting, which prior to the passage of the law had been the primary means of regulation of burro numbers in many areas. Suppression of that control mechanism allowed the already widely dispersed burro population to more fully express its reproductive capacity. Insufficient data regarding burros in the feral

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state, a poorly informed public, and emotionally biased opinions have been the primary sources of opposing views.

Numerous articles have addressed feral burros and their impact on the natural biota and abiota. However, few provide data that are supported by intensive field investigations and quantitative findings. McKnight (1958) comprehensively described the approximate distribution and numbers of burros in the United States and outlined management problems and possible solutions. More recently, researchers have investigated burros regarding their watering patterns (Farrell 1973, unpublished master's thesis, Arizona State University, Tempe, Arizona), social organization and behaviors (Moehlman 1974, unpublished doctoral dissertation, University of Wisconsin, Madison, Wisconsin; Morgart and Ohmart 1976; Morgart 1978, unpublished master's thesis, Arizona State University, Tempe, Arizona; Woodward 1979), population characteristics, movement, habitat use and diets (Morgart and Ohmart 1976, Woodward and Ohmart 1976, Norment and Douglas 1977, Morgart unpublished thesis). In addition, the nutrient content of favored burro forages and burro impact on desert habitats have been examined (Hanley and Brady 1977a, 1977b; Norment and Douglas 1977).

The controversy regarding feral burro impacts on native desert bighorn sheep has attracted much attention (McKnight 1958), yet little field research has been conducted on that subject. Prior to this study, only McMichael (1964, unpublished master's thesis, University of Arizona, Tucson, Arizona) had examined feral burros within desert bighorn sheep habitat and their relationships to one another. Recently, 2 studies of burro and bighorn sheep relationships in northwestern Arizona have been completed (Walker and Ohmart 1978; Walker 1978, unpublished master's thesis, Arizona State University, Tempe, Arizona; Walters and Hansen 1978).

The need for a quantitative investigation of the spatial, temporal, and dietary relationships of sympatric burros and bighorn sheep led to this study. Our objective was to assess the possibility of competitive interaction between the 2 species through an examination of their ecological relationships; these included populations, movements, habitat use, diets, ecological overlap, and social organization.

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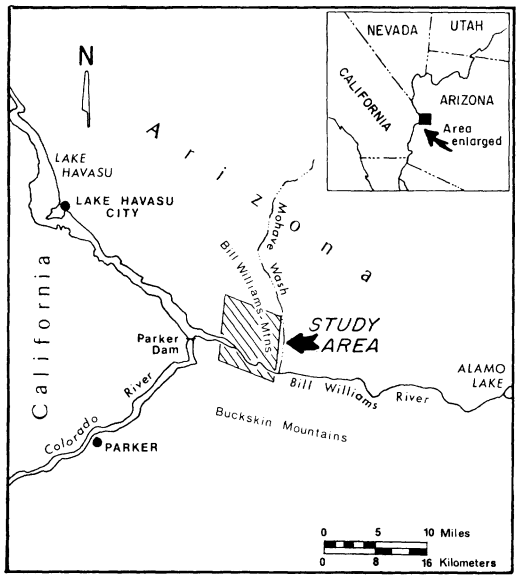

FIG. 1. Study area in the Bill Williams Mountains, Arizona.

STUDY AREA

The study area lies approximately 40 km northeast of Parker, Mohave County, Arizona, principally in the southeastern end of the Bill Williams Mountains (Fig. 1). It encompasses an area of approximately 60 km². The main part of the study area is situated on the north side of the Bill Williams River, just east of the river's delta at Lake Havasu. Occasional observations were made in the other portion of the study area in the Buckskin Mountains, Yuma County, adjacent to the Bill Williams Mountains and directly south of the Bill Williams River. The Planet Ranch, whose cultivated fields and housing facilities border the river, intersects the study area.

The climate in the region is characterized by hot summers and relatively mild winters, with large daily fluctuations in temperature. Analysis of temperature data from Parker, Arizona (elevation 130 m) from 1941 to 1970 yielded an annual mean daily maximum temperature of 31.3 C, and an annual mean daily minimum of 13.5 C (Sellers and Hill 1974). From June 1974 to June 1975, temperatures ranged from a maximum of 47.2 C to a minimum of −2.2 C (National Oceanic and Atmospheric Administration 1974–1975).

Precipitation in the region usually occurs during winter and summer. Winter rains are from storms that sweep in from the Pacific Ocean and that tend to fall gently and steadily for hours or possibly days. Summer rains usually are convective thundershowers that move in from the Gulf of California and the Gulf of Mexico (Jaeger 1957). The mean annual precipitation from 1931 to 1973 was 97 mm, with 62 mm falling from October to March and 35 mm from April to September (Sellers and Hill 1974). Precipitation from June 1974 to June 1975 totaled 49 mm, of which 33 mm fell during December through March (NOAA 1974–1975).

The heavily dissected topography of the area is typified by relatively high talus peaks, mesas, and ridges that slope sharply to washes and foothills of lower elevation (Figs. 2, 3). A broad alluvial floodplain borders the Bill Williams River and supports a dense riparian woodland, except where the Planet Ranch has developed cultivated fields (Fig. 4). Elevations range from approximately 150 m at the river to 597 m at the highest peak.

The dominant plant species on the area are generally indicative of the Colorado Desert (Jaeger 1957). The foothills and the rugged and steep upper regions are generally dominated by creosote bush *Larrea divaricata* Cav., little-leaf palo verde *Cercidium microphyllum* (Torr.) Rose and Johnston, burrobush *Ambrosia dumosa* (Gray) Payne, brittlebush *Encelia farinosa* Gray, staghorn cholla *Opuntia acanthocarpa* Engelm. and Bigel., and ocotillo *Fouquieria splendens* Engelm. Major washes are characterized by little-leaf palo verde, ironwood *Olneya tesota* Gray, smoke tree *Dalea spinosa* Gray, and cheesebush *Hymenoclea salsola* Torr. and Gray. Perennial grasses are scarce, with big galleta *Hilaria rigida* (Thurb.) Benth. being the most common. A low annual herbaceous cover, pro-

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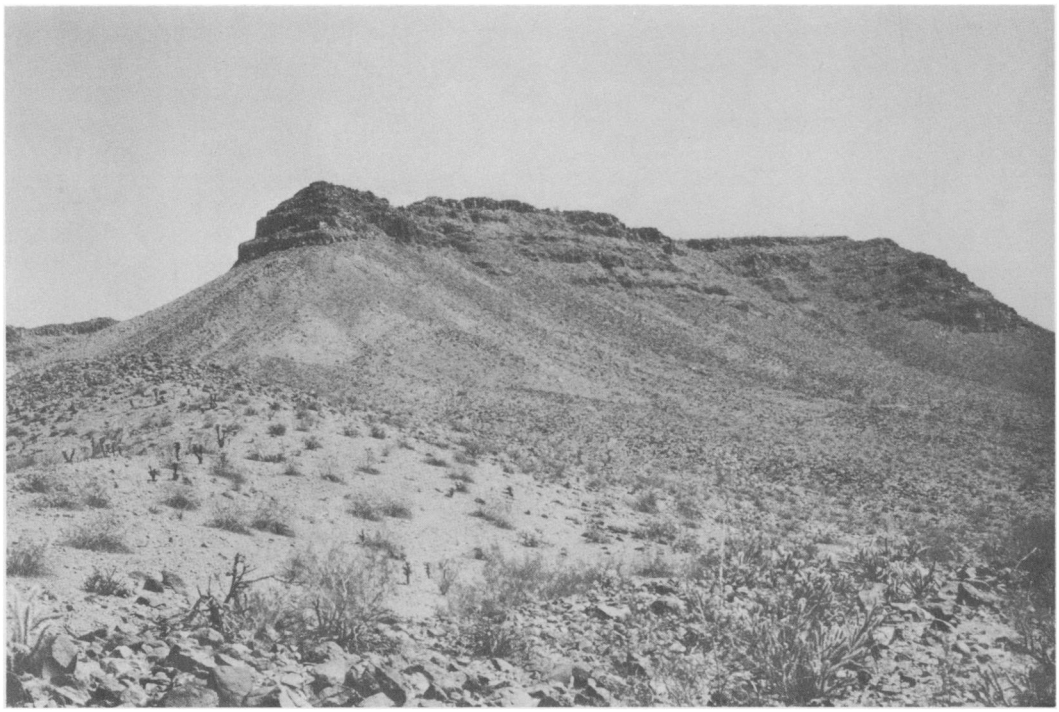

FIG. 2. The more gentle topography on the study area. The long steep slopes extending from this mesa typify the habitats most commonly shared by burros and desert bighorn sheep during the cooler months. The lower flat or rolling foothills were habitats frequently used by burros, but seldom used by bighorn sheep.

duced after winter rains, was dominated by Indian wheat *Plantago insularis* Eastw. The riparian woodland is characterized by cottonwood *Populus fremontii* Wats., Goodding willow *Salix gooddingii* Ball, salt cedar *Tamarix chinensis* Pall., and honey mesquite *Prosopis glandulosa* Torr. Fields cultivated by the Planet Ranch primarily supported bermuda grass *Cynodon dactylon* (L.) Pers. and wheat *Triticum aestivum* L.

The only known permanent water sources were the Bill Williams River and irrigation catchment ponds in the cultivated fields. Alamo Dam, upstream, impedes natural flow of the river and forms Alamo Lake. Free water was present in portions of the river bed during the winter months, but declined in volume as summer approached. Temporary free water became available in washes and in potholes or tinajas following heavy precipitation.

Mule deer *Odocoileus hemionus* and cattle *Bos bos* were the only other ungulates present on the study area. Mule deer were relatively scarce and were seen infrequently. They preferred the riparian woodland and cultivated fields, although they were seen occasionally in the desert habitats. Cattle were pastured on the cultivated fields of the Planet Ranch, but in late summer were released into the riparian woodland. Cattle never were seen utilizing desert areas.

The only potential predators on sheep or burros that commonly occurred in the area were coyotes *Canis latrans* and bobcats *Felis rufus*, although neither appeared to be common in the desert habitats. Mountain lion *Felis concolor* tracks were observed on 1 occasion.

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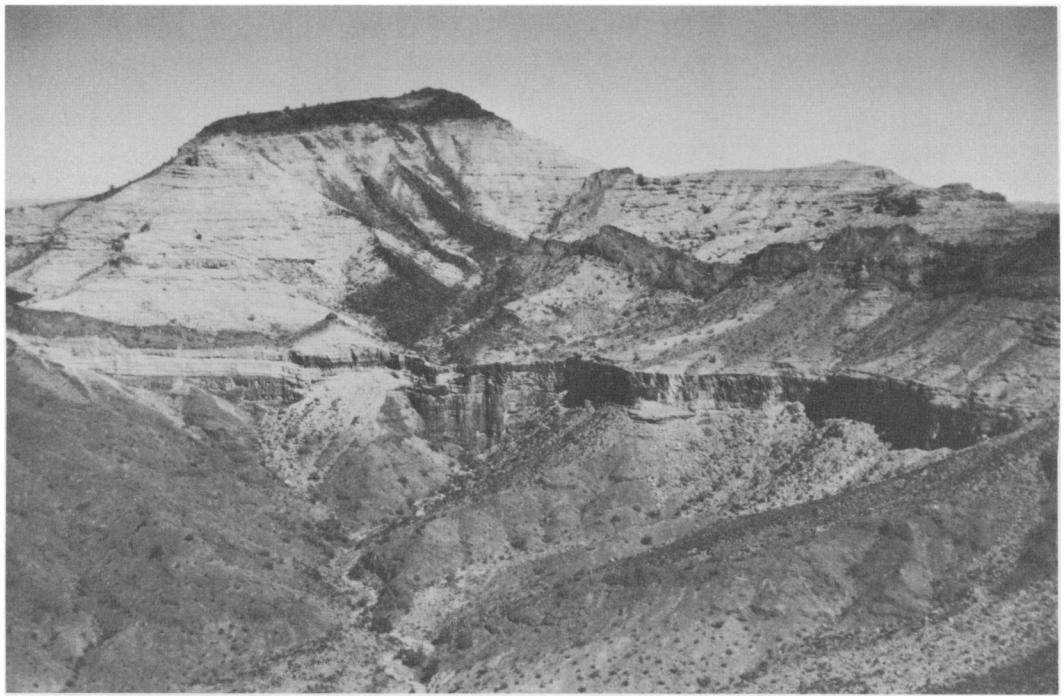

FIG. 3. The highest peak on the area (597 m) typifies the rugged talus terrain that slopes sharply to the lower foothills and washes. These high, rugged areas characterize both the lambing grounds and the habitats seldom used by burros.

METHODS AND MATERIALS

Capture Procedures

Thirty burros (Table 1) and an adult ewe bighorn sheep were captured using the immobilizing drug M99 (Etorphine) combined with the tranquilizing agent azaperone. Dosages used on burros consisted of 2.25 mg M99 and 30 mg azaperone (Ohmart 1974). The ewe was restrained with 2.00 mg M99, 20 mg azaperone, and 2.3 mg atropine. The drug mixtures were injected into the animals upon impact of a syringe shot from a carbon dioxide charged rifle. The effects of M99 were antagonized with 4.5 mg M50-50 (Diprenorphine).

Twenty-three of the 30 captured burros and the ewe were marked with colored (10 cm wide) or radiotransmitter collars (Telonics; Mesa, Arizona) and served as aids in procuring movement and behavioral data. All captured adult jennies were accompanied by either 1 or 2 (each of a different generation) colts. Table 1 lists each of the marked burros, their ear tag number, type of collar, sex, age, and date of capture.

Ages of marked burros were estimated by dentition eruption, replacement, and wear criteria developed from horses (Davis 1966). Woodward (unpublished dissertation) found the dentition eruption and replacement criteria for horses to parallel that in burros, although wear criteria for a full permanent dentition are subjective. Ages of unmarked burros were estimated subjectively as either adult, yearling (1 to 2 years of age), or foal (less than 1 year of age), based on size relative to known age marked burros. Marked burros are referred to by their age, sex, and ear tag number, e.g., yearling jack No. 470, and unmarked burros by age, sex, and letter initials, e.g., adult jack B-S.

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FIG. 4. Aerial view (looking north) of a portion of the study area. The Bill Williams Mountains lie to the north of both the fields cultivated by the Planet Ranch and the Bill Williams River; the latter passes between the 2 fields. The dissected foothills to the left of the fields were shared commonly by burros and bighorn sheep during the warmer months.

Field Observations

Work was initiated in May 1974 and terminated in June 1975. Observations were aided by a 2-wheel drive motorcycle that facilitated access into the study area. Accessibility was limited by lack of roads, dense riparian vegetation, and precipitous topography. One of several major drainages was chosen and ascended daily so that the study area was broadly surveyed every 3 to 4 days. Searching on foot began upon reaching a location where burros and/or bighorn sheep were seen most frequently. High vantage points were sought for viewing and reception of radio signals from instrumented animals.

Upon sighting burros or bighorn sheep, an attempt was made to remain concealed to eliminate possible influence on behavior. Generally, both burros and bighorn sheep became alarmed and stared intently or fled when they detected the observer. For that reason, observations usually were made from distances greater than 150 m.

Bighorn sheep or burros observed were noted as to body color (gray, brown, or fawn), age (adult, yearling, or foal/lamb), sex, collar channel or color (if marked), and distinctive morphological features (if unmarked). Binoculars (7 × 50 mm) aided in locating groups and identifying individuals. Date, time of day, plants foraged on, and the general activities and behaviors of individuals were recorded ad libitum (Altmann 1974). Also, the type of habitat occupied and the geographic location (plotted on a map) were recorded for each herd or individual sighted.

Population Estimates

Estimates of burro numbers on the study area were made using 2 methods,

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TABLE 1.—BURROS CAPTURED AND MARKED IN THE BILL WILLIAMS MOUNTAINS, ARIZONA, 1974–1975

Ear tag number	Kind of collar	Sex	Estimated age (yrs.)[1]	Date of capture
				1974
468	Radio	F	1.5	11 Jan
469	—	M	10.0	11 Jan
470	Radio	M	1.0	19 Feb
1	Colored[2]	F	2.5	19 Feb
2	Colored	F	5.0	19 Feb
3	Colored	M	4.0	19 Feb
4	—	F	6.0	19 Feb
11	Colored	F	8.0	19 Feb
12	Colored	F	—	19 Feb
14	Colored	M	—	19 Feb
36	—	M	0.5	17 Nov
38	Radio	M	8.0	17 Nov
39	Colored	F	6.0	17 Nov
40	Colored	F	9.0	17 Nov
41	—	M	6 weeks	17 Nov
42	Colored	F	4.5	17 Nov
43	Colored	M	2.0	17 Nov
44	Colored	F	9.0	17 Nov
45	—	F	2.0	17 Nov
46	—	M	6 weeks	17 Nov
47	Colored	F	9.0	18 Nov
48	Colored	F	1.5	18 Nov
49	Colored	F	6.0	18 Nov
50	Colored	M	1.0	18 Nov
51	Radio	M	2.0	18 Nov
52	Colored	F	9.0	18 Nov
53	Radio	M	13.0	18 Nov
				1975
65	—	F	3 months	23 Apr
66	Radio	M	10.0	23 Apr
67	Radio	F	10.0	23 Apr

[1] Ages estimated by dentition eruption, replacement, and wear (after Davis 1966).
[2] Each collar was uniquely colored.

each based on a different set of assumptions. One was a cumulative count of marked (color or radiocollared), recognizable (unmarked, but with distinctive morphological features, i.e., scars, facial markings, broken ear, etc.), and nonrecognizable (specific identity unknown; only color, age, and sex recorded) burros. The other was a ratio estimator, the Schnabel binomial model (Seber 1973).

The cumulative count was made by first listing and counting all marked and recognizable burros observed on the study area during a given sampling period. The nonrecognizable (distinguishable only by color, age, and sex) burros seen each day during the sampling period were then placed in 1 of 12 color–age–sex classes (gray or brown adult, yearling or foal, male or female). The number of distinguishable, nonrecognizable burros within each class was then summed for each day. The maximum number of different nonrecognizable burros seen during any one particular day in each class was added to the list of marked and recognizable burros. The total represented a minimum approximation of the number of distinguishable individuals that used the study area during a given sampling period.

The study area was too large and the topography too dissected to allow an accurate direct count of the entire burro population in a few days or even weeks. Therefore, a cumulative count was made over a sampling period of adequate duration to ensure that most of the animals present on the area would be encountered, distinguished, and counted; that sampling period was determined subjectively to be 2.5 to 3.0 months. Counts were made during 3 periods: June through August 1974, January through March 1975, and April through June 1975. By dividing the counts made throughout the study into 3 periods, some of the biases brought about by possible burro immigration and emigration were reduced. Also, time periods of equal lengths were chosen to balance the probabilities of seeing a high number of nonrecognizable burros in each color–age–sex class within 1 day.

Although the counts represented a minimum estimate of the number of burros that used the study area during the sampling periods, they probably overestimated the average of the number present at random points in time. That was because the counts included individuals that may have visited the area infrequently and for durations less than the total sampling period, as well as those habitually seen. Therefore, the cumulative counts may approximate the maximum number of individuals on the area at any point in time during the sampling period.

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Sex, age, and color ratios were derived from burros identified by the cumulative counts during each time period.

Several implicit assumptions must be made in using the cumulative count method; they include the following: (1) duplicate recordings of nonrecognizable individuals were not made during a single day's observation, (2) recognizable burros were always recognized, and (3) all nonrecognizable burros were classified consistently as to age, sex, and color throughout the sampling period.

During January through April and May through June 1975, counts were made of bighorn sheep on the study area. Numbers were estimated, as in burros, by a cumulative count of marked, recognizable, and nonrecognizable individuals. The procedures followed those described for burros except that body color, which did not vary greatly in bighorn sheep, was not used in the nonrecognizable sheep categories to distinguish individuals. The 2 time periods were selected because of apparent substantial changes in the number of sheep. Population counts were not made prior to those periods because sheep were neither followed intensively nor observed critically and distinguished until November when the ewe was radiocollared.

Another estimate of the burro population was made using the Schnabel binomial model (Seber 1973), which was a weighted average of the Lincoln–Petersen ratio estimator. The population estimate was based on successive observations (samples) of marked and unmarked burros using the following formula:

$$N = \left(\sum_{i=1}^{s} M_i n_i\right) \Big/ \left(\sum_{i=1}^{s} m_i\right)$$

where N = estimate of population number, M = total number of marked animals at time i, n = number of animals in the sample at time i, m = number of marked animals in the sample at time i, and s = number of samples.

Each different burro herd or solitary individual sighted within a day constituted a sample. Estimates were made from observations during 3 time periods, June through August 1974, January through March 1975, and April through June 1975. The time periods were identical to those used in the cumulative count of populations and thus allowed comparison of the 2 methods. Also, the time periods were considered of short enough duration to show possible seasonal changes in burro numbers on the study area and constrained the 95 percent confidence intervals within 20 percent of the population estimates. The confidence intervals were calculated using the sum of binomial variances (Seber 1973) and were asymmetrical around the means.

Home Ranges

Recognizable burros sighted 10 or more times (days) in at least 3 different months during May through August 1974 (summer) and/or January through April 1975 (winter–spring) were selected for seasonal home range calculations. None of the sheep was marked or intensively tracked during May through August 1974; therefore bighorn sheep seasonal home ranges were calculated from observations only during January through April 1974 (winter–spring) and during May through June 1975 (spring–summer). The seasonal home ranges were calculated from the months in which more consistent and adequate observational records were obtained. The months were grouped to illustrate the major seasonal changes in the area occupied.

Home range sizes also were calculated for individual burros located more than 20 times (days) in at least 7 different months during May 1974 through June 1975. Home ranges were estimated for bighorn sheep located more than 20 times (days) in each of the 6 months from January through June 1975.

The area of the home ranges was determined by connecting the outlying points of location (Mohr 1947). The area within the polygon was measured with a planimeter. Most of the areas probably are minimal estimates of actual home ranges.

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In general, the Bill Williams River formed the southern boundary of all burro home ranges, except when sightings were made of those individuals roaming south of the river into the Buckskin Mountains. Some burros were not observed at or south of the river, but the river was used as the southern boundary to account for year-round movements to and from permanent water. Bighorn sheep seasonal and semiannual home ranges were measured on the basis of observed locations only, because they apparently did not travel to permanent water in or near the river during winter and early spring.

Nonparametric tests were used to compare and contrast home range sizes, when number of samples permitted, to avoid the assumptions of parametric statistics. Comparisons of 2 and 3 groups were made using the Mann-Whitney and Kruskal-Wallis tests, respectively (Zar 1974).

Habitat Use

Subunits of the study area were determined by dividing the landscape into 7 major habitat types distinguished on the basis of combinations of vegetational and topographic attributes of the terrain. Those were factors thought to demonstrate most critically habitat partitioning between burros and bighorn sheep. Those habitats were described as follows:

1. Foothills: choppy, rolling or flat interfluves (bajada) of less than 300 m elevation; dominated by creosote bush, little-leaf palo verde, and burrobush (Figs. 2, 3, 4).
2. Long steep slope: steep slopes that extended to lower major drainages from mesas, peaks, or ridges of generally greater than 370 m elevation; relatively well vegetated and dominated by little-leaf palo verde, brittlebush, and burrobush (Fig. 2).
3. Rugged talus terrain: talus bluffs, ridges or peaks, generally greater than 300 m elevation with a very rocky or gravelly substrate; relatively sparse in vegetation, especially annual plants; dominated by little-leaf palo verde, desert holly *Atriplex hymenelytra* (Torr.) Wats. and brittlebush (Fig. 3).
4. Washes: sandy bottomed drainages generally greater than 10 m wide; dominated by little-leaf palo verde, ironwood, and smoke tree (Fig. 4).
5. Mesas: broad, flat-topped peaks and ridges generally greater than 300 m elevation; dominated by ocotillo, little-leaf palo verde, and creosote bush (Figs. 2, 4).
6. Cultivated fields: agricultural fields maintained by the Planet Ranch; dominated by bermuda grass and wheat (Fig. 4).
7. Riparian vegetation: streamside vegetation that bordered the Bill Williams River throughout the floodplain; dominated by honey mesquite, cottonwood, Goodding willow, and salt cedar (Fig. 4).

Diets

Quantification of the amounts and diversity of plant species eaten by burros and bighorn sheep was accomplished through microscopic analysis of fecal material; similar to that described by Free et al. (1970). The use of this technique combined with field observations provided a more complete understanding of the diets, especially relative to the amounts of small, low-growing forbs and grasses consumed by the animal. Even with binoculars, at 150 m, such plants usually were inconspicuous to the observer.

Burro feces were collected only from individuals observed defecating. Samples were designated as to whether they were from adults, yearlings, or foals. Bighorn sheep feces were collected less discriminately, but included only pellets still moist inside or those with a dark, shiny, unweathered surface. All were assumed to have been deposited within a few weeks prior to collection. Lamb feces

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were distinguished from those of yearlings and adults from March to August by their much smaller size. Yearling and adult sheep feces could not be distinguished on the basis of size.

More than 20 burro and 20 bighorn sheep fecal samples were collected each month from June 1974 through June 1975, except September, November, and December. After collection, the samples were air dried, labeled, and packaged. Twenty burro and 20 bighorn sheep samples from each month were ground in a Wiley Mill through a 1.0 mm screen. Monthly samples from burros were selected and combined to make a composite of 12 adults, 4 yearlings, and 4 foals. The monthly samples from sheep were selected to form a composite of 16 adults and/or yearlings, and 4 lambs. Those proportions approximate the estimated age ratios of the burro and bighorn sheep populations and thus provide dietary estimates more representative of each population.

One-quarter teaspoon of ground material from each monthly composite was mixed in a Waring blender and washed over a 0.1 mm screen. Twenty microscope slides were prepared from the material so that approximately 3 discernible plant fragments (i.e., epidermal cells, stomata, silica cells, trichomes, etc.) occurred in each microscope field of view at 100 power magnification (Sparks and Malechek 1968). Microscope slides also were made from a collection of 124 species of plants from the study area that provided a reference to the diagnostic features of available forage plants. Each slide was treated with Hertwig's clearing solution (Baumgartner and Martin 1939) and Hoyer's mounting medium (Baker and Wharton 1952).

Twenty microscope fields were located systematically on each fecal slide, yielding 400 fields per month. The fields were examined for the presence or absence of discernible fragments from each plant species. A valid field contained at least 2 identifiable plant fragments. Frequency of occurrence of fragments for each monthly composite was converted to particle density per field (Fracker and Brischle 1944). The particle density of each plant species divided by the total number of particles of all species yielded the percentage relative density, which has been reported to approximate percentage dry weight (Sparks and Malechek 1968). However, Sparks and Malechek analyzed only plant species mixtures that were compounded by hand and not subjected to digestion.

It is possible that highly digestible plants, such as forbs, may be underrepresented by fecal analysis. Conversely, plants of lower digestibility, such as many grasses and shrubs, could conceivably be overestimated. Hansen et al. (1973), however, reported that digestion of highly digestible species reduced the mean size of plant fragments but did not decrease significantly the total number of fragments. Similarly, microscopic analyses and comparisons of rumen and fecal samples from individual bighorn sheep (Todd and Hansen 1973), deer (Anthony and Smith 1974), and pronghorn (Smith and Shandruk 1979) revealed similar species composition. In any event, biases in the technique are assumed to be similar for both burros and bighorn sheep, thereby allowing a valid dietary comparison.

Indexes of overlap in both the seasonal diets and the seasonal use of habitats by burros and bighorn sheep were calculated by summing the percentage use in common (Y)

$$\sum_{i=1}^{n} Y_i$$

for each forage species or habitat i during a particular season; n = the total number of forage species eaten or habitats used (Anthony and Smith 1977). A value of 100 would indicate that both species consumed all of the same forages or used all of the same habitats in the same proportions, whereas a value of 0

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TABLE 2.—SEASONAL ESTIMATES OF POPULATION NUMBERS, DENSITIES, AND ANNUAL RECRUITMENT RATES OF FERAL BURROS AND DESERT BIGHORN SHEEP IN THE BILL WILLIAMS MOUNTAINS, ARIZONA, 1974–1975

	Burros							
	Population estimate				Approximate area size (km^2)	Density estimate (No./km^2)	Recruitment rate estimates (%)	
Season	Cumulative count	Schnabel	95% C.I.[a]	s[b]			Direct count	Age ratio
Jun–Aug 1974	92	57	57.9 ± 10.7	198	28	2.0–3.3	—	—
Jan–Mar 1975	89	55	55.9 ± 8.5	134	60	0.9–1.5	—	—
Apr–Jun 1975	88	57	58.1 ± 8.9	116	57	1.0–1.5	—	—
Annual	—	—	—		—	—	20	23

	Bighorn sheep				
	Population estimate	Approximate area size (km^2)	Density estimate (No./km^2)	Recruitment rate estimate (%)	
Season	Direct count				
Jan–Apr 1975	17	10	1.7	—	
May–Jun 1975	13	13	1.0	—	
Annual	—	—	—	7	

[a] 95% confidence intervals for the Schnabel population estimates using the sum of binomial variances (Seber 1973) are asymmetrical about the means.
[b] Sample size for the Schnabel estimate.

would indicate that no forages or habitats were shared.

THE POPULATIONS

Population Estimates

Burros

Cumulative counts of burros on the study area showed little variation between seasons (Table 2). Ninety-two individuals used the study area during June through August, 89 during January through March, and 88 during April through June, which yielded an annual average of 90 burros. The counts may approximate the maximum number of individuals on the area at any point in time during the sampling period, because they include individuals that may have visited the area infrequently, as well as those habitually seen. Thus, the counts probably overestimate the average of the number of burros present on the area at random points in time during the sampling period.

Seasonal population estimates using Schnabel's binomial model showed a mean of 57 burros on the study area during June through August, 55 during January through March, and 57 during April through June (Table 2). The maximum number of marked animals (M) on the study area during each season was 7, 13, and 17, respectively; the seasonal sample sizes (s) were 198, 134, and 116, respectively. The 95 percent confidence intervals about the population estimates were within 20 percent of the mean estimates.

The distribution of burros encompassed the entire study area of approximately 60 km^2 during January through June 1975, but from June through October 1974, burros occupied approximately 28 km^2. Therefore, estimations of burro seasonal densities were 2.0 to 3.3 km^2 from June through October, 0.9 to 1.5 from January through March, and 1.0 to 1.5 km^2 from April through June. In northwestern Arizona, Walker and Ohmart (1978) reported the density of burros to range from 1.1 to 2.5/km^2 throughout the year.

Bighorn Sheep

From a cumulative count, a minimum of 14 adult and yearling sheep were identified on the area from January through April. Including 3 lambs born in late January or early February, the figure of 17 sheep was thought to be a close approximation of the actual population during January through April (Table 2). After April, none of 4 adult rams was observed until early July, leaving at least 13 sheep

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TABLE 3.—ESTIMATES OF AGE, SEX, AND COLOR RATIOS OF FERAL BURROS IN THE BILL WILLIAMS MOUNTAINS, ARIZONA, FROM CUMULATIVE POPULATION COUNTS, 1974–1975

	Estimated numbers	Sex ratio male:female	Color ratio gray:brown:fawn	Age ratio adult:yearling:foal
Population	90	84:100	1,575:825:100	346:92:100
Adults	58	76:100		
Yearlings	15	133:100		
Foals	17	89:100		

on the study area from April to July. Initiation of the breeding season in early July was evident when 2 reproductively active rams arrived on the study area (Golden and Ohmart 1976).

Based on sightings during January through April, the 17 identified sheep occupied approximately 10 km^2; from May through June, 13 sheep traversed approximately 13 km^2. Density estimates based on those data for the respective month groupings are 1.7 and 1.0 sheep/km^2. Similar estimates from northeastern Arizona ranged from 1.5 to 1.9/km^2 during one year (Walker and Ohmart 1978). The density of bighorn sheep in mountain ranges across Nevada averaged 0.7/km^2 (n = 25) and ranged from 0.1 to 2.3/km^2 (McQuivey 1978); these values may not be comparable to our density estimates because they were based on total available habitat, whereas ours were calculated only from habitat used.

Population Structure

Burros

Sex, age, and color ratios of the burro population showed no seasonal change. Accordingly, mean annual values of sex, age, and color ratios are discussed. A population age ratio of 346 adults to 92 yearlings to 100 foals (n = 90) was calculated (Table 3). The age structure of 20 captured adults (greater than about 2 years of age) was determined to be: 20 percent were less than 3 years old, 10 percent were in their 3rd year or less than 5, and 70 percent were in their 5th year or older (Table 1). Only 1 burro, jack No. 53, was aged at over 10 years. The total sample of 30 captured burros (Table 1) cannot be used to calculate a population age ratio with the aforementioned 3 age groups, because burros less than about 1 year old usually were avoided in the capturing process. It was feared the nonexpandable collars would either slip off over the head or eventually choke the growing colt.

A younger age structure was reported from 20 captured adult burros in the Chemehuevi Mountains, California. Only 25 percent were more than 3 years of age (Woodward unpublished dissertation). Woodward attributed the young age structure to the cessation of human predation with enactment of Public Law 92-195 in 1971. In Death Valley where a National Park Service burro trapping program has resulted in preferential removal of females and young animals, Norment and Douglas (1977) reported an age ratio of 898 adults to 74 yearlings to 100 foals with 69 percent over 4 years of age. In northwestern Arizona, the age ratio of burros was 389 adults to 37 yearlings to 100 foals (Walker and Ohmart 1978).

The population sex ratio was estimated to be 84 males to 100 females (n = 90) (Table 3). The sample of 30 captured burros had a sex ratio of 75 males to 100 females (Table 1). The sex ratio of both adults and foals followed that pattern of predominantly females. The sex ratio of the yearling age group, in contrast, was predominated by males. However, the relatively small numbers of individuals in the yearling and foal age groups negated a clear interpretation of the sex ratio estimates. Twenty foals were known to be born on the study area, 10 jacks and 10 jennies, suggesting an even sex ratio at birth.

The trend of the sex ratios in the Bill

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Williams Mountains (predominantly females) differed from the majority of other studies (McMichael unpublished thesis, Moehlman unpublished dissertation, Woodward unpublished dissertation, Norment and Douglas 1977, Walker and Ohmart 1978). Morgart and Ohmart (1976), on the other hand, observed a similar sex ratio of 75 males to 100 females in approximately 100 burros on Bandelier National Monument, New Mexico.

Three major coat colors were distinguishable and were used to obtain a color ratio of 1,575 gray to 825 brown to 100 fawn (n = 90) (Table 3). The color ratios among each of the 3 age groups showed a consistent trend of predominantly gray, followed by brown and fawn. There were no fawn-colored yearlings observed, but 2 adult jacks, 1 adult jenny, and a jenny foal possessed that distinctive color. The 20 foals born on the area had a color ratio of 1,000 gray to 800 brown to 100 fawn, which generally conformed with the population color ratio.

The genotypes of burros initially introduced into an area no doubt have a major effect on coat color in subsequent generations, but climatic factors associated with elevation may be important also. For example, in the Chemehuevi Mountains, at low elevations of about 150 to 250 m, the color ratio of burros was 614 gray to 100 brown or black in a sample of 37 adults (Woodward unpublished dissertation). Both the elevation and predominance of gray burros were similar to those in the Bill Williams Mountains. In Death Valley National Monument, at higher elevations from about 1,000 to 2,900 m, a predominance of brown or black adult burros (44%), followed by gray (34%), roan gray (20%) and paint (2%) was reported (Moehlman unpublished dissertation). At elevations from 1,615 to 2,494 m on Bandelier National Monument, nearly all burros are brown or black (Morgart and Ohmart 1976). Comparative observations have shown that burros on Bandelier National Monument have thicker and bushier coats than burros in the Bill Williams Mountains (J. R. Morgart pers. comm.). The colder climates in the higher elevated areas may have selected for thicker coats and darker coat colors, which enables greater heat absorption (Hamilton 1973).

Bighorn Sheep

The 17 bighorn sheep on the area prior to May consisted of 11 adults, 3 yearlings, and 3 lambs. Of the 11 adults, 7 were ewes and 4 were rams (2 Class I, 1 Class II, 1 Class III; after Geist 1971). The yearling age group was comprised of 2 rams and a ewe. The sex of the 3 lambs was not determined.

After April, the 4 adult rams were not seen and were presumed to have moved off the study area. The spring ewe-to-lamb ratio was 233 ewes to 100 lambs (n = 10).

The bighorn sheep population in the Bill Williams Mountains was considered too small to justify a projection of age and sex ratios; projections from studies of larger populations are as follows. In northwestern Arizona, Walker and Ohmart (1978) reported a sex ratio of 184 adults to 28 yearlings to 100 lambs in a population of about 34 sheep. From counts of desert sheep at waterholes throughout western Arizona between 1950 and 1954, the age ratio averaged 461 adults to 39 yearlings to 100 lambs and the sex ratio averaged 120 rams to 100 ewes (Russo 1956). The sex ratio of desert sheep in other studies has ranged from nearly 1 to 1 (Deming 1963, Monson 1963) to a predominance of ewes (Aldous 1957, McQuivey 1978, Walker and Ohmart 1978, Leslie and Douglas 1979).

The relatively low number of rams in the Bill Williams Mountains (73:100) is not considered a result of hunting. Bighorn sheep hunting in Arizona is restricted to mature rams with three-quarter or larger horn curls. Since 1961, only 4 rams were reported to have been taken in the Bill Williams Mountains near the Planet Ranch, the most recent in 1969. From 1974 to the present, the area has been

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closed to bighorn sheep hunting (Arizona Big Game Investigations 1961–1975).

Reproduction and Population Dynamics

Burros

Twenty different adult jennies were observed with recently born foals whose birth dates were estimated to range from April 1974 to June 1975. The months of birth were estimated by backdating from their current ages, as determined by relating their sizes to those of known-age colts. A predominant season of foaling could not be determined using chi-square analysis (Woolf 1968), although a sample of 20 foals may not have been adequate to detect seasonality. The gestation period is approximately 12 months (Walker 1975).

Woodward (unpublished dissertation) did not detect a seasonal peak in foaling in the Chemehuevi Mountains. Moehlman (unpublished dissertation) and Norment and Douglas (1977) reported foaling in burros throughout the year in Death Valley, but observed a peak during late spring and summer. Morgart and Ohmart (1976) observed newborn colts only during June through November in Bandelier National Monument. The latter populations live at higher elevations where seasonally cold climates may select for breeding and foaling during more favorable periods.

Natural mortality in burros of all ages appeared to be quite low in this study. None of 23 marked individuals was known to have died, and only 1 case of natural mortality (1% mortality rate) was documented throughout the study despite regular and intensive coverage of the lightly vegetated landscape. The observed mortality was that of a jack of approximately 2 years of age, who was found very sick and unable to walk, and soon died. Examination of blood samples and organ tissue samples failed to reveal the cause of death (E. J. Bicknell pers. comm.). Eleven burro carcasses were discovered, 8 prior to initiation of the study in January 1974 and 3 in June 1974, but all had been shot. The carcasses were found in or around the cultivated fields. These were not considered natural mortality, and the 8 shot in January were not incorporated in the population estimates. No other recent burro carcasses were encountered.

Two methods were used to examine natality (number of births/population number producing foals) in the burro population during the study and each methodology was based on different assumptions. One estimate was based on a direct count of newborn foals on the study area. Since foaling did not occur exclusively during a particular season, natality was estimated from foals born during June 1974 through May 1975. Annual natality was calculated from the summation of natality estimates during each of the 3 seasons in which cumulative population counts were made. Sixteen of the 20 foals born on the study area were born during June 1974 through May 1975 and were produced by an annual average of 79 adults and yearlings; this yielded an annual natality of about 20 percent. Evidence of natural mortality in foals was not observed. Therefore, natality may approximate the annual recruitment rate (number of newborn foals that survive to 1 year of age/population number that produces foals) of the burro population (Table 2). Also, since natural mortality in adult burros appeared low, the 20 percent annual recruitment rate suggests that the burro population increased during the study.

Another estimate of annual natality in the burro population was made using the age ratio of the population. However, "only when age ratios are supported by estimates of rate of increase and of survival or fecundity can they be interpreted critically" (Caughley 1974:562). Therefore, because natural mortality in burros was believed low in all age groups and the population appeared to be increasing, the percentage of foals (19) divided by the percentage of adults and yearlings (81) yielded an estimated 23 percent an-

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nual natality. Assuming low foal mortality, that figure may have approximated the annual recruitment rate (Table 2).

The one documented case of natural burro mortality may not have been a precise estimate of actual mortality in the population. However, we conclude that natural mortality was low and that the estimate of annual recruitment represents an increase in the burro population during the year of study, perhaps at a rate as high as 19 to 22 percent. The seasonal population estimates on the study area did not indicate an increase in numbers, but emigration of several individuals from the study area was documented in the spring of 1975 and probably counteracted a measurable increase in burros within the bounds of the relatively small study area (60 km^2). It is suspected that the burro population over a broader area that encompassed the study area was growing in numbers.

In the Chemehuevi Mountains, Woodward and Ohmart (1976) reported a 20–25 percent recruitment rate in the burro population every 13–18 months. In Death Valley, an increase in the burro population was calculated at nearly 22 percent annually over a 4.5-year period (Norment and Douglas 1977). The burro population existing in a pinyon *Pinus* spp.–juniper *Juniperus* spp.–grassland association on Bandelier National Monument was estimated to have an annual recruitment rate of 29 percent (Morgart and Ohmart 1976).

Jennies in the Bill Williams Mountains less than about 1.5 years old were not observed to be sexually active. Moehlman (unpublished dissertation) reported that the age of first estrus in jennies was about 1.5 years, while Woodward (unpublished dissertation) stated that the first estrus possibly occurred around the age of 10 months.

Bighorn Sheep

Three lambs were born on the study area during January and February. On 28 January the first newborn lamb was observed with its mother, 3 other ewes, and a young adult ram. Between 28 January and 2 February, the radiocollared ewe gave birth to a lamb. The third lamb was not positively identified until March, but was the same size and approximately the same age as the others. During June, 2 lambs were missing and presumed dead, one of which was the progeny of the radiocollared ewe. The third survived at least into January 1976, about a year after birth. The 2 lambs were the only documented cases of natural sheep mortality during the year of study. Accordingly, an estimated 33 percent lamb survival, a 21 percent natality, and a 7 percent annual recruitment rate was computed. The estimate of annual recruitment cannot be reliably interpreted as an increase in the bighorn sheep population. Any undocumented mortality in the small sheep population would neutralize or exceed the estimated 7 percent annual recruitment rate.

The bighorn sheep lambing season in the Bill Williams Mountains corresponded to the season of highest production and abundance of desert forage; winter and spring rains promoted growth in both the annual and perennial desert plants. Similarly, Russo (1956) found that most desert bighorn lambs in Arizona were born between January and March. In southern Nevada the peak in lambing occurred during late February or early March (January to mid-April; Leslie and Douglas 1979) and during April or early May in central Nevada, although young lambs have been observed during almost every month of the year (Hansen 1965, McQuivey 1978). Consequently, the peak of rutting activity in desert sheep may occur from July through October, complementing a gestation period of about 180 days (Frost 1942). Bighorn sheep from colder climates breed in November and December and lambing occurs in the more favorable periods between April and June (Geist 1971).

DAILY AND SEASONAL MOVEMENTS

Movements of burros during summer followed a consistent daily pattern. Dur-

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ing daylight, burros remained in the foothills or washes mostly standing and resting, with occasional foraging. Adults seldom were seen in a bedded position. Numerous sightings were made of burros standing in direct sunlight when temperatures were in excess of 46 C, but they generally sought shade in midday. Continuous, single-file movements to the riparian communities began in the late evening or night, usually before 2000 hours. Nocturnal observations of burros consisted only of occasional sightings while driving adjacent to the river. The infrequent observations, combined with audible brays from jacks and fresh sign (i.e., tracks and droppings) found every morning, indicated heavy burro use of the riparian vegetation and agricultural fields at night. Burros left the riparian areas and traveled back to the desert in the early morning hours, usually by 0600 hours.

During cooler months, a consistent movement pattern was not detected. Also, only sporadic treks by burros were made to the river, as indicated by greatly reduced tracks and droppings along routes to and from the riparian areas. More frequent diurnal foraging and moving, and correspondingly less standing and resting, also were observed during the cooler months.

The repeated treks of burros to and from the riparian communities have carved numerous trails in the landscape throughout the area. Trails on slopes were deeply eroded. In nearby Alamo Lake State Park, Farrell (unpublished thesis) reported that the sandy soils of the region were not compacted when disturbed by burros. However, inhibition of plant growth and accelerated erosion resulted on heavily traveled locations.

The distances that burros and bighorn sheep moved from the Bill Williams River or other permanent water sources (i.e., irrigation ditches and catchment ponds) varied seasonally (Fig. 5). During the warmer periods, June through October 1974 and May through June 1975, both burros and bighorn sheep remained relatively close to permanent water, as

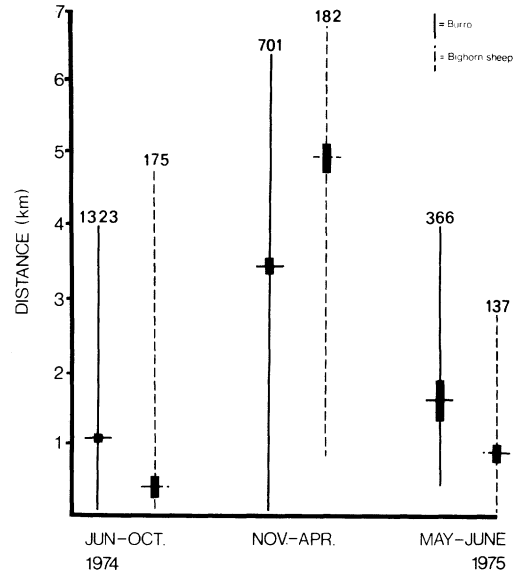

FIG. 5. Seasonal distances of feral burros and desert bighorn sheep sightings from the Bill Williams River or other permanent water sources. Horizontal line = mean distance; vertical line = range of distances; bar = 95 percentage confidence intervals; numbers denote number of sightings.

water requirements were high (Turner 1973, unpublished doctoral dissertation, University of California at Riverside, Riverside, California; Tomkiewicz 1979, unpublished master's thesis, Arizona State University, Tempe, Arizona). Burros maintained mean distances from water of 1.1 and 1.6 km, respectively, during those seasons. Similarly, burros in Death Valley remained within 2 km of permanent water during summer (Norment and Douglas 1977). Bighorn sheep maintained mean distances from water of 0.5 and 1.0 km, respectively. The mean distance of 0.5 km during June through October may be an underestimate, since mostly incidental observations of bighorn sheep (no radiotracking) were made during those months, mostly around water or cultivated fields. A concerted effort to track bighorn sheep was not initiated until November when a ewe was fitted with a radiotransmitter collar.

Blong and Pollard (1968) reported that ewes, lambs, and young desert bighorn sheep in the Santa Rosa Mountains, California, remained within 1.2 km of water

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holes during July and August, but rams traveled out as far as 4.8 km. Similarly, 82, 70, and 49 percent of sheep sighted during summer in southeastern Utah (Irvine 1969), northwestern Arizona (Walker and Ohmart 1978), and southern Nevada (Leslie and Douglas 1979), respectively, were within 1.6 km of water.

Convective storms in late July and early August 1974 provided temporary water in a few locations at 4.0 km or more from the river. At that time, burros and bighorn sheep frequently were observed near those sites, whereas prior to the rains they were seen only within 2.4 km of the river.

During the cooler months, November through April, sporadic rains supplied temporary free water and succulent annual vegetation, permitting burros and bighorn sheep to venture farther from permanent water sources. During that period, burros and sheep moved mean distances of 3.5 and 5.0 km, respectively, from permanent water. During the cooler seasons in Death Valley, burros were seen mostly beyond about 3.2 km from the nearest water (Norment and Douglas 1977). Desert sheep in southern Nevada were sighted 53 percent of the time at distances beyond 3.2 km from water in February through April (Leslie and Douglas 1979). In contrast, Walker and Ohmart (1978) reported that only 10 percent of sheep sightings during winter in northwestern Arizona were 3.2 km or farther from water.

WATERING

Burros

Burros were not seen watering during daylight hours. Watering appeared to be primarily, if not exclusively, a nocturnal activity and was concentrated at certain sections of the river. During summer, burros dug holes daily in the moist sand of the river floodplain and in desert washes after rains, which allowed free water to seep into the excavation. The large number of such holes adjacent to surface water of the river suggests a preference for that type of water.

At Alamo Lake State Park (40 km to the east), Farrell (unpublished thesis) also observed a nocturnal burro watering preference. In contrast, McMichael (unpublished thesis), Moehlman (unpublished dissertation), and Woodward (unpublished dissertation) reported a predominantly diurnal watering habit. Preferred nocturnal watering by burros may be a direct result of human harassment.

When water requirements increased during the hottest months (Tomkiewicz unpublished thesis), burros appeared to water every 24 hours, as evidenced by their daily late evening or night travels to the riparian vegetation and daily fresh sign at water. Increased frequency of summer watering also was reported by Moehlman (unpublished dissertation), Woodward (unpublished dissertation), Norment and Douglas (1977), and Tomkiewicz (unpublished thesis).

Sign of burros defecating, urinating, or wading in water from the river was not observed. However, where water was in short supply, Dixon and Sumner (1939), Russo (1956), Weaver (1959), and Buechner (1960) reported that burros foul, usurp, and monopolize the water holes. On the other hand, pollution of water at watering sites used by burros was not observed by Welles and Welles (1961), McMichael (unpublished thesis), Farrell (unpublished thesis), Moehlman (unpublished dissertation), or Woodward (unpublished dissertation).

Bighorn Sheep

Bighorn sheep watered at almost any hour of the day during the summer, and as frequently as every other day. Irrigation ditches and catchment ponds were the major sources of water. Bighorn sheep never were observed within 4.0 km of permanent water during December through March, which contrasts to observations by Walker and Ohmart (1978) and Leslie and Douglas (1979).

From observations in the Bill Williams

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TABLE 4.—SEASONAL AND ANNUAL HOME RANGES OF FERAL BURROS AND DESERT BIGHORN SHEEP IN THE BILL WILLIAMS MOUNTAINS, ARIZONA, 1974–1975

Individuals	May–Aug 1974			Jan–Apr 1975			May 1974–Jun 1975		
	Home range size (km²)	No. of sightings	Length of record (mos.)	Home range size (km²)	No. of sightings	Length of record (mos.)	Home range size (km²)	No. of sightings	Length of record (mos.)
				Adult jacks					
No. 3	4.4	18	4	11.4	10	4	12.4	37	12
No. 53	2.8	19	3	10.9	28	4	12.2	60	12
No. 66	4.7	19	3	9.6	24	4	11.9	50	10
B-S	2.1	12	3	8.0	16	4	8.8	35	10
No. 38				12.7	13	4	12.7	21	8
G-R	5.7	24	3						
T-S	10.6	17	3						
Mean:	4.9			10.4			11.7		
Standard error:	1.2			0.8			0.7		
				Adult jennies					
No. 468	4.9	27	4						
G-A	4.7	11	3						
B-R	4.1	21	3				15.0	27	7
No. 11	6.5	28	3				33.2	42	11
No. 5	6.5	12	3				10.1	22	7
No. 2	6.0	26	4	11.9	23	4	15.3	56	12
No. 1	7.5	15	4	60.1	10	4	60.1	27	12
No. 44				13.2	16	4	13.2	27	8
No. 40				14.8	11	4			
No. 42				21.0	13	4			
Mean:	5.7			24.1			24.3		
Standard error:	0.5			9.1			7.9		
				Yearling jacks					
No. 14	5.7	27	4	8.5	14	3	12.4	42	9
W-B	8.0	15	4	22.8	10	4	28.0	31	11
No. 470	17.6	46	4				23.3	55	10
Mean:	10.4			15.5			21.2		
Standard error:	3.6			7.2			4.6		
				Yearling jennies					
S-L	3.1	15	3						
T-W	12.2	11	3						
Mean:	7.5								
Standard error:	4.6								
	May–Jun 1975			Jan–Apr 1975			Jan–Jun 1975		
				Bighorn sheep					
Radiocollared ewe	11.4	17	2	13.2	25	4	27.2	43	6
Yearling ewe	8.6	12	2	8.6	14	4	19.4	26	6
Mean:	10.1			10.9			23.3		

Mountains during the summer of 1975, Golden and Ohmart (1976) reported a slight preference by bighorn sheep for watering during the morning hours. Individuals watered as frequently as on 2 successive days, although breaks of several days usually separated sightings. Russo (1956), McMichael (unpublished thesis), and Simmons (1969, unpublished doctoral dissertation, University of Arizona, Tucson, Arizona) also observed a preferred morning watering. During summer, bighorn sheep have been reported to visit water at intervals ranging

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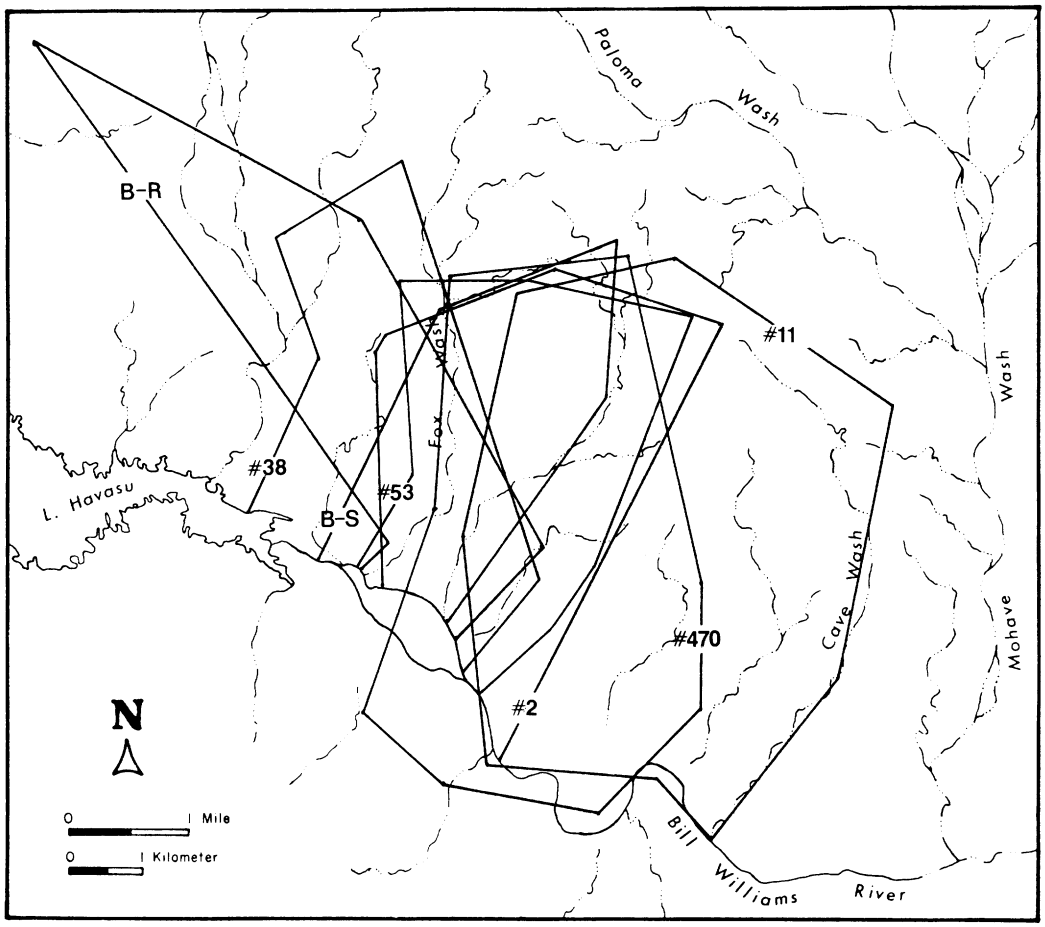

FIG. 6. Spatial relationships of annual (May 1974–June 1975) home ranges from 7 selected feral burros (Nos. 2, 11, 38, 53, 470, B-R, and B-S).

from 1 to 6 days (Welles and Welles 1961, Blong and Pollard 1968, Simmons unpublished dissertation). Those data were supported by a physiological study of penned and free-ranging desert sheep in southern California; the study showed that a minimum of 4 to 5 percent of their body weight in water is required daily in summer (Turner unpublished dissertation).

HOME RANGE

Burros

Seasonal and/or annual home ranges were plotted and measured for 22 marked or otherwise recognizable burros, 7 adult jacks, 10 adult jennies with foals, 3 yearling jacks, and 2 yearling jennies (Table 4).

Seasonal and annual home ranges of both jacks and jennies showed little spatial partitioning and therefore overlapped one another substantially (Figs. 6, 7). The sizes of the summer (May–August 1974) home ranges were significantly smaller ($P < 0.05$) than winter–spring (January–April) home ranges; a similar trend in seasonal home ranges also was reported in Death Valley National Monument (Norment and Douglas 1977).

The mean size of jack home ranges was smaller and less variable than those of

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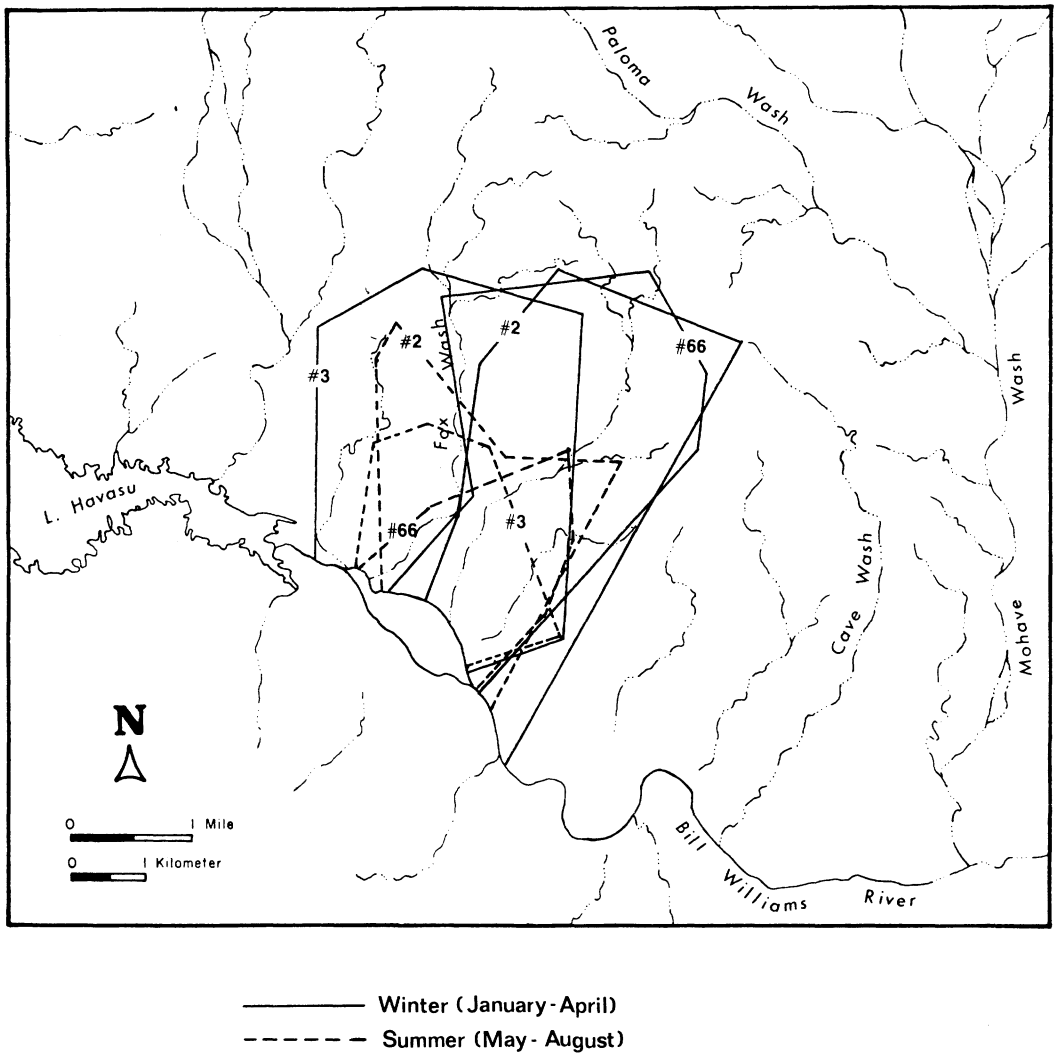

FIG. 7. Spatial relationships of seasonal (May–August and January–April) home ranges from 3 selected feral burros (Nos. 2, 3, and 66).

jennies, except during summer (May–August). However, there was no statistical difference between mean home range sizes ($P > 0.05$) between sexes in all age groups, apparently due to the wide variability among the annual and winter–spring home range sizes of jennies. Moehlman (unpublished dissertation), Woodward (1979), and Norment and Douglas (1977) also reported great variability but no substantial differences between home range sizes of the sexes.

Adult jenny No. 1 had the most divergent winter–spring and annual home range size, 60.1 km^2, that far exceeded in size all other home ranges. In March 1975, she moved from the study area, leaving behind her oldest of 2 colts (an approximately 1.5-year-old jack). In April, she was located approximately 18 km northwest of the point of capture in February 1974. The measured area was conservative since the extension of her movements was represented by only 2 observations, neither of which was beyond 4 km from water at Lake Havasu. It

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was uncertain whether that movement indicated use of a large home range or dispersal to a new area. Nevertheless, a similar burro range extension in spring also was observed by Woodward (unpublished dissertation). Dispersal in young burros was not observed.

During summer, adult jennies with colts of less than about 3 months of age, i.e., jennies No. 468, G-A, and B-R, all ranged over significantly smaller ($P < 0.05$) areas than did jennies with older colts. No such pattern was evident during the cooler months, suggesting that during the summer lactating jennies might have been more restricted in their movements than nonlactating jennies because of increased water requirements.

Home ranges of adults were significantly smaller ($P < 0.05$) than home ranges of yearlings only during summer. Sample size of yearling winter–spring and annual home ranges may be insufficient to demonstrate differences from adults, if they exist.

Yearling jack and yearling jenny home ranges were highly variable in size. During summer, yearling jack No. 470 seldom was seen associated with his mother and had the largest home range (17.6 km²) of yearling jacks. His mother appeared to be adult jenny No. 11, who had a much smaller summer home range (6.5 km²). Yearling jacks No. 14 and W-B frequently were observed with their mothers, jennies No. 2 and No. 1, respectively. These 2 jacks occupied smaller home ranges of 5.7 km² and 8.0 km², respectively, that were of similar size to their mothers' home ranges, 6.0 and 7.5 km², respectively. During winter and spring, the above pattern was not observed. Seasonal and annual mean home ranges of yearling jacks were consistently larger than those of adult jacks.

The 2 yearling jennies never were observed with their maternal parents. S-L appeared to be about 1 year of age and had a smaller home range (3.1 km²) than T-W (12.2 km²), who was approximately 2 years old. T-W was observed primarily with bachelor jack groups and was seen copulating on a number of occasions. S-L usually associated with jennies and colts and never was observed to be sexually active.

The annual home ranges of burros in the Bill Williams Mountains ($\bar{x}$ = 19.2 km², n = 14) were significantly smaller ($P < 0.05$) than those both in Death Valley National Monument ($\bar{x}$ = 68.1 km², n = 24), where distinct summer and winter home ranges were occupied (Norment and Douglas 1977) and in the Chemehuevi Mountains, California ($\bar{x}$ = 31.9 km², n = 12), where an extensive riparian habitat and cultivated fields were lacking (Woodward 1979). In contrast, annual home ranges in pinyon–juniper–grassland associations of Bandelier National Monument, New Mexico ($\bar{x}$ = 2.9 km², n = 21) were significantly smaller ($P < 0.05$) (Morgart unpublished thesis).

Bighorn Sheep

Seasonal and semiannual home ranges were plotted and measured for the radiocollared ewe and a recognizable yearling ewe. The home ranges of the radiocollared ewe slightly exceeded in size and overlapped those of the yearling ewe (Table 4, Fig. 8). The radiocollared ewe and the yearling ewe occupied 13.2 and 8.6 km², respectively, during January through April. From May through June they occupied 11.4 and 8.6 km², respectively. From January through June 1975 the radiocollared ewe ranged 27.2 km² and the yearling ewe ranged 19.4 km².

In southern Nevada, the annual home ranges of ewes averaged 16.9 and 8.2 km² for radiocollared adults (n = 5) and marked yearlings (n = 4), respectively (Leslie and Douglas 1979). They also reported that the seasonal home ranges in radiocollared adult ewes (n = 4) averaged 9.8 km² from September through January, 4.8 km² from February through April, and 6.5 km² from May through July.

Infrequent sightings of at least 4 adult rams on the study area, which ceased altogether after April, suggested that they

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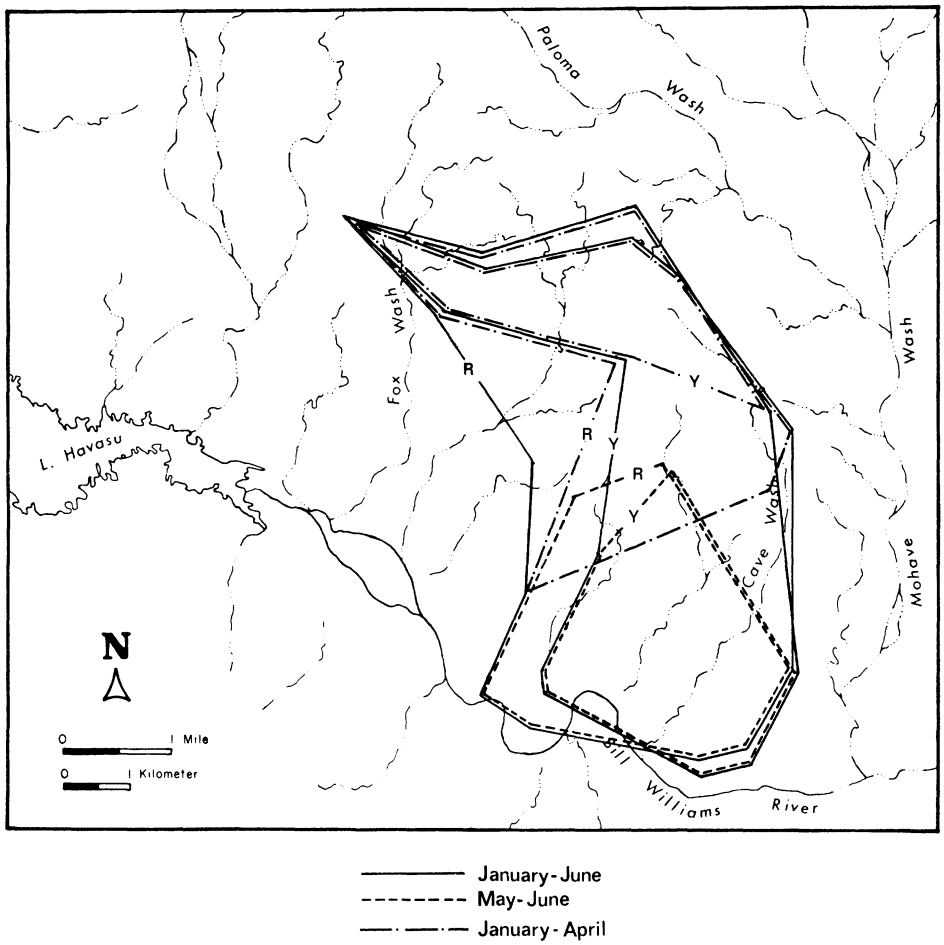

FIG. 8. Spatial relationships of semi-annual (January–June) and seasonal (January–April and May–June) home ranges of the radiocollared ewe (R) and a yearling ewe (Y).

roamed out of the study area and that they probably had larger home ranges than ewes. That assumption was supported by data from southern Nevada, where it was found that annual home ranges of radiocollared adult rams ($\bar{x}$ = 24.7 km², n = 5) were nearly half again as large as those of adult ewes (Leslie and Douglas 1979).

DISTRIBUTION AND OVERLAP

The distribution of burro and bighorn sheep sightings varied seasonally but showed that both species occupied much of the same area year-round. The distributions are considered relatively coarse-grained, because they were measured by the outer perimeter of the sightings on the study area. Distributions of both species were plotted to show areas of sympatry during June through October 1974, November through March 1974–1975, and April through June 1975.

The distribution of burros was larger than that of bighorn sheep in each season. During June through October, burros occupied 65 percent of the range of bighorn sheep (Fig. 9). Distributional overlap of bighorn sheep range by burros reached its peak (100%) during November through March when the distribution

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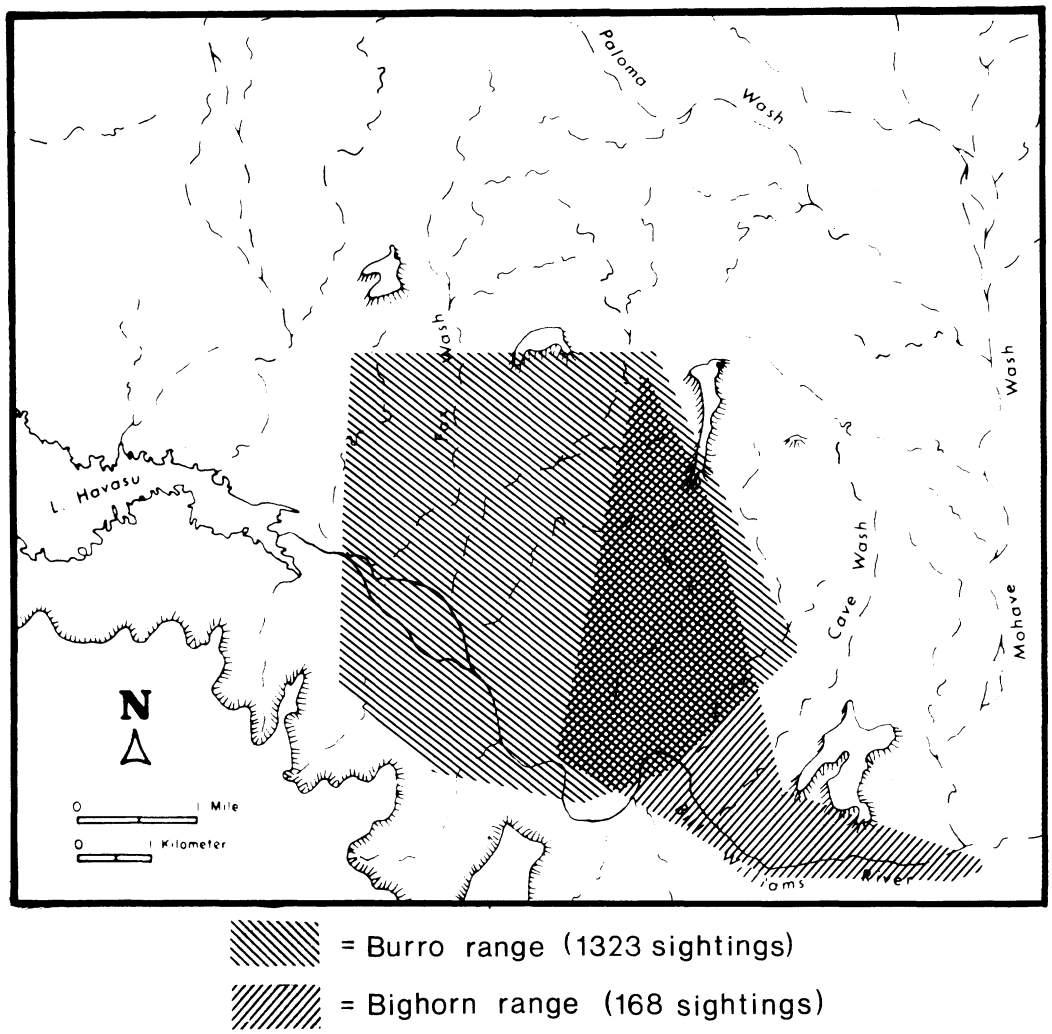

FIG. 9. Distribution of feral burro and desert bighorn sheep sightings in the Bill Williams Mountains, Arizona (June–October 1974).

of burros completely encompassed that of bighorn sheep (Fig. 10). During April through June, the overlap of burros on bighorn sheep range was 85 percent (Fig. 11). The number of burro sightings within the area of distributional overlap exceeded that of bighorn sheep during all seasons.

HABITAT USE

A seasonal comparison of the percentage frequency of burro and bighorn sheep sightings in the 7 habitat types recognized in the study area is summarized in Table 5. The 7 types were foothills, long steep slopes, rugged talus terrain, washes, mesas, cultivated fields, and riparian vegetation. The major seasonal changes in habitat use were shown by comparing data from June through October 1974, November through March 1974–1975, and April through June 1975.

Burros

Burros were observed most frequently in foothills during all 3 seasons: 59 per-

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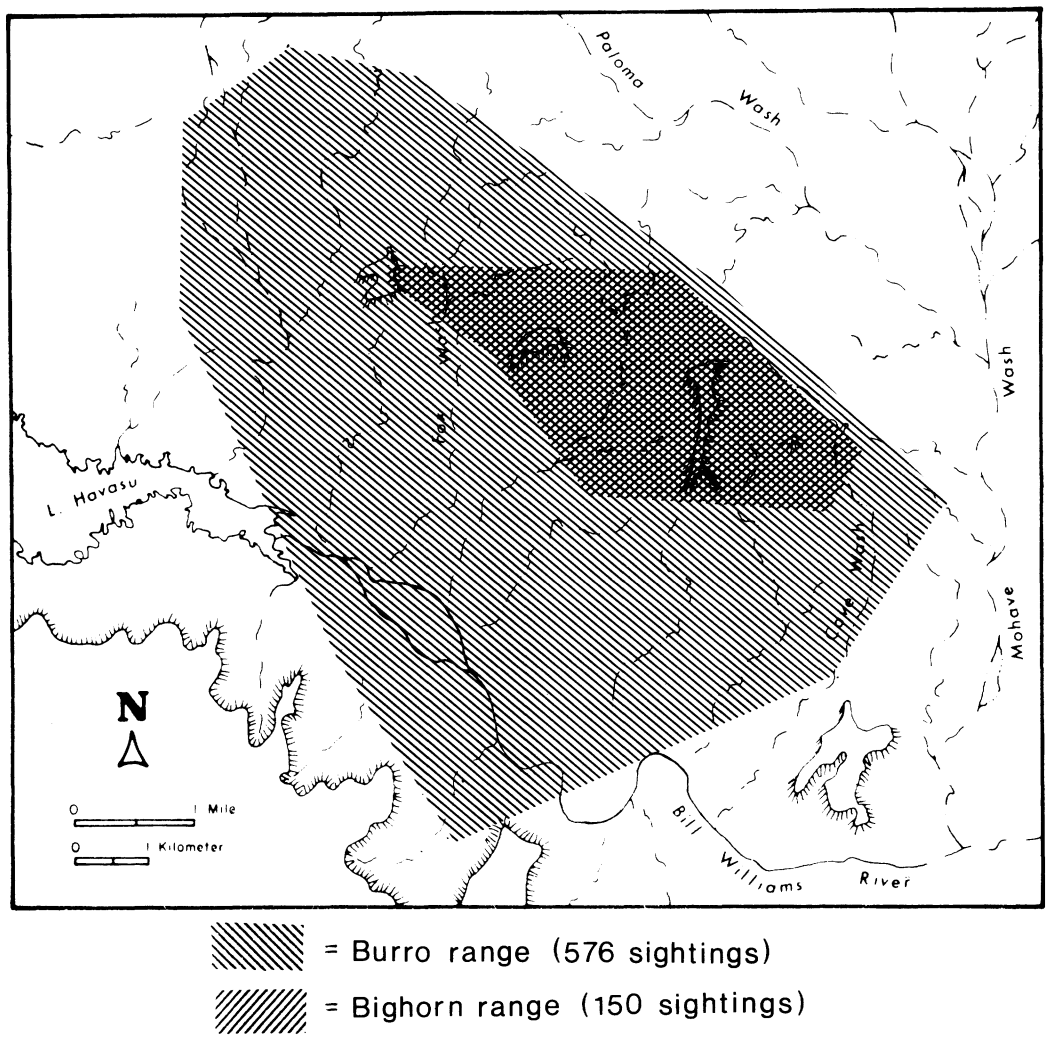

FIG. 10. Distribution of feral burro and desert bighorn sheep sightings in the Bill Williams Mountains, Arizona (November 1974–March 1975).

cent of burro sightings in June through October, 55 percent in November through March, 76 percent in April through June (n = 2,469 sightings). The majority of those observations were in rolling foothills or flat bajadas in approximately the western half of the study area, where bighorn sheep were seldom observed (Fig. 2). Washes (31%) also were used frequently during June through October. From November through March, use of long steep slopes (33%) was slightly less than use of foothills. Burros never were observed in rugged talus terrain (Fig. 3) and therefore islands of nonuse existed within the relatively coarse-grained distribution maps (Figs. 9, 10, 11).

Habitat use represents only diurnal observations. Nocturnal use of riparian vegetation and cultivated fields probably was more than that indicated by those values, especially during summer. This was supported by sign and occasional nocturnal sightings.

Bighorn Sheep

Sightings of bighorn sheep were most frequent in the foothills during the warm-

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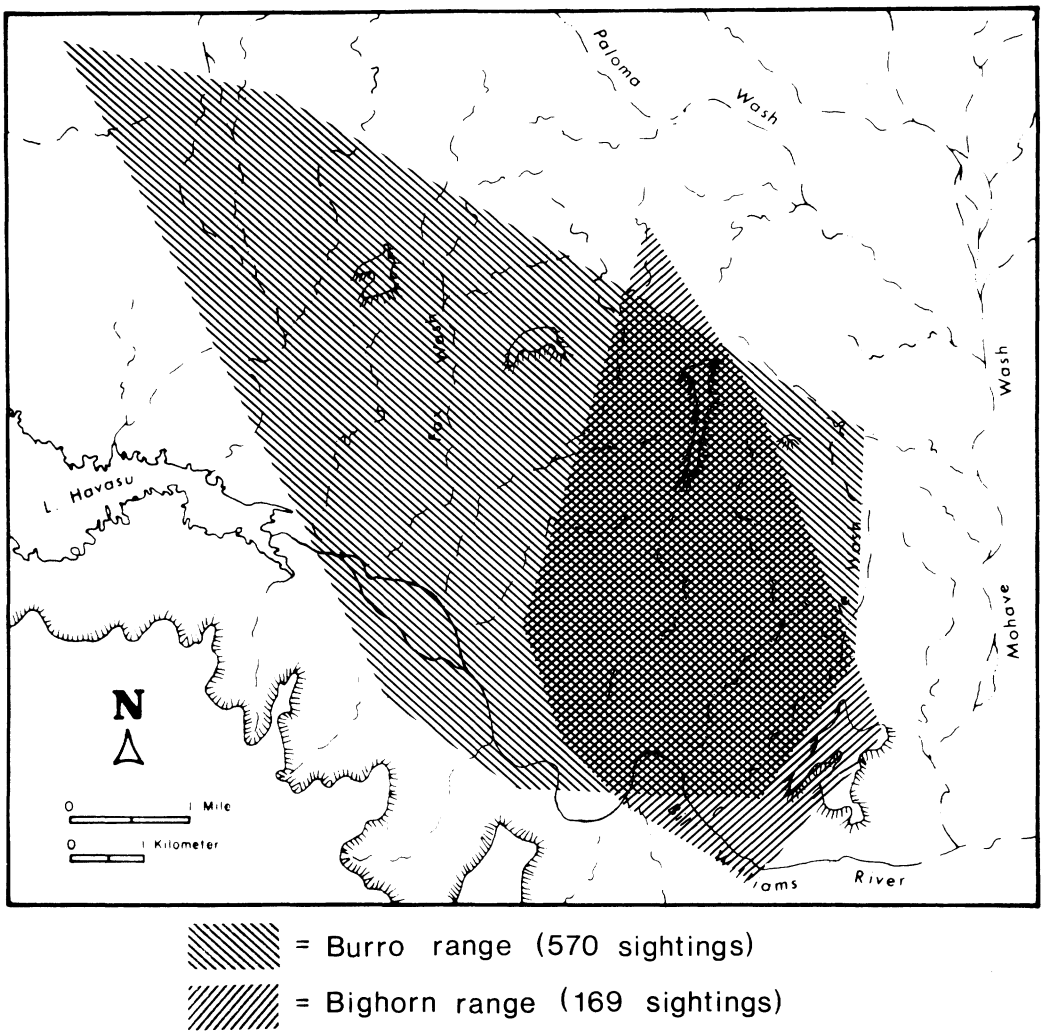

FIG. 11. Distribution of feral burro and desert bighorn sheep sightings in the Bill Williams Mountains, Arizona (April–June 1975).

est seasons, June through October (49%) and April through June (36%, n = 337 sightings, Fig. 4). Also during those 2 seasons the edges of the cultivated fields adjacent to rugged escape terrain were used frequently by bighorn sheep, 39 and 24 percent, respectively.

During cooler months, November through March, bighorn sheep were never seen among foothills, but instead used predominantly long steep slopes (67%) and rugged talus terrain (21%, n = 150 sightings, Figs. 2, 3). Mesas (12%) were the only other habitat type in which sheep were seen in that season.

Based on 48 sightings, bighorn sheep, especially the ewes, showed a preference for rugged talus terrain (52%, Fig. 3) shortly before, during, and after the lambing season (January and February). Long steep slopes (35%) and mesas (13%) also were used at that time. Two of the 3 lambs were observed shortly after birth with their mothers and other sheep in the higher and more isolated reaches of the study area. The rugged and remote fea-

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TABLE 5.—PERCENTAGE FREQUENCY OF FERAL BURRO AND DESERT BIGHORN SHEEP SIGHTINGS IN VARIOUS HABITAT TYPES THROUGHOUT THE STUDY AREA IN THE BILL WILLIAMS MOUNTAINS, ARIZONA, 1974–1975

Habitat	Jun–Oct 1974		Nov 1974–Mar 1975		Apr–Jun 1975	
	Burro	Sheep	Burro	Sheep	Burro	Sheep
Foothills	59	49	55	0	76	36
Long steep slopes	3	1	33	67	4	15
Rugged talus terrain	0	4	0	21	0	13
Washes	31	0	9	0	19	5
Mesas	0	0	2	12	0	7
Cultivated fields	5	39	1	0	1	24
Riparian	2	7	0	0	0	0
Total	100	100	100	100	100	100
Number of sightings	1,323	168	576	150	570	169

tures of those habitats apparently provided seclusion and protection.

The selection of inaccessible areas with expansive views during lambing corroborates observations by Russo (1956). An exception was reported by Simmons et al. (1963) in the Kofa Mountains, Arizona, when a ewe was found with her lamb just after parturition in gentle, easily accessible terrain.

During March, bighorn sheep, including ewes with lambs, showed a preference for the mid to lower portions of long steep slopes (82%, n = 98 sightings). The slopes apparently supplied more plentiful forage, especially annual forbs, than the rugged talus terrain.

DIETS

Burros

Fecal analysis showed a total of 49 plant species, 2 of which were not identifiable, in the diet between June 1974 and May 1975. Fecal samples were not obtained during September, November, and December. The average annual diet consisted of 22 percent grasses and sedges, 33 percent forbs, 40 percent browse (woody plants and cacti), and 5 percent unknowns (Table 6). Use of grasses and sedges, forbs, and browse varied seasonally (Fig. 12). During the warmer months, grasses and sedges and browse were the primary forage types eaten. Most grasses were cultivated in fields, whereas sedges bordered the edge of the river; both grew during the warm season. The majority of riparian woody plants also grew during the summer, whereas desert browse grew primarily after winter rains.

Browse became the forage type consumed most in winter, until February, when winter rains propagated the growth of annual forbs. Forbs were the preferred foods when green and succulent in the spring, despite the fact that desert browse plants also were sprouting new shoots and leaves. As forbs cured with the warming temperatures of late spring (after April), grasses and sedges and browse again became major forage types.

The 10 major plant species consumed by burros accounted for 85 percent of their annual diet (Table 6). The annual forb, Indian wheat, was the most important food item (26%) and was the most abundant forb on the study area. It was consumed primarily after winter rains, which stimulated its germination and growth. The nutrient content of Indian wheat while green was reported to be high compared to several other burro forages analyzed (Hanley and Brady 1977a).

Bermuda grass was the forage next in importance (18%). It was the most abundant perennial grass on the study area, yet highly localized in distribution. It was consumed primarily in summer, when cultivated in the fields for cattle

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TABLE 6.—PERCENTAGE RELATIVE DENSITY[1] OF PLANT SPECIES IN THE DIETS OF FERAL BURROS AND DESERT BIGHORN SHEEP IN THE BILL WILLIAMS MOUNTAINS, ARIZONA, AS DETERMINED BY FECAL COMPOSITION ANALYSIS, 1974–1975

Species	Jun–Oct 1974			Jan–Mar 1975			Apr–Jun 1975			Average[3]	
	Burro	Sheep	Overlap[2]	Burro	Sheep	Overlap	Burro	Sheep	Overlap	Burro	Sheep
Grasses and sedges:											
Aristida adscensionis		0.1		0.1						tr[4]	tr
Avena sativa	tr									tr	
Bromus catharticus				tr						tr	
Cynodon dactylon	23.0	12.9	12.9	1.4	0.1	0.1	25.6	6.2	6.2	17.6	6.7
Hilaria rigida					tr						tr
Scirpus olneyi	9.2			0.2						4.1	
Sorghum sudanense	tr	0.6	tr	tr	0.1	tr		0.7		tr	0.4
Tridens spp.	0.8			tr			4.5			0.4	
Triticum aestivum								1.2		0.5	0.4
Total	33.1	13.6	12.9	1.8	0.3	0.1	30.1	8.1	6.2	22.7	7.6
Forbs:											
Calycoseris wrightii		0.2									tr
Chaenactis carpoclinia								tr			tr
Coldenia plicata		0.2									tr
Cruciferae	3.5	2.3	2.3	1.8	1.9	1.8	0.4	4.0	0.4	2.3	2.7
Cryptantha spp.	0.8	3.8	0.8	1.5	6.3	1.5	1.4	8.2	1.4	1.3	6.1
Datura meteloides				0.1	0.5	0.1		0.1		tr	0.2
Dicoria canescens		0.2									tr
Eriogonum spp.	0.1	tr	tr	1.4			1.4	1.1	1.1	0.7	tr
Erodium cicutarium		0.1		0.2	0.4	0.2		0.4		tr	0.2
Eucnide urens								0.2			tr
Fagonia californica	tr				0.4			tr		tr	tr
Geraea canescens		0.6			tr			0.7			0.5
Langloisia setosissima				0.2	tr	tr		tr		tr	tr
Lotus tomentellus					0.3						tr
Lupinus sparsiflorus	0.3	0.8	0.3	0.4				0.2		0.3	0.4
Medicago sativa					tr			0.5			tr
Melilotus indicus	tr	2.0	tr	tr	0.6	tr		0.4		tr	1.1
Mentzelia spp.				tr	tr	tr	0.1	0.8	0.1	tr	0.3
Mimulus bigelovii	tr			0.1	0.9	0.1		0.3		tr	0.4
Oenothera spp.		0.1		3.2	0.4	0.4	1.3	1.7	1.3	1.5	0.7
Pectocarya spp.					0.2			tr			tr
Phacelia spp.	tr			tr	0.4	tr		0.4		tr	0.3
Plantago insularis	6.3	6.7	6.3	47.5	27.1	27.1	29.9	15.2	15.2	26.4	16.3

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TABLE 6.—CONTINUED

Species	Jun–Oct 1974			Jan–Mar 1975			Apr–Jun 1975			Average[3]	
	Burro	Sheep	Overlap[2]	Burro	Sheep	Overlap	Burro	Sheep	Overlap	Burro	Sheep
Psathyrotes ramosissima	tr									tr	
Senecio douglasii								0.3			0.1
Sonchus oleraceus								2.2			0.7
Trichoptilium incisum				tr						tr	
Xanthium spp.	0.1				tr					tr	tr
Total	11.2	17.0	9.7	56.5	39.6	31.2	34.5	36.9	19.5	32.8	31.0
Woody plants and cacti:											
Acacia greggii	0.3	0.4	0.3		2.1			0.4		0.1	0.9
Acamptopappus sphaerocephalus		tr						0.5			1.0
Ambrosia dumosa	tr	2.3	tr	4.1	8.4	4.1	0.6	6.7	0.6	1.6	5.4
Asclepias albicans				tr						tr	
Atriplex spp.	0.4	0.4	0.4	0.1	5.4	0.1		2.0		0.2	2.5
Baccharis glutinosa		tr									tr
Bebbia juncea				0.2	0.2	0.2		0.4		tr	tr
Cassia armata				tr						tr	
Cercidium microphyllum	8.1	10.6	8.1	20.3	5.0	5.0	2.3	2.8	2.3	10.4	6.7
Dalea spp.	0.3	0.5	0.3	0.9	1.3	0.9	tr	1.1	tr	0.5	0.9
Encelia farinosa	0.9	2.0	0.9	1.0	7.6	1.0	3.3	3.9	3.3	1.5	4.5
Ephedra fasciculata		0.8			0.3			0.2			0.5
Fouquieria splendens	0.5	2.7	0.5	0.2	1.2	0.2		1.5		0.3	1.8
Funastrum hirtellum								0.2			tr
Haplopappus spinulosus				0.6	0.2	0.2		5.1		0.2	1.5
Hofmeisteria pluriseta	0.2			0.3						0.2	
Hymenoclea salsola	0.3	4.4	0.3	0.5	2.9	0.5	tr	2.0	tr	0.3	3.3
Hyptis emoryi	1.3	8.1	1.3		8.3		0.2	5.6	0.2	0.6	7.5
Krameria grayi	0.6	0.6	0.6	0.2	0.1	0.1		0.9		0.3	0.5
Larrea divaricata	0.4	4.6	0.4	1.0	0.9	0.9		4.6		0.5	3.2
Lycium spp.	tr	2.6	tr		1.5			0.8		tr	1.7
Olneya tesota	0.2	0.2	0.2							0.1	0.1
Opuntia acanthocarpa	1.9	2.0	1.9	3.2	2.1	2.1	2.7	4.1	2.7	2.7	2.2
Prosopis glandulosa	23.0	5.1	5.1	5.4	0.7	0.7	19.6	1.2	1.2	14.7	2.5
Salvia spp.		0.2			0.3			0.3			0.2
Sphaeralcea spp.	0.1	10.5	0.1		8.0			4.1		tr	7.5
Tamarix chinensis								0.3			tr
Tessaria sericea	10.0			1.5			1.6			5.1	
Total	48.6	58.0	20.4	39.6	56.5	16.0	30.4	48.7	7.0	39.7	54.0

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TABLE 6.—CONTINUED

Species	Jun–Oct 1974			Jan–Mar 1975			Apr–Jun 1975			Average[3]	
	Burro	Sheep	Overlap[2]	Burro	Sheep	Overlap	Burro	Sheep	Overlap	Burro	Sheep
Unknowns											
I	6.3	8.6	6.3	1.9	1.7	1.7	5.0	4.0	4.0	4.5	5.3
II	0.8	0.3	0.3	0.2	0.2	0.2		0.1		0.3	0.2
III		2.5			1.7			2.2			1.9
Total	7.1	11.4	6.6	2.1	3.6	1.9	5.0	6.3	4.0	4.8	7.4
Grand total	100.0	100.0	49.6	100.0	100.0	49.2	100.0	100.0	40.0	100.0	100.0
Number of species	36	38	26	39	42	28	18	48	14	49	58

[1] Percentage relative density was calculated from the frequency of occurrence of plant fragments in feces and has been reported to approximate percentage dry weight (Sparks and Malechek 1968).

[2] Overlap represents the percentage use in common of shared forages. An index of dietary overlap was calculated each season by summing the percentage use in common of shared forages (Anthony and Smith 1977).

[3] Fecal samples were collected every month during June 1974 through May 1975, except September, November, and December.

[4] tr refers to trace amounts, less than 0.1 percent.

forage or when growing in small stands along sections of the river.

Mesquite (15%), a riparian species, was the third most important forage plant. The summer-produced fruits were eaten when available. Feeding observations, as well as a preponderance of pod and seed remains in feces, indicated a selection for the fruits.

Little-leaf palo verde was a common tree throughout the study area and was the fourth major plant in the annual burro diet (10%). It was a staple throughout the year, especially when grasses and forbs were less available in late summer through early winter. Hanley and Brady (1977a) found little-leaf palo verde to be a good source of phosphorus and β-carotene in late summer and fall.

The browsing of little-leaf palo verde by burros was done in a destructive manner (Fig. 13). Rather than selecting a portion of the annual new growth at the branch tips, as did bighorn sheep, burros usually chewed and broke off branches up to 200 cm in length and 4 cm in diameter. They then shredded and consumed a small portion of the broken end of each branch and discarded the remainder. The green bark also was peeled off and eaten. During 10 palo verde foraging bouts, averaging approximately 30 min in duration, burros removed an average of 23 limbs per bout. The mean length of the removed limbs was 48 cm (range: 10 to 150 cm); the mean diameter was 1.5 cm (range: 0.5 to 4 cm). Farrell (unpublished thesis) also observed this browsing habit on little-leaf palo verde near Alamo Lake. Woodward (unpublished dissertation) and Walker and Ohmart (1978) made no mention of this destructive method even though blue palo verde *Cercidium floridum* Benth. was a major food item.

Nearly all little-leaf palo verde trees close to the river, and many farther away, received heavy browsing by burros, evidenced by numerous old and recently broken and chewed branches scattered around the tree. In extreme cases, all branches had been torn from the trunks

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of smaller trees. Ocotillo and smoke trees were browsed in a similar manner but were consumed in relatively low quantities.

The riparian species, arrowweed *Tessaria sericea* Nutt. (fifth at 5%) and bulrush *Scirpus olneyi* Gray (sixth at 4%), were important forage plants. Use of those plants was almost exclusively during the summer months, which coincided with their period of growth.

Staghorn cholla (seventh at 3%) was one of the most peculiar items in the diet. Due to the formidable spines, which protect the succulent branches, it is normally viewed as unpalatable. Burros primarily consumed the older branches of this cactus, that supported decadent spines.

The desert shrubs, burrobush (eighth at 2%) and brittlebush (ninth at 2%), were taken primarily in winter and spring when growth and highest nutrient quality occurred (Hanley and Brady 1977a). Burrobush was one of the most common shrubs on the study area. It contained the highest crude protein level of all desert browse species analyzed by Norment and Douglas (1977). Although it was consumed in relatively low quantities, many shrubs of that species showed overt signs of heavy utilization, especially nearer the river. The majority had hedged, flat-topped shapes that differed from the larger round and crown-shaped individuals farther from water. Heavy use of burrobush was apparent primarily in the rolling foothills and washes to the west of the range occupied by bighorn sheep, where burros were observed most frequently. The hedged appearance probably has resulted from cumulative burro use over many years.

Forget-me-not *Cryptantha* spp. (tenth at 1%), an annual forb, was most available in the spring. Consumption was so minor throughout the year that seasonality was not obvious.

Big galleta grass was quite scarce on the study area, but it was the most common native perennial grass. It occurred locally in swales and small drainages. Although it was not detected in the burro diet by fecal analysis, all plants observed were heavily utilized, even in locations exclusive of bighorn sheep range.

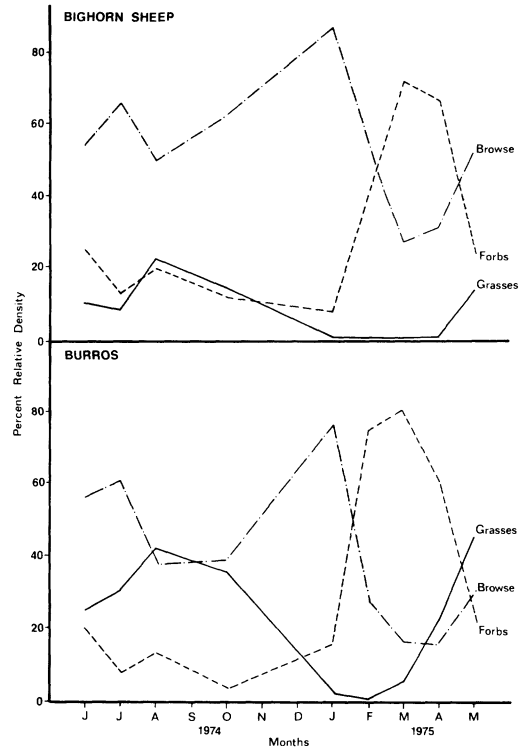

FIG. 12. Monthly consumption of grasses and sedges, browse, and forbs by feral burros and desert bighorn sheep in the Bill Williams Mountains, Arizona, 1974–1975.

Creosote bush (0.5%) was an unusual plant in the burro diet since few herbivores are known to eat it. It was uncommon in the diet but was one of the most dominant shrubs on the study area. From observations, it appeared that the woody branches and not the leafy portions were eaten.

Browning (1960) analyzed the content of 20 burro stomachs (spring and fall) in Death Valley National Monument and found 10 percent grasses, 39 percent forbs, and 50 percent browse. He also observed predominant use of forbs in spring and browse in fall. In the Chemehuevi Mountains, California and in northwestern Arizona, habitats similar to that of the Bill Williams Mountains (except without

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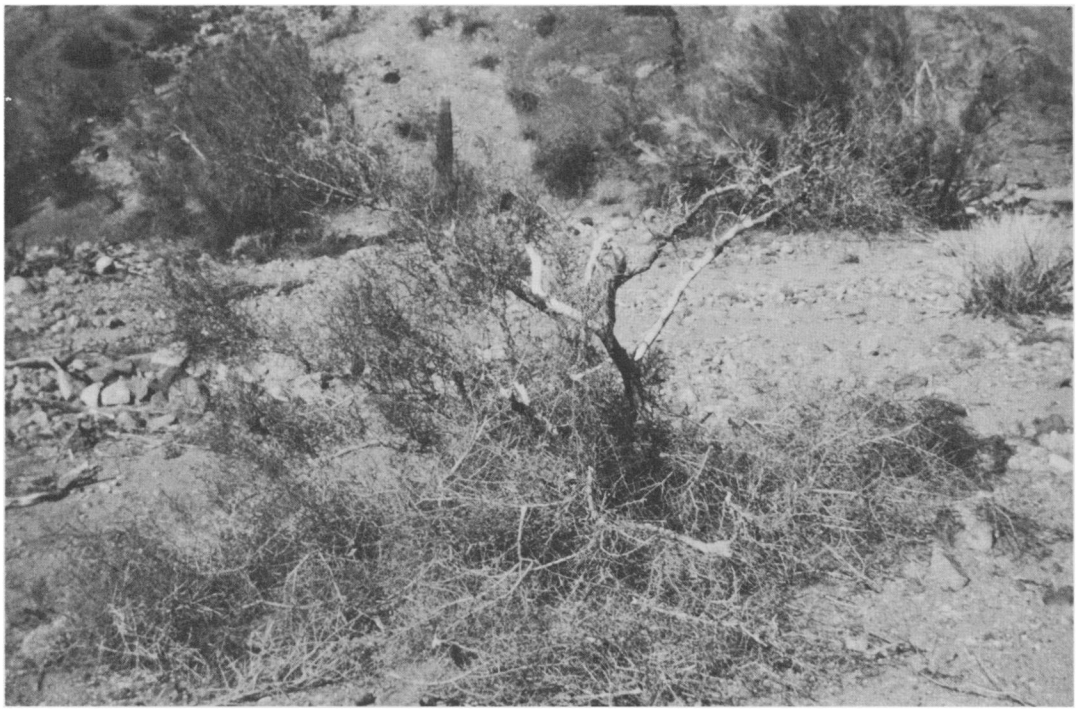

FIG. 13. Little-leaf palo verde tree severely defoliated by burros.

cultivated fields), fecal analysis showed the burro diet to consist of 4 percent grasses, 30 percent forbs, 61 percent browse and 5 percent unknowns (Woodward and Ohmart 1976) and 14 percent grasses, 47 percent forbs, 37 percent browse, and 2 percent unknowns (Walker and Ohmart 1978), respectively; Indian wheat was the major food in both studies. Hansen and Martin (1973) found that burros in the lower Grand Canyon relied principally upon grasses, possibly a reflection of the abundance of grasses in the area. Similarly, in pinyon–juniper–grassland associations on Bandelier National Monument, blue grama *Bouteloua gracilis* H. B. K. was preferred by burros (Morgart and Ohmart 1976, Morgart unpublished thesis). In the burro's native habitat in Ethiopia, Africa, Klingel (1971) reported wild asses to be grazers.

Bighorn Sheep

Fecal analysis showed a total of 58 different species of plants in the diet during June 1974 through May 1975; 3 were not identifiable. Fecal samples were not obtained during September, November, and December. The average annual diet consisted of 8 percent grasses, 31 percent forbs, 54 percent browse (woody plants and cacti) and 7 percent unknowns (Table 6). Use of grasses, forbs, and browse varied seasonally (Fig. 12). Browse dominated the diet during summer through winter. Winter rains propagated the production of a low carpet of annual forbs, which were the preferred foods in March and April. As the forbs dried out in late April, browse was again consumed most. Grasses were eaten in relatively low quantities throughout the year. Peak consumption of grasses occurred during the summer months when growth was greatest.

The 10 major species consumed by bighorn sheep accounted for 67 percent of their annual diet (Table 6). The annual forb, Indian wheat, was the forage species eaten in greatest amounts (16%). It was preferred in late winter and spring

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when most available. The sixth major plant, forget-me-not (6%), was also an annual forb and also taken primarily in spring.

The major browse plants in the bighorn sheep annual diet were: globemallow *Sphaeralcea* spp. (tied for second at 8%), desert lavender *Hyptis emoryi* Torr. (tied for second at 8%), little-leaf palo verde (fourth at 7%), burrobush (seventh at 5%), brittlebush (eighth at 5%), cheesebush (ninth at 3%), and creosote bush (tenth at 3%). Generally, all were consumed predominantly from summer through early winter. Burrobush, however, was eaten primarily from winter through spring, which was its period of growth.

From field observations during spring months, the green or flowering inflorescence of brittlebush appeared to be a preferred bighorn sheep food item. Microscopic discernibility of this part of the plant in fecal material was low, such that it may have been underrepresented by fecal analysis.

Creosote bush (3%), normally considered unpalatable to large grazing animals, was an important plant in the early summer diet of bighorn sheep. The small, silky fruits were available then, and from foraging observations they appeared to be selected.

Bermuda grass (fifth at 7%) was the only grass consumed in any quantity. Use of it was restricted almost totally to the summer months, when it was cultivated in the fields.

Barrel cactus *Ferocactus* spp. was among the most unusual species in the diet of bighorn sheep, although it was not detected by fecal analysis. Several were observed that had been hollowed, presumably as a result of consumption by bighorn sheep. A young adult ram and several ewes were observed utilizing the succulent core of several barrel cacti in January, after the ram broke through the protective shield of long and rigid spines with his horns. After numerous blows by the ram to one barrel cactus, the plant toppled over and the ram moved on to another. Simmons (unpublished dissertation) also reported that bighorn sheep ate barrel cactus in the Cabeza Prieta Game Range, Arizona.

Many saguaro cacti *Cereus giganteus* Engelm., that possibly had been girdled by sheep, were observed in rugged and remote terrain although foraging on saguaros was not observed. Russo (1956) and Simmons (unpublished dissertation) both observed sheep butting and feeding on saguaros. Burros never were observed eating saguaros, although horses have been reported to do so (Russo 1956).

The dominance of browse in the diets of desert bighorn sheep in Arizona also has been reported by Russo (1956), Walker and Ohmart (1978), and Hansen and Martin (1973). Russo (1956) compiled a list of 107 plants that desert bighorn sheep are known to utilize in Arizona, based on observations by himself and other researchers, including Halloran and Crandell (1953). Only 23 of those species occurred in the diets of the sheep in the Bill Williams Mountains, further illustrating the generalized foraging habits of this species. Very few of the 107 plants were grasses, yet Geist (1971) described mountain sheep (referenced mostly to sheep of colder climates) as some of the most selective grazers. In northwestern Arizona, desert sheep consumed 8 percent grasses, 43 percent forbs, 48 percent browse, and 1 percent unknowns (Walker and Ohmart 1978). In the lower Grand Canyon, fecal analysis showed that grasses were a major component of the annual diet of desert bighorn sheep (Hansen and Martin 1973). Grasses comprised 62 percent of fall and winter diets of bighorn sheep in southern Nevada (Brown et al. 1977). The preponderance of woody plants in the diet of desert bighorn sheep in western Arizona probably is more a function of plant availability (scarcity of grasses) than preference.

ECOLOGICAL OVERLAP

Ecological overlap between 2 sympatric species infers a similarity in one or more of their niche dimensions. The niche dimensions may be represented by

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TABLE 7.—SEASONAL ESTIMATIONS OF THE AMOUNT OF FORAGES CONSUMED IN COMMON PROPORTIONS BY BURROS RELATIVE TO THAT BY BIGHORN SHEEP IN AREAS OF SYMPATRY, BILL WILLIAMS MOUNTAINS, ARIZONA, 1974–1975

	Jun–Oct 1974	Nov 1974–Mar 1975	Apr–Jun 1975
Ratio of the number of burro sightings to bighorn sheep sightings in areas of sympatry (S_b/S_s)	146/100	143/100	122/100
Ratio of the total amount of forage consumed by burros to that consumed by bighorn sheep in areas of sympatry C[1] (S_b/S_s)	438/100	429/100	366/100
Dietary overlap (D)[2]/100	0.50	0.49	0.40
Ratio of the amount of (shared) forages consumed in common proportions by burros to that by bighorn sheep in areas of sympatry C(D/100) (S_b/S_s)	219/100 (2/1)	210/100 (2/1)	146/100 (1.5/1)
Habitat overlap (H)[2]	43%	49%	66%

[1] C, the ratio of the amount of forage consumed by 1 adult burro to that by 1 adult sheep was calculated by multiplying the ratio of their metabolic weights ($W_{kg}^{.75}$), 1.5/1, times the ratio of their approximate passage rates of digesta, 2/1 (see text for explanation); 1 burro was estimated to consume roughly 3 times the amount of forage as 1 adult bighorn sheep: C = 3.

[2] Indexes of overlap represent the sum of the percentage use in common of shared forages or habitats (Anthony and Smith 1977).

3 characteristics: (1) spatial utilization of the environment, (2) pattern of temporal activity, and (3) items used for food (Pianka 1978). The extent of ecological overlap between feral burros and desert bighorn sheep was assessed through a quantitative analysis of overlap in their seasonal use of habitats and forage species in areas of sympatry.

The number of plant species used in common, proportional to the total number of plants eaten by both burros and bighorn sheep, varied from 54 percent during June through October to 53 percent during January through March and to 27 percent during April through June. Since forage species were consumed in unequal proportions, the percentage of plant species used in common does not adequately represent dietary overlap. A more appropriate measure of dietary overlap is a similarity index that sums the percentage use in common of each burro and bighorn sheep forage species (Anthony and Smith 1977) (Table 6). For example, during June through October, bermuda grass comprised 23 and 13 percent of the diets of burros and bighorn sheep, respectively, yielding a percentage use in common or overlap index of 13 percent. The summation of the percentage use in common of each plant consumed during that season, in addition to bermuda grass, produced a 50 percent index to dietary overlap. The overlap indexes were 49 percent during November through March and 40 percent during April through June (Table 7). Dietary overlap between feral burros and desert bighorn sheep in Grand Canyon National Park, Arizona was 48 percent during August 1977 (Walters and Hansen 1978); 80 percent of the sheep were observed within the range of burros. In northwestern Arizona, dietary overlap was 38, 41, 60, and 51 percent during the summer, fall, winter, and spring of 1976–1977 (Walker and Ohmart 1978).

The 10 major plant species eaten by burros and bighorn sheep comprised 85 and 67 percent of their annual average diets, respectively. Six of those species were shared: Indian wheat, bermuda grass, little-leaf palo verde, forget-me-not, burrobush, and brittlebush. Use of those species totaled 59 and 46 percent in the diets of burros and bighorn sheep, respectively. The monthly consumption of the 3 most important forages shared by burros and bighorn sheep (Figs. 14, 15, 16) fluctuated in a very similar seasonal pattern that corresponded to plant phe-

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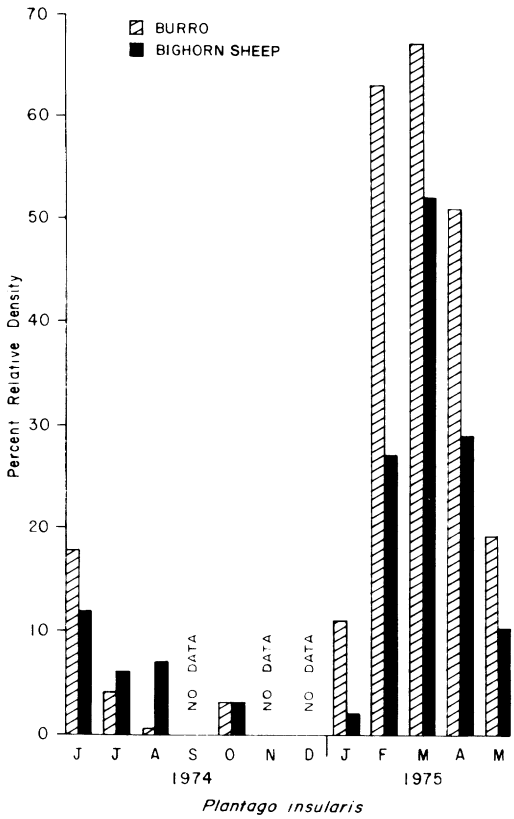

FIG. 14. Monthly consumption of Indian wheat by feral burros and desert bighorn sheep in the Bill Williams Mountains, Arizona, 1974–1975.

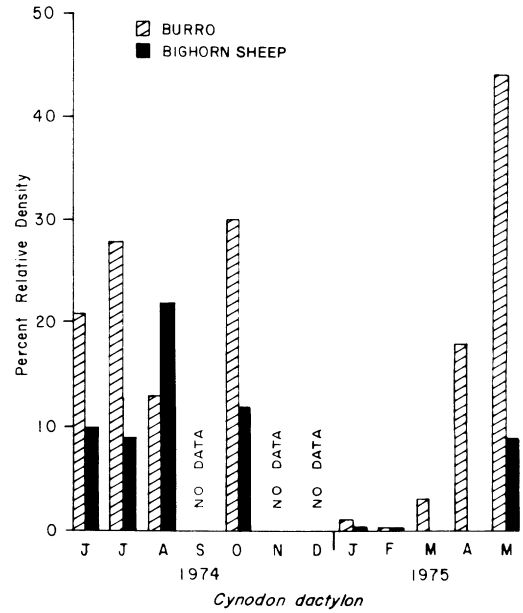

FIG. 15. Monthly consumption of bermuda grass by feral burros and desert bighorn sheep in the Bill Williams Mountains, Arizona, 1974–1975.

nology. During most months, burro consumption of those plant species surpassed that of sheep.

The proportion of the seasonal distributions of bighorn sheep overlapped by burros provided a relatively coarse-grained measure of the spatial and temporal utilization of the landscape. As discussed earlier, burros overlapped 65 percent of the bighorn range from June through October (Fig. 9), 100 percent from November through March (Fig. 10), and 85 percent from April through June (Fig. 11). A more detailed evaluation of their spatial and temporal relationships was provided by comparing the percentage frequency of sightings of each in various habitat types within the areas of sympatry (Table 8). Percentage frequency (percentage use) approximates the proportion of time spent in each habitat, assuming the habitats were surveyed uniformly.

Seasonal habitat overlap was calculated, as in dietary overlap, by summation of the percentage use in common of each habitat type (Table 8). The overlap indexes were 43 percent from June through October, 49 percent from November through March, and 66 percent from April through June. Overlap was greatest on the foothill habitat from June through October (26%) and from April through June (50%) and on the long steep slope habitat from November through March (44%).

The diets of burros and bighorn sheep were determined from fecal samples collected randomly over the entire study area and are believed to represent the average diet of each population. Since the 2 species spent only portions of their time in the same habitats, it is probable that the proportions of plant species actually consumed, and therefore dietary overlap, on shared habitats may have dif-

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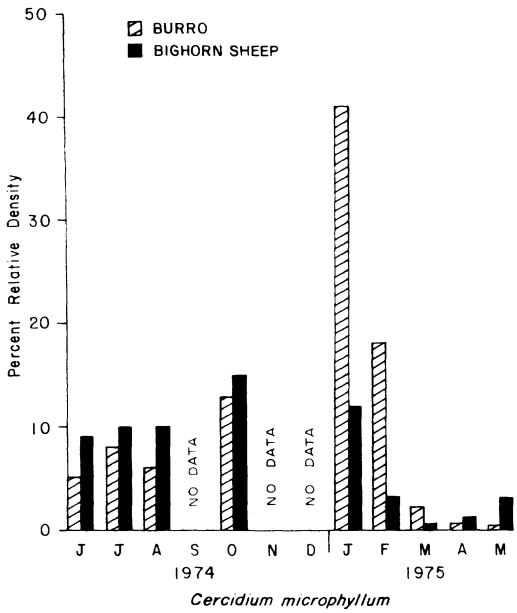

FIG. 16. Monthly consumption of little-leaf palo verde by feral burros and desert bighorn sheep in the Bill Williams Mountains, Arizona, 1974–1975.

fered from that over the total study area. However, the dietary overlap values of the burro and bighorn sheep populations probably are conservative estimates of overlap in shared habitats only. This is because plant species on shared habitats were not uniformly distributed throughout the study area and shared plants more likely than not were eaten primarily in the same habitats, where they would be most available.

Additional insight into dietary overlap was gained from rough seasonal approximations of the relative amounts of shared forages consumed by burros and bighorn sheep in areas of sympatry. The estimates were based on: (1) the seasonal indexes of dietary overlap (each approximates percentage dry weight of forage used in common), (2) the ratio of the number of burro sightings to bighorn sheep sightings in areas of sympatry during each season, and (3) the approximate amount of forage consumed by 1 adult burro relative to 1 adult bighorn sheep.

To our knowledge, estimates of absolute forage consumption rates for both burros and bighorn sheep are lacking. However, the approximate amount of forage consumed by 1 adult burro relative to 1 adult bighorn sheep might be calculated by the ratio of their ecological metabolic rates times the ratio of their rates of passage of food through the digestive tract.

The mean standard metabolic rate of mammals is 70 times the 0.75 power of their body weight in kg or 70 $W_{kg}^{.75}$ (Kleiber 1961). Assuming that burros and bighorn sheep both are equally active and spend similar amounts of time outside their physiologically defined thermoneutral ranges (this is not known, but will be assumed), then the relative amount of en-

TABLE 8.—PERCENTAGE FREQUENCY OF FERAL BURRO AND DESERT BIGHORN SHEEP SIGHTINGS IN VARIOUS HABITAT TYPES IN AREAS OF SYMPATRY IN THE BILL WILLIAMS MOUNTAINS, ARIZONA, 1974–1975

Habitat	Jun–Oct 1974			Nov 1974–Mar 1975			Apr–Jun 1975		
	Burro	Sheep	Overlap[1]	Burro	Sheep	Overlap	Burro	Sheep	Overlap
Foothills	57	26	26	38	0	0	61	50	50
Long steep slopes	0	3	0	44	67	44	4	13	4
Rugged talus terrain	0	12	0	0	21	0	0	6	0
Washes	26	0	0	13	0	0	30	7	7
Mesas	0	0	0	5	12	5	0	3	0
Cultivated fields	17	59	17	0	0	0	5	21	5
Riparian	0	0	0	0	0	0	0	0	0
Total	100	100	43	100	100	49	100	100	66
Number of sightings	89	61		215	150		158	130	

[1] Overlap represents the percentage use in common of habitats. An index of habitat overlap was calculated each season by summing the percentage use in common of shared habitats (Anthony and Smith 1977).

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ergy required by each species/unit time (ecological metabolic rate, Moen 1973) is the ratio of their metabolic weights ($W_{kg}^{.75}$). The average adult burro weighs about 115 kg (Norment and Douglas 1977) and the average bighorn sheep weighs about 65 kg (Russo 1956), yielding a ratio of 35 to 23 or 1.5 to 1. However, because cecal digestion is used by burros and ruminant digestion by bighorn sheep, they have different passage rates of digesta (Janis 1976). Actual passage rates for those 2 species are not known, but horses have been reported to pass food about twice as fast as cows (Balch and Campling 1965, Vander Noot et al. 1967), and we will assume that relationship to be comparable for burros and bighorn sheep. From the above, it is estimated that 1 adult burro consumed roughly 3 times the amount of forage as 1 adult bighorn sheep on an equal diet.

The ratio of burro sightings to bighorn sheep sightings is a measure of the relative amounts of time spent by each species in shared habitats, assuming an equal capability of being seen. The ratio was 146 to 100 during June through October 1974, 143 to 100 during November 1974 through March 1975, and 122 to 100 during April through June 1975 (Table 7). Those ratios multiplied by 3 produced the ratio of the total forage consumed by burros to the total forage consumed by bighorn sheep in areas of sympatry; these were 438 to 100 during June through October, 429 to 100 during November through March, and 366 to 100 during April through June (Table 7).

Burro and bighorn sheep diets were not identical in either the species or the proportions consumed. Therefore, the seasonal dietary overlap indexes were multiplied by the respective ratios of total forage consumption to yield the ratio of the amount of (shared) forages consumed in common proportions by burros to that consumed by bighorn sheep; these were 219 to 100 during June through October 1974, 210 to 100 during November 1974 through March 1975, and 146 to 100 during April through June 1975 (Table 7). As can be seen, burro consumption of shared forages was about twice that of bighorn sheep during summer through early spring (June to March) when habitat overlap averaged 46 percent. During late spring and early summer (April to June), habitat overlap was 66 percent and burro consumption of shared forages exceeded that of bighorn sheep by about 1.5 to 1.

The seasonal habitat and dietary overlap values and the relative forage consumption estimates provide indexes to ecological overlap, but do not demonstrate whether or not burros and bighorn sheep partitioned or competed for resources. Competition occurs when overlapping species share one or more resources that are in short supply. In addition, competitive interaction reduces the amount of limiting resource(s) available to the other species, which in turn reduces the fitness of each population (Pianka 1978). The "competitive exclusion principle" states that 2 species cannot coexist on the same limiting resource(s) (Hardin 1960).

Presently, we can only speculate as to what factors limit the desert bighorn sheep population in the Bill Williams Mountains. Therefore, the presence of burro–bighorn sheep competition in the strict sense cannot be assessed definitively. However, by incorporating empirical data with appropriate ecological theory, we will make an assessment of the potential for exploitation competitive interaction between burros and bighorn sheep in a later section.

INTERSPECIFIC INTERACTIONS

Interference competition arises from direct encounters that inhibit the utilization of a resource (Pianka 1978). Interference competition between burros and bighorn sheep was not observed for access to either forage or water. Water was not in limited supply on the study area. In addition, bighorn sheep watered at the fields during most hours of the day, in contrast to nocturnal watering of burros that was primarily at the river.

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The lambing season might be considered a potential period for spatial competition, since during and shortly after parturition, ewes and lambs are relatively immobile. Interference competition never was observed during lambing and neither burros nor their sign were observed in the isolated and rugged lambing areas. Shortly after lambing, rams, ewes, and lambs were seen twice on long steep slopes in close proximity (to about 10 m apart) to burros. On both occasions, each species seemingly showed no concern for the other's presence, as indicated by continuance of previous activities. In one instance, a jenny and her yearling jack were observed near 14 bighorn sheep (2 rams, 6 ewes, 3 yearlings, and 3 lambs). That close association lasted several hours as the burros and sheep occasionally intersected paths while foraging across the slope. In another instance, 12 bighorn sheep (2 rams, 5 ewes, 2 yearlings, and 3 lambs) were observed moving downslope toward a herd of 9 burros (1 adult jack, 4 jennies, and 4 colts) that were standing and resting. Several sheep foraged to within 10 m of the burros and either continued to forage or bedded down. The burros and bighorn sheep maintained foraging and resting activities for approximately 10 min, after which the sheep slowly moved back upslope. On numerous occasions during spring and summer the 2 species were observed within approximately 150 m of each other, neither displaying apparent concern. The lack of interference competition between burros and bighorn sheep also was reported by Welles and Welles (1961) in Death Valley and by Walker and Ohmart (1978) in northwestern Arizona, despite the fact that both species were observed simultaneously at watering holes.

Burros were seen in close proximity to mule deer on the edge of the riparian vegetation and close to cattle in cultivated fields. In each instance, no concern was demonstrated by either species. On 1 occasion, a coyote was seen walking within 30 m of 2 jacks without stimulating any response from the burros.

SOCIAL GROUPING AND GROUP SIZE

Burros

Burros were observed as solitary or in various types of social groupings. Six types were recognized based on the age and sex of individuals in the groups,

(1) dominant jack group (1 adult jack with 1 or more adult jennies and colts),
(2) mixed group (2 or more adult jacks with 2 or more adult jennies and colts),
(3) bachelor group (2 or more jacks, occasionally with a jenny),
(4) jenny group (1 or more jennies and colts),
(5) solitary jack, and
(6) solitary jenny.

Except for a jenny and her colt(s), group compositions were very unstable. The same individuals seldom were observed together on successive days. Frequently, individuals were seen to join or leave groups within the same day. Greatest group interchange seemed to occur during summer when daily movements were made to and from the riparian communities. At night, much mixing and splitting of groups apparently occurred while burros congregated at watering sites and cultivated fields. Bachelor groups were perhaps the most unstable of all. Instability of groups and similar types of groupings also were reported for wild asses in Ethiopia (Klingel 1974, 1977) and for feral burros in other southwestern desert ecosystems (Moehlman unpublished dissertation, Woodward 1979).

No major seasonal changes were detected in the frequency of sightings of the various types of social groupings or solitary individuals. Therefore, the percentage frequency of sightings of social groupings and solitary individuals are discussed on an annual basis. Dominant jack herds comprised 31 percent of 467 herd sightings and were the most commonly seen social grouping. Jenny herds (28%) also were seen frequently. Jennies

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with newborn colts usually isolated themselves from other burros for a week or more following parturition. A colt ordinarily remained with its mother at least until she produced another colt. Woodward (unpublished dissertation) found the period between production of successive colts to be roughly 16 to 18 months in the Chemehuevi Mountains, California. Moehlman (unpublished dissertation) observed jennies producing colts on an average of every 3 years in Death Valley, California.

Solitary jacks were a very common observation (22%), but a solitary jenny rarely was seen (1%). Bachelor herds (17%) were sighted more often than mixed herds (2%). In bachelor herds having a jenny in association, the jacks usually reacted indifferently toward one another, even when an estrous yearling jenny was present. Exceptions occurred on 2 occasions when several jacks were observed fighting for access to an estrous jenny. Agonistic encounters between jacks were more common in mixed herds, but such interactions usually were of short duration, followed by a division of the group into dominant jack and bachelor groups.

The monthly mean, range, and standard deviation of burro numbers observed per group is shown in Table 9. Only slight seasonal changes in group size from the annual average group size of approximately 4.7 burros were observed. In general, mean and maximum group sizes were slightly larger during the warmer months, June through October, than were group sizes during November through May. December was an exception, but data were collected only from aerial observation, which seemingly would favor the location of larger groups over smaller, less conspicuous groups or solitary animals. The number of burros observed ranged from solitary animals to a dominant jack group of 21. Dominant jack groups were consistently the largest of the social groupings. In Death Valley, burros generally were seen in groups of 2–3 individuals (Moehlman unpublished dissertation).

TABLE 9.—MONTHLY MEAN GROUP SIZE OF FERAL BURROS IN THE BILL WILLIAMS MOUNTAINS, ARIZONA, 1974–1975

Month	Mean herd size	Range	Standard deviation	Number of herds sighted
1974				
Jun	5.1	1–18	4.1	115
Jul	5.3	1–21	4.9	96
Aug	4.9	1–20	4.7	32
Sep		No data		
Oct	6.4	1–16	4.8	11
Nov	4.0	1–10	3.4	7
Dec	6.3	3–20	6.2	7
1975				
Jan	3.6	1–12	2.6	42
Feb	3.8	1–13	3.2	44
Mar	3.9	1–10	2.4	48
Apr	3.2	1–16	3.1	43
May	4.7	1–15	4.1	58
Jun	4.7	1–19	4.3	38
Annual	4.7			541

Bighorn Sheep

Due to the scarcity and sporadic observations of adult rams, most groups of bighorn sheep sighted on the area were ewe–yearling–lamb associations. Occasionally during the cooler months, all-adult ram groups and mixed groups were seen. During spring, the 3 lambs born on the area would often group together and travel with 1 ewe or yearling among the group, a behavior also reported by Welles and Welles (1961). Bighorn sheep of all ages (except lambs) and sexes were seen as solitary individuals. Groups of bighorn sheep were more stable in composition than burro groups.

Large seasonal changes in the mean number of bighorn sheep per group were observed (Table 10). January and February (lambing season) were the months in which the smallest groups were seen ($\bar{x} = 2.7$). Following the lambing season through May, the groups increased in size to their maximum ($\bar{x} = 7.9$). In summer, the sheep maintained a smaller group size ($\bar{x} = 4.6$).

On the extremely arid Cabeza Prieta Game Range, Arizona, an average number of bighorn sheep per group varied

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TABLE 10.—MONTHLY MEAN HERD SIZE OF DESERT BIGHORN SHEEP IN THE BILL WILLIAMS MOUNTAINS, ARIZONA, 1974–1975

Month	Mean herd size	Range	Standard deviation	Number of herds sighted
1974				
Jun	5.1	1–10	2.7	18
Jul	4.2	1–10	3.1	14
Aug	4.8	1–8	3.1	5
Sep		No data		
Oct	7.0	—	—	1
Nov	4.0	—	—	1
Dec		No data		
1975				
Jan	2.8	1–6	1.8	8
Feb	2.6	1–6	1.7	10
Mar	8.2	1–15	4.6	12
Apr	8.0	2–13	4.6	4
May	6.6	1–9	2.8	8
Jun	4.4	1–8	2.3	19
Annual	4.7			100

between 2 and 3 individuals each month throughout the year (Simmons unpublished dissertation). Although Simmons observed a range of from 1 to 16 sheep in a herd, 78 percent of the groups consisted of 3 or fewer animals. In the Bill Williams Mountains during May through August 1975, Golden and Ohmart (1976) reported a mean bighorn group size of 4.4. The pattern of seasonal changes in group size in the Bill Williams Mountains was comparable to that observed in southern Nevada (Leslie 1977).

SYNTHESIS AND CONCLUSIONS

Populations

Eruptions of ungulate populations have been documented on numerous occasions following either liberation of a population into a new environment, a drastic reduction in an established population, and/or an increase in food supply (see Caughley 1970). Population eruptions typically are followed by a marked decline in numbers.

In approximately the last 100 years, burros have dispersed throughout parts of the Southwest (McKnight 1958), but nowhere is there evidence to show that burro numbers have reached equilibrium or declined. Human predation (i.e., shooting for sport or meat) apparently has been a major factor controlling the growth of burro populations in relatively recent years (McKnight 1958), until the passage of Public Law 92-195 in December 1971. For example, prior to 1971, the "100-Burro Club" was in existence. The club was established by ardent adversaries of free-ranging burros and gave membership to those who claimed to have killed 100 or more burros. Remnants of initiation to the club might be visible still in many areas in the form of burro "graveyards," where groups of burros were shot in mass. Burro barbecues also were quite popular in several towns along the Colorado River in Arizona and California.

Along with the cessation of human predation, the lack of predation by native species and the lack of diseases and parasites in burros (Ohmart unpublished data), it is not surprising that the number of burros appears to be on the increase, not only in the Bill Williams Mountains (perhaps at a rate as high as 19 to 22%, Table 2), but in the Black Mountains of northeastern Arizona (Walker unpublished thesis), in California (Woodward and Ohmart 1976, Norment and Douglas 1977), and in New Mexico (Morgart and Ohmart 1976) as well. Burros outnumbered bighorn sheep 5 to 1 in the Bill Williams Mountains (Table 2) and 4 to 1 in the Black Mountains, Arizona (Walker and Ohmart 1978). Within the perimeter of the area occupied by sheep, burros were sighted more frequently than sheep (Table 7). Thus, in the Bill Williams Mountains, and in other areas where large populations of burros are no longer controlled by man, it may be that burro numbers have grown to the point where they are on the verge of reaching an equilibrium and perhaps undergoing a marked decline, but this is only speculation.

Diets

All ungulates face the same general problems in maximizing fitness; they

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must eat, avoid being eaten, and reproduce. Following the paradigm of natural selection, an ungulate evolves behavioral and morphological adaptations that optimize the tradeoffs between those problems. Thus, within the constraints of effective predator defense and successful mating, we would expect strong selective pressures towards efficient procurement of energy and nutrients for maintenance and reproduction. Optimal foraging theory (e.g., Emlen 1966, MacArthur and Pianka 1966, Schoener 1971, Westoby 1974, Charnov 1976, Andersson 1978) basically predicts that an animal selects food in a way that maximizes the balanced intake of energy and nutrients, while minimizing the time and energy spent searching for food. Thus, the diets of burros and bighorn sheep, being similar in proportions of grasses and sedges, forbs, and browse (Fig. 12) and having an average (weighted by season) annual overlap index of 47 percent (Table 7), suggest that the factors controlling forage selection by both may also be similar, although not identical.

The types of forage that ungulates prefer have been correlated to several morphological parameters that include (1) body size, (2) mouth size, (3) type of digestive system (cecal or ruminant), and (4) the ratio of rumen volume to metabolic body weight (body weight to the three-fourths power) (e.g., Hungate et al. 1959; Hofmann 1968; Bell 1970, 1971; Jarmen 1974; Janis 1976; Hanley 1980, unpublished doctoral dissertation, University of Washington, Seattle, Washington). Hanley (unpublished dissertation) has synthesized literature pertaining to forage selection in ungulates and his model is summarized as follows.

Briefly, body size has a positive correlation with the absolute amount of energy required by an ungulate (Moen 1973) or the energy intake/unit time. Mouth size has a negative correlation with the degree of forage selectivity that is physically possible within both time and energy constraints (Jarmen 1974). The rumen contrasts to the cecum in that it limits the rate of passage of food particles until they are digested to a certain size, whereas, food particle size does not restrict the rate of passage through the cecum (Janis 1976). Thus, a cecum can permit a diet higher in fiber (cellulose, lignin, hemicelluloses, etc.) and lower in cell solubles (lipids, sugars, starches, proteins, etc.) than can a rumen. Finally, the ratio of rumen volume to metabolic body weight regulates the time that food is retained in the rumen and thus determines the degree to which cellulose can be digested (Hungate et al. 1959, Nagy et al. 1969). A higher ratio generally promotes longer retention which is conducive to digesting foods higher in cellulose (Nagy et al. 1969, Hanley unpublished dissertation).

Burros can be described relative to the forage selection model as having a medium to large body size, a large mouth size, and a cecal digestive system. Bighorn sheep, in contrast, have a medium to small body size, a small mouth size, a ruminant digestive system, and a rumen volume to metabolic body weight ratio that is larger than that of a deer (Geist 1971). By comparing the 2 species, the model predicts that burros (1) have a greater absolute energy requirement and may spend more time foraging/unit time, (2) are less able to forage selectively, and (3) can subsist on a diet higher in fiber and lower in plant cell solubles than would be expected for bighorn sheep.

We do not have quantitative data regarding the amount of time that the 2 species spent foraging/unit time, but qualitative observations follow the predictions of the model in that burros, with a larger body size, appeared to spend more time foraging than did sheep. Also in line with the model's predictions is the fact that sheep commonly were observed selecting the tender, young branch tips of browse, the flowers of brittlebush and ocotillo, and the small fruits of creosote bush. Burros, on the other hand, consumed rather nonselectively the fibrous, old woody (highly lignified) branches of little-leaf palo verde, ocotillo, smoketree, and creosote bush, and possibly others. (Burros did select the fruits of mesquite, but they occurred in relatively large and

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tight clusters.) Furthermore, burros ate a considerably larger proportion of grasses than did bighorn sheep (Table 6, Fig. 12). Of the 3 major forage types, grasses generally are highest in cellulose (Cook 1972). Bighorn sheep, however, having a larger rumen volume to metabolic body weight ratio than deer, which are primarily browsers (Kufeld et al. 1973), are adapted to a high cellulose, grass diet (Geist 1971, Todd 1972), but apparently less so than burros.

Strong similarities in the diets of burros and bighorn sheep stemmed mainly from their selection for green annual forbs in late winter and spring and from their reliance on browse, and to a lesser extent grasses, when forbs cured during the hot dry months. In general, browse maintains higher nutritive levels as it matures than either forbs or grasses (Cook 1972, Hanley and Brady 1977a).

Habitat Use

Optimal foraging theory in a patchy environment (MacArthur and Pianka 1966) predicts that an animal should forage in those habitats that maximize the balanced intake of energy and nutrients and that minimize the time and energy required to find food. Because the diets of burros and bighorn sheep were not identical, but showed considerable overlap, we should expect habitat selection by the 2 species also to be similar but not identical. In fact, the average (weighted by season) annual index of habitat overlap was 50 percent, which was nearly identical to the dietary overlap index of 47 percent (Table 7).

Foothill habitat was predominant adjacent to the Bill Williams River. Consequently, both burros and bighorn sheep occupied foothills most frequently durin summer, as high temperatures and increased water demands (Turner unpublished dissertation, Tomkiewicz unpublished thesis) kept them relatively close to water (Table 5, Fig. 5). The wash habitat also was prominent near the river and was commonly used by burros for shade and as a source of forage. In contrast, bighorn sheep seldom used washes and did so only to forage on verdant forbs in spring. As burros and bighorn sheep moved farther from permanent water during the cooler months, they began to use the long steep slopes and rugged talus terrain more frequently, which were not prevalent near the river. Nevertheless, burros retained a preference for the foothill habitat, whereas bighorn sheep primarily used the long steep slopes and rugged talus terrain. Apparently bighorn sheep preferred steep and rugged habitats when food and water resources were not limited.

As can be seen, the major contrasts in habitat use by burros and bighorn sheep were related primarily to the degree of ruggedness; bighorn sheep favor heavily dissected foothills, rugged talus terrain, or long steep slopes throughout the year, and burros favor the more gentle, rolling foothills and washes, and long steep slopes. Despite those contrasts, burros so outnumbered bighorn sheep that within the perimeter of the range of bighorn sheep, burros were sighted more often (Table 7).

The above patterns of habitat selection are consistent with those observed for mountain sheep throughout North America and for wild asses in Africa. Mountain sheep have evolved to exploit forage in dissected and rugged terrain (Buechner 1960, Geist 1971), whereas wild asses are adapted to open plains, as well as relatively mountainous terrain (Klingel 1971, 1977). Detailed descriptions of the habitat inhabited by African wild asses are lacking, but Klingel's (1977) photographs of wild asses show the terrain to be much less rugged than the precipitous areas typically used by mountain sheep.

With their respective adaptations, we suspect that sheep are able to exploit plants of a given nutritive value in the most rugged terrain more efficiently than can burros, not necessarily because of greater gains (intake of energy and nutrients/unit time) by sheep, but possibly because the costs (time and energy spent

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searching/unit time) are less for sheep. In fact, the most rugged portions of the study area apparently were not used by burros. Conversely, we predict that sheep would be able to forage efficiently on level or rolling topography, but because they carry a relatively large rumen and are constructed for leaping over precipitous ground, they are relatively slow and more vulnerable to predators on level terrain (Buechner 1960). Thus, natural selection apparently has selected for an innate inhibition to roaming too far from rugged topography and into habitats with low visibility. From that, it is not surprising that sheep in the Bill Williams Mountains showed an aversion to the densely vegetated riparian habitats and the bajadas or rolling foothills, and only used the margins of the level cultivated fields that were adjacent to steep and rugged escape terrain. Despite the contrasts between burros and bighorn sheep in selecting habitats, they both regularly coinhabited sharply dissected foothills and long steep slopes, suggesting that both are well adapted for efficiently exploiting food in those habitats.

Home Ranges

Burt (1943) defined home range for mammals as the area that an animal learns and habitually patrols. Referring once again to optimal foraging theory, we would expect an animal in its home range to maximize energy and nutrient intake/unit area while minimizing the time and energy spent searching/unit area. Thus, the size of an animal's home range would be assumed to approach the minimum area necessary to provide all of its requirements (Sanderson 1966), yet large enough to optimize foraging.

Animals having a larger body size and a greater absolute energy requirement generally have larger home ranges than do smaller animals of the same trophic level (McNab 1963, Harestad and Bunnell 1979). Calculations of annual home ranges for burros ($\bar{x}$ = 19.2 km², n = 14) and semiannual home ranges for ewes ($\bar{x}$ = 23.3 km², n = 2) (Table 4) were contrary to that generalization. However, the similarity in home ranges between the 2 species may be explained by the fact that burros have a larger mouth size and a cecal digestive system, which make them less selective foragers and better able to tolerate fibrous forage than sheep. Thus, we hypothesize that a burro, with its seemingly greater absolute energy demands, harvests more plant tissue/unit area/unit time than a sheep, such that the burro is able to maintain an annual home range size similar to or smaller than bighorn sheep.

In theory, as either the intake of energy and nutrients/unit time decreases or the time spent searching for food/unit time increases (such as that which may occur from a seasonal decrease in forage quality or quantity), an animal occupying a minimum home range must roam over more area to meet its energy demands. Conversely, when forage conditions are more favorable in terms of quality and quantity, we would expect that a smaller area would be required.

In the Bill Williams Mountains, green and relatively high quality forage (Hanley and Brady 1977a) was available throughout most of the year. The desert habitats (foothills, washes, long steep slopes, rugged talus terrain, and mesas) supported plants that produced growth from January to May, following winter–spring rains, whereas growth in riparian vegetation and cultivated fields (i.e., bermuda grass) occurred from April to October. Consequently the winter–spring (January–April) home ranges of bighorn sheep were positioned within only the desert habitats, 1.6 km or more from the river; whereas the early summer (May–June) home ranges included several cultivated fields and water sources, as well as the riparian edge and desert habitats adjacent to them (Fig. 8). The seasonal ranges were of similar size (Table 4).

Burros, in contrast, had winter–spring (January–April) home ranges that were significantly larger than either their summer (May–August) home ranges or the

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seasonal home ranges of sheep (Table 4). During summer, burros roamed, as did sheep, over areas close to and including the green forage and water in the cultivated fields and riparian vegetation; however, the summer home ranges of burros were smaller than those of sheep. During winter and spring, burros were compelled, as were sheep, to exploit the green and growing forage (particularly annual forbs) in the desert habitats, while the vegetation in the fields and along the river remained dormant. But unlike sheep, burros maintained occasional travels to the river, apparently for water, which created relatively large winter–spring home ranges (Fig. 7).

Group Size

Grouping in ungulates has been interpreted as having evolved to reduce the probabilities of an individual being taken by a predator Leuthold 1977). Group association has advantages and disadvantages. For instance, if group size is so large that the dispersion of forage around each individual is reduced by the foraging of conspecifics, individuals may forage at different speeds or along different feeding paths to meet their requirements, thereby causing the group to fragment (Jarmen 1974). Group size in a social animal, then, should approach the maximum number of individuals that can associate in a given set of resource conditions without significantly reducing each member's ability to forage optimally.

On the basis of seasonal changes in food quality and quantity in the Bill Williams Mountains, we would expect the largest groups of burros and sheep to be formed during late winter and spring and to decline through summer and fall. Except for the periods during fall and winter (during lambing, January–February), mean group size in bighorn sheep generally followed the expected pattern; groups during lambing averaged about 3 individuals, but increased to approximately 8 in spring and declined to 4–5 through summer (Table 10). The relatively small mean group size during lambing may have been a result of both pregnant ewes near parturition and ewes with very young lambs either seeking solitude for security or traveling at speeds different from other sheep. Too few groups of sheep were observed during fall and early winter to reliably interpret data on group size during these seasons.

Group size in burros followed a pattern contrary to what would be expected on the basis of forage quality and quantity alone in that larger groups were observed during summer and fall than during winter and spring; however, seasonal changes were not substantial (Table 9). Water requirements for burros (Tomkiewicz unpublished thesis) may have been the major variable controlling group size. The high concentration of burros along the river in summer (Table 2, Fig. 5) may have promoted groups of larger size. The chances for interaction and group formation were enhanced as burros congregated nightly at water in the riparian habitat. Burros were more dispersed during the cooler months, so that perhaps the unstable associations, once fragmented, were less likely to regroup.

Ecological Overlap and Competition

Ecological overlap between burros and bighorn sheep was assessed from seasonal calculations of coarse-grained distributional overlap (weighted annual mean = 83%), fine-grained habitat overlap (weighted annual mean = 51%), and dietary overlap (weighted annual mean = 47%) (Table 7; Figs. 9, 10, 11). Those figures, while indicating a high degree of overlap in foods consumed and areas used for foraging, do not necessarily connote exploitation competition, as it is not known what factors limit the burro and bighorn sheep populations in the Bill Williams Mountains.

The notion that the supply of vegetation could limit populations of herbivores

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has been rejected by many ecologists, because rarely are herbivores seen to eat more than a fraction of above ground tissue (White 1978). Several theoretical ecologists (Hairston et al. 1960, Slobodkin et al. 1967) have proposed that herbivore populations are most often limited by predators and seldom by food, except where protected by man or natural events. They contend that plants compete for space and that

> a community in which this space is frequently emptied through depletion by herbivores (capable of destroying their food source) would run the risk of replacement by another assemblage of species in which the herbivores are held down in numbers by predation below the level at which they damage the vegetation (Hairston et al. 1960:423).

In reality, several studies have indicated ungulate populations to be limited by the supply of nutritional forage prior to complete depletion of the vegetation (e.g., Taber and Dasmann 1957, Sinclair 1974, Phillipson 1975, Coe et al. 1976). The mistake in rejecting the idea of population regulation by food has been to assume that whatever an herbivore eats satisfies its nutritive requirements (White 1978). It is well known that ungulates are not able to digest nor ingest all plant tissues, either because the plants manufacture secondary compounds that are nondigestible or toxic (Freeland and Janzen 1974), or because they protect otherwise vulnerable tissue with thorns, spines, or a hedged growth form.

From the above, White (1978) hypothesized that the major environmental component limiting the abundance of animals is the relative shortage of accessible and nutritional (adequate nitrogen in particular) food for maintaining rapid growth and survival in the very young. It is our view that most ungulate populations, including burros and bighorn sheep, could be and probably are limited by the supply of digestible plant tissue that can be harvested economically (energetic and nutritive gains equal or exceed losses). If that supply constitutes a large proportion of the total vegetational biomass for a period long enough to allow an ungulate population to increase, then a high degree of utilization could result before carrying capacity is reached; eruptions of ungulate populations might be explained on this basis (Caughley 1970). Conversely, if that supply is a small proportion of the total vegetational biomass during the critical season (when food supply is at an annual low), then the population would level off or decline at a lesser degree of utilization.

In theory, the process of exploitation competition between 2 species may be described as consisting of 5 major stages: (1) niche overlap, (2) shortage of shared and limiting resources, (3) reduced absolute fitness of individuals, (4) decline in numbers of 1 or both populations, and (5) ecological separation (equilibrium). Because niche overlap between burros and bighorn sheep is high, it is unlikely that ecological separation and equilibrium have been reached. Possible changes in the absolute fitness of individuals and a decline in 1 or both populations attributable to the presence of the other species could not be assessed in this study. Such assessments could be made definitively only by comparing an allopatric sheep population and an allopatric burro population to sympatric populations of burros and sheep, all existing in environments having similar site potentials. The availability and nutritive quality of shared forages also was not measured quantitatively; however, if we can assume that the burro and bighorn sheep populations are limited by the supply of quality nutritional forage, then the obvious depletion of shared forages in some areas and the increasing burro population provided strong inferences that exploitation competition either was occurring or was imminent. Heavy utilization by burros was apparent, particularly on littleleaf palo verde, burrobush, and annual forbs in the foothill and wash habitats near the river. (By early summer, only the cured forbs lying beneath the protection

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of shrubs were present.) Although the most noticeable impact was found to the west of bighorn sheep range, heavy utilization also was visible within the sheep range.

Hanley and Brady (1977b) documented quantitatively the impact of burros on a desert habitat nearly identical to the foothill and wash habitats in the Bill Williams Mountains. Their study was conducted simultaneously with this study and was only 13 km away in the Aubrey Hills, Arizona. They reported that burro impact was most pronounced in "secondary washes," areas sustaining the greatest canopy cover and density of vegetation. Browse utilization ranged from heavy within 2.5 km from water to light or moderate beyond 2.5 km from water (Lake Havasu). Overgrazing decreased the canopy cover of burrobush from 2.26 to 0.04 percent, and decreased the total canopy cover for all species from 8.64 to 2.80 percent. A palo verde–burrobush community existed away from the lake, but closer to the lake a palo verde–creosote bush community was created by burro overgrazing. Site potentials were similar at varying distances from water. In Death Valley, Norment and Douglas (1977) reported that 46 percent of all shrubs had been browsed, while the survival of 12 percent was threatened (burrobush was one of the most heavily impacted). The composition of annual plant communities in California has been reported to be modified by heavy cattle grazing (Pitt and Heady 1979), suggesting that burro utilization also could affect annuals.

Because the niches of burros and bighorn sheep are composed of both exclusive and shared foods and habitats during each season, the outcome of exploitation competition probably would be a separation in the use of shared habitats and/or in the use of shared forages that are in limiting supply in shared habitats. The superior species of the competitive interaction probably would be determined by population size, rate of increase, and ability to exploit shared forages. Clearly, burros have the advantage over sheep in terms of a higher population size (even in areas of sympatry burros were sighted more frequently than sheep) and a more rapid rate of increase (Table 2). The ability of each in exploiting food resources may depend largely on their digestive capabilities, cecal (burro) versus ruminant (bighorn sheep).

The actual process of fermentation in the cecum of horses and the rumen of artiodactyls (i.e., cattle) appears to be comparable (Alexander 1952). However, the rates of passage of digesta differ. Passage of food in the ruminant requires that the food particles be reduced to a size suitable to pass through the reticulo-omasal orifice. As the fiber (cellulose, hemicelluloses, lignin, etc.) content of food increases, the time required to reduce the particle size of food in the rumen also increases. Therefore, if the amount of cell solubles (soluble sugars, proteins, etc.) and digestible fiber in the food is not sufficient to meet the ruminant's nutritive requirements, the animal cannot support itself because the passage rate of food of low digestibility cannot be increased (Janis 1976).

Horses and other equids, on the other hand, are not limited by the need to reduce the particle size of food for passage through the digestive system. For example, the rate of passage in the horse is nearly twice that in the cow (Balch and Campling 1965, Vander Noot et al. 1967). Thus, to maintain the same nutrient absorption per unit time as a ruminant, horses have to have a greater intake and a faster rate of passage at the expense of a reduced efficiency of digesting cellulose (Janis 1976). For example, ponies are reported to have a substantially greater intake of food per unit body weight than do domestic sheep on a similar diet (Haenlein et al. 1966). Therefore, it seems reasonable that burros could exist on a diet too high in fiber to support bighorn sheep, and that a reduction in the supply of low fiber forage would limit sheep before it limits burros. In other

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words, a larger proportion of the vegetational biomass (e.g., more fibrous plant tissue) is usable by burros than by sheep; this may explain why burros are able to exist at higher densities, to increase more rapidly, and to deplete more of the vegetation than bighorn sheep.

From the above, exploitation competition between burros and bighorn sheep would lead to a reduction in the availability of low fiber, quality forage which would render the burro as the superior competitor. Optimal foraging theory in patchy environments (MacArthur and Pianka 1966) predicts that bighorn sheep as a result would spend less time, or no time at all, foraging in shared habitats and/or would subsist primarily on exclusively used food resources (perhaps with the addition of new food types); this is because the costs of foraging would be higher and/or the returns from the forage would be less. Sheep then would be relegated to surviving mainly in the most rugged habitats that cannot be exploited as efficiently by burros and perhaps in the fields cultivated by the Planet Ranch that provide an abundant supply of green forage around permanent water during the hottest months. The fairly limited extent of rugged habitats in the Bill Williams Mountains not used frequently by burros and the seasonality and localized distribution of fields raises the question as to whether or not the sheep population could be maintained in viable numbers. For example, in ungulates, inbred young, which are more likely to be produced in small populations, have been shown to have a significantly higher mortality than noninbred young (Ralls et al. 1979). However, should the bighorn sheep population be able to sustain itself in the face of burro competition, the point of equilibrium in their populations most likely would be at or near the number of sheep that could be supported by exclusive or abundant food resources in shared habitats and/or by food resources in habitats used exclusively. That point of equilibrium is shown graphically by hypothetical zero-isoclines for a model of exploitation competition (Fig. 17), one in which the 2 species have both exclusive and shared resources (Schoener 1974, 1976).

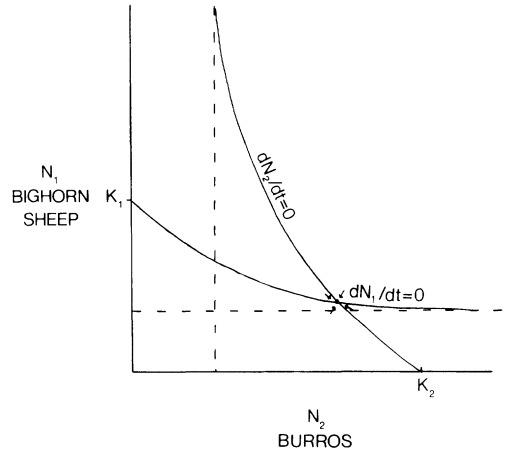

FIG. 17. Hypothetical zero-isoclines for a model of exploitation competition (Schoener 1974, 1976) between feral burros and desert bighorn sheep in the Bill Williams Mountains; species have both exclusive and shared resources. The point of equilibrium is predicted to be at or near the number of sheep that could be supported by exclusive or abundant food resources in shared habitats and/or by food resources in habitats used exclusively (horizontal dashed line).

The controversy regarding the status of burros in the United States is a complex problem. From an ecological perspective, the conflict in opinions revolves basically around 2 viewpoints. One views the burro as a feral exotic, because it has evolved in northeastern Africa and has been domesticated and selectively bred since about 4,000 B.C. The other views the burro as a North American native via the theory that burros have reoccupied the niche left vacant after Paleoindians brought an ass-like *Equus* spp. to extinction in the late Pleistocene.

There is little doubt that the burro is well adapted to the deserts of the Southwest, as judged from its increasing populations and its ability to exploit desert forage. But in the Bill Williams Mountains, as well as in other areas, much of the desert vegetation, and probably des-

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ert bighorn sheep and other endemic fauna, does not appear to be well adapted to burros. Therefore, if the burro is viewed as either a feral exotic or an unsatisfactory replacement of some Pleistocene *Equus* spp., we would predict from fundamental ecological theory that uncontrolled burro populations would reach an equilibrium only after severely depleting and perhaps eventually bringing to extinction several species of native flora and fauna. However, even if one accepts the vacant niche theory and views the burro as a satisfactory successor to a Pleistocene *Equus* spp., we would predict equilibrium to be reached only after "nonresistant" (nonadaptive) phenotypes of native flora and fauna had been reduced or eliminated and only after selection had favored the more adaptive and resistant phenotypes; this may occur on an evolutionary time scale. In any event, we predict that in the Bill Williams Mountains the growing burro population will continue to deplete the vegetational cover over the landscape and will bring about a reduction in the population of desert bighorn sheep and probably other native fauna, unless controlled.

In determining the fate of burro populations throughout the southwestern United States, we believe that decision makers must carefully weigh the benefits derived from burros relative to the potential threats they present to certain components of what we perceive, in recent time, as the natural ecosystem. It is our opinion that desert bighorn sheep are too valuable a natural resource and too limited in numbers and distribution to accept the risks of coexistence with burros. Other factors such as mining, powerlines, recreationists, and cattle grazing in sheep habitats already are having negative impacts on the limited desert bighorn sheep populations in the arid Southwest and increasing burro numbers add one more. Burros can and are thriving in habitats which do not support sheep populations. Therefore we recommend the removal of burros in all areas where they are sympatric with desert bighorn sheep and in areas that have potential for future bighorn sheep transplants.

SUMMARY

The burro is a domestic descendent of the African wild ass. Feral burros have become widely distributed and abundant in the Southwest since the end of the nineteenth century. The increase in burros has been implicated as having contributed to the concomitant decline in bighorn sheep numbers. The ecological relationships of feral burros and desert bighorn sheep in the Bill Williams Mountains, Arizona, were studied from May 1974 through June 1975 to assess possible competitive interaction.

Burro population estimates, using the Schnabel binomial model and a cumulative count method, were from approximately 60 to 90 individuals, respectively. Natural mortality in burros appeared low, while annual natality was estimated to be from 20 to 23 percent, indicating a relatively high annual recruitment rate and an increasing population. From a cumulative count, at least 17 bighorn sheep occupied the study area. Only 1 of 3 lambs born in January and February survived 1 year after birth, yielding an annual natality of 21 percent, an annual recruitment rate of 7 percent, and a 33 percent annual lamb survival.

The movements and distributions of burros and bighorn sheep were restricted to close proximity of permanent water and growing riparian and cultivated vegetation during the warmer months (May through October), due to high temperatures, relatively low rainfall, and dormant desert forage conditions. Both species moved farther from the river during cooler months (November through April) as rains rejuvenated growth of annual and perennial desert forage and supplied ephemeral free water.

Annual home ranges of burros (n = 14) averaged 19.2 km² (range: 8.8–50.1 km²). Burro winter–spring home ranges were significantly larger than those in summer, whereas seasonal home ranges of bighorn

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ewes were of similar size. Semiannual (January through June) home ranges of bighorn ewes (n = 2) averaged 23.3 km² (range: 19.4–27.2 km²).

Burros occupied a large proportion of bighorn sheep range during June through October 1974 (65%), November 1974 through March 1975 (100%), and April through June 1975 (85%). The foothill habitat type was the most widespread type near the river and was used predominantly by burros during all seasons (2,469 sightings). Bighorn sheep principally occupied the foothill habitat in the warmer months (April through October, 337 sightings). In the cooler months (November through March, 150 sightings), when food and water resources were not as limited, bighorn sheep were seen most commonly on long steep slopes.

Fecal analysis revealed that the annual burro diet consisted of 22 percent grasses and sedges, 33 percent forbs, 40 percent browse, and 5 percent unknowns, while the annual bighorn sheep diet consisted of 8 percent grasses, 31 percent forbs, 54 percent browse and 7 percent unknowns. The number of plant species used in common, proportional to the total number of plants eaten by both burros and bighorn sheep, averaged (weighted on an annual basis by season) 47 percent. Indexes of dietary and habitat overlap or the summation of the percentage use in common of shared forage species and shared habitats, averaged (weighted on an annual basis by season) 47 and 51 percent, respectively. In areas of sympatry, burros were estimated to consume roughly from 1.5 to 2.0 times as much of shared forages (in common proportions) as the bighorn sheep population.

Six of the 10 major plants consumed by burros and bighorn sheep were shared and comprised 59 and 46 percent of burro and bighorn sheep diets, respectively. The annual forb, Indian wheat, was preferred by both. In areas of sympatry, habitat overlap was greatest on long steep slopes from November through March (44%) and on foothills from April through June (50%).

Burro–bighorn sheep interference competition for access to either food or water was not observed. Both were seen foraging in close (10 m) proximity and seemingly showed no concern for the other's presence.

The monthly mean group sizes of burros varied little from the annual average of 4.7 individuals. The monthly mean herd sizes of bighorn sheep fluctuated from 3 individuals during the lambing season to 8 individuals in late spring, when forage was most abundant. Burros were seen most frequently in unstable dominant jack herds (1 adult jack and 1 or more jennies and colts). Ewe–yearling–lamb groups were the most common sightings of sheep.

Populations of a number of ungulate species have been reported to erupt, once liberated into a new environment. These eruptions generally were followed by a marked decline. The large and increasing population of burros in the Bill Williams Mountains and the protection from shooting afforded by Public Law 92-195 in December 1971 suggest that this population too, may soon level off and perhaps decline.

Optimal foraging theory, as applied to ungulates, basically predicts that within the constraints of predator defense and successful mating, an individual evolves behavioral and morphological traits to maximize a balanced intake of energy and nutrients and to minimize the time and energy spent searching for food. The theory was used as a basis for comparing and interpreting diets, habitat use, home ranges, and group size of burros and bighorn sheep.

Generally, both burros and bighorn sheep selected green and growing vegetation year-round, primarily annual forbs and desert browse during winter and spring, and riparian browse and cultivated grasses (primarily bermuda grass) during summer and fall. The cecal digestive system of burros apparently allowed them to consume more woody plant tissues and grasses than bighorn sheep, whereas the lesser absolute energy re-

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quirements and smaller mouth size in bighorn sheep presumably permitted greater selectivity of branch tips, flowers and fruits of browse.

Major contrasts in habitat use were in the selection of the most rugged terrain by bighorn sheep and the preference for gentle, rolling foothills by burros. Burros apparently cannot exploit the most rugged areas as efficiently as sheep because the vegetation is too sparse and/or the costs of foraging are too great for burros. Bighorn sheep, on the other hand, have evolved inhibitions to using either level ground away from rugged escape terrain or dense riparian vegetation of low visibility, presumably because of increased vulnerability to predation in those habitats. Both species frequently co-inhabited long steep slopes, rugged foothills, and the margins of cultivated fields.

Although burros are larger and presumably have a greater absolute energy requirement than bighorn sheep, they occupied a mean annual home range approximately the same size as the semiannual home ranges of ewe bighorn sheep. Apparently burros were able to harvest more plant tissue/unit area/unit time over the same amount of area because their cecal digestive system allowed them to subsist on more fibrous forage, thereby reducing the need to forage selectively.

The summer home ranges of both species were positioned around permanent water and the green, growing vegetation in cultivated fields and riparian habitats, as well as the adjacent desert habitats supporting dormant forage. The winter–spring home ranges of bighorn sheep were of similar size to their summer home ranges but were approximately 1.6 km from the river and thus encompassed only desert habitats and the green annual forbs and browse they supported. The winter–spring home ranges of burros also encompassed desert habitats farther from the river, but in contrast, they were enlarged greatly by sporadic treks to water at the river.

Group size in bighorn sheep generally appeared to correlate with the lambing season (January–February) and seasonal changes in quantity and quality of desert forage. The smallest mean group size occurred during the lambing period as pregnant ewes or ewes with very young lambs either sought solitude or traveled and foraged at different rates from other sheep. Mean group size increased to the maximum in late winter and early spring as rains rejuvenated growth in annuals and browse, but declined to a relatively stable size through summer, as desert forage either died or entered dormancy.

The slight seasonal changes in mean group size of burros appeared to be controlled primarily by their demands for water. The largest groups were formed in summer as they congregated near permanent watering sites. As water demands decreased during the cooler months, burros dispersed from permanent water and formed smaller groups on the average.

The high degree of dietary and habitat overlap documented in this study could not be interpreted as demonstrating burro–bighorn sheep competition for food in the strictest sense, because it was not known what factors in the environment were most limiting to the burro and bighorn sheep populations. However, we conclude from both empirical data and theory that most ungulates, including burros and desert bighorn sheep, very likely are limited by the fraction of the total vegetative biomass that is of sufficient nutritive value and digestibility for growth and reproduction. From that, the obvious depletion by burros of several forages shared with bighorn sheep suggested that exploitation competition between the 2 species either was occurring or was imminent. The burro's larger population size, more rapid rate of increase, and cecal digestive system, the latter of which allows subsistence on a larger segment of the vegetation biomass (i.e., lower quality, more fibrous forage), indicate that the burro would be the superior competitor. Thus we predict that, following competitive equilibrium, the bighorn sheep population would be relegated

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mainly to surviving in the most rugged habitats that could not be exploited as efficiently by burros and, during the summer, at the edges of the cultivated fields that provide an abundant supply of green forage adjacent to rugged escape terrain and permanent water.

While the burro is undoubtedly well adapted to the deserts of the Southwest, much of the desert vegetation in the Bill Williams Mountains and other areas does not appear to be resistant to utilization by burros. Regardless of whether the burro is viewed as a feral exotic or as a satisfactory replacement of an extinct *Equus* spp. from the late Pleistocene, uncontrolled growth of the burro population in the Bill Williams Mountains is predicted to reach equilibrium only after they further deplete the vegetational cover over the landscape and reduce the population of desert bighorn sheep, and possibly other native fauna.

In determining the fate of the burro in the Southwest, decision makers must carefully weigh the benefits of maintaining burro populations relative to the costs and potential threats that they present to our natural resources. It is our view that desert bighorn sheep are too valuable a natural resource and too limited in numbers and distribution to accept the risks of coexistence with burros. We recommend the removal of burros from areas where they are sympatric with desert bighorn sheep and from areas that have the potential for future bighorn sheep transplants.

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Special Issue:
The Feral Horse

Reviewed

IMPACTS OF FERAL HORSES GRAZING ON RANGELANDS: AN OVERVIEW

Michael A. Smith, PhD

ABSTRACT

The potential impacts on vegetation and watersheds in the western U.S. by feral horses are discussed. Feral horses select open habitats with relatively large amounts of grass. Horse diets are largely grasses but shrubs are used in some areas. Utilization levels are proportional to animal numbers but equivalent numbers of horses may consume more than cattle because of differing digestive physiology. Predicted vegetation changes under heavy feral horses use may result in range dominated by unpalatable shrubs. Watershed conditions would probably not change except under heavy use by horses when soil compaction, soil disturbance and fouling of water holes could result.

Since 1971 and passage of the Wild Horse Protection Act, feral horses have increased on western rangelands. These increases and the implication of impacts to range resources and other grazing animals have become a concern to a broad spectrum of people involved with western rangelands. Impacts can be broadly categorized as affecting three areas, plant community composition, watershed values and other range animals, principally grazers. Plant communities and watershed values are the focus of this paper. While impacts to range plant communities and watersheds may be predictable in general terms, every area where horses occur has unique features that will undoubtedly result in variation in the kind and extent of impacts to resources. The present report suggests several attributes of animals and range and techniques of measurement that should be useful in assessing impacts and management efforts on a local basis.

DETECTING IMPACTS

Habitat selection is of importance in detecting impacts by indicating where impacts may occur to resources on other animals and in determining availability of preferred resources. A preferred method of determining what habitats are selected is periodic relocation of a number of marked, easily identified, or radio-telemetry collared animals. Systematic observation of all available habitat types for numbers of animals using them suffers from being prone to bias from differential visibility of animals within the habitats and will generally require more time than relocation of marked animals. An area census differs from observation of available habitats principally in requiring a census of the population and thus a search of the entire area available. Logistically formidable, the area census will generally be biased in favor of habitats allowing better visibility of animals.

Dietary studies reveal what species are likely to be of concern in determining available forages and in utilization measurements. Nutritional assessments require quantitative dietary information. Microscopic examination of fecal samples will generally provide the best quantitative measure of dietary composition as horses are not suitable for other techniques such as esophageal fistulas, which are commonly used with cattle or sheep. Observations of feeding animals provide less quantitative information but with relatively tame animals are quite useful. Utilization of all available vegetation can be used to indicate dietary composition but is logistically difficult to employ over large areas. Utilization data is generally low in precision and utilization by different herbivores is difficult to distinguish.

Utilization studies indicate the amount of herbage removed and when employed primarily on important dietary constituents provide an early indication of change in the plant community. Utilization amounts should be assessed in light of the resistance of the plant species to grazing and to season of use, dormant season use being less severe. Utilization of marked plants determined by estimating standing biomass before and after grazing is perhaps the most effective estimate for an individual species. Determining percent removed based on height of remaining plants may

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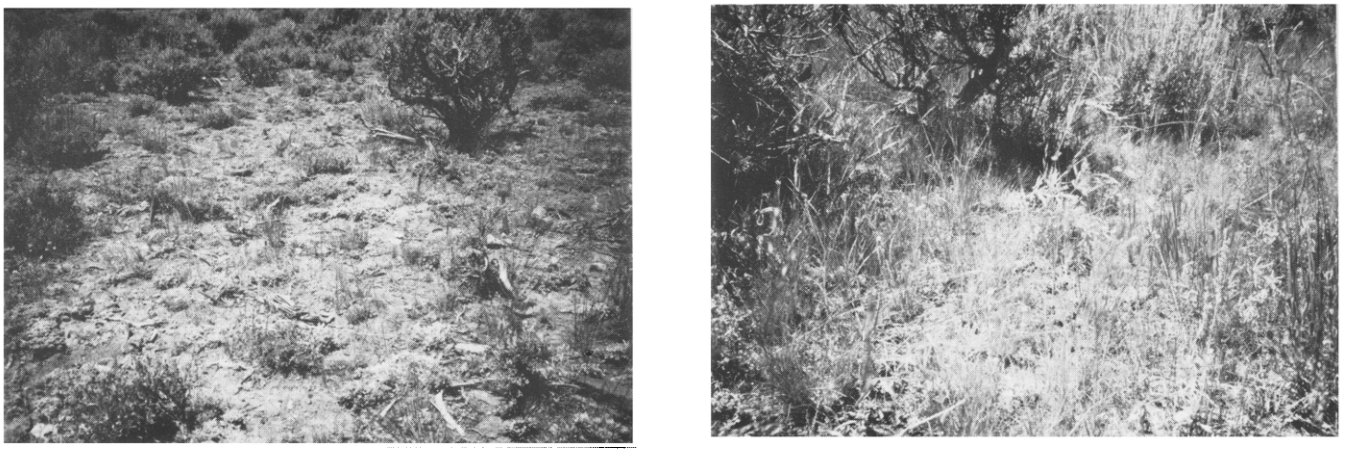

Figure 1. Comparison of August range condition in a western horse range. Area on left is heavily grazed and area on right is rarely grazed by feral horses. Soil conditions and elevations are similar.

also be quite effective. Determination of utilization from the difference in vegetation weight on caged and adjacent uncaged plots measured after grazing is useful for estimating use of the total vegetation but less efficient if only certain species are of interest. Vegetation trend studies detect change in the composition of vegetation and therefore indicate that impact due to grazing has already occurred. Vegetation changes must be evaluated with respect to whether or not the change is desirable. Permanently located plots, periodically evaluated for cover or density of different species frequently provide the most practical means of determining whether change is occurring. Determination of plant species composition through harvest of small plots by species quantifies the extent of change in vegetation but is seldom practical for monitoring studies.

Watershed condition or change in condition indicate generally the cumulative effects of impacts of grazing on vegetation or in many cases, the effects of other activities in the watershed that influence water flow and sediments. Consequently, watershed conditions should not be attributed to grazing without examination of other factors such as road building or stream channelization. With respect to grazing, residual plant cover on uplands and along streams is useful as an early indicator of future watershed condition as less cover indicates that more erosion may occur. Upland erosion indicated by rills or gullies, stream sediment or poor streambank condition, e.g. sloughing and channel widening, indicate that damage has already occurred. The land manager must determine the source of damage and initiate management to repair the damage.

CHARACTERISTICS OF HORSES

Due to the variety of places where feral horses occur, considerable generalization as to their habits and impacts must be made. Caution should be exercised in applying the following generalizations, as exceptions are always possible.

Habitats

Habitats selected by horses frequently tend to be relatively open and, of those available, to have a high proportion of grass in the mixture of vegetation. Seasonal variation also occurs in response to snow cover and water supplies. Horses in Oregon use open mountain tops rather than valleys in one area studied. Horses in Nevada have used ridges in winter and lower elevations near water in spring and summer. In an Alberta foothill and montane situation, open ridges were used in winter and most other available habitats at some time during other seasons. Studies in central Wyoming have found low growing sagebrush-grass and grass types used year round. Wind-swept ridges and plains received more use during snow covered periods. Areas 4-8 km away from water were used in late fall and winter compared to spring and summer use nearer water.

Diets

Grasses have been found to be the principle component of horse diets regardless of season or location. Two notable exceptions have been found. Wyoming studies show up to 40% of wintering horse diets to be shrubs. Winterfat (*Ceratoides lanata*) and horsebrush (*Tetradymic canescens*) were widespread but a relatively small part of total vegetation in the Red Desert area studied. Summering horse diets contained lesser amounts of only winterfat. A study in New Mexico indicated up to 28% shrubs in horse diets.

Utilization

Utilization levels achieved by horses are the key annual evaluation of management and must be related to animal numbers and forage production. Horses in equivalent num-

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bers may eat more than ruminants because of differing digestive physiology. Segregating use by different animals is difficult in common grazing allotments. In Wyoming Red Desert studies, bunch grasses and palatable shrubs received the heaviest use. Rhiomatous grasses were used much less and forbs were used rarely.

Vegetation Trend

Changes in range (ecological condition) due to feral horses have not been documented even though changes undoubtedly have occurred. Based on feral horse diets, however, a shift in vegetative composition toward unpalatable shrubby species would be expected, given excessive numbers of horses. In many areas these kinds of changes may have already occurred due to grazing by other species. Under current management with control of numbers and locations where horses occur, vegetation changes except on a local basis are unlikely.

Watershed Condition

Watershed condition as affected by feral horses has received little attention. Studies of grazing distribution and habitat selection indicate use of much larger areas than livestock. A more dispersed impact on upland watershed condition is suggested. Concentration near water as with livestock can cause local damage to vegetation. Pawing and rolling in pond margins appears to be characteristic of horses and may affect other users. In general, horse impact on watershed is probably similar to effects of other large hoofed animals. Generally, significant impacts on watershed conditions have been only noticeable at high animal densities.

SUMMARY

The greatest impact of feral horse grazing would generally be on the grass component of selected habitats. Selected habitats vary seasonally but generally contain higher proportions of grass than others available. Horses travel over and use large areas. Utilization and other impacts will be more dispersed than cattle but proportional to numbers and forage availability. Ecological condition of ranges could decline to communities dominated by unpalatable shrubs with heavy use. Watershed conditions should not change except under heavy use resulting in reduced ground cover, soil disturbance and compaction.

POTENTIAL COMPETITIVE INTERACTIONS BETWEEN FERAL HORSES AND OTHER GRAZING ANIMALS

Michael A. Smith, PhD

ABSTRACT

This paper discusses the potential for competition between feral horses and the major domestic and native grazing animals on western U.S. ranges. Habitat selection and dietary composition for each animal is noted. Potential for competition may exist between animals that consume large amounts of grass and at least seasonally occupy open foothill or grass and grass-shrub habitats. Cattle, domestic sheep, elk, and bighorn sheep were most likely to interact negatively with horses.

Of the controversies associated with feral horses on western rangelands, one generating considerable emotion is the potential for competition with other users of rangeland. While interactions among animals may involve behavior, competition between grazing animals largely involves food supplies. The essential elements of competition involve use by two animal species of the same habitats and foods although not necessarily at the same time. The common use of resources must result in reduced nutritional levels, reduced birth or survival rates, and consequently, lower population levels for one or both species. These latter conditions are rarely met or at least are rarely obvious. To evaluate the potential for competition two species must be examined with respect to habitat use and dietary composition overlap and resources must be in short supply relative to animal numbers. This report compares the feral horse and several common western range grazing animals with respect to habitat use and dietary composition. Habitat use and diets of animals across the West will vary due to differences in local habitat and food availability therefore more or less potential for competition may exist in local situations.

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POTENTIAL INTERACTIONS

Horse habitat use may be seasonally variable depending on water availability and snow cover. Habitats used include rougher topography. Selected habitats will generally have

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Fort Irwin, California

Feral Burro Populations: Distribution and Damage Assessment

B. L. Tiller

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Richland, Washington 99352

Executive Summary

The following report was prepared by the U.S. Department of Energy's Pacific Northwest National Laboratory (PNNL) under MIPR#76DOEWA018 for use by the National Training Center, Fort Irwin, CA (NTC) to document 1) regional use of the NTC by burros, 2) influence of available water sources for burro use, 3) burro-related damage at several NTC sensitive habitat areas, and 4) management recommendations. All work described in this report was conducted in 1996 and 1997.

Roadside transects were conducted and mapped using Geographical Positioning Systems/ Geographical Information Systems (GPS/GIS) to indirectly measure relative abundance of feral burros (scat per mile) and to examine the spatial relationship of burro use to permanent or semi-permanent water sources that exist on the NTC. We also surveyed several permanent springs for burro-related damage and mapped the impact areas using GPS/GIS to quantify the extent of damage and to provide guidance on size and extent of burro exclosures in those areas. Photographs of the spring sites were also archived and permanent photo points were established for long-term monitoring of feral burro damage areas. In addition, aquatic invertebrate data collected during another spring site study were summarized and discussed in relation to burro-related impacts on the NTC's sensitive habitats. Several water-quality parameters were also obtained from each spring, including temperature, dissolved oxygen, pH, and total dissolved solids.

Roadside surveys demonstrated that spring sites profoundly influenced burro movements on the NTC, as over half of all burro signs observed during this study were found within 1 mile of known spring sites. Relative densities of burro signs on the NTC were low (less than 2 scat per mile) near Garlic Springs, Drinkwater Spring, and Bitter Springs; moderate (between 5 and 15 scat per mile) near McLean Lake, Cave Spring, and Desert King Spring; and high (greater than 15 scat per mile) at Two Springs and Leach Springs. We also observed four different herds of burros (totaling 21 individuals) near Leach Springs and one herd of 9 near McClean Lake.

Desert King Spring site assessment suggested low burro-related impacts there. The site had been used as a watering hole by burros; however, the spring consists of water trickling through an abandoned bath-tub, presumably put there from pre-military prospecting activities. Garlic Spring and Drinkwater Spring have barbed-wire fencing surrounding the spring, which effectively prevents extensive burro use there. Bitter Springs site had very little evidence of burro use, presumably due to the site's isolated location along the southern NTC border. Data collected during this study demonstrate significant impacts on xeric and/or riparian habitats at Cave Spring, Two Springs, and Leach Springs by feral burros. Cave Spring is a non-riparian rock quarry water pool; however, burro trails and loafing areas near the spring have damaged the surrounding xeric plant communities and the surface terrain at a significant cultural resource site. Leach Spring and Two Springs had extensive burro-related damage that has affected riparian habitat there. The results suggest that management measures be taken to better protect riparian-type sites from feral burro-related impacts.

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1.0 Objectives

The U.S. Army National Training Center (NTC), Fort Irwin, California, has a population of feral burros which resides both on the base and on portions of the NTC's proposed expansion area. Casual observations throughout the NTC, and particularly at several spring sites, suggest that burros may be having adverse impacts on native vegetation, water, soils, and cultural resources. If burro populations need to be controlled to preserve and maintain certain ecologically- or culturally-significant areas, the NTC must have sufficient data on the burro's demographic and regional-use characteristics to select among a variety of management options.

Prepared by the Pacific Northwest National Laboratory[(a)] (PNNL) for the NTC, this report assesses burro population distributions and analyzes environmental impacts caused by burros. The report also includes recommendations for management of burros to prevent further damage to some of the sensitive habitats and describes possible long-term monitoring activities for future burro management.

(a) Pacific Northwest National Laboratory is operated by Battelle for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830.

2.0 Background

Domesticated Somalian and Nubian wild asses (*Equus asinus*), i.e., burros, were introduced into Mexico by Spaniards in the 1530s, and the animal populations spread northward into what is now the United States as a consequence of Spanish colonization. These hardy, desert-adapted animals provided transportation for people and equipment in this country for more than three centuries. Burros were introduced into areas that became National Parks more than 100 years ago by miners. Following the decline of mining activities, the advent of railroads, and the availability of motorized vehicles, burros were released to be become free-roaming (Woodward 1976; Clutton-Brock 1981). Since then, feral burros have maintained viable and/or increasing populations throughout much of the southwestern U.S., and in many cases, to the point at which population-control measure have been employed in an effort to conserve natural and cultural resources.

The control of feral burros was curtailed in California in 1953 when the state provided them with official protection. In 1959, Congress halted the pursuit of wild horses and burros from motorized vehicles by passing the "Wild Horses Annie Act," named after Mrs. Velma Johnston of Reno, NV, who intensively lobbied, almost single-handed, for its passage. Public Law 92-195, Wild and Free Roaming Horses and Burros, passed in 1971, provided protection for burros on federal lands administered by the Bureau of Land Management (BLM) and U.S. Forest Service.

Throughout the western United States, it became readily apparent that uncontrolled populations of wild horses and burros were detrimental to soils, native plant and animal communities, and cultural resources of the desert ecosystem. Recent literature demonstrates burros to be responsible for extensive habitat damage by overgrazing, selective species removal, trampling of plants, soil disturbance leading to erosion (Farrell 1973; Koehler 1974; Carothers et al. 1976; Fletcher and Wauer 1976; Woodward and Ohmart 1976; Norment and Douglas 1977), impact on small vertebrates (Carothers et al. 1976; Yancey and Douglas 1983; Yancey 1984), and competitive interactions with desert bighorn sheep (Seegmiller and Ohmart 1981; Dunn and Douglas 1982; Ginnett and Douglas 1982).

The need to manage these impacts and the mechanisms for doing so have been clearly established. Congress recognized the issues and established the wild horse and burro herd management areas and the parameters for management through the Wild Free Roaming Horses and Burro Act of 1971 (Public law 92-195) as amended, Section 3(b)(2). The Act requires that, if an overpopulation exists on a given area of public lands, appropriate action will be taken to remove excess animals from the range so as to achieve appropriate herd-management levels. The Public Range Improvement Act of 1976, Federal Land Policy and Management Act of 1976, and the California Desert Protection Act of 1994 (CDPA) include wild horse and burro population control measures. Also, the California Desert Conservation Area (CDCA) Resources Management Plan of 1980 identified herd-management areas (HMAs) and established appropriate management levels for wild horses and burros. In this plan, lands outside of the established HMAs are to be managed for other resources to the exclusion of horses and burros.

The Naval Weapons Center, China Lake, CA (NWC), is a military reservation encompassing 1,095,680 acres of southern California desert. The Mojave "B"/Randsburg Wash Test Range Complex lies within the Slate Mountain HMA and also lies immediately adjacent to the west border of Fort Irwin NTC. In 1980, NWC and BLM aerial count estimates of burros residing on the NWC were between 3,500 and 5,700 individuals and 700-800 feral horses. In an effort to coordinate with feral equine management efforts on federal lands administered by the BLM and National Park Service, the NWC has prepared a Final Environmental Impact Statement. The BLM and NWC have administratively managed for zero burros in the Slate Mountain HMA. Thus, burro round-ups and adoption programs have been conducted by the BLM and the NWC to continue management of a balanced ecosystem. In addition, the CDCA established the need for burro removals to occur on lands adjacent to the HMAs to control immigrating herds.

The NTC is located in the central Mojave Desert south of Death Valley and south-east of the NWC in San Bernardino County, CA. The NTC has been protected from public intrusion for over 50 years and is an important natural resource of the Mojave Desert ecosystem. The NTC lies immediately adjacent to the Slate Mountain Range's 156,000-acre HMA.

3.0 Methods

The NTC contains several water sources, some natural and others established during the pre-military mining activities (Figure 1). PNNL biologists conducted roadside surveys in the early summer of 1997 to illustrate regional use of the NTC by feral burros and documented the presence and quantity of burro-related damage at some of the springs. Water quality data and invertebrate communities were also summarized from Mueller and Blanton (1997) and related to the observed burro use at these areas.

We used scat-group density as an index for animal abundance (Neff 1968; Lancia et al. 1994) and recorded the number of burro scat-groups found along secondary roadways (Figure 2). We enumerated burro fecal piles (scat) along over 80 kilometers (km) (50 miles) of secondary roadways throughout the NTC in June 1997. Roadway surveys were mapped using GPS/GIS to indirectly measure the relative abundance of feral burros (scat per distance traveled) and examine the spatial distributions of burro use and proximity of significant water sources throughout the NTC. Secondary roads were classified as those that were not routinely bladed but were routinely used during training activities. This provided at least some consistency for visibility of burro scat along roadways where human activities may otherwise cause considerable changes in detection. One and sometimes two individuals surveyed the entire roadway for scat including the edges of roadways up to where vegetation did not look damaged by traffic. Vehicle speeds ranged between 5 and 10 miles per hour. We also set the truck trip meter to zero at the beginning and recorded number of sightings, mileage, activity types, and other special features of the area (e.g., shade tree or major burro trail crossing etc.). Scat was classified as either new (0 - 1 week), recent (1 week - 2 months), old (2 months - 1 year), or very old (greater than 1 year) for future examination of temporal changes in area-use patterns (see Appendix A).

At least 90 coordinate points were collected using the GPS at each scat observation and along all roadways, with dilution of precision no greater than 6%. All data were then post-processed (Geo-PC v. 2.2, Magellan Systems, Inc.) with base-station data from Los Angeles Communications, CA. In a few cases where scat densities were too great to be worth recording every observation, we recorded the number of scat observed per 0.4 km (0.25 mile)[(a)] section of road.

Since open water is scarce in the arid desert, this is often a limiting factor for ungulates. Previous studies have illustrated burros or burro groups in close proximity to significant water seeps or retention areas (Reddick 1981; Douglas and Hurst 1993). In addition, spring sites typically are rich in flora and fauna and are often near or within a culturally significant site. In this light, we focused damage assessment efforts in regions according to nearest permanent or semi-permanent spring site. One exception, however, was McLean Lake, where large missile craters near the south-central end of the otherwise dry lake-bed collected and retained

(a) All transect measurements include mile conversions for practical convenience when collecting additional data from vehicle trip meters.

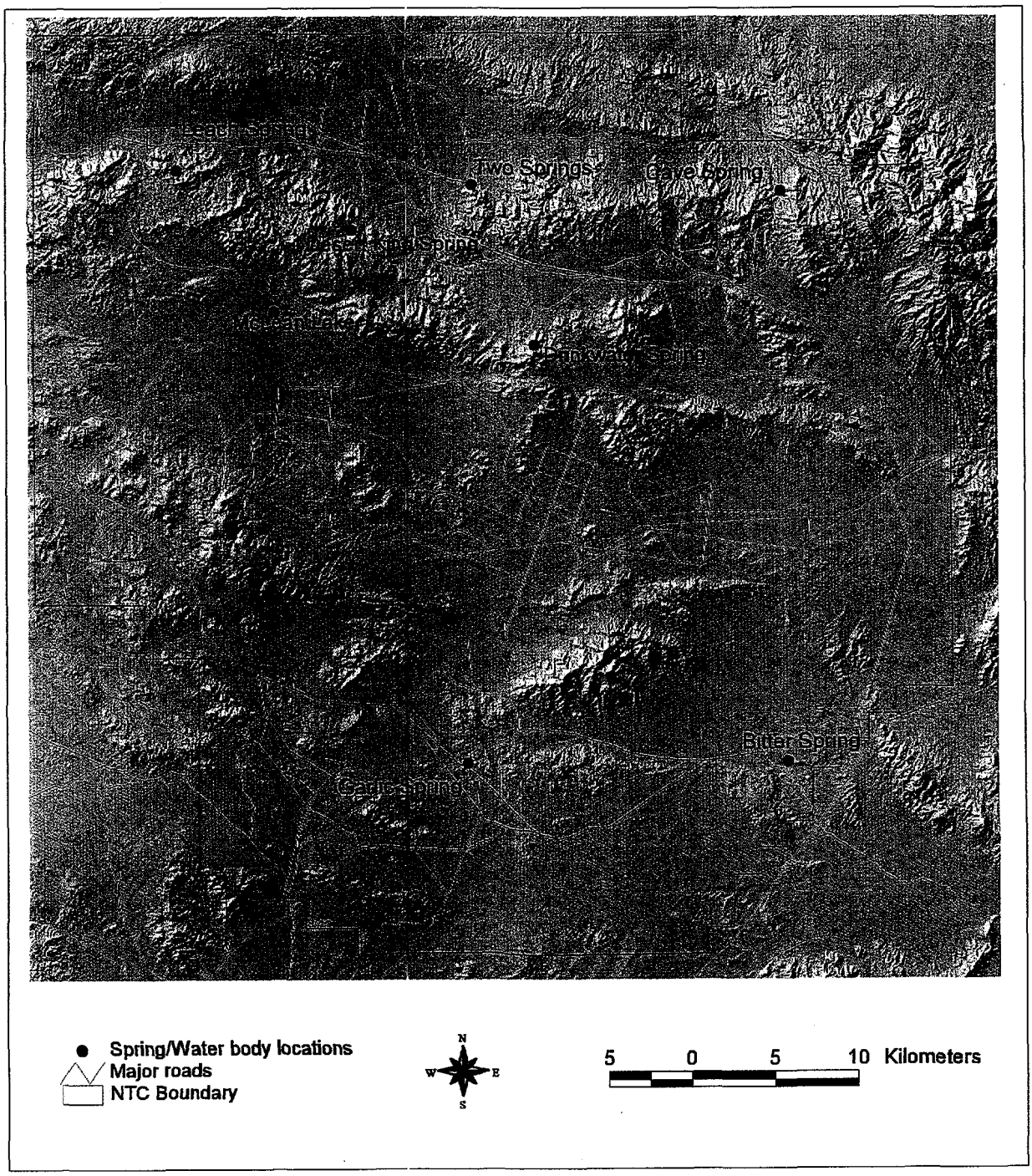

Figure 1. Fort Irwin National Training Center and Locations of Permanent or Semi-Permanent Spring Sites

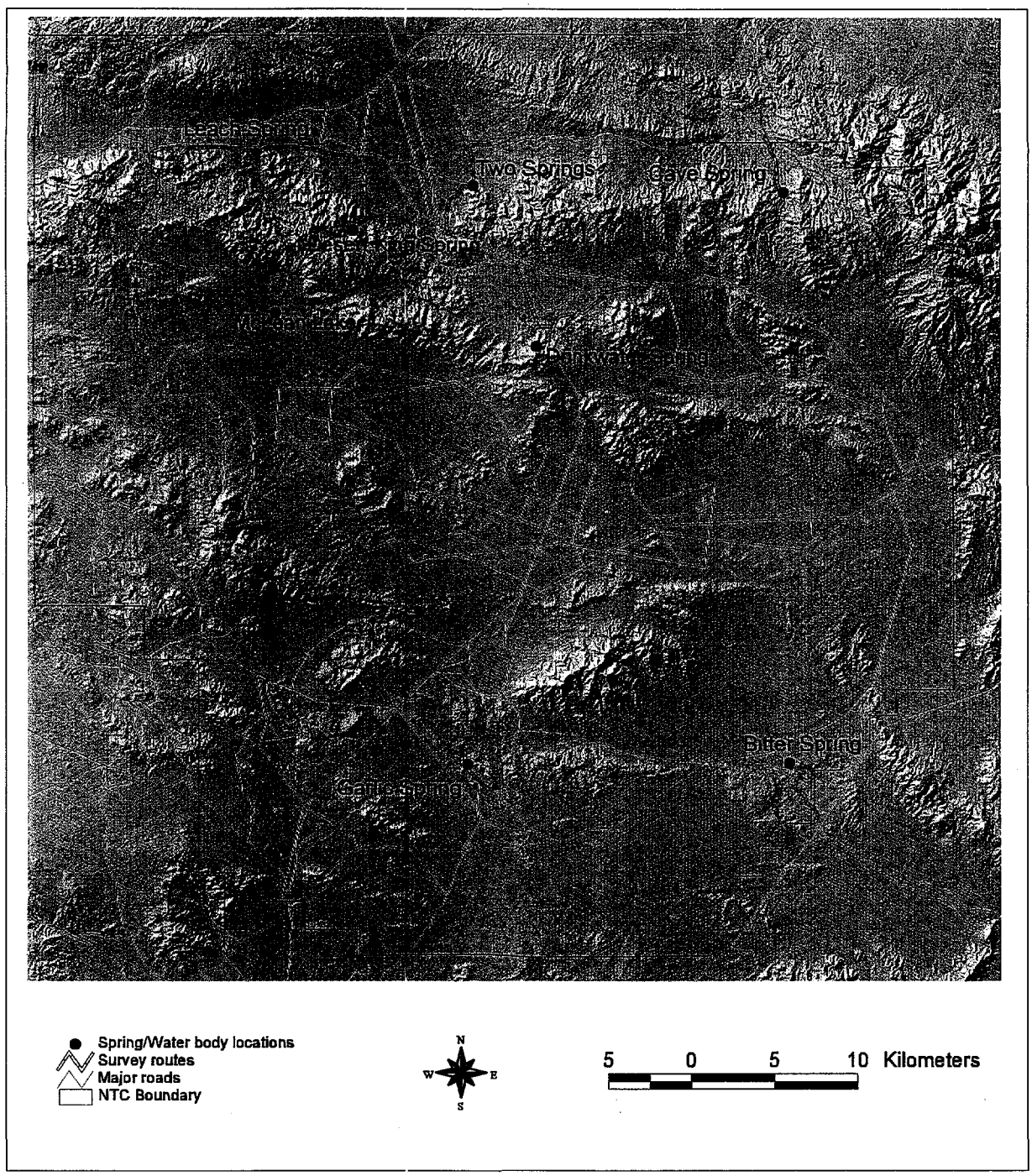

Figure 2. Fort Irwin National Training Center Burro Study Regions - Garlic Spring Road Survey Distance was 9.3 km (5.8 mi), Bitter Spring = 6.0 km (3.7 mi), Drinkwater Spring = 21.5 km (13.4 mi), McLean Lake = 15.8 km (9.8 mi), Cave Spring = 3.7 km (2.3 mi), Desert King Spring = 16.4 km (10.2 mi), Two Springs = 8.7 km (5.4 mi), and Leach Spring = 15.4 km (9.6 mi)

open water pools, sometimes for weeks after a rainfall. The sewage lagoons immediately adjacent to the Fort Irwin base proper (cantonment) were omitted from this study because burros have not been reported in or near the cantonment.

We also surveyed several permanent springs for burro-related damage and mapped the areas using GPS/GIS (as described above) to quantify the extent of damage and provide estimates of the size and extent of burro exclosures for those areas. The GIS data layers and spatial analyses were completed using ARC/INFO (ESRI, Redlands, CA). This software was used to illustrate area damage categories and to analyze road-side survey results.

Photographs of burro-related damage areas were digitized and archived, and permanent photo points were established at selected spring sites for long-term monitoring of the feral burro damage areas. In addition, aquatic invertebrate data collected during another spring site study (Mueller and Blanton 1997) was summarized according to intensity of burro-related impacts. Several water quality parameters were obtained from each spring.

Physical and chemical measurements were taken in the field at each sampling site to characterize the springs. Temperature and dissolved oxygen (DO) were measured with a Yellow Springs Model Y58 dissolved oxygen/temperature recorder, and pH and total dissolved solids (TDS) were measured with hand-held analytical probes. Measurements were taken in flowing sections exposed to sunlight.

Contacts were made with representatives of California Fish and Game Department (CF&G), the BLM, university ecologists, the National Park Service, and other military land managers to determine what is known regarding feral burro populations in areas surrounding the NTC.

4.0 Results

Results are drawn below for distributions of burros, based on scat counts, the impacts of burros on spring sites, and water quality at the springs.

4.1 Burro Distributions Relative to Water Sources

The February 1997 reconnaissance observations suggested that burros frequently used the secondary roadways during their night-time movements on the NTC. We used scat-group density as an index for animal abundance (Neff 1968; Lancia et al. 1994) and recorded the number of burro scat-groups found along secondary roadways in the survey regions (see Figure 2). Survey regions were identified according to the nearest water source. Over 80 km (50 miles) of secondary roadways were surveyed on the NTC and included over 550 burro scat observations (see Appendix A).

Figure 3 summarizes this data by region and reports the results as the number of burro scat-groups observed per unit distance (km). Leach Spring, Two Springs, and Desert King Spring regions all contained relatively high densities of burro scat (8 - 15 scat/km). Very little evidence of burro use was detected at Bitter Springs or Drinkwater Springs, and no evidence was found at Garlic Springs.

Over half of all scat recordings were within 1 kilometer (0.62 mile) from the water sources (see Figure 4). This illustrated the important role that spring sites play in the distribution of burros or burro groups on the NTC.

Sightings of scat more than 4 km from any spring site is in part explained by the presence of moderate burro activity found around McLean Lake (see Figure 3). No permanent or semi-permanent springs exist in this area. Therefore, the nearest distance calculations of scat from this area referred to either Desert King Spring or Leach Spring. McLean Lake does, however, contain large missile craters near the south-central end of the otherwise dry lake-bed. These craters collected and retained rainwater and run-off, sometimes for weeks after a rainfall. The presence of new, recent, old, and very old scat (Appendix A) suggested burros are year-round residents of the McLean Lake region.

Garlic Spring is located just east of the cantonment (Figure 2). We did not observe burro activity during reconnaissance or roadway surveys there. A perimeter fence with three lines of barbed wire had been placed around the spring site and surrounding area (approx. 50 m x 50 m).

Bitter Springs is also a relatively low burro-use area (see Figure 3). The spring is an isolated water source on the eastern boundary of the NTC. The spring site itself is a semi-permanent water source but almost 1 kilometer of the sandy soiled wash area is covered with mesquite (*Prosopis juliflora),* salt cedar (*Tamarix pentandra*) and other emergent vegetation. No evidence of riparian-type habitat damage was visible at this bitter springs, neither in the spring nor the fall of 1997. Mueller and Blanton (1997) reported that one small water pool there in 1996 had been dug out by burros.

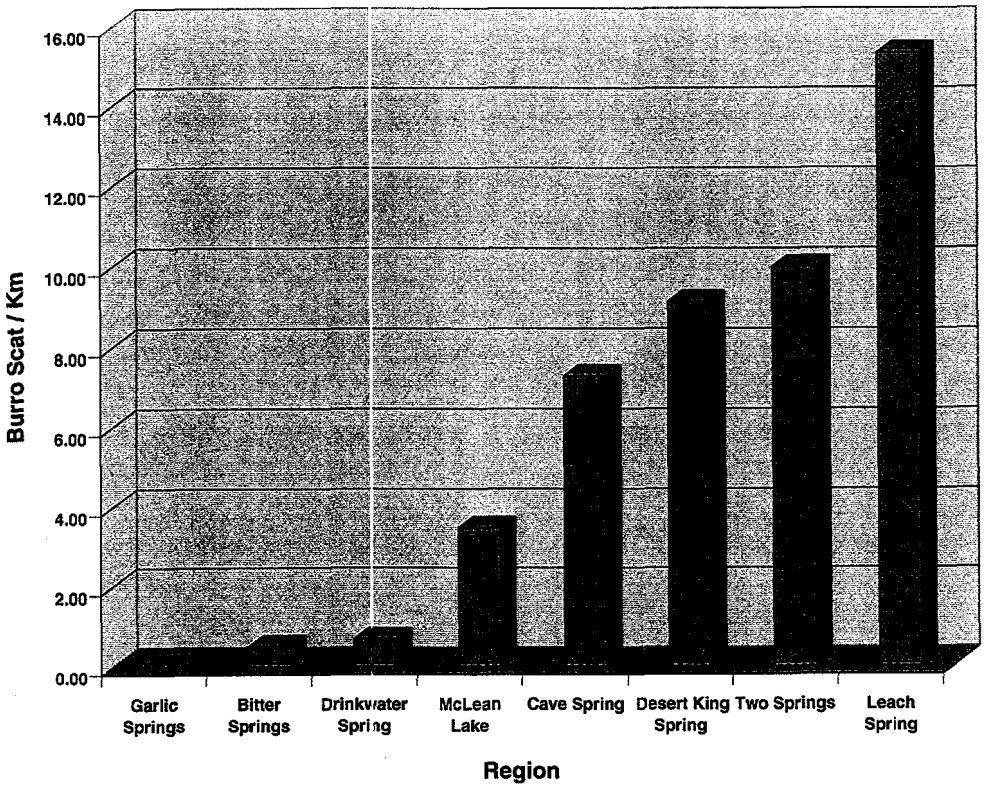

Figure 3. Relative Abundance Estimates of Burro Scat on the NTC

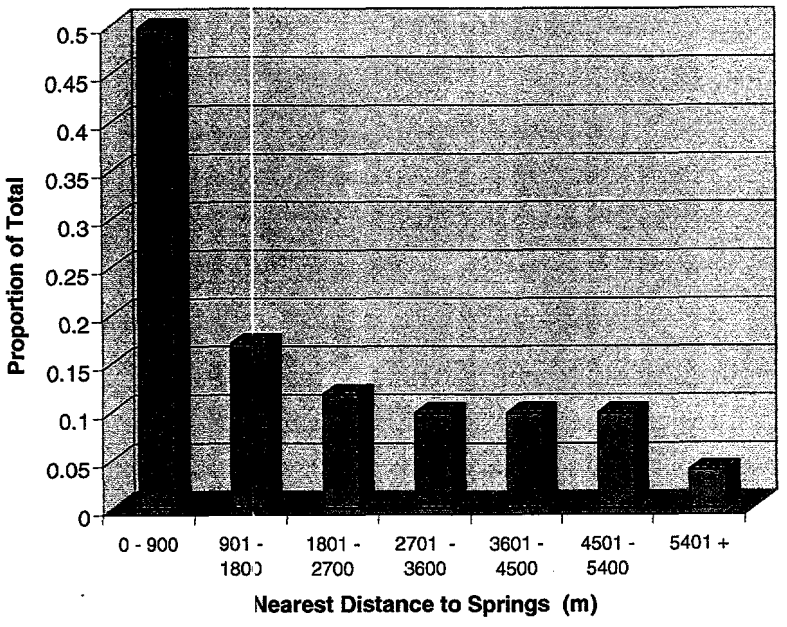

Figure 4. Location of Burro Scat Relative to Nearest Distance to Spring

Drinkwater Spring site is located in the north-central region of the NTC and is relatively close to much of the high-use burro areas (Figure 2). The semi-permanent spring site is within a xeric gully and consists of dense and vigorous stands of *Atriplex sp.* (the ocular estimate of average mean shrub height was 1 m). Two large creosote (*Larrea tridentata*) shrubs (approximately 2 m tall) and one large (1 m) bunch grass grow near the center of this area. The site has been fenced off with concertina wire (30 m x 30 m). Although one section of the wire allows foot traffic into the densely vegetated areas, the burros do not appear to be using the area at all. Some burro use was noticeable outside the fencing (Figure 3).

4.2 Site-Specific Impacts

This section documents site-specific damages caused by burros at the moderate and high-use spring sites. The McLean Lake region was not included as a damage-assessment site because it was not considered a sensitive habitat.

4.2.1 Cave Spring

Cave Spring (Figure 5) is a small pool which originates from a cavern at the base of a canyon near the northeastern portion of the NTC and is a remnant of mining activities prior to the 1930s. The wetted portion of the spring was 1.5 m wide and 8 m long with maximum water depth 1.3 m. The substratum consists of bedrock and gravel with organic matter. Water trickles from the cave into a grass/shrub vegetation area of about 3 m^2, then evaporates and/or disappears into the ground. The vegetation consists of vigorous *Atriplex sp.* shrubs with an understory of mixed annual grasses.

Burros frequently visit this spring site. The open water available to burros is a small (2 m x 1 m) pool, which extends into the granitic cavern. The size and configuration of the spring itself limits the available area for riparian plant and animal communities. Much of the surrounding area moistened by spring water was trampled down by burros.

Large stands of *Atriplex sp.* and desert Baccharis (*Baccharis sergiloides*) were present at the base of the spring seepage area. The burros did not appear to be browsing on these lower adjacent shrubs, but the burro trails leading into the water hole have left the ground devoid of plant life. Also, a 10 m x 10 m area immediately south of the spring has been used as a loafing area and is devoid of live vegetation (approximately 25% aerial ground cover of dead *Atriplex*) (Figure 6). It is likely the flora is dead here because one large live poplar tree (*Populus sp.*, approximately 4 m tall) provides shade next to the spring. Burros using this area have many other shade or loafing sites available because of the sheer cliffs and rocky bluffs in the canyon but seem to prefer the shade immediately adjacent to the spring source.

Cave Spring and the surrounding area is a culturally significant site (see Figure 7). Following mining abandonment by propectors, the area was used as a stop-over for travelers heading to or from Death Valley in the early 1900s. Disturbance of surface terrain on and around the cave entrances appears to have been caused primarily by burro loafing and bedding activities around the site.

Figure 5. Available Water at Cave Spring - Showing no emergent vegetation in burro trailways.

Figure 6. Cave Spring (left side) - Illustrating severe soil and vegetation damage from burro trampling and loafing. Photo also includes the shade tree (right side).

Figure 7. Cave Springs Cultural Site - Shade tree in Figure 6 is located at left edge of this photo. Shrubs (bottom of photo) were damaged by burro-related activities.

4.2.2 Leach Spring

Leach Spring originates from a man-made mine shaft near a rock outcrop formation in the northwest portion of the NTC (see Figure 2). The water pools were 15-25 cm in depth, and the water was clear but visibly turbid near the lower region watering hole, which is visited by burros. The substratum was mainly sand and cobble with mud in places. The stream bed width averaged about 60 cm.

This is also the closest water source to NWC. Burros have free access to the upper-most region of the Leach Spring. The spring travels from this upper region to several small pools within a rock-surrounded cavern along the mid-region of the spring. The mid-region of this spring acts as a natural exclosure to burro use and provides a reference riparian community in the absence of burro use (Figure 8). Vegetation within the undisturbed region was greater than 100% ground cover and was composed primarily of desert baccharis (75%), *Juncus sp.* (10%), mixed bunch-grasses (10%) and other species (5%) (see Appendix B). The lower regions of

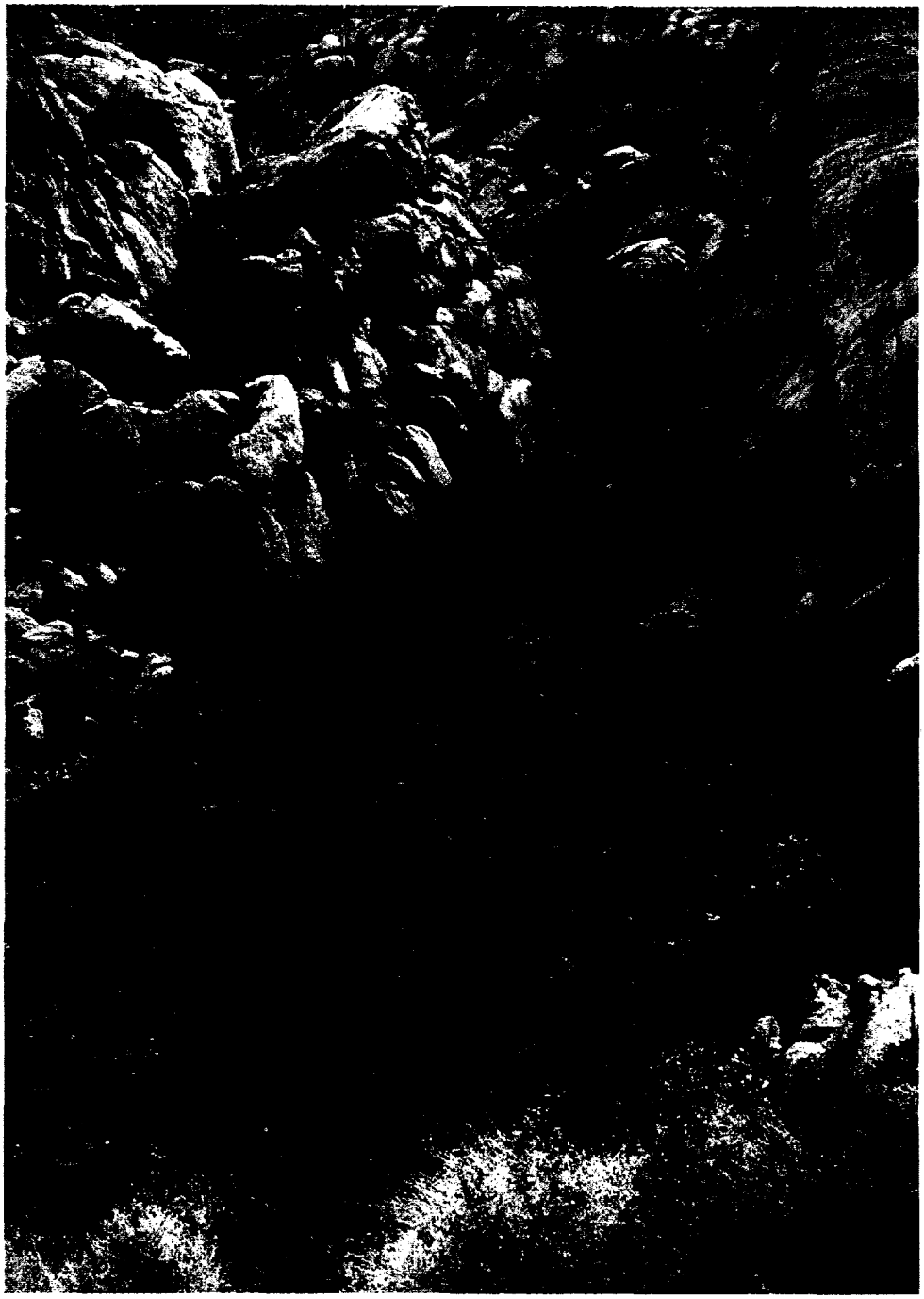

Figure 8. Leach Springs, Mid-Stream Region - Steep rocky terrain excludes burro use.

Leach Spring provided no natural protection from burro intrusion, evident from the numerous burro tracks, scat, and extensive loss of vegetation (see Figures 9 and 10). One colony of rushes *(Juncus spp.)* found in lower region had been recently browsed by burros and were all 10 cm or less in height, as compared to *Juncus* plant heights ranging from 30 to 100 cm in the undisturbed region of the spring.

We also found two large (greater than 5 meters tall) willow trees (*Salix sp*) in the lower impact region of Leach Springs. Both had been commonly used as shade trees by burros. The sheer trampling and bedding by burros at one tree has resulted in 100% bare ground there (see Figure 11). Bare ground cover under the second tree was 50% as some large fallen logs prevent burros from loafing there. We also estimated between 95% and 100% bare ground for the upper regions of Leach Spring, where burros use was high.

Leach Spring also had considerable impact by early prospecting activities. A pipe had been installed, beginning at the source of the spring and ending down near the willow trees. A large tub was also present near the *Juncus* patch, further reducing the available area with wetted soil for emergent vegetation. Water does not flow through the pipe.

We calculated aerial coverage of Leach Spring using GPS data (±1 m) and Arc/Info. All riparian vegetation was mapped according the intensity of burro use (Appendix C). The following table illustrates extent of aerial damage from burros at Leach Spring:

No Impact = Undisturbed, 0% bare ground	Moderate Impact = 50% - 90% bare ground	High Impact = 91% - 100% bare ground
272 m^2	566 m^2	236 m^2

Over 1,000 square meters of riparian vegetation was identified at Leach Springs. Undisturbed areas include only the mid-region of the spring site, where steep and rocky terrain essentially excluded burros from using that region. The second category refers to riparian regions where bare ground exposure was dominant (50% - 90%) but vegetation was present and vigorous there. High-impact areas were defined as those areas where bare ground was greater than 90% aerial cover and living vegetation was essentially absent.

4.2.3 Two Springs

Two Springs (Figure 12) is located near the north-central boundary of the NTC (see Figure 2) and consists of three small pools about 30 cm in depth, with riparian vegetation throughout the area. The immediate xeric plant community around Two Springs had also been used extensively by burros (see road transect data). GPS mapping of the water-influence area included over 670 m^2 of riparian vegetation primarily comprised of sedge (*Carex sp.*) and *Ranunculus sp.* Bunchgrasses (*Polypogon spp.)* and *Artemisia leudoviciana* were also sub-dominant in the riparian plant community. The soils were a mix of gravel/sand and sand/silt. Burros had recently been browsing and trampling near the center of the spring seep (*Carex sp.*, 10-cm height versus an unbrowsed height of 30 cm). Aerial extent of the intensively browsed section was 38 m^2 (Appendix C).

Figure 9. Leach Springs Lower Region - Extensive burro-related damage at the watering area.

The *Atriplex sp.* (saltbush) dominated community adjacent to the Two Springs has been influenced by shallow ground-water and impacted by burros (see Appendix C). We mapped over 8,900 m^2 dominated by saltbush and creosote shrubs that exhibited plant vigor resulting from the regional water source. Burro trails, loafing, and bedding activities in the nearby saltbush-dominated community were also very apparent.

This site also appeared to be within a burro pathway which ran north toward Death Valley or directly west toward China Lake NWC. It appeared that burros frequently travel between Two Springs and Leach Spring.

4.3 Water Quality

Table 1 presents the physical and chemical data for several springs identified in this study (data from Mueller and Blanton 1997). None of the water quality parameters indicated any relationship to burro use intensity. Water temperature varied and was related to the time of day samples were collected. Dissolved oxygen (DO) was quite variable and ranged from a low of

Figure 10. Leach Springs - Illustrates saltbush (*Atriplex sp.*) community adjacent to spring site, where burro trampling and loafing have caused extensive damage to the xeric plant communities.

Figure 11. Leach Springs Shade Areas Under Willow Trees Used by Feral Burros - Note extensive damage to vegetation and soil stability (*Juncus sp.* patch in background).

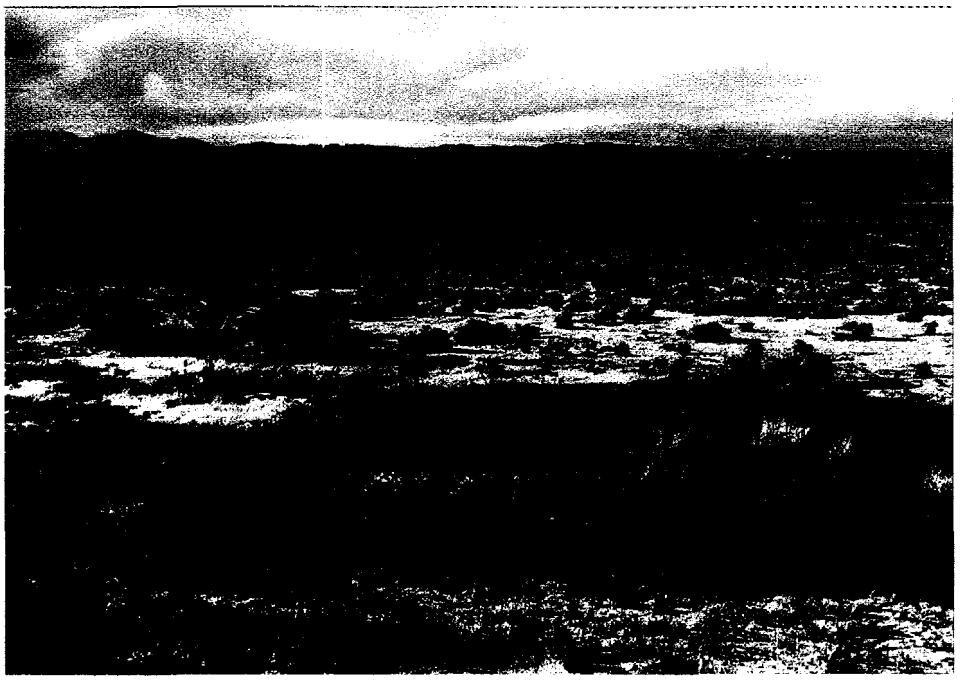

Figure 12. Two Springs

4 mg/l at Garlic Spring to a high of 15.2 at Cave Spring. Total dissolved solids (TDS) ranged from 171 mg/l at Leach Spring to 1280 mg/l at Bitter Spring during the spring of 1996. The high value at Bitter Spring was probably due to the sample being taken at a small isolated pool. Both TDS and pH were similar in range to water-quality parameters observed at springs sampled during 1995 in the Avawatz Mountain range just east of the NTC (Cushing and Mueller 1996).

Table 1. Physical and Chemical Measurements of Springs on the NTC, April 1996 (water data summarized from Mueller and Blanton 1997)

Water Source	Burro Use Index	Temp (ºC)	D.O. (mg/l)	TDS (mg/l)	pH	Number Invertebrate Families
Garlic Spr.	None	21.1	4	352	7.91	16
Bitter Spr.	Low	17.2	8.8	1280	8.33	10
Cave Spr.	Moderate	12	15.2	299	8.65	16
Two Spr.	High	16.2	4.5	399	7.7	6
Leach Spr.	High	10.6	11.4	171	7.32	17

This table also presents an index of relative richness of benthic invertebrates based on two comprehensive surveys at each spring during 1996 and a less comprehensive survey at Garlic and Bitter Springs in the spring of 1997. The diversity ranged from 6 to 17 families, with no apparent relationship to amount of burro use of the springs. Leach and Cave Springs had the most diversity of Coleoptera with six genera, followed by Two Springs with three genera. Mueller and Blanton (1997) also identified two new genera of Carabidae new to California, collected from Leach Spring during March 1996. Cave and Leach Springs were also the only locations where genera of Gerridae were found. Also, a single specimen of Salididae was collected from a light trap at Leach Spring.

Seed shrimps (Ostracods) were identified at Leach and Bitter Springs during 1996. Researchers found literally thousands occurring in the disturbed areas degraded by frequent burro activity at the lower region of Leach Spring and in small isolated pools at Bitter Spring.

No threatened, endangered, or state sensitive species listed by the California Fish and Game Department were identified at any of the sampling sites. Mueller and Blanton (1997) also compared the identified genera with the California Insect Survey listing of California's endangered insects and found at least two families proposed for listing, one Diptera (Ephydridae) and one Coleoptera (Curculionidae), which were not identified to species.

5.0 Discussion

Spring sites in the Mojave Desert ecosystem support more flora and fauna than any other community type known there (Krzysik 1984; Jakle 1985; Brandt et al. 1995). Roadside surveys demonstrated that spring sites profoundly influenced burro use of the NTC. Relative densities of burro sign on the NTC were low (less than 2 scat per mile) in the southern regions of the NTC near Garlic Spring, Bitter Spring and Drinkwater Spring; moderate (between 5 and 15 scat per mile) near McLean Lake, Cave Spring, Desert King Spring; and high (greater than 15 scat per mile) at Two Springs and Leach Spring.

Desert King Spring site assessment suggested low burro-related impacts there. The site had been used as a watering hole by burros; however, the spring existed as a water trickle that ran through an abandoned bath-tub, presumably put there from pre-military prospecting activities. Garlic Spring and Drinkwater Spring had barbed-wire fencing surrounding the spring that effectively prevented extensive burro use there. Garlic Spring lies within 3 km of the cantonment, which may partly explain the lack of burro use in the surrounding areas. The Bitter Springs site had very little evidence of burro use, presumably due to the site's isolated location along the southern NTC border. McLean Lake area has no spring site nor does it contain any relatively diverse and sensitive habitats (aside from the playa), but burros seem to use this valley on a regular basis. Large depressions created from military artillery have allowed water to collect there, providing temporary watering holes for burros. The McLean Lake region may also act as a corridor or stop-over for burros travelling between Leach Lake, Desert King Spring, and Two Springs.

Data collected during this study demonstrate significant impacts on xeric and/or riparian habitats at Cave Spring, Two Springs, and Leach Spring by feral burros. Cave spring is a non-riparian rock quarry water pool; however, burro trails and loafing areas near the spring site have caused moralities to the surrounding xeric plant communities and, as a result, have impacted surface terrain at a significant cultural resource site. Leach Spring and Two Springs had extensive burro-related damage that has affected riparian and adjacent xeric habitat there.

Aquatic resource surveys at water sources on the NTC in 1996 indicated that Cave Spring, Leach Spring, and Garlic Spring contained the most diverse macroinvertebrate communities throughout the NTC. Physical water measurements taken at selected spring sites did not depict any relationship to the frequency of burro use there. Mueller and Blanton (1997) found different macroinvertebrate compositions on the NTC when the water source was a pool versus faster-flowing reaches. Macroinvertebrate compositions could have been influenced by burro activities, causing change in the water flow patterns; however, no relationship to burro activity was observed.

Evidence (scat pellet-groups or tracks) of spring site usage by bighorn sheep (*Ovis canadensis*) was not observed at any spring site on the NTC. Brandt et al. (1995) found evidence of bighorn sheep at several springs in the Avawatz mountain range (proposed expansion area along eastern border).

6.0 Management Recommendations

The need to manage burro-related impacts to the environment and the mechanisms for doing so have been clearly established. Congress recognized the issues and established the wild horse and burro herd management areas and the parameters for management through the Wild Free Roaming Horses and Burro Act of 1971 (Public Law 92-195 as amended). Section 3(b)(2) requires that if an overpopulation exists on a given area of public lands, action is necessary to remove excess animals from the range so as to achieve appropriate herd management levels. The Public Range Improvement Act of 1976, the Federal Land Policy and Management Act of 1976, and the California Desert Protection Act of 1994 (CDPA) include wild horse and burro population control measures. Also, the California Desert Conservation Area (CDCA) Resources Management Plan of 1980 identified herd management areas (HMAs) and established appropriate management levels for wild horses and burros. In this plan, lands outside of the established HMAs are to be managed for other resources to the exclusion of horses and burros.

6.1 Phase I: Burro Removals, Spring Site Exclosures, and Alternate Waterholes

Direct reduction of burro numbers that reside near heavily impacted areas on the Fort Irwin NTC is needed to mitigate burro-related impacts at the spring sites studied in this report. Burro removal activities should focus on areas near Leach Spring, Two Spring, Cave Spring, and McLean Lake. These sites, which were heavily used by burros during this study, contain some of the most diverse aquatic macroinvertebrate communities found on the NTC and support the fact that they should be preserved as such. The relatively close proximity of Two Springs and Leach Spring to each other also substantiates the need to reduce burro access to both sites so as not to displace burro use from one spring to the other. Cave Spring also demonstrated high burro use there, but mitigation here is pivotal to the maintenance of a culturally significant site rather than to riparian habitat

The NWC's Final Environmental Impact Statement (FEIS) and Environmental Assessment for horse and burro population management on and adjacent to the base provides the framework for the determination of a Full-Force Effect and Finding of No Significant Impact by the BLM for removal of burros in the Slate Mountain HMA and adjacent areas in 1998. The NWC's FEIS identifies round-ups and water traps as routinely used techniques to effectively remove burros from these areas. Collaborative efforts with BLM and NWC are desired since the CDCA recommends lands outside the established HMAs also be managed for excessive burro populations (Slate Mountain HMA manages for zero burros).

Physical barriers should be placed around the aquatic resources that have been damaged by burros. These sites include Leach Spring, Two Springs, and Cave Spring. Desert King Spring exhibited moderate burro use of the area but the man-made disturbances at this small (1 m x 1 m) spring site have eliminated any significant natural features that may have existed there (except the presence of water). Spring site enhancement work at Desert King Spring should first be done to mitigate damage caused by human activities. Afterwards, a small-scale burro exclosure could be easily assembled there.

Spring site exclosures should coincide with burro-removal activities to prevent additional immigrating herds from establishing a regional use pattern (or water resource dependency) there. Exclosures should be of a design that prevents only burros from accessing the spring sites. It is possible that longer stretches of open water will develop by protecting the upper regions of the selected spring sites. In these cases, it may be possible to allow burros access to the lower regions without causing significant detrimental impacts to the spring site.

Alternate watering holes (passive water trough system) also need to provided to burros at three of these mitigation sites to ensure animals not captured during the direct removal efforts are not displaced to other spring sites currently not occupied by, or protected from, feral burros (a few sites on the NTC but primarily those in the Avawatz Mts.). Bighorn sheep are currently the only large herbivores utilizing spring sites in the Avawatz Mountains (Brandt et al. 1995). Watering troughs should be placed at Leach Spring, Two Spring, and possibly Cave Springs pending hydro-geological logistics there.

6.2 Phase II: Monitoring Burro Abundance, Distributions, and Spring Site Recoveries

The lack of intensive burro use at Garlic Spring, Drinkwater Spring, and Bitter Springs suggests little or no need for burro reduction/exclosure efforts there. However, annual or bi-annual road surveys should be conducted to continue monitoring regional use patterns by burros since population control measures will affect available water sources on the NTC. Burros not captured and removed directly during round-ups or trapping efforts may simply be displaced to other springs or water sources on the NTC.

Spring sites protected by burro exclosures in 1998 should be subsequently visited (monthly) to ensure continued integrity of the barriers. Plant composition, percent bare ground, and benthic invertebrates should be routinely (at least every other year) measured and site photographs taken and archived to document changes in the aquatic resources and riparian and/or adjacent xeric plant communities.

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Appendix A

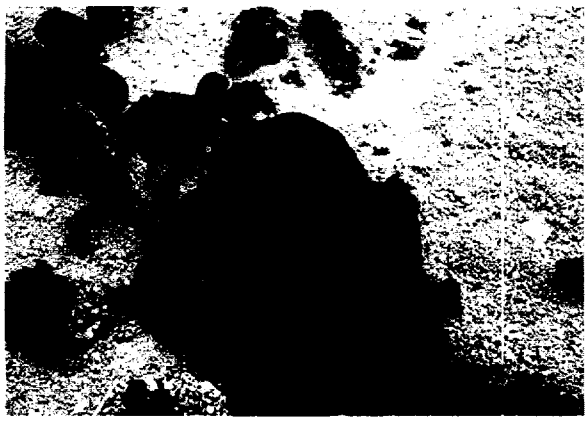
Burro Density Summary Data and Scat Classifications

Appendix A

Burro Density Summary Data and Scat Classifications

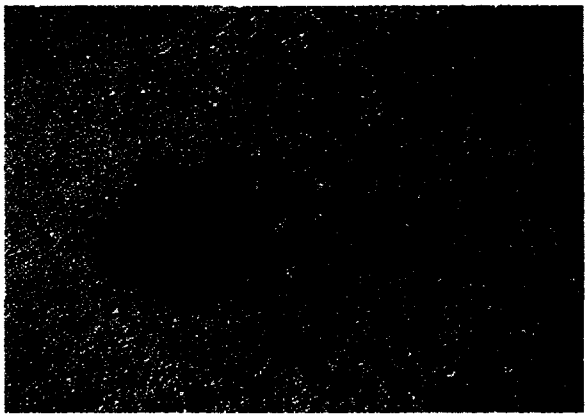
	Scat Classifications								
Nearest Spring	**New**	**Recent**	**Old**	**Very Old**	**Scat total**	**Total miles**	**Total km**	**Scat/Km**	**Scat/Mile**
Garlic Spring	0	0	0	0	0	5.8	9.3	0.00	0.00
Bitter Spring	0	1	2	0	3	3.7	6.0	0.50	0.81
Drinkwater Spring	0	3	1	11	15	13.4	21.6	0.70	1.12
McLean Lake	9	17	26	3	55	9.8	15.8	3.49	5.61
Cave Spring	5	8	11	3	27	2.3	3.7	7.29	11.74
Desert King Spring	19	48	58	25	150	10.2	16.4	9.13	14.71
Two Springs	2	42	38	5	87	5.4	8.7	10.01	16.11
Leach Spring	25	81	103	28	237	9.6	15.5	15.33	24.69
Totals	60	200	239	75	574	60.2	96.9		

Scat Classification "NEW":
Very dark, moisture still present.

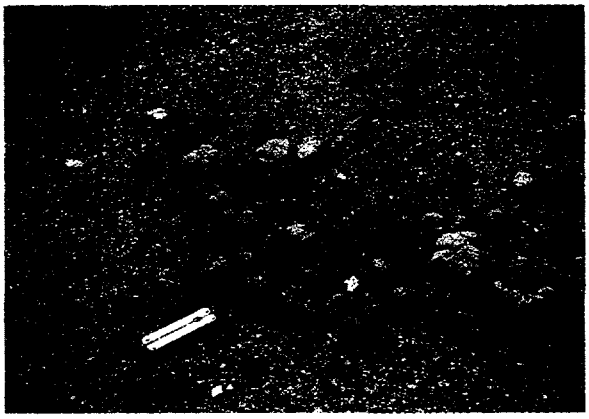


Scat Classification "RECENT":
Scat still dark in color but moisture is absent.

Scat Classification "OLD":
Scat is dry and slightly faded.



Scat Classification "VERY OLD":
Scat is very faded and not necessarily in-tact.



Appendix B

Plant Composition at Leach Spring and Two Springs

Appendix B

Plant Composition at Leach Spring and Two Springs

I) Plant Composition of Leach Springs Undisturbed Riparian Region (less than 5% bare ground)

75% *Baccharis sergiloides*
10% *Juncus sp.*
10% Rye Grass (*Elymus sp.)*
5% others:
Grasses - *Polypogon monspeliensis*

Forbs - *Brickellia sp.*
Datura sp.
Emmenanthe penduliflora
Solanum sp.
Shrubs - *Encelia farinosa*
Artemisia ludoviciana
Hymenoclea salsola

II) Plant Composition of Two Springs Riparian Region (less than 5% bare ground but heavily browsed)

80% *Carex sp.*
10% *Ranunculus sp.*
5% *Polypogon sp.*
5% *Artemisia ludoviciana*

Appendix C

GIS Figures for Leach Spring

Appendix C

GIS Figures for Leach Spring

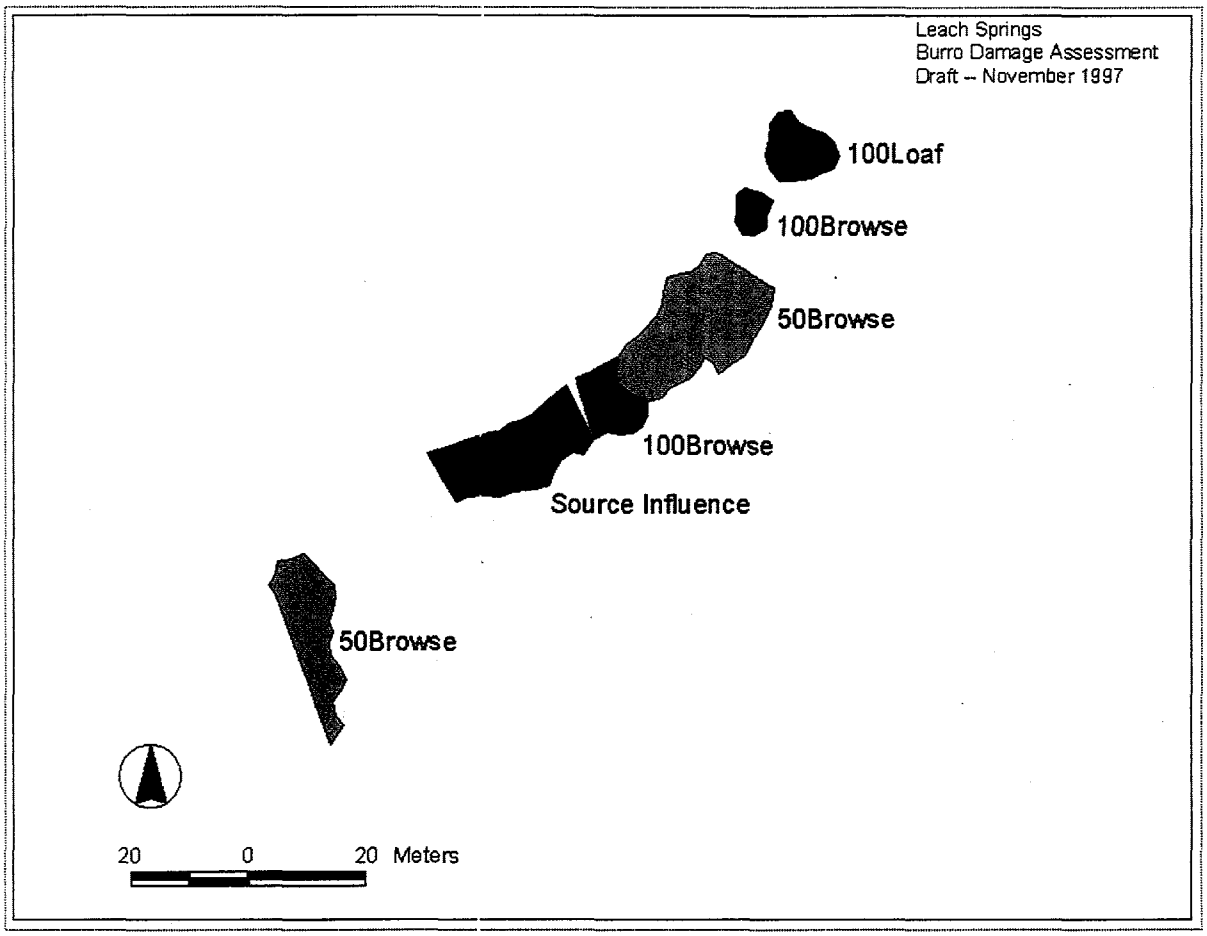


Figure C.1. GIS Map Layer of Leach Spring - Lower left, light red "50 Browse" is upper-region of spring site where burros have browsed on over 50% of all vegetation. Green-colored "Source Influence" section is area where steep rocky cliffs prevent burros from entering. "100 Browse" are areas where burro use has eliminated virtually all living vegetation. "100 Loaf" is the lower region of the spring site where willow trees provide shade for burros. Virtually all living vegetation in this area has eliminated. The map does not include damage to xeric community from trails, etc.

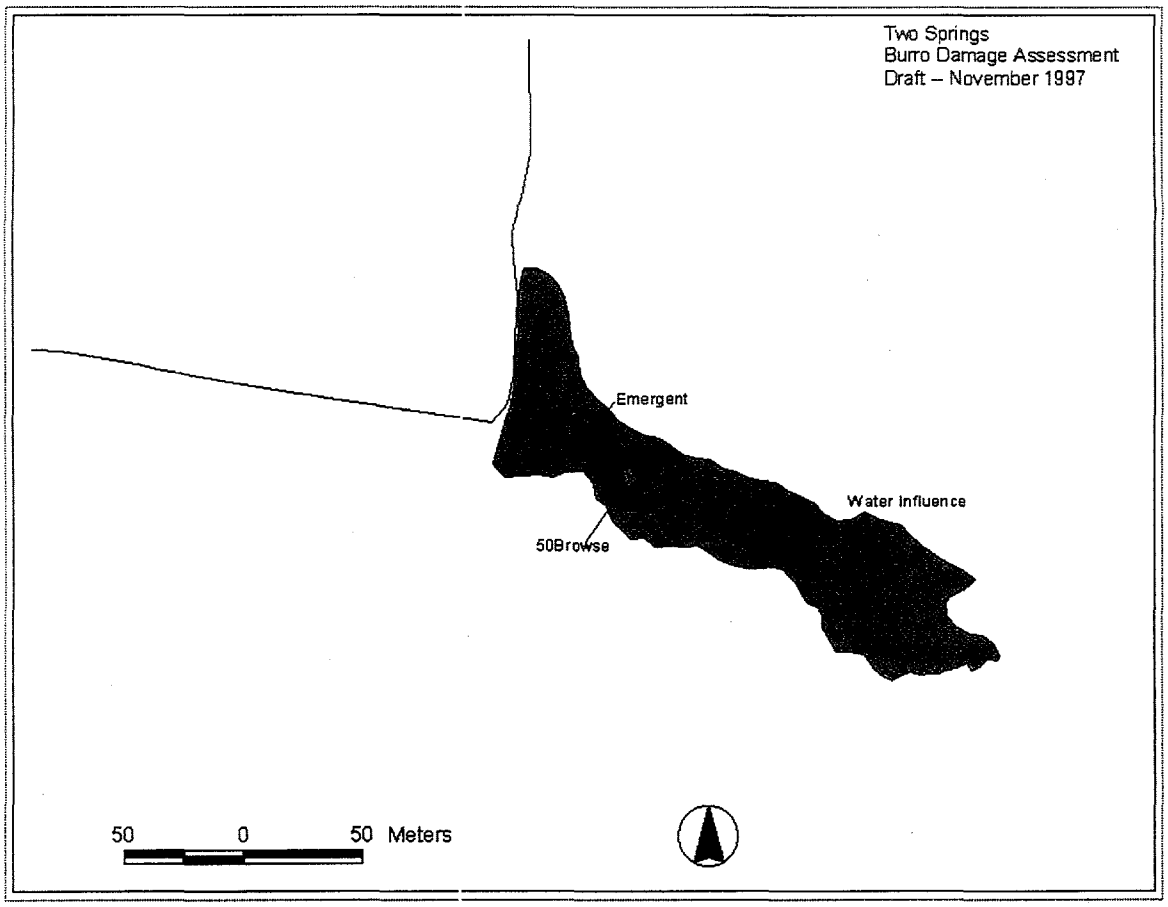


Figure C.2. GIS Map Layer for Two Springs in June 1997 - Light blue color "Emergent" comprised primarily of *Carex sp.* and *Ranunculus sp.* and illustrates aerial extent of riparian-type plants. "50 Browse" is area where burros have browsed upon over 50% of the plants there. *Carex sp.* was 10 cm tall as compared to 30 cm tall in remainder of "Emergent." "Water Influence" was all areas where the xeric community was more vigorous because of the water source.

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Environmental influences on movements and distribution of a wild horse (Equus caballus) population in western Nevada, USA: a 25-year study

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Environmental influences on movements and distribution of a wild horse (*Equus caballus*) population in western Nevada, USA: a 25-year study

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Wild horse populations in the American West have been heavily managed to regulate horse numbers since the inception of the Free-Roaming Wild Horse and Burro Act of 1971. The Montgomery Pass Wild Horse Territory (MPWHT) on the California/Nevada border is unique in the absence of human intervention there across the past 30 years. This has provided the opportunity to observe long-term patterns in the natural relationship between wild horses and their environment and to examine environmental impacts on the horse population and its activities, movements and distribution on the range. In this study multiple variables in the physical environment and in horse behaviour were monitored seasonally across 25 years beginning in 1987. Distinct summer (higher elevations) and winter (lower elevations) range use was characteristic for more than 60% of the population during the first 7 study years, with subsequent gradual but marked reduction in use of summer range. While approximately 20% of the population continued to annually use the historical summer range, the majority divided into two geographically and functionally separate subpopulations that resided year round in the historical winter range and adjacent areas on opposite sides of the MPWHT. Mountain lion predation on foals was restricted to the summer range, and exodus of horses from the summer range resulted in increased foal survival where horse subpopulations eventually resided. The long-term consequences of increased horse numbers in the MPWHT remain under continued study. The present study has shown that wild horses are highly adaptive and individually varied in response to environmental pressures. It has also demonstrated the value of long-term monitoring of wild horse populations to reveal underlying dynamics and their potential management implications.

Keywords: wild horse; environmental factors; population distribution; population dynamics; Nevada, USA

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Introduction

Approximately 40,000 free-ranging wild horses (*Equus caballus*) inhabit public lands in the western USA (USDI/BLM Wild Horse and Burro Program website, http://www.blm.gov/wo/st/en/prog/whbprogram/history_and_facts/quick_facts.html; History and Facts, 30 December 2013). Wild horses are protected by the Federal Free-Roaming Wild Horse and Burro Act of 1971 and are managed primarily by the United States Department of the Interior (USDI) Bureau of Land Management (BLM) with some involvement by the United States Forest Service (USFS), U.S. Fish and Wildlife Service (USFWS) and state agencies. Wild horse populations show annual

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rates of increase from 9% to more than 20% (Eberhardt et al. 1982; Turner and Kirkpatrick 1986; Wolfe et al. 1989; Garrott and Taylor 1990). Due to continued increase in these populations despite fixed or declining available habitat, the BLM has attempted to regulate wild horse numbers.

To enable effective population management, reliable information is needed on environmental factors and social dynamics influencing wild horse demography and distribution. It is known that movement and distribution patterns of various mega fauna, including ungulates, are affected by variables such as seasonal weather, food and water availability, social relationships and presence of other species (Honda 2009; Beschta et al. 2013). Despite the existence of nearly 180 federally designated free-roaming wild horse populations in the western United States (USDI/BLM Wild Horse and Burro Program website; History and Facts, 30 December 2013), there are few formal studies of these populations and their environment (Berger 1986; Feist and McCullough 1976; Turner and Morrison 2001). In part, this dearth has been consequent to the BLM round-up/adoption programme to achieve mandated limits of population size in these herds. Round-ups, with associated removal of horses from given populations, are routinely scheduled (approximately every 4 years), and may impact social organization and horse distribution. It appears that horse movements within and between range areas are in part dictated by social structure, and these movements can ultimately influence overall horse distribution (Turner et al. 1981; Berger 1986). Hence, populations experiencing periodic round-ups are unlikely to be useful for studies of long-term aspects of naturally driven horse distribution. An additional unnatural condition that exists for most horse populations is that they are not truly free-ranging but are, ultimately, limited by fences.

One notable exception to the horse removal/adoption and perimeter fencing issues is the Montgomery Pass Wild Horse Territory (MPWHT) on the central Nevada/California border. This horse population is not restricted by perimeter fences and has not experienced removals for the past 30 years. The latter is largely the result of a well-established pattern of mountain lion (*Felis concolor*) predation on these horses, with evidence of a pattern of seasonal prey switching by the mountain lions between horse foals and mule deer (Turner et al. 1992; Turner and Morrison 2001). This unusual relationship has prevented horse population growth, thereby obviating the need for removals. Although the prey switching phenomenon and lack of fences are not representative of western wild horse populations, these circumstances offered the rare opportunity to document the long-term functioning of a wild horse population in the absence of purposeful human interventions.

The purpose of this study was to examine environmental factors potentially influencing the wild horse population of the MPWHT and to determine the impacts of these factors on activities, movements and distribution patterns of that population. This report contains multi-variable data across 25 years and represents the longest continuous methodical study of a western USA wild horse population.

Methods

Study area

The MPWHT occupies 600 km^2 in Mono County, California, and Mineral County, Nevada centered at 38.5730 N, 118.3010 W (Figures 1 and 2). Elevations range from

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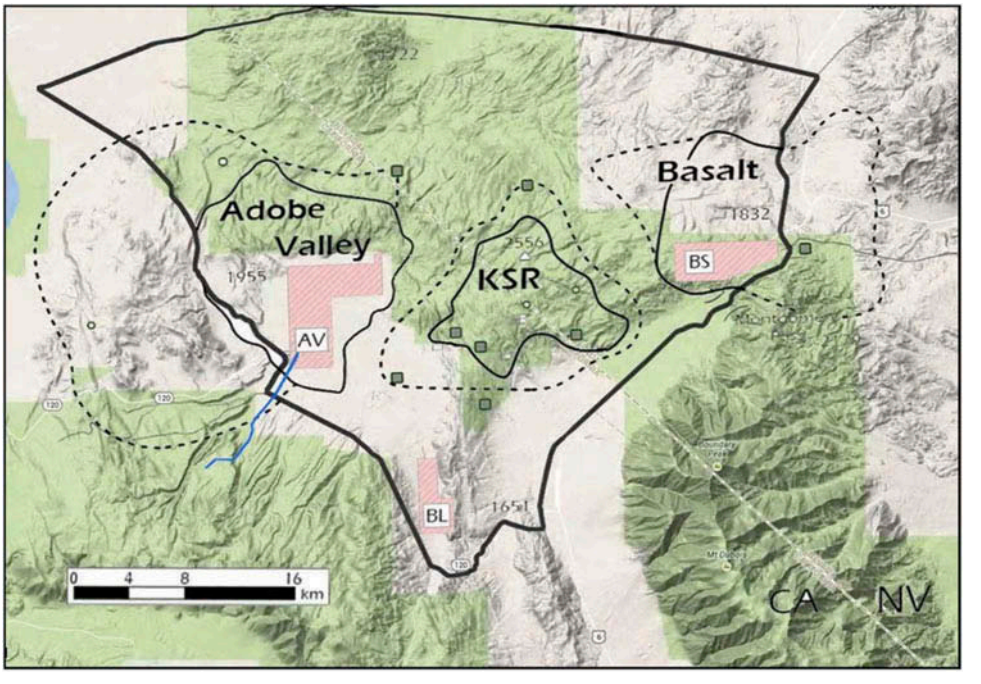

Figure 1. Montgomery Pass Wild Horse Territory (MPWHT) Map. The MPWHT lies on the California–Nevada border. Agency jurisdictions are USFS (green) and BLM (white). The three major horse areas are KSR (key summer range, i.e. upper elevations), Adobe Valley and Basalt (both historical winter range, lower elevations). Dotted lines within and outside the territory boundary represent additional horse use associated with the three main use areas. Hatched pink areas are grazing allotments (AV = Adobe Valley, BL = Black Lake, BS = Basalt). Closed squares are permanent springs. Open circles are seasonal springs. The blue line is Adobe Creek running into AV. Numbers are elevations (m), and triangle is highest point in MPWHT (2556 m). The lower left and right perimeters of the Territory roughly coincide with two paved roads (Routes 120 and 6). Relief aspect of map is courtesy of Google Earth.

1600 m in the peripheral portions of the MPWHT to 2600 m in the central portion, with lower elevations used by horses throughout the year, and upper elevations used May through September. October and May are usually transition months. The upper-elevation portion of the MPWHT is denoted henceforth as the "Key Summer Range" (KSR).

The boundaries of the MPWHT were originally assigned by BLM in 1972 and were derived from limited data of historical horse presence in the chosen areas. The boundaries are uniquely unfenced but are approximately delineated on three sides by paved roads, which some horses regularly cross. In 1987 the Inyo National Forest and BLM partnered in MPWHT management and formed a Coordinated Resource Management Planning committee, which adjusted the MPWHT map boundaries to more appropriately reflect horse use. Additional changes in horse distribution occurred during this study.

Most of the territory is located in sagebrush steppe and pinyon–juniper (*Pinus–Juniperus*) habitat (Figure 2A, B), with the predominant species in the latter being

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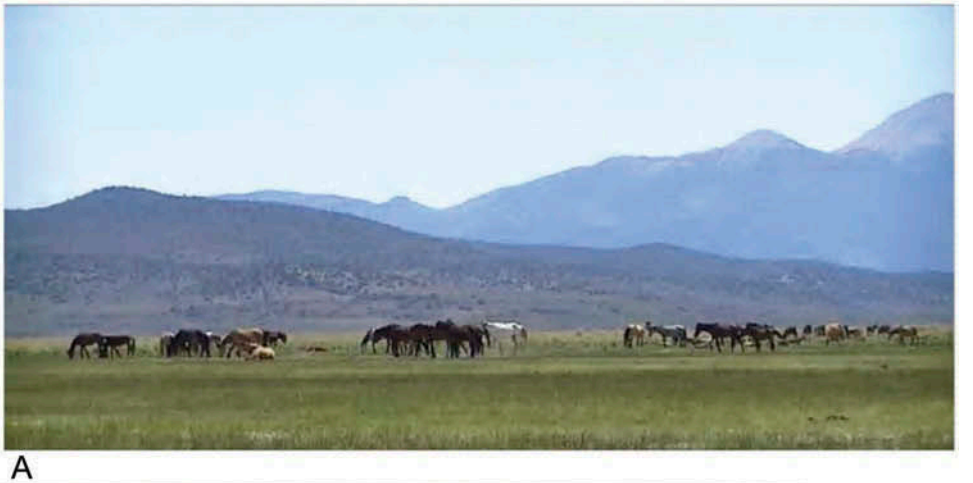

A

B

C

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pinyon pine (*Pinus monophylla*). The understorey is characterized by sagebrush (*Artemesia nova* and *Artemisia tridentata*), bitterbrush (*Purshia tridentata* and *Purshia glandulosa*) and rabbitbrush (*Chrysothamnus viscidiflorus*). Principal grasses are Great Basin wildrye (*Elymus cinereus*), western wheatgrass (*Agropyron smithii*), Indian ricegrass (*Oryzopsis hymenoides*), fescue (*Festuca occidentalis*), bluegrass (*Poa* sp.), and *needlegrass* (*Stipa* sp.). Various phorbs (especially *Lupinus* sp. and *Suaeda* sp.) are present depending on rainfall (Dedecker 1991; Spira 1991).

Data collection

This report provides quantitative and qualitative data derived from seasonal monitoring of wild horses, mountain lions (henceforth "lions"), mule deer and associated environmental variables across a 25-year period. These data are also correlated with information from Federal and State agencies on precipitation, forage and human activity across the study period.

The database for this report was derived from > 10,000 hours of field observation contributed by > 30 experienced individuals. Four to nine people worked in groups or worked separately and collectively logged up to 1300 field hours annually. In addition, > 300 hours per year were spent tracking lions with dogs between 1988 and 1995. Ground-based observations were systematic, with pairs of observers assigned to specific areas and waterholes. Each area was monitored in the same pattern over 1–2 days, and this pattern was repeated two to three times in a week. Work began in April and continued through October (sampling in August was sporadic except in 1993–1995). Systematic aerial surveys (3–4 hr each) using a replicated flight pattern were conducted from May to October at least once by helicopter and/or twice by fixed-wing aircraft as described previously (Turner et al. 1992). Seasonal supplementary and corroborative observations were provided periodically by field staff of the federal and state agencies assigned to the MPWHT.

The territory is seldom accessible by vehicle during winter. With the exception of monitoring in January 1987 and 1988 by the research team (comprising a 1-week ground survey and an aerial survey each year), winter surveys were limited to periodic observations by local research assistants.

Animals

Specifics of the methods for determining locations, enumerations and activities of horses and lions have been previously reported (Turner et al. 1981;

Figure 2. (A) Image is looking east at horses in Adobe Valley (lower-elevation historical winter range at 1880 m.), with key summer range (KSR) in farthest-horizon background on left. Distance to centre of KSR is approximately 13 km. The White Mountains begin on far right, eventually rising to > 4600 m. (B) Image of horses at 2500 m elevation in typical KSR showing sage and pinyon/juniper habitat. (C) Representative horse band (trailing stud, three mares and foal). Colour of mare in centre (bay) represents > 40% of population. Colour of stud in rear (grey) represents < 10% of population. Background hill depicts intermediate-range elevation between lower and KSR areas.

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Turner et al. 1992; Turner and Morrison 2001). These methods are summarized below.

Horses

Reliable estimates of the horse population were generated from the collection of repeated aerial and ground observations made in 13 geographic subdivisions comprising the territory. In the most intensively studied areas complete enumeration was achieved on a regular basis with the use of individual horse and band cohort identification (Figure 2C). Observations were supplanted by periodic video and photographic records.

Mountain lions

Lions in this study were extremely stealthy (< 25 random physical sightings during the entire study), which required reliance on data based primarily on paw tracks, scratch marks, scat and radio-telemetry, with the latter performed from 1987 through 1995 (Turner and Morrison 2001).

Hunting lions has been banned in California since 1972. Although lion hunting occurs in Nevada, historically it has been infrequent in the MPWHT and was suspended from 1987 to 1995 (S. Stiver, Nevada Department of Wildlife, personal communication).

A given lion showed long-term regular use of a given area and limited overlap with other lions in areas of use. Identification of individual lions by track size proved reliable (Fjelline and Mansfield 1989; Smallwood and Fitzhugh 1993), with positive correlation of track-based identification and radio-telemetry. Most lion/horse water use was limited to seven springs, making regular circumferential inspection of the spring area useful for track monitoring.

Lions were radio-collared using California Department of Fish and Game (CDFG) procedures (Jessup and Clark 1986) and standard telemetry was employed (Telonics Inc., Mesa, AZ, USA; Telemetry Systems, Inc., Sarasota, FL, USA). Capture of lions was accomplished using a CDFG-trained tracker (R. Orisio) and dogs. Eight adult lions (three males, five females) were tagged between 1987 and 1995. Aerial and ground radio-telemetry was used to ascertain lion locations and common routes of travel, which was helpful in locating foal carcasses. Between 2001 and 2011, predation data were based primarily on foal survival rates (ratio of present-year yearlings to previous-year foals) and lion track.

Mule deer

The MPWHT serves as winter range for a portion of a migratory mule deer (henceforth "deer") population (Casa Diablo herd). The summer home for most of this population is the eastern slope of the Sierra Nevada Mountains west of highway 395 at approximately 37.8 N and 119.1 W (north of June Lake and south of Lee Vining, CA; Jones and Stokes Associates, Inc. 1999). A portion of this herd annually moves approximately 50 km eastward from the Sierra Nevada to the middle elevations of the MPWHT in September/October and returns to the Sierra in March/April (Taylor 1988). Seasonal deer numbers in the MPWHT during the study were

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estimated from collation of observations by the research team, local hunters and periodic aerial winter counts by the CDFG. The purpose of estimating mule deer presence in the MPWHT was to determine whether low deer numbers (i.e. insufficient lion prey) were a potentially limiting variable regarding lion presence and horse distribution.

Water

Information on water availability in the MPWHT was derived from precipitation data and observations of permanent and seasonal groundwater sources.

Precipitation

Mean annual precipitation in the MPWHT region is < 30 cm, most of which falls as winter snow. Maximum daily average temperature in July is 39°C, and winter lows average − 10°C (Powell and Klieforth 1991). A drought throughout the Great Basin, including the MPWHT, occurred from 1987 to 1993 (Morton et al. 1995).

A semi-quantitative scale for precipitation was generated from three sources. First, monthly precipitation records for each month of the study years were obtained from the U.S. Forest Service Fire Office remote automated weather station (RAWS) for the recording station closest to the MPWHT (Benton, California, which is < 3 km from the eastern MPWHT boundary). Second, the water level of a small (< 80 m diameter) seasonal pond (McNamara Lake) near the centre of the MPWHT was recorded across each May/June. Third, the activity of seasonal springs in the area was recorded each May/June because most precipitation occurred from February through April. A relative scale of 1–10 (where 10 = wettest) was established from these data to enable relative moisture assessment across the study. The 2006–2011 data did not include RAWS input.

Groundwater

There were seven permanent water sources within the horse use areas, which were active across the entire study (Figure 1). Four of these were used by horses year round and three (in the KSR) were used in all seasons except winter. There were also five seasonal water sources (dependent primarily on winter snowfall) that were available generally from April to July (Figure 1). Since water availability can markedly influence wildlife distribution, major water-site use by horses of known identity was field monitored in May/June and September/October from 1987 to 2004.

Forage and range condition

In June and September of 1990 and 1991 an assessment of range condition/forage was performed, and range carrying capacity was estimated for the KSR, riparian areas and selected winter-range areas of the MPWHT (USDA Inyo National Service unpublished files, Lee Vining, CA 1990/1991). The methodology employed standard walking grids and focused on key grasses and phorbs. Utilization was across five categories ranging from "no use" (0–5%) to "severe use" (81–100%), and employed the dot-count method for key species (USDA Inyo National Forest, range utilization protocol, Lee Vining, CA). As part of this assessment, both forage types and relative

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amounts were recorded. Preferences for forage types were determined by observation of horses eating and of plant types eaten and uneaten after horses vacated an area. Corroborative evidence of food preferences was obtained from a separate study of plant species present in faeces of MPWHT horses (L. Coates-Markle, personal communication).

Horse-dependent factors

The fundamental wild horse harem-band social structure (Turner et al. 1981; Berger 1986; Turner and Kirkpatrick 1986) is characteristic of the MPWHT population (Turner and Morrison 2001). Routine alerts, daily movements of harems, the timing of these movements and many daily social activities are usually directed or influenced by a dominant (sometimes referred to as "lead") harem mare (Feist and McCullough 1976; Waring 1983). In this context, "dominant" refers to having an active leadership role more than behaviourally dominating other band members, although both were true for some mares. The role of this dominant mare in four well-identified MPWHT harem bands was studied from 1994 to 1996. These bands were chosen on the basis of ease of identification (colours/markings), band size (six to eight horses), and previously noted consistent presence of the same dominant mare and the same harem stallion. At least one foal was produced annually in each band. Each band was monitored in May, June and September to determine: (1) approximate daily travel distance, (2) travel routes taken, (3) grazing-site preferences, (4) dominant mare initiation of travel and (5) band tolerance to intrusion. The latter was based on estimated distance of a perceived intruder (people on horseback or in a vehicle) when a band alerted and moved away. The estimated distance which the band moved before stopping was also recorded.

Other factors

Grazing allotments

Three cattle-grazing allotments were located in the MPWHT and were in use from June through September when the study began. All were flat, sagebrush habitat in lower-elevation (1000–2000 m) parts of the range: Adobe Valley (fenced) in the western portion, Black Lake (fenced) in the southern portion and Basalt (unfenced) in the eastern portion. The wild horse use pattern of human-controlled water sites was monitored across the study.

Human presence

A variety of human activities occurred during the study, including public hunting, bird watching, range/animal monitoring by management agencies and researchers, educational/commercial wild horse observation trips and random recreational travel by the public through portions of the MPWHT on horseback or in motorized vehicles. The record of these activities across seasons and years was based on observations by researchers (primarily spring and autumn) and by employees of BLM, USFS and CDFG who periodically monitored areas of the MWPHT. In

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addition, anecdotal information was obtained from private citizens who regularly visited the MPWHT in association with private-sector uses noted above.

Data analysis

Eleven variables were examined either throughout the study or during selected periods within the study. The variables comprised horse numbers, lion numbers, mule deer numbers, seasonal horse movements, horse geographic distribution, lion geographic distribution, incidence of predation, water (precipitation/surface), forage (availability/use), horse behaviour and human presence. Data for each variable across the study were reported annually as a single value, with value units differing among variables. In cases where an average across multiple years was determined, values were presented as mean ± SD (Zar 1984). Database complexity and autocorrelation issues precluded application of time-series statistical analysis to across-study data sets. However, presentation of data graphically revealed well-defined temporal patterns, which facilitated interpretation. Data for water, forage and human presence employed a scale based on the highest-value year as 100%. Aspects of horse behaviour (dominant-mare role in band movement and intrusion tolerance) were assessed across 3 years for four specific harem bands, and the data were analysed separately for each band.

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Results

Horse numbers

The MPWHT adult horse population during 1987–2006 averaged 137 ± 12 (range 103–169). An annual average of 28 ± 4 foals (range 18–35) were born in this period. Foaling began in mid-April and > 80% was completed by the end of June.

The total horse population (all ages) varied considerably across the study, ranging from a low of 138 in 1995 to a maximum of 312 in 2011 (Figure 3). A notable period of population decrease followed by a period of increase occurred during the first half of this study. Horse numbers ranged from 184 in 1987 to 204 in 1991, declined markedly to 138 in 1995 and increased again to 220 by 2001. Also, between 2002 and 2011 the number of horses in all but one portion of the MPWHT varied < 12%. In that portion (Adobe Valley), which was historically a winter range area, horse numbers increased from 43 in 2005 to 180 in 2011 (Table 1). This increase began after cessation of cattle presence in the Adobe Valley grazing allotment. Abundant in water and feed, this site became accessible to horses via open gates and unmaintained fences and was devoid of lions. Many horses using this site became residents in this area year-round during this period.

Lion activity and predation

The total May–October lion population using the MPWHT was relatively stable at four to five animals from 1987 through 1991 and averaged 3.8 ± 0.4 across the entire study. It increased to eight animals in 1993, and then slowly decreased through 1999 to the original numbers. From 2001 to 2011 lion numbers did not exceed three adults (Figure 4). The year-round lion population never exceeded four adults. The number

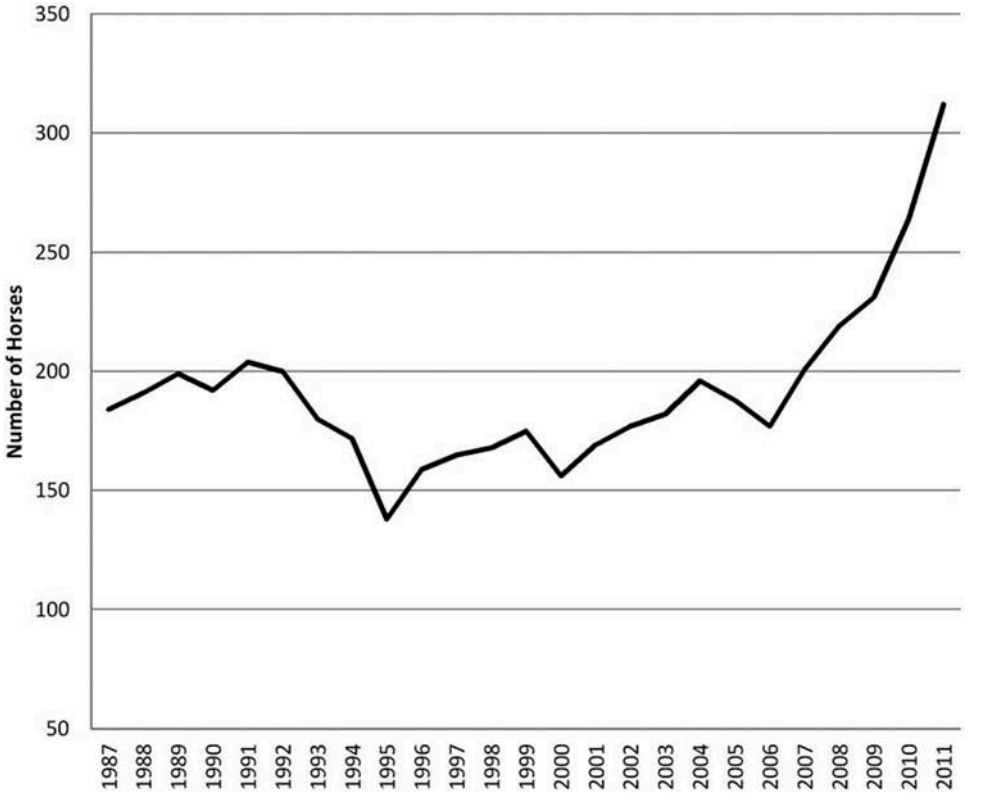

Figure 3. Annual total number of horses in the Montgomery Pass wild horse population. Numbers represent reliable estimate for all range areas (not complete enumeration).

Table 1. Horse numbers in the Adobe Valley portion of the Montgomery Pass Wild Horse Territory (MPWHT) (1999–2011).

Year	Adult	Yearling	Foal	Total
1999	30	5	5	40
2000	28	3	6	37
2001	12	1	2	15
2002	43	3	10	56
2003	28	3	6	37
2004	41	4	7	52
2005	33	4	6	43
2006	69	5	8	82
2007	76	6	22	104
2008	82	9	14	105
2009	101	11	20	132
2010	126	16	26	168
2011	132	20	28	180

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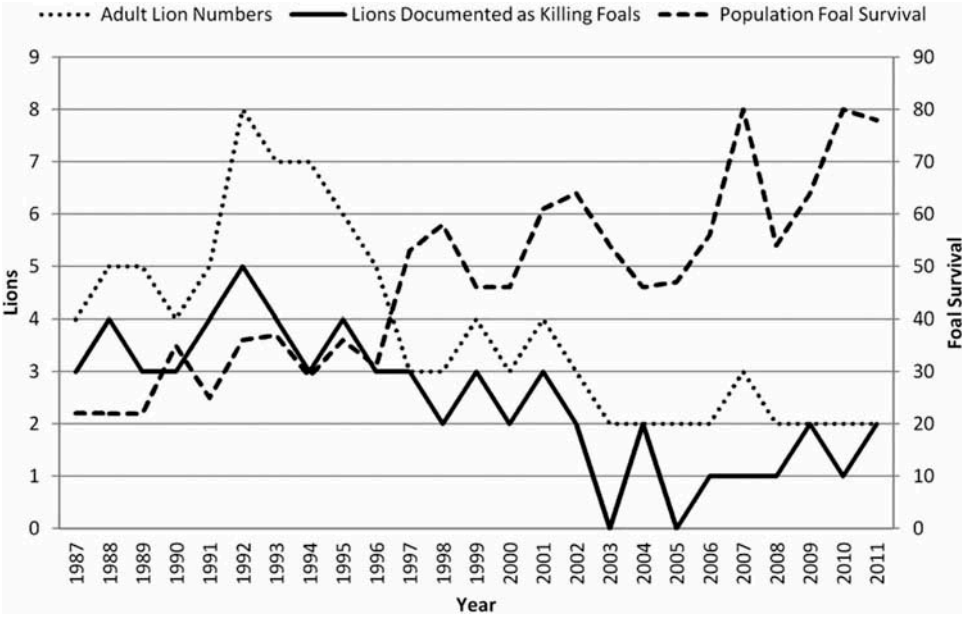

Figure 4. Relationship of mountain lions and foal survival in the Montgomery Pass Wild Horse Territory (MPWHT). Data are based on annual assessment between May and September. The majority of predation occurred in the key summer range (KSR). Adult lion numbers and foal survival in the MPWHT: foal survival is presented as the ratio of current-year yearlings to previous-year foals expressed as a percentage, lion numbers are for individual lions documented by telemetry, track and/or sighting. The majority of lions were recorded in the KSR.

of lions documented to have killed a foal in a given year ranged from zero to five, with two to three documented for the majority of years (Figure 4). The total number of lions killing foals was unknown.

During the telemetry portion of the study, 90% of radio-collar signals were located within the KSR. Male lions showed less reliable patterns of use and less overlap than females. From 1992 to 1995 it appeared that all but two lions using the KSR were collared. The exceptions were one female (with only three toes on the left front paw) and one male (largest pad recordings in the study, 66–68 mm). The regularity of these specific tracks in known travel routes and at watering sites allowed confidence in the identifications without collaring. No lion activity was observed in the historic lower-elevation horse winter range areas (lower-elevation, broad sage flats). Data for lion kittens during portions of this study have been previously reported (Turner and Morrison 2001).

Of the foals found dead across the study, 75–89% was attributable to predation by lions (Turner and Morrison 2001). Killed foals averaged 13.5 ± 4.93 annually during the most intensive lion-monitoring period of the study (1987–1995), comprising 45.1% of foals produced during this period. Foal age at time of predation averaged 1.5 ± 0.66 months (range 1 week to 9 months). Of 56 foals whose age at death could be estimated, 50.0% were killed during May, 32.1% in

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June, 10.7% in April, and 3.6% each in July and September. The predation rate averaged < 30% of the annual foal population between May and September from 2001 to 2011. Overall, 68% of all documented lion-killed foal carcasses were located within the KSR.

The use of present-year yearling to previous-year foal ratios to estimate predation rates in this study includes natural (non-predation) mortality. However, natural mortality in wild horse populations is generally low. Garrott and Taylor (1990) reported 3.2% foal mortality in horse populations (n = 243) using habitat similar to the MPWHT without regular predation. Also, in the most eastern sage-flat portion (Basalt) of the MPWHT, where horses did not mingle with other range areas and predation was absent, foal mortality averaged 4.3%. As the vast majority of foal mortality in the MPWHT was due to predation, the yearling-to-foal ratio was considered a viable estimate of predation rate. Annual survival rates estimated for foals averaged 0.48 ± 0.12 and ranged from a low of 0.22 during 1988–1989 to a high of 0.80 in 2009–2010 (Figure 4). In the Adobe Valley portion of the MPWHT, which consisted of broad sagebrush flats with no demonstrable predation, foal survival ranged from 66.3% in the 1990–1994 period to 80.0% in the 2006–2010 period. In contrast, the foal survival rate in the KSR during these periods was 14.1% and 15.9%, respectively (Table 2). It is noteworthy that the horses using the Adobe Valley were a mixture of horses living year-round and horses seasonally using both the Valley habitat and lion-occupied habitat. As year-round use of the Adobe Valley increased after 2005 and fewer seasonal-use horses were present, foal survival rates were greater.

Based on individually identified yearlings observed the following year as 2 year olds, yearling survival averaged 0.90 ± 0.08, ranging from a low of 0.5 in 1994–1995 to a high of 1.0 in eight of the annual periods. Adult survivorship averaged 0.91 ± 0.02, ranging from a low of 0.81 in 1992–1993 to a high of 1.0 in seven of the annual periods. The horse population was at its lowest levels (< 160) in 1995, 1996 and 2000, averaging 82.1% of the 25-year average (Figure 4).

Table 2. Effect of horse redistribution on foal survival in segments of the Montgomery Pass Wild Horse Territory.

Redistribution status	Years monitored	Foal survival* Yearlings / Foals (%)	
		Key summer range	Adobe
Pre	1990–1994	3.0 / 21.2 (14.1)	3.6 / 5.6 (64.3)[†]
During	2000–2004	1.0 / 6.6 (16.2)	4.1 / 6.2 (66.1)[†]
Post	2006–2010	1.0 / 6.3 (15.9)	14.4 / 18.0 (80.0)[‡]

*Average of present-year yearlings divided by previous-year foals (eg., 1994 yearlings/1993 foals).

[†]Includes Adobe horses using key summer range periodically during summer and year-round Adobe horses.

[‡]Includes previous key summer range horses using Adobe year-round.

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Mule deer presence

At the beginning of this study in 1987, the Casa Diablo deer population was estimated to be near 1500 (Taylor 1988; V. Bleich, CDFG, personal communication). Helicopter surveys between 2007 and 2011 revealed Caso Diablo deer population estimates from 2438 to 3009 (J. McKeever, CDFG, personal communication). The deer that annually migrate into and out of the MPWHT represent < 10% of the Casa Diablo herd (Table 3). Both resident and seasonal lions regularly preyed on this deer population throughout the study, and radio-telemetry data (obtained in the study and from CDFG files) indicated that some lions followed the deer herd during migration.

During the course of the study, the deer population that wintered in the MPWHT fluctuated but gradually declined (Table 3). Although deer carcasses and numerous deer faeces were found in the spring in years when snow melt was late (deer migration was delayed), there was commonly little evidence of deer other than scattered bones. Lion predation was documented as the cause of death in three freshly killed deer (in separate years) that had returned early in September to the MPWHT.

Seasonal horse movements

The relationship of horse locations and density across the study area is presented for several periods in the study in Figure 5. From 1987 through 1993, > 50% of the herd spent the months from May through September in the higher, cooler elevations (2400–2600 m) of the central portion of the range (KSR). For the remainder of the study period horse numbers in the KSR during these months gradually declined, with use by only 19% of the population in 2001 and only 13% in 2009 (Figure 5). During these same years the percentages of horses using lower-elevation (peripheral) areas (including some areas outside the demarcated MPWHT) were 41% and 12%, respectively. The period of greatest horse summer use of range locations outside the MPWHT was from 1995 to 2006 (Figures 5 and 6). The annual season-driven transition from KSR use to lower-elevation winter range use occurred on average between mid-September and mid-October. Some horses used the KSR area year

Table 3. Mule deer numbers using the Montgomery Pass Wild Horse Territory in winter.

Year*	Number of deer
1987[†]	225
1988[†]	204
1992[‡]	280
1997[§]	148
2002–2009[¶]	128[¶]

*Deer were counted in December and January, and were located primarily in the key summer range area and lower elevations of southern portion of Montgomery Pass Wild Horse Territory.
[†]Estimates derived from ground and aerial counts by research team.
[‡]Counts by lion tracking team.
[§]Estimate from aerial count (private fixed-wing).
[¶]Average of annual helicopter-based counts by CDFG (unpublished agency files) from 2002 to 2009.

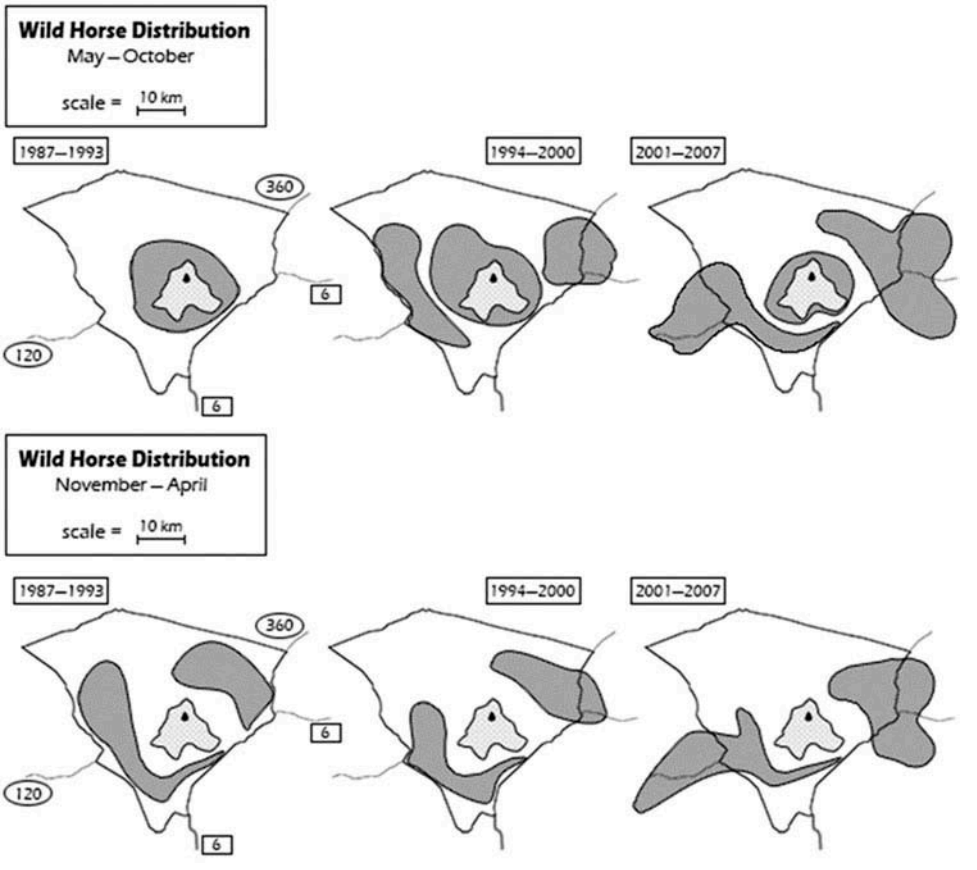

Figure 5. Changes from 1987 to 2007 in patterns of the geographic distribution of wild horses in the Montgomery Pass Wild Horse Territory (MPWHT). The central, lightly shaded area is the key summer range (KSR). The black mark within it is the highest elevation in the Territory (elevation decreases 360 degrees around it throughout). Dark shaded areas indicate regular horse use and represent > 90% of the population. Many wild horse populations in the intermountain west accommodate to seasonal conditions, spending winter at lower elevations and summer at higher elevations. The pattern across years in the MPWHT changed from summer horse concentration in the KSR to decreasing return to KSR from winter range. In addition to establishment of decreased KSR use and increased year-round use of historical winter-range areas, expansion of the geographic use areas occurred in the latter, including seasonal use beyond MPWHT map boundaries.

round, wintering at lowest KSR elevations, which were generally near the snow line. The spring return from winter range to summer range occurred between mid-April and mid-May for most horses. More than 90% of the horses that ceased using the KSR across the study wintered inside the MPWHT. However, between May and late September from 1995 to 2011, these horses distributed themselves across range areas both inside and outside the MPWHT (Figure 6).

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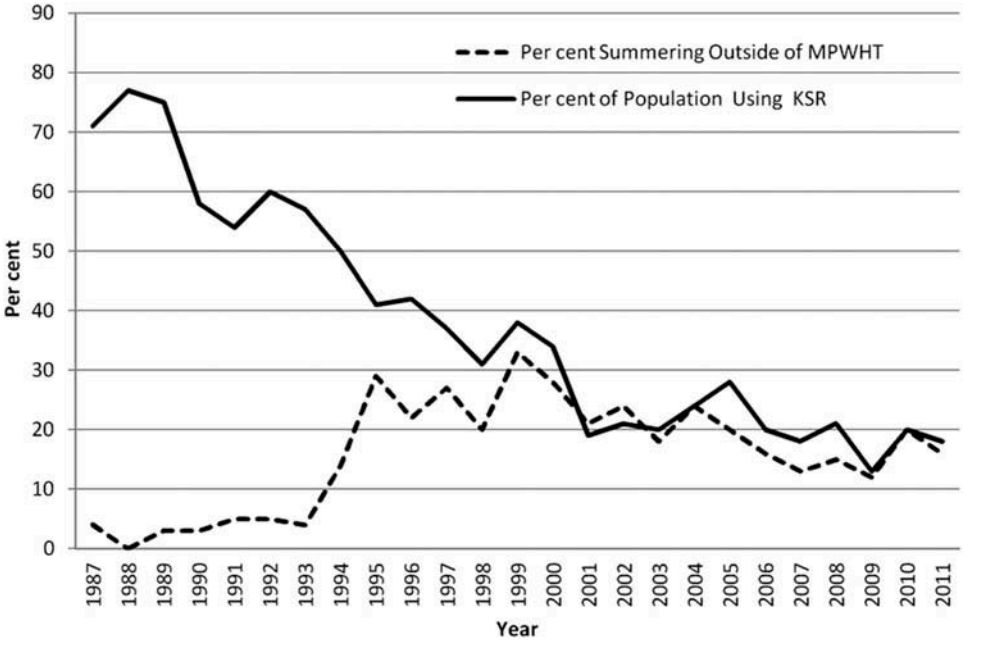

Figure 6. Montgomery Pass Wild Horse Territory (MPWHT) horse use of non-key summer range (KSR) areas. Use outside the MPWHT primarily includes areas east of Basalt and west of Adobe Valley.

Surface water and precipitation

Snowfall in the MPWHT occurred annually and variably from November through March. When snow was present, horse travel was unrestricted. However, horses generally favoured grazing in proximity to the snow line and followed the snow line upward as spring melting occurred.

MPWHT horse movements and distribution in summer and autumn were linked to locations of permanent and ephemeral (seasonal) springs. This was of less importance in winter when snow was present.

Across the study, the Benton RAWS data showed that the months averaging greatest precipitation were January (7.0 cm), April (8.1 cm), August (9.5 cm) and November (13.8 cm). Semi-quantitative precipitation estimates from McNamara Lake (pond) and observations from annual seasonal spring activity showed a similar across-years pattern to the Benton RAWS data. Mid-summer presence or absence of seasonal water sources also correlated with the above data. Occasional summer thunderstorms provided short-term pools of water across the range, but these were of insufficient duration to impact horse distribution. In summary, water in the MPWHT was highly variable across the study, with dry periods in the 1987–1991 and 2000–2004 intervals and the wettest period from 1993 to 1996 (Figure 7).

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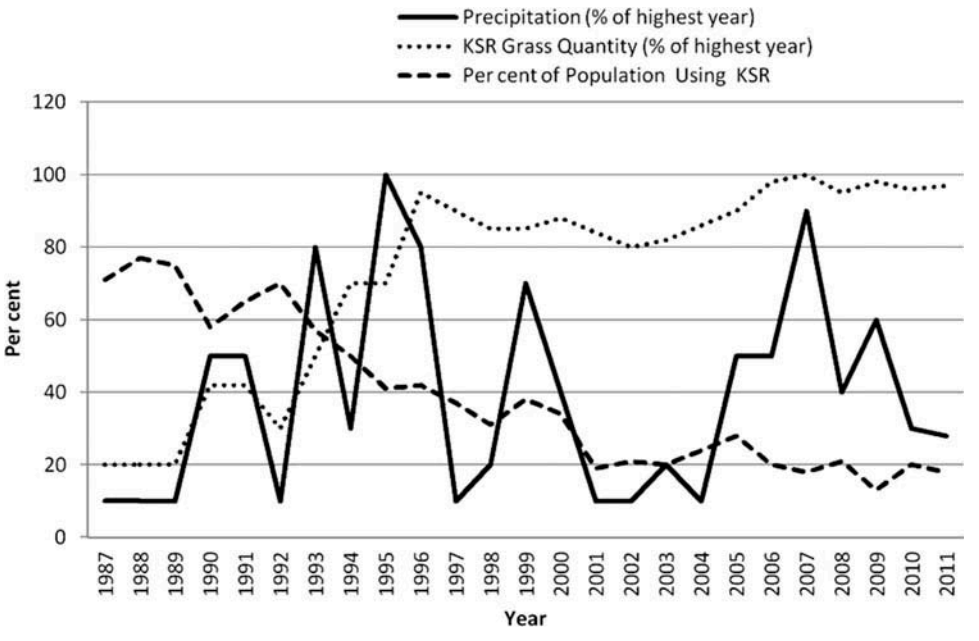

Figure 7. Annual key summer range (KSR) use in relationship to KSR condition and annual Montgomery Pass Wild Horse Territory (MPWHT) precipitation. The latter two data sets are presented in relative fashion as per cent of highest year.

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Range condition

The years 1990 and 1991 were among the driest during the study and were also the years of greatest horse numbers using the KSR. The period in which most of the redistribution occurred was after 1993 and was one of markedly greater KSR grass quantity than in 1990–1991, and so represented a conservative estimate of possible impact of KSR food supply on horse numbers or their redistribution (Figure 8).

The focus of utilization assessments was on areas within 2 km of water sources. Utilization varied widely across assessed sites, with the majority being from 10–60% ("slight" to "moderate"). The average 1990/1991 KSR utilization was 42% near water and 28% in outlying areas, with regular horse presence during that period averaging 119 horses. Based on these data and allowable utilization of 35% without impairing sage/grassland habitat health (Holechek et al. 2004), the KSR carrying capacity was estimated to be approximately 340 horses. Selected non-KSR areas at lower elevations were concurrently assessed and averaged 30% utilization. The monitored areas comprised < 15% of the total territory. However, significant portions of the unmonitored areas were represented by extreme alkaline conditions and very poor range quality.

The portion of the horse population known to use the KSR during the 1990/1991 range assessment was < 150 animals. The non-KSR range areas were more than eight-fold larger and considerably lower in horse density than the KSR (with the exception of Adobe Valley). The supply of preferred feed in the portions of these areas regularly used by horses appeared sufficient in quantity throughout the

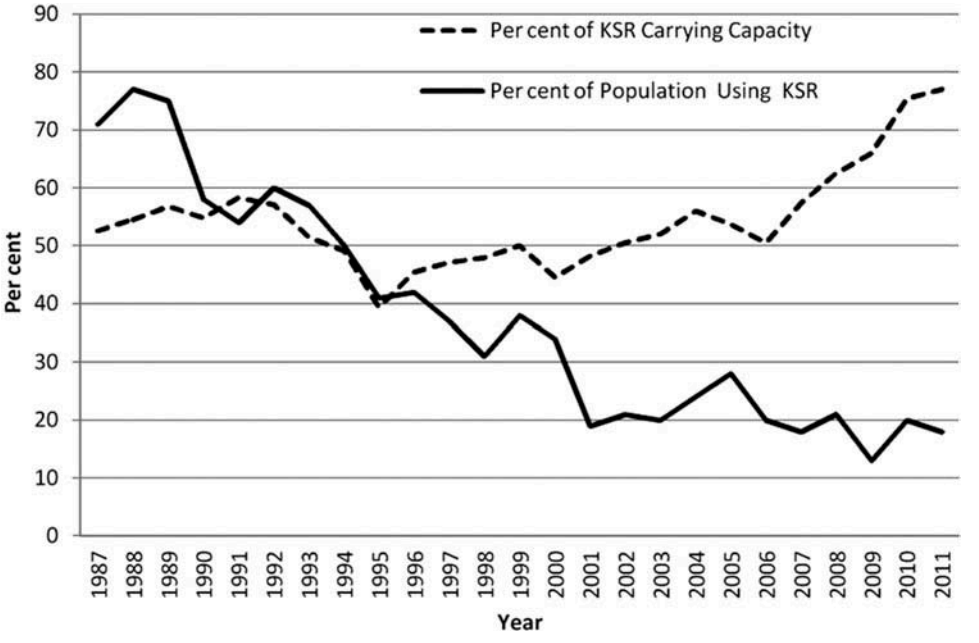

Figure 8. The relationship of key summer range (KSR) horse use and carrying capacity in the context of the Montgomery Pass Wild Horse Territory (MPWHT) horse population. As KSR horse numbers decreased, use outside the KSR increased. Total population range use is presented as a percentage of KSR carrying capacity. As total population increased across years, it remained < 80% of carrying capacity for KSR alone, suggesting that considerable population growth can continue without reaching carrying capacity.

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study based on periodic subjective assessment whenever researchers passed through them. While a checkerboard pattern of feed quantity was observed throughout the MPWHT, the overall range conditions where horse use was common were similar in utilization to that observed in the 1990/1991 KSR range assessment. Available grass and phorb types were generally similar to those in the KSR.

As part of the MPWHT horse redistribution, rapidly rising horse numbers in one range area (Adobe Valley) reached 180 animals in 2011. The Adobe Valley horse numbers were 53% of the carrying capacity estimated for the KSR in 1990/1991 (Figure 8). Horses that were regularly present in Adobe Valley also used adjacent lower-elevation range areas, which comprised an overall size approximately four-fold larger than the Adobe Valley flatland. In Basalt and other lower-elevation portions of the MPWHT the horse numbers never exceeded 60.

In 1995, 2002 and 2010 utilization inventories were performed in selected locations in the KSR, Basalt and Adobe Valley. General range condition was considerably better in Adobe Valley (Adobe Creek flows into it) than in Basalt, which is approximately 1000 m. lower in elevation and has less annual precipitation and only two permanent springs. Utilization averaged less than 40% in all

range areas in all years assessed except for 2010 in Adobe Valley, where it averaged 56%. Usage decreased as distance from water sources increased. KSR areas showed predominately "light" use from 2000 forward, and range condition steadily improved.

Grazing allotments

One allotment (Black Lake) was fenced and remained in seasonal livestock use throughout the study. A second allotment (Basalt) was unfenced and was unused by livestock after 2003, although water troughs within it were filled through 2006. Horses were permitted to graze with cattle on this allotment throughout the study. The third allotment (Adobe) was fenced and was active through 2005. Adobe Creek is a permanent water source that flows year round through the allotment. It is < 3 m wide and < 1 m deep and disappears within the allotment, irrigating an 8-km^2 open flat of grass and sedges. The upper portion of Adobe Creek (approximately 1.5 km length) is unfenced and was always accessible to the horses. However, the associated graze-rich allotment was fenced, and horses generally did not have access. Both the upper portion of the creek and the portion within the allotment (when gates were occasionally left open) were used by horses, with their preference being the latter. After 2004, the fencing was not maintained and horses had full access to the allotment year round via broken, unrepaired fences and open gates.

Human presence

Wild horses are generally averse to human presence, so the possible impact of human activities on horse movements and distribution was examined. Recreational activity, small-scale mining, seasonal (May–September) livestock grazing and hunting occurred in the MPWHT for decades before and during this study. There was very little human presence from October through April. A significant aspect of the livestock grazing has been the development of existing water sites and establishment of water troughs in areas naturally without water, with potential impact on distribution of horses and other species. In addition, fencing associated with some water sites and with grazing allotments can influence animal distribution and movement. In general, the horse range-use patterns related to the above factors were well established and relatively consistent at the onset of this study.

In 1986 a local company began an annual series of 4-day educational (most associated with university extension programmes) trips into the MPWHT from mid-May through mid-June. These trips generally accommodated 8 to > 20 guests and were focused on observing wild horses in their peak foaling/breeding period in the KSR area. In 1993 a second company began a similar programme in the KSR area. While these trips were designed for minimal intrusion on the horses (i.e. use of binoculars and no direct approach), they represented a marked increase in human presence (Figure 9). In some years between 1994 and 2007, more than 200 guests travelled into the KSR. In addition an undetermined level of local use (motorized vehicle and horseback recreational activity) occurred during this period.

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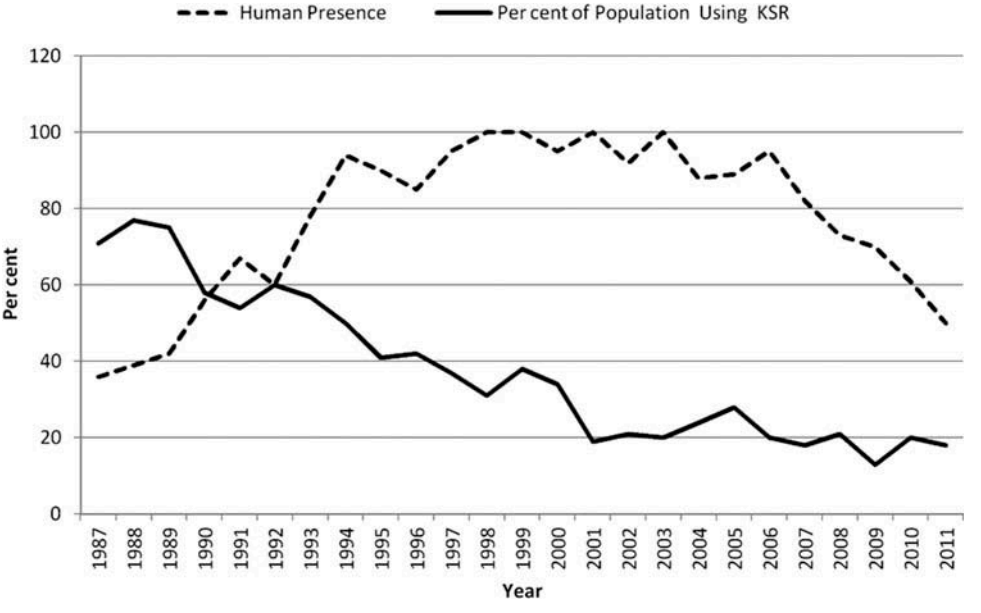

Figure 9. Key summer range (KSR) use by horse population and human presence. Data are for use from May to September. Human presence is presented as per cent of its highest year. Human presence includes private sector activities, educational/commercial activities and research/management activities. Human presence was generally greatest during the horse breeding/foaling period (May–June).

Horse-dependent factors (band movements and behaviour)

Initiation of band movement

Daily movements by all four specifically monitored bands to and from water were common early in the day, especially in summer months, and were usually initiated by the dominant mare. The dominant mare also initiated an overall average of 84.0 ± 7.6% of observed cases of a band leaving a site to travel for any reason (Table 4). In many cases in which the harem stud or another band member initiated travel, the dominant mare led the travel soon after movement began. In addition to initializing daily band movements, the dominant mare usually led the band to grazing sites and chose when to stop. This was regularly observed in all four of the monitored bands.

Grazing-site preferences

Three of the four dominant mares exhibited repeated, and in some cases regular, visits to one or more particular sites. Predominance of one or two grass species at a given site was common. Analysis of fresh faecal samples collected at grazing sites indicated that the most commonly consumed plant species were Great Basin wild rye, lupin, Indian rice grass, fescue, needle grass and various phorbs. Rushes and sedges were used in riparian areas (L. Coates-Markle, personal

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Table 4. Response of Montgomery Pass Wild Horse Territory (MPWHT) harem bands to intrusion by humans or other horses.

Harem band[1]	No. of horses per band	Incidence of dominant mare initiating travel (%)[†]	Average estimated Intrusion-tolerance distance (m)[‡]	Average estimated travel-distance (km)[§]	No. of events observed[¶]
A	8	45 / 52 (87)	202 ± 76	1.0 ± 0.4	14
B	6	32 / 43 (74)	620 ± 122	2.1 ± 0.6	16
C	8	37 / 40 (92)	805 ± 119	2.4 ± 0.6	10
D	7	39 / 47 (83)	163 ± 63	0.7 ± 0.3	13

[1]The stallion and lead mare in a given band remained with that band during the observation period 1994–1996.
[†]Per cent of travel events initiated by dominant (lead) mare with or without apparent intrusion by humans or other horses.
[‡]Estimated minimum distance (mean ± SD) permitted between grazing band and intruder before alerted band moved off (distance determined by reticle binoculars in 25-m increments).
[§]Denotes travel distance (mean ± SD) in response to intrusion before band stopped and reinitiated grazing (distance estimated by reticle binoculars and topographical map in 0.1-km increments).
[¶]Applies to both intrusion-tolerance and travel-distance columns.

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communication). These findings were confirmed by spotting-telescope observations of horses ingesting feed in the four selected target bands. Invariably the dominant mare was noted to ingest the predominant grass type of the site that she had chosen for grazing. These forage species were present in varying amounts across most of the MPWHT.

Intrusion tolerance

The dominant mares in two of the four regularly monitored bands were markedly less tolerant of intrusions than the lead mares of the other two bands (Table 4). When travel occurred, the less tolerant bands travelled significantly further before grazing was resumed. The estimated average intrusion-tolerance threshold for the two bands with lowest intrusion tolerance was 725 m, and these bands travelled an average of 2.4 km before stopping. The average intrusion-tolerance distance for the more tolerant bands was 175 m, and they travelled an average of 0.85 km before resumption of grazing. Both of the low-tolerance bands permanently vacated the KSR (one in 1994 and one in 1995), and both of the high-tolerance bands remained in the KSR through 2004. They were not monitored thereafter. Incidental observations of dominant mares in various other bands in subsequent years revealed a wide range of tolerance to intrusion among bands, with vigilance being greatest during the foaling season. The dominant mare and stallion in specifically monitored bands did not change during the monitoring periods, although changes in band membership, primarily among younger adults, did occur.

Band travel

Although daily travel distances varied both within and between the above four bands, some bands generally travelled greater distances than others. Two of the studied bands (one high-tolerant, one low-tolerant) usually travelled < 5 km across 2 days and remained within 2–4 km of preferred water. The other two bands travelled > 8 km daily, often between two distant watering sites. Each band exhibited preferred travel routes and travel patterns tended to be habitual rather than random.

Discussion

It is known that wild horse populations in the western USA generally move to higher elevations in the spring, following the annual green-up and its associated high nutrition (Berger 1986). The majority of horses remain in the cooler upper elevations through the summer. This phenomenon has been observed annually in several horse ranges by the author. This pattern was extant in the MPWHT herd for a number of years before the present study (Mennick 1979) and continued during the first 7 years of this study (1987–1993). However, progressive changes in the MPWHT horse distribution developed in the remainder of the study. This redistribution eventually involved approximately two-thirds of the herd and consisted of decreased KSR use with associated increased summer (and eventual year-round) use of historic lower-elevation winter range. In addition, use of areas outside the historically mapped territory increased. As noted previously, some horses used KSR at its lower elevations (near snow line) throughout the winter.

These alterations have persisted to the end of the study, with a resultant division of the original seasonally congregating population into three essentially separate subpopulations: (1) KSR, (2) Adobe Valley and (3) Basalt. The MPWHT topography and limited water sources have fostered complete isolation of the Adobe Valley horses from the Basalt horses. The former are on the west side, and the latter are on the east side, separated by 18 km of rough terrain with nearly 2 km vertical relief. While the KSR horses do winter at lower elevations, these are generally more north and south, separate from the east-side and west-side subpopulations. Nonetheless, some horse bands that had annually used the KSR in the first decade of the study had also routinely wintered in the Adobe Valley and its surrounding hills. Since the KSR and Adobe Valley areas are within 6 km of each other, occasional mingling of some KSR horses with Adobe Valley horses continues.

Some increase in summer use of the historical winter range had been observed as part of horses gradually vacating the KSR by the late 1990s. However, an unusual aspect of the redistribution was the dramatic increase in numbers in Adobe Valley from 2006 to 2011. This cannot be explained solely by redistribution from the KSR to Adobe Valley. Whereas a number of individually identified horses and bands that had regularly summered in the KSR were present in Adobe Valley after 2005, previously identified bands from adjacent non-KSR range areas were also moving into the Adobe Valley to benefit from the high-quality grazing and water availability. Furthermore, with no incentive to leave, they were remaining there year round. While this adaptation is not surprising, the rapid rate of ingress is unexplained.

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The number of horses summering in the Adobe Valley was 40–52 between 1999 and 2004 and was 43 in 2005, which was the final active year of that grazing allotment. Between 2005 and 2011 the horse numbers there rapidly and steadily rose to 180 (more than half of the MPWHT population). Other range areas showed small increases in horse numbers but never exceeded 60. An interesting question is how numerous bands of horses occupying different range areas multi-kilometre distances from each other and in some cases > 15 km from Adobe Valley become aware of the availability of grazing/water there.

A factor that probably contributes to the marked increase in horse numbers in Adobe Valley is the absence of predation in that range area. Although there was no predation in the Adobe Valley at any time during the study, the high foal survival rate evidenced itself more obviously as the numbers of horses (and therefore mares) in that area markedly increased. The relationship across years of decreasing KSR use to increasing population of surviving foals is apparent when these measures are plotted together (Figure 10).

Although the impetus for redistribution may be complex, the data have revealed some potential factors to be more likely candidates than others. Based on pattern comparisons across years for various factors in relation to horse use of KSR, it is unlikely that water availability or feed availability influenced redistribution of horses. Travel distances to water were not different inside and outside the KSR and in some areas were closer in the KSR. In the driest years the usual seasonal water sources were

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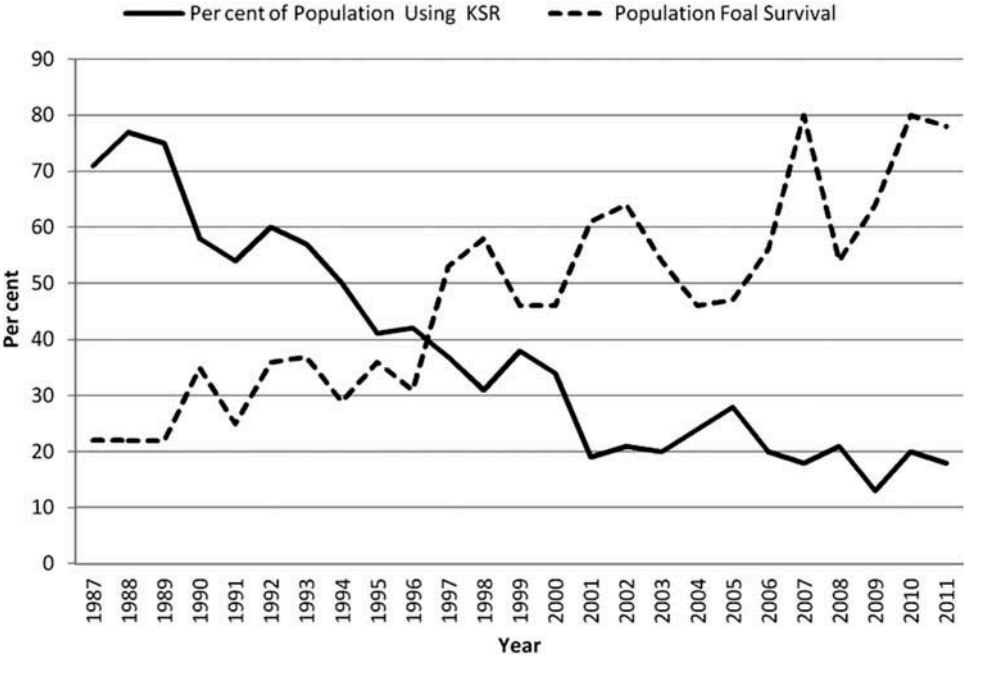

Figure 10. Relationship of reduced key summer range (KSR) use on whole-population foal survival. KSR is the primary area of lion use and predation. Foal survival is presented as the ratio of current-year yearlings to previous-year foals expressed as a percentage. Foal survival data are for the entire Montgomery Pass Wild Horse Territory (MPWHT) population.

absent, so yielding in some years greater horse density in the proximity of the permanent water sites. It appears unlikely that this was related to horse redistribution because there were permanent springs in the KSR, and horse numbers remained high in the KSR during the driest years of the study when seasonal water sources were dry.

Unusually elevated precipitation from 1993 through 1996 (except 1994) may have facilitated redistribution. The presence of many ephemeral water sites and improved feed in normally unproductive areas may have enabled horses under pressure from other sources to leave the KSR and not return to it in the following years. It is noteworthy that the exodus from KSR began during the wettest period of the study (Figure 7).

On the basis of the range assessments performed across the study it appears that food availability was not a significant factor in horse redistribution. Assessment of range condition and grass utilization was not frequent or extensive during the study, but heavy or severe utilization was rarely observed and most use was light to moderate. KSR use was maximal in the early years of the study, when KSR feed was least abundant. However, the estimated carrying capacity of 340 for the KSR always exceeded the seasonal demands in the KSR by at least two-fold. Preferred grasses and phorbs were present in a number of range areas outside the KSR. Although it is possible that depletion of a favoured plant species could lead to eventual horse movements out of the KSR, the large scale of the KSR exodus makes this unlikely.

The horse redistribution has clearly applied more grazing pressure on the lower-elevation range areas, and a careful assessment of carrying capacity in these areas is warranted. However, the entire horse population was approximately 312 in 2011, and this number is < 80% of the carrying capacity determined for the KSR alone in 1990/1991. Considering that these years represented one of the driest periods in the study with the majority of the population summering there, it appears unlikely that the current horse numbers are approaching the carrying capacity of this much larger range area. Furthermore, most of the range areas experiencing increased horse numbers have not seen dramatic increases in use. Whereas a large increase in use might be expected eventually in Adobe Valley, the presence of its large riparian area with quality replenishing forage and large adjacent range areas may moderate range impact as horse numbers rise. Nonetheless, the high rate of foal survival in the non-predation areas that hallmarked the horse redistribution raises this issue for the future, making continued monitoring wise. For example, extended heavy range use could potentially deplete seed stock, with resultant lower carrying capacity and prolonged recovery time even with fewer horses present.

In addition to geographic redistribution during the study, an increase in geographic dispersal outside the historical map-delineated MPWHT was observed (Figure 6). This was possibly because of the combined increase in the number of horses migrating into lower-elevation range areas and the consequence of the lack of predation in those areas resulting in increased foal survival (i.e. further population growth). Hence, horses probably spread out to accommodate increasing density. The increased local dispersal may explain in part why the utilization in some areas did not increase proportionally to increased horse numbers. It is noteworthy that in both areas where horse presence outside the MPWHT was significant there was a major water source adjacent (within 1–2 km) to the territory boundary and no restrictive fences.

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Regardless of the fluctuations in deer numbers during the study, the annual winter presence of > 100 deer in the MPWHT in every year in which such observations were recorded suggests that there was sufficient winter prey for the estimated two to four lions that resided there year round. It therefore appears unlikely that deer presence or numbers influenced the occurrence of predation on horses or horse redistribution.

Two factors that did correlate negatively with horse exodus from the KSR were mountain lion activity and level of human presence. The association is apparent when these three variables are presented in a single figure (Figure 11). Lion numbers were maximum at the time when horses began leaving the KSR. However, lion presence and predation on wild horse foals was reported to have occurred regularly for at least 20 years before this study (Mennick 1979). Nonetheless, increasing lion numbers may have been a factor in stimulating horse redistribution. Clearly the mountain lion predation on foals has played a critical role in moderating growth of the MPWHT horse population during this study.

The relationship of human presence to lion numbers was not a focus of this study. However, it is apparent that both lion and horse numbers decreased as human presence increased. Although human presence in the KSR may have stimulated both horses and lions to leave, it is possible that the lions left because the prey left. Conversely, the prey may have left because the predator number was increasing. The

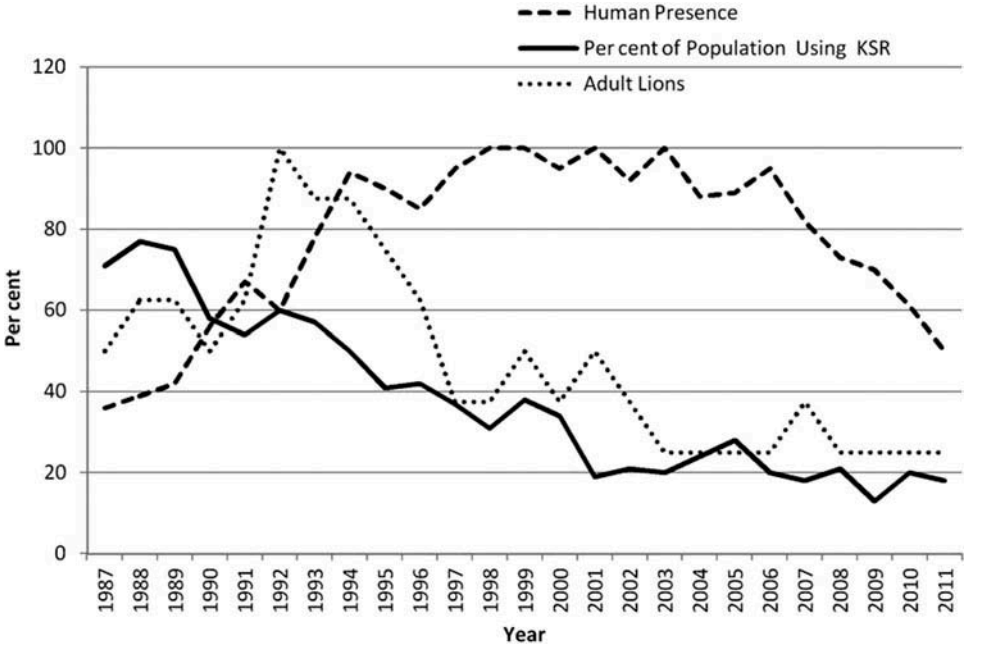

Figure 11. Relationships of human presence, horse key summer range (KSR) use, and lion numbers in the Montgomery Pass Wild Horse Territory (MPWHT). Human presence (May–September) is presented as per cent of its highest year. Horse KSR use is presented as per cent of the total population using the KSR. Adult lion numbers are presented as the percentage of the maximum single-year lion number.

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present database cannot resolve the cause–effect relationship of these variables. Regardless, a relevant consequence of horse redistribution to range areas of poor lion habitat (lower-elevation sagebrush flats) has been the marked increase in population foal survival and overall population size (Figures 3 and 10). Interestingly, predation has continued on horses that remained in the KSR, and the foal survival of Adobe Valley horses is four-fold greater than for current KSR horses (Table 2).

In the first 3 years of the study (1987 through 1989) > 70% of the MPWHT population summered in the KSR. During this period regular human presence in May and June was increasing. It may be that in the face of this increase some horse bands reached a threshold of tolerance for human presence. The fact that the two bands of horses with the lowest intrusion tolerance permanently vacated the KSR supports this view. The fact that the focus of human activity in the KSR was during the foaling/breeding period may have intensified any human contribution to the decrease in horse numbers there.

Although the observations of dominant-mare roles in this study were limited formally to four harem bands, the findings were robust and were not contradicted by any other subjective observations across the study. Clearly, the choice of a given grazing site and when to leave it was predominantly made by the dominant mare. Invariably in bands with the same dominant mare across several years, the travel routes and the favoured grazing areas were similar from year to year. Based on the observation that dominant-mare decisions strongly influenced band movements in this study, it appears likely that dominant mares also played a significant role in population redistribution. While all four of the individually identified and monitored harem bands in this study maintained stable band membership among the adults, subjective observations across multiple years and numerous bands revealed considerable variation in stability among bands.

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Summary and conclusion

In summary, annual monitoring across a 25-year period has revealed a gradual but marked redistribution of horses in the MPWHT. This redistribution has involved horse movements both within and beyond the historical map boundaries of the territory, and has led to three sub-populations, which have become in essence geographically and functionally separate. Neither food nor water were limiting in the KSR, and were therefore unlikely to be a stimulus for these changes. However, several separate years of extremely wet conditions may have facilitated larger-scale, long-distance summer transitions from KSR to lower elevations and the retention of horses at lower elevations thereafter. An additional contributory factor for the latter may have been increased availability of feed and water associated with cessation of commercial use of lower-elevation grazing allotments during the time of horse exodus from the KSR. Two factors that were temporally well correlated with the marked reduction in KSR use were increased KSR mountain lion predation and increased annual KSR human presence during the spring foaling/breeding period. In the context of social dynamics and in view of the fact that some horses continued to use the KSR while many did not, it is hypothesized that the horse bands that were more tolerant of lion and human presence remained there.

This study has documented aspects of the dynamics of the MPWHT and the impacts of these dynamics on wild horse activity and distribution there. Many

variables and their complex interplay can potentially influence geographic horse movements and distribution. However, clear associations of some variables with horse redistribution became apparent across numerous years of study, strongly suggesting greater or lesser influences. The across-years database has shown that the horses are sensitive to environmental pressures and are adaptive at both the individual level and population level. It is interesting that despite the absence of intrusive management in this horse population, the effects of human presence (e.g. visitation, observation, grazing allotments) appear to have influenced horse distribution. In this case, however, it is the horses that are making the choices of where, when and why, and the human factor is simply one component of the ecosystem dynamic. The presence of long-term human observation in the MPWHT has enabled documentation of numerous dynamics moulding this wild horse population. It has also revealed that the wild horse/mountain lion relationship there is presently undergoing significant change. If the evolving horse distribution pattern on the range continues to thwart the extant predator–prey relationship, continued horse population growth will certainly require more active management to assure habitat well-being.

A stipulation in the Federal Wild Free-Roaming Horses and Burros Act of 1971 (Public Law, 92–195) is that wild horse populations be managed in a manner that "achieves and maintains thriving natural ecological balance on the public lands". The MPWHT is the only well-studied wild horse population in the western USA that has probably satisfied this stipulation across the past 30 years, considering its unique, natural status that presently exists. Continued monitoring of the MPWHT can strengthen its value as a reference base for use in management considerations for other wild horse populations. In the presently shifting ecological landscape of the MPWHT this monitoring will also aid the exploration of management options for the MPWHT.

The study of the MPWHT was intended to explore wild horses in a "free-roaming" state, based in part on the absence of perimeter fences there. However, the dramatic horse influx associated with the downfall of the exclosure fence in the Adobe Valley grazing allotment strongly shows how fences interfere with the expression of "free-roaming". On a much larger scale, the majority of wild horse populations in the western USA are restricted by perimeter fences and often by internal fences as well. This situation is clearly exhibited in the current problems facing the BLM with overpopulation of horses on fixed ranges and the consequent habitat loss. Using the MPWHT as a reference base for wild horses in natural balance with their environment shows that wild horses in most populations are not free-roaming and are not in a natural balance. Assuming that removal of fences is not an option, achieving a natural balance will require major conceptual changes in wild horse management.

As noted in the Introduction to this study, most wild horse populations in the western USA increase 9–20% annually, making population management in these fixed habitats extremely difficult. The MPWHT has had the natural benefit of ongoing predation to limit horse population growth. However, most wild horse populations do not experience significant predation, and introduction of predators is not a publicly acceptable or realistic solution. Therefore, most populations must be intensively managed by regular human intervention. There are only two permissible (i.e. non-lethal) means available to accomplish this under the Wild Horse and Burro Act of 1971: physical removal of horses from the range or reduction of their fertility rates. Although the former has been the predominant and intensive path, it has chronically lagged

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population growth rates (USDI/BLM Wild Horse and Burro Program website; History and Facts, 30 December 2013) and has the disadvantages of periodic disruption of social structure and imposition of gene pool biases. The most successful approach for limiting reproduction has been contraceptive vaccines (Turner et al. 1997, 2007, 2008; Kirkpatrick and Turner 2008; Ransom et al. 2011), which have been used in wild horses for more than 20 years and do not have the disadvantages associated with horse removals. More recently, fertility control has become a greater focus for large scale wild horse management application (Turner and Rutberg 2013).

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Disclosure statement

No potential conflict of interest was reported by the author.

Supplemental material

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INFLUENCE OF PREDATION BY MOUNTAIN LIONS ON NUMBERS AND SURVIVORSHIP OF A FERAL HORSE POPULATION

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ABSTRACT—In an effort to expand our knowledge of the ecology of feral horses (*Equus caballus*), we initiated a study of the Montgomery Pass Wild Horse Territory (MPWHT), located along the California-Nevada border at the northern end of the White Mountains. We report on 11 years (1987–1997) of data on numbers, productivity, and survivorship of the feral horse population in the MPWHT. The majority of the MPWHT is located in pinyon-juniper (*Pinus–Juniperus*) woodland. The adult horse population averaged 150 individuals, with a significant decrease occurring across the study. The number of foals born ranged between 29 and 35 through 1993, dropped to 22 to 24 for 1994–1996, and rebounded to 31 in 1997. Although mule deer (*Odocoileus hemionus*) are the primary prey of mountain lions (*Felis concolor*), extensive predation on foals occurred in MPWHT. The average number of foals killed each year by mountain lions was 13.5 (45.1% of foals produced). There was a significant difference in the proportion of foals killed by coat color relative to the distribution of colors born into the population. Annual survival (May to April) rate for foals averaged 0.32, ranging from a low of 0.23 during 1987–1988, to a high of 0.48 in 1996–1997. Yearling survival averaged 0.88, ranging from a low of 0.5 in 1994–1995, to a high of 1.0 in 5 of the annual periods. Adult survivorship averaged 0.92, ranging from a low of 0.81 in 1992–1993, to a high of 1.0 in 4 of the annual periods. The lion population was 4 to 5 from 1987 through 1991, increased to 8 in 1992, and then slowly decreased through 1996. Number of lions dropped to 3 animals in 1997. The resident mountain lion population is significantly influencing number of horses in the MPWHT, primarily through predation of foals. Increased foal survival during the latter part of our study, and especially during 1997, was apparently related to a substantial decrease in number of lions.

RESUMEN—En un intento de ampliar nuestro conocimiento de la ecología de los caballos salvejas (*Equus caballus*) iniciamos un estudio del Territorio de los Caballos Montgomery Pass Wild Horse Territory (MPWHT), localizada al noroeste de las Montañas Blancas a lo largo de la frontera de los estados de California y Nevada. Reportamos 11 años de datos entre 1987–1997 de la abundancia, la productividad, y la sobrevivencia en la población de los caballos salvajes en el MPWHT. La mayoría del MPWHT esta localizada en bosques piñon-cedro (*Pinus–Juniperus*). El promedio del tamaño de la población de caballos adultos fue de 150 individuos, con una significativa disminución a través del estudio. El número aproximado de crías nacidas fue entre 29 y 35 durante 1993, disminuyó a 22–24 en 1994–1996, y aumentó después a 31 en 1997. Aunque el venado mula (*Odocoileus hemionus*) es la presa principal del león de la montaña (*Felis concolor*), depredación extensiva de las crías ocurrió en MPWHT. El promedio de crías matadas en cada año por leones de la montaña fue 13.5 (ó 45.1% de las crías producidas). Hubo una diferencia significativa en la proporción de crías matadas por el color de la piel en relacion a la distribución de colores nacidos en la población. La tasa de sobrevivencia anual de (de mayo a abril) para crías fue un promedio de 0.32, de una tasa mínimade 0.32 crías sobrevivientes 0.23 a 0.24 durante 1987–1989, a un a máxima de 0.48 en 1996–1997. El promedio de la sobrevivencia de los jovenes de un año fue anual 0.88 de un mínimo de 0.5 en 1994–1995, a un máximo de 1.0 en 5 períodos anuales. El promedio de la sobrevivencial anual de los adultos fue 0.92, de un mínimo de 0.81 en 1992–1993 a un máximo de 1.0 en 4 períodos anuales. La población de los leones fue de 4–5 animales de 1987 a 1991, aumentó a 8 animales en 1992, después disminuyó lentamente a hasta 1996. La población bajó a 3 animales en 1997. Nuestro estudio indica que la poblacion residente del león de la montaña influye significativamente en el número de caballos en el MPWHT, principalmente

por la depredación de las crías. La mejor sobrevivencia de las crías durante la última parte de nuestro estudio, especialmente during 1997, a lo mejor serelaciono a la sustancial diminución de número de los leones.

Free-ranging feral horses (*Equus caballus*), commonly called wild horses or mustangs, derive from intentional and unintentional releases of domestic horses that have occurred since the arrival of Europeans. Over 60% of western feral horses occur in Nevada (Turner et al., 1997). Feral horses are protected by federal legislation, and are managed primarily by the Bureau of Land Management, with involvement by the United States Forest Service and other federal and state agencies depending on location.

Feral horse populations show annual rates of increase of 9 to 20% (Eberhardt et al., 1982; Turner and Kirkpatrick, 1986; Wolfe et al., 1989; Garrott and Taylor, 1990). Because feral horses have few natural predators and are protected from hunting, the government periodically removes individuals from the wild and puts them up for public adoption in an attempt to manage herd sizes. Thousands of horses are removed per year, an effort that is both time and labor intensive. Therefore, scientists and managers have been exploring alternative methods of population control, including contraceptive drugs (e.g., Kirkpatrick et al., 1990; Turner et al., 1997). To enable effective population management, additional information is needed on environmental factors influencing demography, including influence of weather, range conditions, and predators on populations of wild horses.

We initiated a study of the Montgomery Pass Wild Horse Territory (MPWHT or territory), located along the California-Nevada border between the southern end of the Excelsior Mountains and the northern end of the White Mountains. Preliminary observations indicated this herd was not increasing in numbers and, in fact, might be declining due to predation by mountain lions (Mennick, 1979; Turner et al., 1992). We report on 11 years (1987–1997) of data on numbers, productivity, and survivorship of feral horses in the MPWHT.

STUDY AREA—The MPWHT occupies 600 km^2 in Mono Co., California, and Mineral Co., Nevada (Fig. 1). Elevations range from 1,600 to 2,600 m, with lower elevations used by horses during winter and harsh spring storms, and upper elevations used during summer. Most of the territory is located in the pinyon-juniper (*Pinus–Juniperus*) vegetation type, with predominant species being pinyon pine (*Pinus monophylla*). The understory is characterized by sagebrush (*Artemesia nova* and *A. tridentata*), bitterbrush (*Purshia tridentata* and *P. glandulosa*), and rabbitbrush (*Chrysothamnus viscidiflorus*). Principle grasses are Great Basin wildrye (*Leymus cinereus*), Indian ricegrass (*Oryzopsis hymenoides*), and needlegrass (*Stipa*). Various forbs (especially *Lupinus*) are present depending on rainfall (DeDecker, 1991; Spira, 1991).

Mean annual precipitation in the region is ca. 30 cm, most of which falls as winter snow. Maximum daily temperatures in July are near 26°C, and winter lows are near −10°C (calculated from Powell and Klieforth, 1991). A drought throughout the Great Basin began in 1987 and continued until winter 1992–1993 (Morton et al., 1995). The area contains several dirt roads, but none of the interior roads are maintained. Water is available from 11 springs (6 permanent) that usually form ephemeral ponds, longevity of which depends on winter snowfall. In most years by mid-June only the permanent springs were running.

Hunting mountain lions has been banned in California since 1972. Although lion hunting occurs in Nevada, it has been historically infrequent in the MPWHT. At our request, lion hunting was suspended in the territory and on adjacent lands from 1987 to 1995.

METHODS—Sampling was conducted by 4 to 9 people ($\bar{x}$ = 5.5, *SD* = 1.63) for 55 to 142 person days (1 person day = ca. 10 person hours); ($\bar{x}$ = 95, *SD* = 31.2) per year, plus an additional 20 to 35 person days ($\bar{x}$ = 29, *SD* = 5.7) per year tracking lions with dogs. Ground sampling was systematic, with pairs of observers assigned to specific areas and waterholes. Each area was covered in the same pattern over 1 to 2 days, and this pattern was repeated 2 to 3 times in a week. Sampling began in April (March in 1990) and continued through October (sampling in August was sporadic except in 1993–1995). Systematic aerial surveys (3 to 4 h each) using a replicated flight pattern were conducted from May to October by helicopter (1 to 2 surveys) or fixed-wing aircraft (4 to 6 surveys; Turner et al., 1992). The territory is seldom accessible by vehicle during winter, and, with the exception of monitoring in January 1987 and 1988 which consisted of a 1-week ground survey and

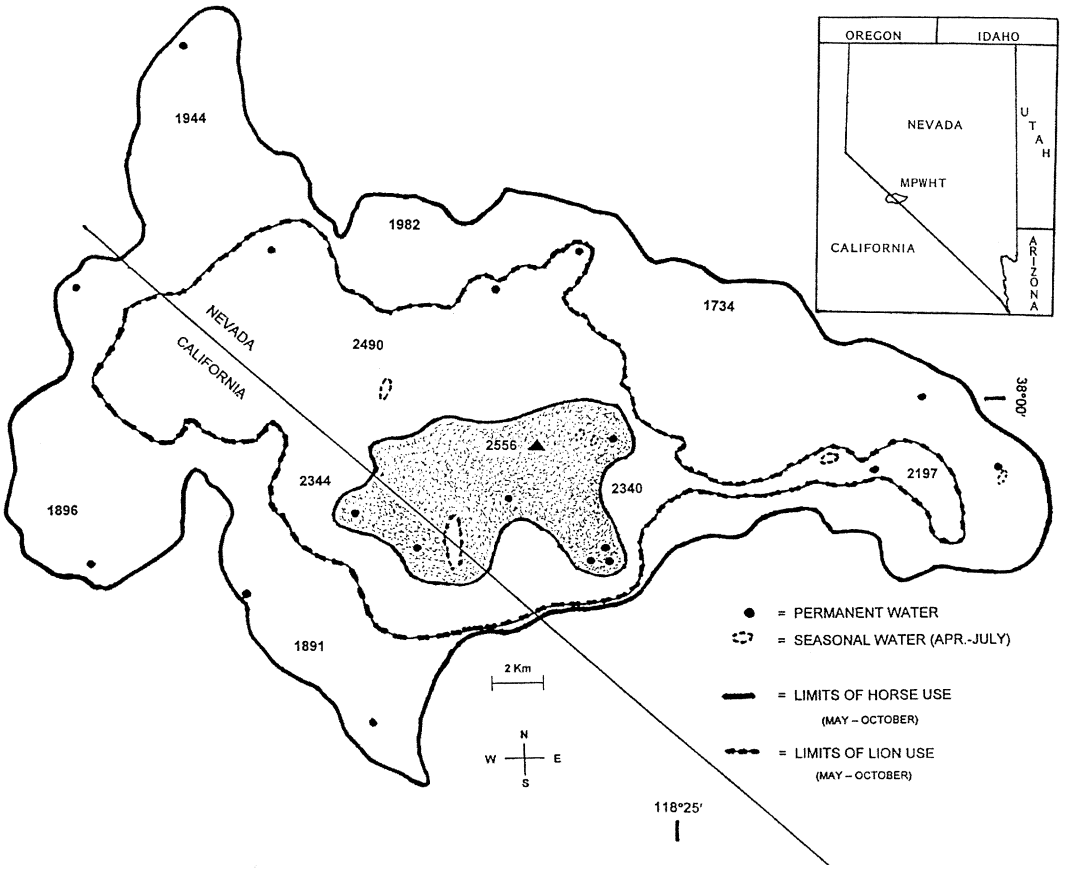

FIG. 1—Delineation of areas used by feral horses and mountain lions in the Montgomery Pass Wild Horse Territory, Mono Co., California, and Mineral Co., Nevada, 1987 through 1997. Shaded area contains: 1) 68% of all lion-killed foal carcasses located; 2) highest density of lion tracks observed; and 3) majority of radiotelemetry signals recorded. Numbers are elevation in meters.

an aerial survey each year, we did not conduct winter surveys.

We established a record of size, sex, color, and markings of individual horses to identify them (Turner et al., 1981; Berger, 1986). Major coat colors consisted of black, dark brown, bay (medium brown), sorrel (light reddish brown), buckskin (yellow/gold), and gray/white. Horses inhabiting the MPWHT are divided into bands usually composed of an alpha male (herd stallion), several adult females (in a social hierarchy), and subadults and foals of both sexes (Turner et al., 1992). The presence of bands made for easier identification of horses because we could characterize the composition of relatively small groups of animals.

We crossed the territory searching for horse tracks and other sign to locate animals. In addition, wranglers from 2 pack stations (commercial outfitters) conducting tours of the area provided us with data during May and June. Intensive searches for horse carcasses were made when a band member (usually a foal) was missing. Foals that could not be relocated despite the presence of their mothers in a band were presumed dead. For carcasses located, time of death was approximated based on the last visual sighting and carcass condition. Lion kills were characterized primarily by tooth punctures in the skull, claw marks on the hide, and brush piled on the carcass (Turner et al., 1992). We think that our sampling methods approached a total enumeration of the population (Turner et al., 1992). Annual foal, yearling, and adult survival were calculated as the number of a cohort alive at the end of a given biological year (May to April) divided by initial cohort size. Data from 1987 through 1991 were reported previously by Turner et al. (1992).

Locations of lions were determined through track observations and by radiotelemetry of radio-collared lions. Differentiating between uncollared lions was based on a minimum track size difference of 3 mm

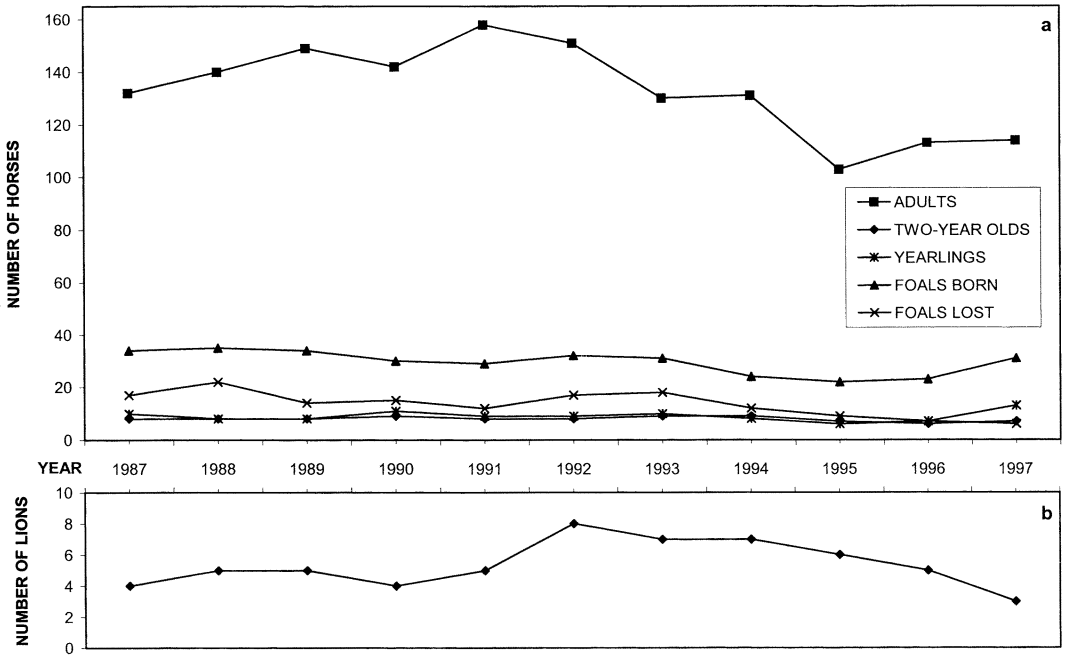

FIG. 2—Change in numbers over time of: a) feral horses, and b) mountain lions occurring in the Montgomery Pass Wild Horse Territory, Mono Co., California, and Mineral Co., Nevada, 1987 through 1997.

(Fjelline and Mansfield, 1990; Smallwood and Fitzhugh, 1993), regularity in geographic location of track, mutual exclusion of fresh track by date and location, and presence of offspring track. Most lion/horse water use was limited to 6 springs, making regular circumferential inspection of the spring area useful for track monitoring. Lions were radiocollared using standard telemetry transmitters (Telonics, Inc., and Telemetry Systems, Inc.), receivers (Telonics, Inc.), and 2-element Yagi antenna. All captures and collaring were performed using California Department of Fish and Game (CDFG) procedures and training (Jessup and Clark, 1986). A CDFG-trained tracker using dogs assisted with capture of lions. Eight adult lions (3 males, 5 females) were tagged from 1987 to 1995, with all but 2 (1 male, 1 female) tagged between 1992 and 1995. Radio-fixes were made to ascertain if and when lions were in the territory and to quantify overlap in lion ranges. Telemetry was not used to determine home-range sizes or specific movements of lions.

RESULTS—The adult horse population averaged 150 ($\bar{x}$ = 149.9, *SD* = 18.29), with a significant decrease (r = −0.661, P = 0.027; Zar, 1984) occurring across the study period (Fig. 2). From 1987 to 1991 the population increased significantly (r = 0.937, P = 0.019), and it showed a significantly decreasing trend for the period from 1991 through 1997 (r = −0.861, P = 0.013).

An average of 30 foals ($\bar{x}$ = 29.5, *SD* = 4.59) were born each year during our study. Foaling began in mid-April and >80% was completed by mid-July. Number of foals born ranged from 29 to 35 through 1993, dropped to 22 to 24 for 1994–1996, and then increased to 31 in 1997 (Fig. 2).

During our study 82 to 89% of the foals found dead were attributable to predation by lions (see also Turner et al., 1992). Number of foals killed each year by lions averaged 13.5 (*SD* = 4.93) throughout the study. This was an average of 45.1% (*SD* = 12.57) of the foals produced each year, with the annual percentage ranging from 16 to 63%. Number of foals killed ranged annually from 12 to 22 between 1987 and 1994. After 1994 verified kills comprised from 19 to 41% of the total foal population, with <10 foals killed in 1997. Foals averaged 1.5 months (*SD* = 0.66, range = 1 week to 9 months) of age when killed. Most foals were <2 months old when killed, although predation occurred up to 6 months of age. In addition to foals, 3 adult horses were found killed by lions: a 2-, 3-, and 4-year-old in 1991,

TABLE 1—Distribution of foals by coat color, and foals killed by mountain lions according to coat color, Montogomery Pass Wild Horse Territory, California and Nevada, 1987 through 1997.

Coat color	Foals born		Foals killed		Proportion (killed/born)
	n	%	*n*	%	
Sorrel	47	14.5	21	37.5	0.45[1]
Bay	143	44.0	13	23.2	0.09
Buckskin	52	16.0	10	17.9	0.19
Brown/black	66	20.3	8	14.3	0.12
Gray/white	7	1.8	0	0.0	0.00
Other[2]	10	3.0	3	5.4	0.30

[1] Proportion of foals killed was greater than for all other common colors observed ($P < 0.01$, Dunnett-type comparison test for proportions).

[2] This group included a mix of colors and was not included in statistical analysis.

1992, and 1993, respectively. No significant trend ($r = -0.015$, $P = 0.966$) in age at death was evident. Of 56 foals whose age at death could be estimated, 50.0% were killed during May, 32.1% in June, 10.7% in April, and 3.6% each in July and September.

Total foals observed and lion-killed foals were categorized according to coat color. Bay was the predominent coat color among foals, but sorrels comprised the highest percentage (37.5) of foals killed (Table 1). There was a significant difference ($\chi^2 = 20.998$, $df = 5$, $P = 0.0008$) in proportion of foals killed by coat color relative to distribution of colors born into the population. Furthermore, the killed/born proportion of sorrel color was significantly greater than for any other color ($P < 0.01$, Dunnett-type test for proportions; Zar, 1984).

Annual survival rates for foals averaged 0.32 ($SD = 0.073$, $n = 10$ years), ranging from a low of 0.23 during 1988–1989, to a high of 0.48 in 1996–1997 (Fig. 3). The annual survival rate in 1996–1997 was 23% greater than the next highest year (0.39, 1993–1994) during the study period. Overall, 68% of all lion-killed foal carcasses that we documented were located within a relatively concentrated area (Fig. 1). Yearling survival averaged 0.88 ($SD = 0.165$), ranging from a low of 0.5 in 1994–1995 to a high of 1.0 in 5 of the annual periods. Adult survivorship averaged 0.92 ($SD = 0.088$), ranging from a low of 0.81 in 1992–1993 to a high of 1.0 in 4 of the annual periods. Adult survivorship dropped to its lowest levels across the 1991–1992 to 1994–1995 periods, averaging only 0.84 ($SD = 0.075$, $n = 4$).

The lion population was relatively stable at 4 to 5 animals from 1987 through 1991, increased to 8 animals in 1993, and then slowly decreased through 1996. The population dropped to 3 animals in 1997 (Fig. 2). The overall lion population size averaged 5.2 ($SD = 1.60$) during the study. About 90% of the total telemetry locations for lions were contained within the primary use area of the horses (Fig. 1). Male lions showed less reliable patterns of use and less overlap than females. During the collaring period from 1992 to 1995 (based on combined information from differential track measurement and telemetry) it appears that we had a collar on all but one female (this female had only 3 toes on the left front paw) and one male (largest pad recordings in the study, 66 to 68 mm). In other years we do not know the exact lion numbers. However, the regularity of specific-sized tracks in certain areas and at watering sites gave us reasonable confidence in the count of females, and unless there were several males using the same pathways (unlikely due to territoriality) and with about the same track size, we were correct in assessing males as well.

We had adequate data to determine territory overlap for 3 adult female lions in 1992 (29 fixes, June to November), and 3 adult females (20 fixes, June to November) and 2 adult males (20 fixes, May to November) in 1993. The same 3 females were sampled in both years. During 1992 a minimum of 5 adult female lions (3 collared) co-occurred within the horse territory, whereas in 1993 these same 5 females co-occurred with 3 adult male lions (2 collared). We do not know if these male lions were present during 1992, although we determined that at least 2 different males were present based on track monitoring.

One to 3 lion kittens were present in the summers of all years studied except 1989, 1994, and 1997. We made visual sighting of 2 different mothers with 2 kittens and 1 mother with 1 kitten during the study. The remainder of mothers with kittens were determined by track, so we did not know if more than 1 kitten was present.

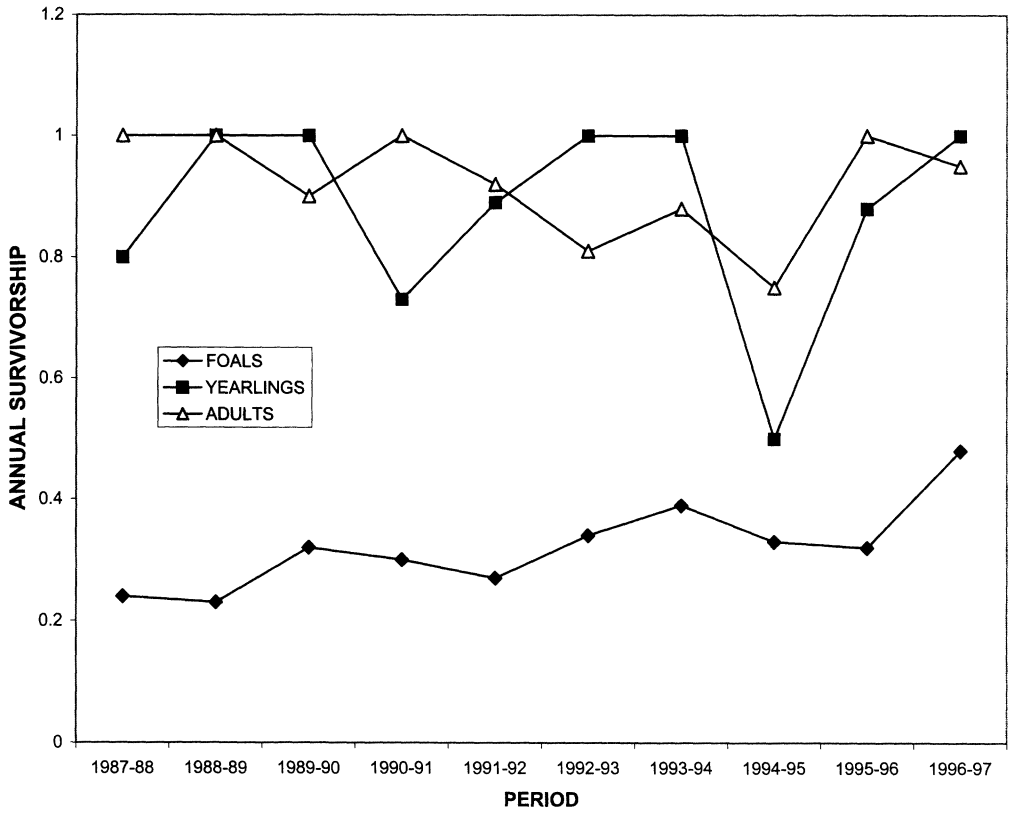

FIG. 3—Changes in annual survivorship of feral horses occurring in the Montgomery Pass Wild Horse Territory, Mono Co., California, and Mineral Co., Nevada, 1987 through 1997.

DISCUSSION—Our study indicates that the mountain lion population in the MPWHT significantly influences the number of horses there. This influence is exerted primarily through predation on foals. The increase in foal survival during the latter part of our study (especially during 1997) apparently was related to the coincident decrease in lion numbers. Foal survival in other ranges varied from 0.72 to 0.97 (Turner et al. 1992), whereas survival in our study only exceeded 0.39 in 1 year. The foaling rate in the MPWHT is greater than that reported for other western wild horse herds (Turner et al., 1992). It has been suggested that loss of offspring in a wildlife population can result in a compensatory increase in productivity (Keith, 1974; Sinclair, 1989). Although the high foaling rate in the MPWHT is consistent with such a hypothesis, no comparative control area exists. There are meager data regarding foal survival rates in most feral horse populations. Since the report of Turner et al. (1992), the authors have been given anecdotal information about significant predation on horses in 5 other territories in central and northern Nevada (J. Axtell, D. Catoor, G. McFadden; pers. comm.). Greger and Romney (1999) hypothesized that high foal mortality in southern Nevada was due to lion predation and reported foal survival rates comparable to those in our study.

In a previous study (Turner et al., 1992) comparison of frequency of tracks by lions in winter and summer in the MPWHT suggested increased lion activity/numbers in winter. A migratory mule deer (*Odocoileus hemionus*) population also is present as prey in the MPWHT in winter. Turner et al. (1992) suggested that some lions in the MPWHT were year-round residents and exhibited seasonal prey switching, whereby they fed on deer that migrated into the range in winter, and switched to foals when deer departed and foals became available in the spring and summer. It is our opin-

ion, based on year-to-year telemetry/track data, that the lions that we have monitored May through October inhabit the MPWHT year round and are therefore resident. Although we do not have data to verify this, it seems unlikely that our monitored lions would vacate their territories each winter and reclaim them each spring, ousting other lions. Because most foal kills occurred from May to October, we have attributed most foal predation to the resident lions.

We do not know why numbers of lions declined toward the end of our study. Hunting pressure was low to non-existent. The migrant mule deer population which winters in the MPWHT decreased 40% over the course of our study from an estimated 500 animals in 1987 to less than 300 in 1997 (Sönke Mastrup, CDFG, Sacramento, pers. comm.). The decline in migrant (winter resident) deer numbers should not increase lion predation on foals, however, because deer departed before the majority of foals were born. We do not have an estimate of resident deer density, but it appears to be small based on our track observations during spring and summer. Also, during field observations made in May and June across the 11-year study, only 3 fresh deer carcasses (compared to 56 foal carcasses) were discovered. Dogs tracking lions went well outside our study area into winter range of deer and many carcasses of deer killed in winter were seen by lion trackers there. Because lions are opportunistic predators, with deer generally accepted as preferred prey (Iriate et al., 1990), it seems unlikely that many deer remained in the MPWHT during summer. Nevertheless, we can only speculate that the decline in wintering deer numbers contributed to the observed decrease in lions in 1997 in the MPWHT.

An unrelated, intensive study of radio-collared lions conducted about 60 km south of the MPWHT showed a substantial decline in lion numbers there during 1997 as well (V. Bleich, CDFG, pers. comm.). The reason for this decline has not been determined. Recruitment into the pool of lions preying on foals seems likely, because adult females often had a kitten with them at the carcass. Continued monitoring of the MPWHT lion population, including more extensive radio tracking, would help resolve the issue of lion dynamics.

Lions appeared to select for foals with sorrel coat color. In contrast, bay colored foals were underrepresented in the lion kills, even though they were the most numerous coat color (Table 1). In our opinion, lions select for sorrel foals because this color more closely approaches the color of mule deer occupying MPWHT than any other foal coat color. If this hypothesis is true, and if predation continues, then over time selection against sorrel coat color should occur. Insufficient time has probably elapsed to date for selection to have occurred. Anecdotal reports indicate that lion predation rarely occurred prior to the 1970s. Additionally, California law protecting lions from hunting only began in 1972.

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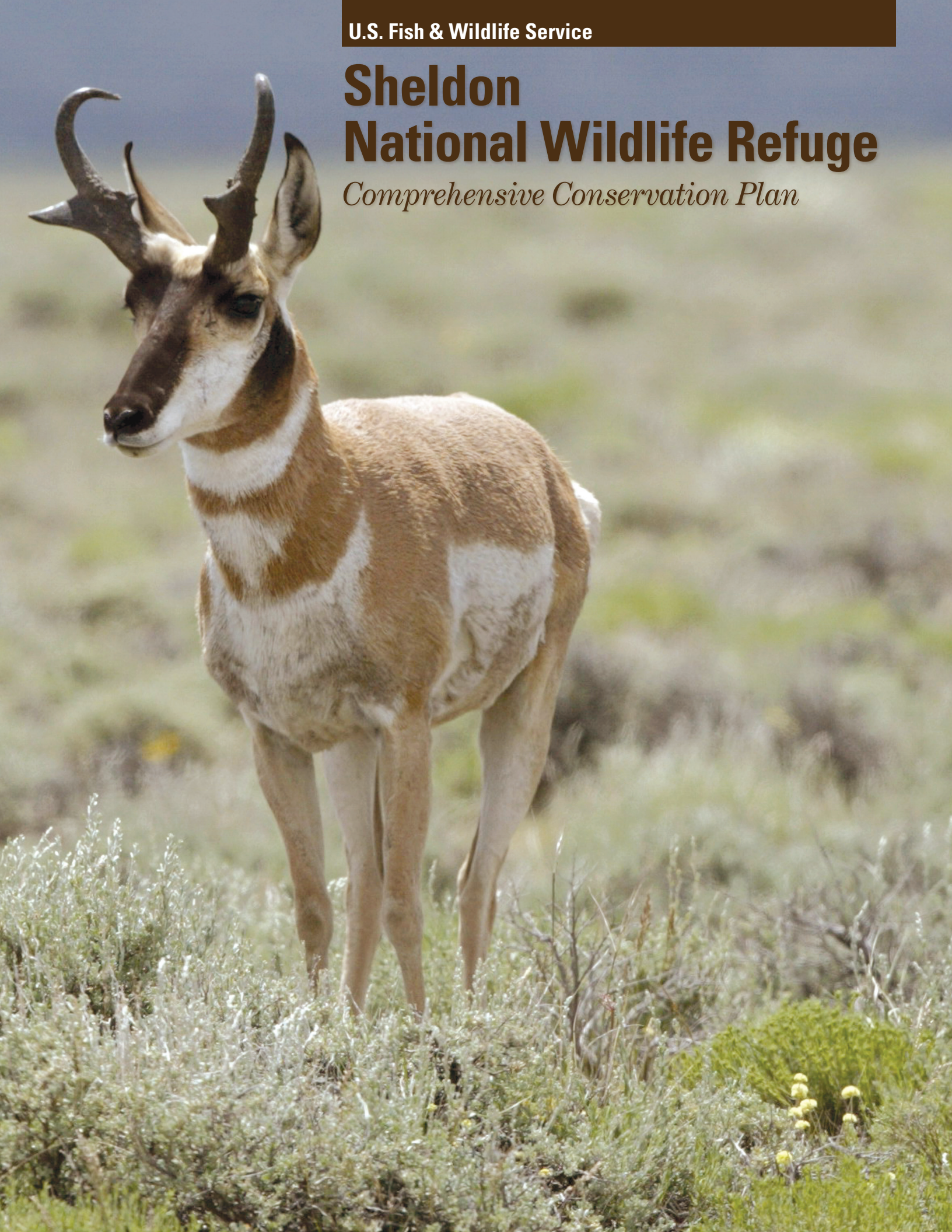
U.S. Fish & Wildlife Service

Sheldon National Wildlife Refuge

Comprehensive Conservation Plan



Our Vision for the Future

Sheldon National Wildlife Refuge will foster a strong land ethic and provide scientific leadership through collaboration with a diverse network of partners and utilize the highest principles of conservation. Sheldon Refuge will promote opportunities for people to actively seek and discover natural and cultural treasures in the vast and rugged high desert characterized by solitude, abundant wildlife, and wildlands free from human influences. Management will focus on Sheldon Refuge's wild character, biological integrity, and contribution within the larger landscape of the Great Basin as driven by natural ecological processes. As a result, Sheldon Refuge will perpetuate its unique cultural history and critical role in the preservation and study of the sagebrush-steppe ecosystem with its diverse and vital native species.

Comprehensive Conservation Plans provide long-term guidance for management decisions and set forth goals, objectives, and strategies needed to accomplish refuge purposes and identify the Service's best estimate of future needs. These plans detail program planning levels that are sometimes substantially above current budget allocations and, as such, are primarily for Service strategic planning and program prioritization purposes. The plans do not constitute a commitment for staffing increases, operational and maintenance increases, or funding for future land acquisition.

Sheldon National Wildlife Refuge
Comprehensive Conservation Plan

Prepared by:
U.S. Fish and Wildlife Service
Sheldon-Hart Mountain National Wildlife Refuge Complex
P.O. Box 111
Lakeview, Oregon 97630

September 2012

Approved: Robyn Thorson
Regional Director, Pacific Region
Portland, Oregon

SEP 27 2012
Date

U.S. Fish and Wildlife Service
Sheldon National Wildlife Refuge
Comprehensive Conservation Plan
Approval Submission

In accordance with the National Wildlife Refuge System Administration Act, as amended, the U.S. Fish and Wildlife Service completed a Comprehensive Conservation Plan (CCP) for Sheldon National Wildlife Refuge (Refuge). The purpose of this CCP is to specify management direction for the Refuge for the next 15 years. The goals, objectives and strategies for improving the Refuge conditions—including the types of habitat we will provide, partnership opportunities, and management actions needed to achieve desired future conditions—are described in the CCP. The Service's preferred alternative for managing the Refuge is described in this CCP and the effects on the human environment were described in the Draft CCP and Environmental Impact Statement.

This CCP is submitted for the Regional Director's approval by:

_____ 9/25/2012

Project Leader — Date

Sheldon-Hart Mountain National Wildlife Refuge Complex

Concur: _____ SEP 27 2012

Acting Refuge Supervisor — Date

Concur: _____ 9/27/12

Regional Chief — Date

U.S. Department of the Interior, Fish and Wildlife Service

Record of Decision
for the
Sheldon National Wildlife Refuge
Final Comprehensive Conservation Plan and Environmental Impact Statement

Washoe and Humboldt Counties, Nevada, and Lake County, Oregon

Through this Record of Decision (ROD), the U.S. Fish and Wildlife Service (Service) selects the comprehensive conservation plan (CCP) for the Sheldon National Wildlife Refuge (Refuge). This ROD includes brief summaries of the alternatives considered, the public involvement process, and the rationale for selecting Alternative 2, as described in the Final CCP and environmental impact statement (EIS), for management of the Sheldon Refuge. The CCP will provide guidance for managing and conserving the Refuge's natural resources and public use activities over the next 15 years.

Alternatives Considered

In the Draft CCP/EIS the Service evaluated three alternatives for the Refuge, including a no-action alternative (Alternative 1) as required under the Council on Environmental Quality's regulations (40 Code of Federal Regulations [CFR] 1500-1508).

Alternative 1. Under Alternative 1, the no-action alternative, we would assume no change from current management; this alternative is considered the base from which to compare the other two alternatives. We would continue to focus our management activities on maintaining relatively stable populations of approximately 800 feral horses and 90 feral burros within the Refuge. Fish populations in Big Spring Reservoir would be maintained through continued stocking of sterile rainbow trout. Our management of Refuge habitats would continue to include the use of prescribed fire and mechanical treatments to achieve habitat management objectives.

Current public uses including hunting, fishing, guiding, research, rock collecting, wildlife observation, photography, environmental education, and interpretation would continue. Few actions would be taken to expand public uses or reduce ongoing resource impacts from public uses. All existing designated campgrounds and roads would continue to be maintained at their current locations. We would continue to manage the Refuge's existing 341,500 acres of proposed wilderness area, to protect and preserve its natural primitive character, opportunities for solitude and primitive recreation, and other special resource values. A basic level of inventory, monitoring, and protection for cultural and historic resources would occur within the Refuge.

Alternative 2. Under Alternative 2, our preferred alternative, current fish, wildlife, habitat, and public use management would continue, with the following key enhancements.

- Improvement of native habitat conditions would be facilitated by removal of all feral horses and burros from the Refuge within 5 years.
- Nonnative rainbow trout in Big Spring Reservoir and Virgin Creek would be replaced with trout species indigenous to the region (i.e., Lahontan cutthroat trout, Alvord cutthroat trout, or redband trout), and populations would be maintained through restocking if necessary.

- Increased control of noxious weeds and other invasive plants would be implemented, including increased weed control along road corridors.
- Removal of western juniper would be undertaken where juniper woodlands are encroaching upon sagebrush-steppe habitats.
- Rehabilitation and restoration of degraded habitats would occur, using intensive management techniques (i.e., seeding, erosion control structures, and recontouring).
- Removal of abandoned livestock water developments would occur, along with restoration of spring, playa, wet meadow, and stream habitats to more natural conditions where beneficial to wildlife.
- Improved recreation opportunities would be provided by relocating and enlarging the visitor contact station, improving campground facilities, developing an accessible interpretive trail, creating a self-guided auto tour route, and improving signage of routes open to vehicle use.
- Vehicle access to the Refuge would be improved when we reopen existing routes, following revisions to proposed wilderness area boundaries. More frequent maintenance of improved gravel roads would also occur.
- Relocation of up to nine campgrounds and realignment of road segments would occur, to reduce erosion and impacts to sensitive riparian areas and cultural resources. Seasonal road closures would be implemented as appropriate, to protect sensitive species and habitats.
- Areas managed for wilderness values will include those currently proposed for wilderness designation under Alternative 1, and additional wilderness study areas identified during the 2009 Sheldon Refuge Wilderness Review. As a result, a larger portion of Sheldon Refuge (424,360 acres) would be managed for wilderness character than under the other alternatives.
- There would be increased inventory, protection, and quality of interpretation for historic and cultural resources.

Alternative 3. Under Alternative 3, changes to current management would include removing all feral horses and burros from the Refuge over a period of 15 years; replacing nonnative trout in Big Spring Reservoir with trout species indigenous to the region, but not maintaining the trout population through restocking; and managing habitats by creating conditions where natural processes such as fire could be allowed more frequently with less dependence on prescribed fire and other intensive management actions. Current public uses would continue, but some facilities would be consolidated and some uses would be curtailed. Vehicle access to the Refuge would be reduced due to the closure of two roads, and reduced road maintenance, which would occur on existing primary roads only. Both of these actions would result in fewer miles of primitive routes open to the public. The area managed for wilderness character would include 236,791 acres, which would provide less long-term protection and preservation of wilderness values than the other alternatives. In addition, this alternative would provide the least amount of protection and preservation of historic resources, compared to the other alternatives.

Environmentally Preferable Alternative

The definition of "environmentally preferable alternative" (40 CFR 1505.2(b)) is different from that of the preferred alternative. The environmentally preferred alternative generally causes the least damage to the environment and best protects natural and cultural resources. For this CCP/EIS, Alternative 2, our preferred alternative, is also the environmentally preferable alternative for the Refuge. Under Alternative 2, we would continue to conduct current wildlife and habitat management, with the following additional actions beneficial to fish and wildlife, and their habitats.

- Remove all feral horses and burros from the Refuge within 5 years to allow recovery of sensitive wildlife habitats.

- Replace nonnative rainbow trout in Big Spring Reservoir and Virgin Creek with trout species indigenous to the region.
- Determine population trends, distribution, and migratory patterns of priority species such as pronghorn, greater sage-grouse, and other sagebrush obligate species, to better inform future management strategies.
- Initiate baseline surveys and/or increase monitoring for bats, reptiles, and amphibians.
- Increase weed-control efforts to include road corridors.
- Increase emphasis on removal of western juniper where it has encroached into sagebrush habitats, to restore the relative abundance of juniper woodlands and sagebrush-steppe habitats to pre-Euro-American settlement conditions.
- Relocate up to nine designated campgrounds to reduce impacts to riparian habitats and cultural resources.
- Realign 12 miles of roads to reduce soil erosion, and implement seasonal road closures to reduce impacts to sensitive habitats and wildlife.
- Rehabilitate and restore damaged and degraded habitats using intensive management techniques (i.e., seeding, erosion control structures, and recontouring).
- Where possible, use only native seed in rehabilitation activities.
- Initiate baseline surveys and increase monitoring for aspen, rare plants, microbiotic crusts, and other identified plants and habitats.
- Restore and rehabilitate at least 1 mile of Virgin Creek habitat.
- Submit a recommendation through the Department of the Interior to Congress, to revise the Refuge areas previously proposed for wilderness designation. The revision would include areas with less evidence of human development and disturbance, where fewer repeated management activities would be needed to restore and maintain biological integrity, diversity, and environmental health, which would provide the best opportunities for solitude and primitive and unconfined types of recreation.

Public Involvement

We initiated the public scoping phase of our planning process in May 2008 by announcing our intention to complete a CCP/EIS in the Federal Register. Simultaneously, we issued a press release and distributed Planning Update 1 announcing the planning process and a series of open house meetings, and requesting public comments. We held five public open house meetings in 2008, and several additional meetings with county, state, and federal agencies, and key stakeholder groups.

Planning Update 2 was distributed in April 2009. We summarized the scoping comments we received and the significant planning issues we identified, in the update. We developed a preliminary set of draft management alternatives based on scoping comments, expert opinion, and Service policy. We released the preliminary draft alternatives, including the Service's preferred alternative, for public review and comments in June 2010, in Planning Update 3. Additional meetings with the State of Nevada and key stakeholder groups followed. Based on the comments we received, we modified the alternatives and presented them in the Draft CCP/EIS.

In September 2011, we announced the availability of the Draft CCP/EIS in the Federal Register and simultaneously sent a news release to local media. We also distributed Planning Update 4 to more than 4,500 interested individuals, organizations, and agencies. We included descriptions and a summary table of the alternatives in Planning Update 4, including our preferred alternative, and provided information for obtaining a copy of the Draft CCP/EIS and submitting comments. We addressed the public comments we received on the Draft CCP/EIS in the Final CCP/EIS. In our

response to comments, we clarified the rationale for a number of management actions and objectives. We also modified our preferred alternative to include additional fish species for stocking, to allow use of nonnative seed for habitat restoration under certain circumstances, to allow a greater use of helicopters and motorized equipment in the maintenance of water guzzlers, to provide for greater coordination with the Nevada Department of Wildlife prior to removal of abandoned water developments and restoration of spring and playa habitats, and to minimize disturbances to and displacement of wildlife, by leaving certain historic routes closed to vehicle use.

In July 2012 we released the Final CCP/EIS through a notice in the Federal Register. We also issued a press release and mailed Planning Update 5 to interested individuals, organizations, agencies, and local media. We informed the public that the Final CCP/EIS was available and a Record of Decision would be issued no sooner than 30 days. During the 30-day review period we received a number of comments, most related to horse and burro management and maintenance of artificial water sources, substantially similar to comments we received on the Draft CCP/EIS and addressed in the Final CCP/EIS. Other comments requested the Service to select an alternative presented in the Final CCP/EIS. Based on these comments, no changes to the Final CCP/EIS were made.

Interested and affected parties are being notified of our decision, and we are making this Record of Decision and supporting references available for public review through our Web site and at our offices in Portland and Lakeview, Oregon.

Decision

The Service has selected Alternative 2 as described in the Final CCP/EIS for implementation on the Refuge. Alternative 2 is the most effective alternative for addressing key issues identified during the planning process and will best achieve the purposes and goals of the Refuge, as well as the goals of the National Wildlife Refuge System. Implementation of the CCP will occur over the next 15 years.

Factors Considered in Making the Decision

In reaching this decision, the Service reviewed and considered the following: Impacts identified in Chapter 6 of the Draft and Final CCP/EIS; relevant issues, concerns, and opportunities presented by agencies, organizations, and individuals throughout the planning process, including comments on the Draft and Final CCP/EIS; and other relevant factors, including the purposes for which the Refuge was established, and statutory and regulatory guidance.

Alternative 2 was selected for implementation for the following reasons.

- Alternative 2 will best achieve the Refuge's purposes and fulfill the Service's mission, is consistent with the principles of sound wildlife management, and will facilitate priority public uses that are compatible with the purposes of the Refuge.
- Habitat conditions will improve and provide benefits to native wildlife populations quicker, by removing all feral horses and burros from the Refuge as soon as it is practicable.
- The Refuge will be managed for a natural mosaic of Great Basin habitat types and the native species that depend on them. We will incorporate several new components to current habitat management, and focus on restoration of natural processes and rehabilitation and restoration of degraded habitats. A broad range of management tools will be available for application including prescribed and natural fire, mechanical treatments, and water management as necessary to meet the life history requirements of native wildlife species. The combination of these components will contribute to achieving the Refuge's vision, purposes, and goals.

- We will provide an achievable balance of opportunities for priority and compatible public uses (hunting, fishing, guiding, research, rock collecting, wildlife observation, photography, environmental education, and interpretation), while providing sufficient protection for wildlife and their habitats.
- We will protect Refuge resources by monitoring wildlife population trends and distribution, improving public information, and inventorying biological, cultural and historic resources.
- A larger portion of the Refuge will be managed for wilderness character, and the overall quality of the Refuge's wilderness resources (as measured by naturalness, untrammeled character, opportunity for solitude, and opportunities for primitive or unconfined types of recreation) will be improved.

Alternative 1 was not selected as the preferred alternative for the following reasons.

- We would continue to maintain feral horse and burro populations over the long-term under Alternative 1. The existing feral horse and burro management program is not adequate to reduce populations and would continue to result in major adverse impacts to fish and wildlife habitats throughout the Refuge.
- Limited habitat restoration and improvement would be conducted, whereas the preferred alternative expands upon current management activities and provides needed habitat improvements through the use of a broad range of management tools and increased efforts to control and remove invasive and nonnative species.
- The majority of water control structures would remain abandoned and unmaintained, whereas under our preferred alternative we will remove abandoned livestock water developments throughout the Refuge and restore spring, playa, wet meadow, and stream habitats, and wilderness character to more natural conditions beneficial to native fish, wildlife, and plant species, and wilderness recreation.
- Public uses such as overnight camping and vehicle use in sensitive habitats and cultural sites would continue, with few actions to minimize adverse impacts to wildlife.

Alternative 3 was not selected as the preferred alternative for the following reasons.

- Removal of feral horse and burro populations from the Refuge would have occurred over a longer timeline, resulting in continued and greater adverse impacts to native fish and wildlife and their habitats, compared to actions in Alternative 2.
- Only minimal use of mechanical habitat management tools such as mechanical thinning, mowing, and prescribed fire would have occurred.
- Alternative 3 would have resulted in a more gradual recovery of degraded habitats by emphasizing natural recovery, often with an expected low probability of success.
- Alternative 3 also would have maintained a limited focus on minimizing public use impacts and improving public use opportunities, interpretation and educational materials, and cultural resource protection.

Measures to Minimize Environmental Harm

Public concerns, potential impacts, and measures or stipulations to mitigate impacts are addressed in the Final CCP/EIS. Practicable measures to avoid or minimize environmental harm that could result from implementation of Alternative 2 have been identified and incorporated into Chapter 2 (Alternatives, Goals, Objectives, and Strategies), Chapter 6 (Environmental Effects), Appendix D (Compatibility Determinations), and Appendix G (Wilderness Minimum Requirements Decisions and Analyses) of the Final CCP/EIS. The stipulations identified in the compatibility determinations in Appendix D ensure that public and other uses are compatible with the National Wildlife Refuge

System mission and Refuge purposes. The alternatives identified in the Wilderness Minimum Requirements Decisions and Analyses in Appendix G ensure our management actions are necessary to meet the minimum requirement for administering proposed areas as wilderness and necessary to accomplish the purposes of the Refuge. The stipulations and other mitigation measures identified in the preferred alternative in Chapter 2, Appendix D, and Appendix G are adopted by the Service in this ROD, and will be implemented by Refuge and Service staff members, partners, and volunteers.

Findings Required by Other Laws and Executive Orders

The proposed action complies with all federal laws and executive orders related to the CCP planning process. A compliance statement has been prepared, which explains how the selected alternative complies with the requirements of the National Wildlife Refuge System Administration Act, as amended (16 U.S. Code [U.S.C.] 688dd-688ee); the National Environmental Policy Act (42 U.S.C. 4321 et seq.); the Endangered Species Act (16 U.S.C. 1531-1544, 87 Stat. 884); the National Historic Preservation Act (16 U.S.C. 470-470b, 470c-470n); the Wilderness Preservation Act of 1964; Executive Order 11644, Off-road Vehicles; Executive Order 11988, Floodplain Management; Executive Order 11990, Protection of Wetlands; Executive Order 12372, Intergovernmental Review; Executive Order 13186, Protection of Migratory Birds; and Executive Order 12898, Environmental Justice.

For Further Information

Questions about the Final CCP/EIS may be directed to John Kasbohm, Project Leader, Sheldon-Hart Mountain National Wildlife Refuge Complex, P.O. Box 111, Lakeview, Oregon 97630, phone number (541) 947-3315, fax number (541) 947-4414, and email Sheldon-Hart@fws.gov.

Robyn Thorson — SEP 27 2012

Regional Director, Pacific Region — Date
Portland, Oregon

Supporting References

U.S. Fish and Wildlife Service. 2011. *Sheldon National Wildlife Refuge Draft Comprehensive Conservation Plan and Environmental Impact Statement.* U.S. Fish and Wildlife Service, Sheldon-Hart Mountain National Wildlife Refuge Complex. Lakeview, OR.

U.S. Fish and Wildlife Service. 2012. *Sheldon National Wildlife Refuge Final Comprehensive Conservation Plan and Environmental Impact Statement.* U.S. Fish and Wildlife Service, Sheldon-Hart Mountain National Wildlife Refuge Complex. Lakeview, OR.

Note: This ROD and supporting references are available for public review at the Sheldon-Hart Mountain National Wildlife Refuge Complex, 20995 Rabbit Hill Road, Lakeview, Oregon 97630, and the U.S. Fish and Wildlife Service, Division of Planning, Visitor Services, and Transportation, 911 NE 11th Avenue, Portland, Oregon 97232. These documents can be found on the internet at http://www.fws.gov/pacific/planning/main/docs/NV/docssheldon.htm.

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Executive Summary

This document is a summary of the Comprehensive Conservation Plan (CCP) for long-term management of the Sheldon National Wildlife Refuge located in northwest Nevada. The U.S. Fish and Wildlife Service (Service) is required by the National Wildlife Refuge System Administration Act of 1966 (as amended) to develop and implement a CCP for the long-term management of all national wildlife refuges. This CCP presents a 15-year plan for the conservation of fish, wildlife, and plants within Sheldon National Wildlife Refuge (referred to here as Sheldon Refuge) primarily through monitoring of their populations, management and restoration of their habitats, and control of invasive and feral species. The CCP also includes management of public uses such as wildlife observation and photography, hunting, fishing, environmental education, interpretation, and rock collecting in a manner that is compatible with the primary conservation purposes for Sheldon Refuge. Appropriateness findings, compatibility determinations, and minimum tool analysis for public uses and activities that are part of the Service's management direction are included with the CCP as appendices.

The management direction presented in the CCP is the outcome of a public planning process, which was initiated in 2007 and has involved thousands of individuals, non-profit organizations, state and local agencies, and tribal governments.

The Final CCP/EIS (USFWS 2012) was approved, and a Record of Decision (ROD) was signed by the Service's Regional Director in Portland, Oregon. This CCP is the action selected through the Record of Decision; it will guide management of Sheldon Refuge for the next 15 years.

Refuge Information and Background

Located in a remote area of northwestern Nevada, Sheldon Refuge encompasses 575,000 acres of sagebrush-steppe habitat within the Great Basin and is managed by the Service. Originally established in 1931 for the conservation and protection of the once-imperiled pronghorn (*Antilocapra americana*), Sheldon Refuge (along with its refuge complex companion, the Hart Mountain National Antelope Refuge) now conserves habitat for a number of additional native, rare, and imperiled species of fish, wildlife, and plants that depend upon the sagebrush-steppe ecosystem.

Blanketing high basalt tablelands and mountains, which average 6,000 feet in elevation, the vast expanses of sagebrush habitats are dotted with springs, pockets of aspen (*Populus* spp.), and isolated stands of mountain mahogany (*Cercocarpus ledifolius ledifolius*). Only at its edges does the refuge vary noticeably, with the pale rhyolite of Virgin Valley on the eastern edge, which holds highly prized black opal, and the high escarpment on the western edge where western juniper (*Juniperus occidentalis occidentalis*) dominates.

Beginning in the late 1800s and lasting until the mid-1990s, homesteading and ranching had a noticeable influence on habitats through ranching operations, livestock grazing, and wildland fire suppression. Influence from these activities remain in the form of abandoned water developments, feral horses, and continued fire suppression—all of which continue to influence habitat and natural conditions throughout Sheldon Refuge.

With the exception of a two-lane paved highway, a few scattered buildings, abandoned water troughs, and some primitive dirt roads, Sheldon Refuge appears today much as it has for the past

12,000 years or more that people have lived in this region. This long history of habitation is apparent throughout the refuge from the prehistoric stone tools, petroglyphs, and ancient campsites that remain. Today people continue to hunt, hike, and camp within Sheldon Refuge but for recreation rather than subsistence. Management of eight proposed wilderness areas continues to protect the remoteness, primitive character, and opportunities for solitude within 341,500 acres of Sheldon Refuge.

Wildlife observation and photography are two of the most popular activities enjoyed by nearly all visitors either by vehicle, or on foot in the refuge backcountry. A number of visitors also participate in hunting for big-game and upland birds during the fall seasons throughout much of Sheldon Refuge. Areas closed to hunting include approximately 34,000 acres in the western portion of the refuge, which represents the original refuge established in 1931, and the area surrounding the Refuge Headquarters at Dufurrena. Opportunities for waterfowl hunting exist but are constrained by the lack of habitat and limited areas of open water for hunting. Fishing at the Dufurrena Ponds, Catnip Reservoir, and at Big Spring Reservoirs (when water is available) is another activity popular with Nevada residents mostly during the summer months. During the spring and early summer, rock collecting is the primary public use activity within the Virgin Valley area of Sheldon Refuge.

Public uses throughout Sheldon Refuge are supported by various facilities, including 13 designated primitive, semi-primitive, and developed campgrounds, informational kiosks, the Refuge Headquarters at Dufurrena, and a network of roads ranging from paved highway to rugged two-track routes suitable only for high-clearance four-wheel-drive vehicles. Hunting guides and outfitters provide additional visitor services under Special Use Permits from the Service.

As a large and relatively undeveloped area, Sheldon Refuge provides rare opportunities to study and research the fish, wildlife, and plants that occur in the sagebrush-steppe. Current and recent work conducted by the Service and in partnership with other Federal agencies, the State of Nevada, universities, and non-profit organizations include studies of Greater sage-grouse (*Centrocerus urophasianus*) populations, American pika (*Ochotona princeps*) distribution, desert lizard populations, amphibian distribution, bat species distribution, feral horse and burro population movements and impacts, and effects from fire.

Refuge Purposes, Vision, and Management Goals

The primary purposes for Sheldon Refuge are:

- "...as a refuge and breeding ground for wild animals and birds..." Executive Order (EO) 5540 dated January 26, 1931

- "...set apart for the conservation and development of natural wildlife resources and for the protection and improvement of public grazing lands and natural forage resources..." EO 7522 dated December 21, 1936

- "...to conserve (A) fish or wildlife which are listed as endangered species or threatened species....or (B) plants..." 16 United States Code (U.S.C.) 1534 (Endangered Species Act of 1973)

- "...for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." 16 U.S.C. 715d (Migratory Bird Conservation Act)

The Service's vision for Sheldon Refuge included in the CCP is stated as follows:

> *Sheldon National Wildlife Refuge will foster a strong land ethic and provide scientific leadership through collaboration with a diverse network of partners and utilize the highest principles of conservation. Sheldon Refuge will promote opportunities for people to actively seek and discover natural and cultural treasures in the vast and rugged high desert characterized by solitude, abundant wildlife, and wildlands free from human influences. Management will focus on Sheldon Refuge's wild character, biological integrity, and contribution within the larger landscape of the Great Basin as driven by natural ecological processes. As a result, Sheldon Refuge will perpetuate its unique cultural history and critical role in the preservation and study of the sagebrush-steppe ecosystem with its diverse and vital native species.*

This vision for Sheldon Refuge will be achieved through management toward the following goals as stated in the CCP:

Goal 1: Manage feral horse and burro populations consistent with the purposes for Sheldon Refuge, the National Wildlife Refuge System Administration Act, national wildlife refuge policy, and to protect and preserve a diverse assemblage of native plant and wildlife species, habitats, and naturally functioning systems characteristic of the Great Basin Ecosystem.

Goal 2: Protect, maintain, and restore sagebrush-steppe and associated upland communities characteristic of the Great Basin Ecosystem.

Goal 3: Restore, protect, and maintain the structure and function of riparian and aquatic habitats characteristic of the Great Basin Ecosystem.

Goal 4: Protect unique and rare habitats, wildlife, and communities.

Goal 5: Using an integrated approach, prevent, control, or eliminate non-native species that threaten Sheldon Refuge resources.

Goal 6: Collect information and create partnerships necessary to support adaptive management decisions at a landscape scale.

Goal 7: Provide an active fire management program.

Goal 8: Provide visitors of diverse interests and abilities with the opportunities to experience a variety of quality wildlife-dependent recreational and interpretive activities on vast, rugged, and remote high desert landscapes. These experiences will enhance visitors' understanding of and appreciation for the unique natural and cultural resources conserved by Sheldon National Wildlife Refuge and the National Wildlife Refuge System.

Goal 9: Protect and manage Sheldon National Wildlife Refuge Wilderness Study Areas to maintain wilderness character and values.

Goal 10: Protect and manage the prehistoric, historic, and paleontological resources of Sheldon Refuge to ensure present and future generations recognize the significance of the area's past.

Goal 11: Reduce illegal and unauthorized activities on Sheldon Refuge.

Management Issues

Development of the CCP was driven primarily by the need to address several important management issues as identified by the Service, local tribal governments, state governments, other Federal agencies, and the public. The following major issues were identified and expressed by the public, various constituents, and Service staff, and have been analyzed and addressed during CCP development.

- Management of feral horses and burros
- Western juniper encroachment into adjacent sagebrush-steppe habitats
- Wildland fire and its management related to both lightning-caused and prescribed burning
- Control of invasive non-native plants
- Management of sport fishing
- Management of campgrounds
- Recommendations for proposed wilderness areas
- Public access, especially vehicle access

Management Direction

The Service has selected the management direction outlined in the CCP because it will more likely restore degraded habitats throughout Sheldon Refuge currently being adversely impacted by: populations of feral horses and burros; the presence of abandoned and unnecessary commercial livestock developments; continued long-term suppression of lightning-caused wildland fire; the introduction and rapid spread of invasive non-native weeds along road corridors; and designated camping areas located within riparian areas and/or prehistoric cultural sites.

The selected management direction will best implement Service policy for the removal of feral horses and burros from Sheldon Refuge; for management for self-sustaining high-quality sport fishing opportunities; and for designation of roads and motorized vehicle routes in support of wildlife-dependent public uses that minimize adverse impacts to refuge resources. The recommendation for proposed wilderness areas will allow intensive management and manipulation of habitats within those portions of Sheldon Refuge where action is most needed, while at the same time protecting and preserving wilderness values within those portions of the Refuge where only minimal manipulation of habitats or management activity is needed or anticipated.

The primary habitat management action will be the removal of feral horses and burros from Sheldon Refuge. Other actions will rehabilitate and restore a variety of sites and small areas to improve habitat conditions, including the removal of abandoned livestock water developments from springs throughout Sheldon Refuge. In addition spring, springbrook, playa, wet meadow, and stream habitats throughout Sheldon Refuge will be restored to more natural conditions. A broad range of management tools will be available for application including prescribed and natural fire, mechanical treatment, and water management as necessary to meet native wildlife life history requirements. In many cases, management will restore, maintain, or mimic natural ecosystem processes. Sheldon Refuge will increase efforts to control, reduce, and remove feral, invasive, exotic, and noxious non-native species.

Wildlife-dependent public uses will be highlighted with opportunities for hunting, fishing, wildlife observation, photography, interpretation, and environmental education maintained or improved from present conditions. Rainbow trout (*Salmo gairdneri*) in Big Spring Reservoir and Virgin Creek will be replaced with trout indigenous to the region (i.e., Lahontan cutthroat trout [*Oncorhynchus clarki henshawi*], Alvord cutthroat trout, or redband trout [*O. mykiss* spp.]). Up to nine designated campgrounds will be relocated and some road segments realigned to reduce erosion and impacts to sensitive riparian areas, but the size, general location, or types of developments currently found at these campgrounds will remain unchanged.

Other actions will include relocation and enlargement of the visitor contact station, improvement of campground facilities, development of an accessible interpretive trail, the creation of a self-guided auto tour route, and improved signing of routes open to vehicle use. Sheldon Refuge will close some existing primitive unmaintained routes to public use by motorized vehicles to protect various refuge resources. Management action will be taken to reduce impacts from other existing routes. In addition, visitors will be required to register all off-highway vehicles for use on refuge roads and routes designated open to vehicle use.

Areas managed for wilderness values will include those currently proposed for wilderness designation and additional areas for wilderness study as part of the 2009 Sheldon Refuge Wilderness Review. As a result, a larger portion of Sheldon Refuge (424,360 acres) will be managed for wilderness character than under current practices. The areas recommended for wilderness designation by Sheldon Refuge are somewhat different in location and configuration than those currently proposed than under the CCP's management direction, but the total area recommended is essentially the same.

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Chapter 1. Introduction, Purpose of, and Need for Action

1.1 Introduction and Background

Located in a remote area of northwestern Nevada, the Sheldon National Wildlife Refuge (referred to here as Sheldon Refuge) encompasses 575,000 acres of sagebrush-steppe habitat within the Great Basin (Figure 1.1) and is managed by the U.S. Fish and Wildlife Service (the Service). Originally established in 1931 for the conservation and protection of the once-imperiled pronghorn (*Antilocapra americana*), Sheldon Refuge (along with its refuge complex companion Hart Mountain National Antelope Refuge) now conserves habitat for a number of additional native, rare, and imperiled species of fish, wildlife, and plants that depend upon the sagebrush-steppe ecosystem.

Blanketing high basalt tablelands and mountains, which average 6,000 feet in elevation, the vast expanses of sagebrush habitats are dotted with springs, pockets of aspen, and isolated stands of mountain mahogany. Only at its edges does the refuge vary noticeably, with the pale rhyolite of Virgin Valley on the eastern edge, which holds highly prized black opal, and the high escarpment on the western edge where western juniper (*Juniperus occidentalis occidentalis*) dominates.

With the exception of a two-lane paved highway, a few scattered buildings, abandoned water troughs, and some primitive dirt roads, Sheldon Refuge appears today much as it has for the past 12,000 years or more that people have lived in this region. This long history of habitation is apparent throughout the refuge from the prehistoric stone tools, petroglyphs, and ancient campsites that remain. Today people continue to hunt, hike, and camp within Sheldon Refuge, but for recreation rather than subsistence.

This Comprehensive Conservation Plan (CCP) is the action selected in our Record of Decision; it will guide management of Sheldon Refuge for the next 15 years. The CCP sets forth management guidance for Sheldon Refuge, as is required by the National Wildlife Refuge System Administration Act of 1966 (16 U.S. Code [U.S.C.] 688 dd-688 ee, as amended by the National Wildlife Refuge System Improvement Act of 1997), to address significant problems that may adversely affect the populations and habitat of fish, wildlife, and plants, and the actions necessary to correct or mitigate such problems. The Refuge System Improvement Act mandated that a CCP be developed for each refuge in the National Wildlife Refuge System.

1.2 Purpose and Need for the Comprehensive Conservation Plan

The purpose of the CCP is to provide reasonable, scientifically grounded guidance for improving Sheldon Refuge's shrub-steppe, riparian, wetland, woodland, grassland, and cliff-talus habitats, for the long-term conservation of pronghorn, native plants and animals, and migratory birds. The CCP will identify appropriate actions for protecting and sustaining the biological features of Sheldon Refuge's pronghorn, Greater sage-grouse (*Centrocerus urophasianus*), California bighorn sheep (*Ovis canadensis*), and pygmy rabbit (*Brachylagus idahoensis*) populations and threatened, endangered, or rare species. The Decision Record for the 2008 Sheldon National Wildlife Refuge Horse and Burro Management Environmental Assessment (EA) stated feral horses and burros would be managed to maintain population levels that existed at that time. However, this Decision Record also stated this management direction would be re-evaluated as part of the Sheldon Refuge CCP. A final purpose of the CCP is to provide guidance for providing high-quality public use programs in

hunting, fishing, wildlife observation, photography, camping, environmental education, and interpretation.

Not only are CCPs for all national wildlife refuges required under the National Wildlife Refuge System Improvement Act, a CCP for Sheldon Refuge is needed for a variety of reasons. Primary among these is the need to identify and deal with key threats to the above habitats, including invasive plants and animals, altered fire regimes, and altered hydrological regimes. There is a need to address Sheldon Refuge's role in the conservation of Greater sage-grouse and pygmy rabbits and their habitats because these species use certain refuge habitats for all life history needs. There is also a need to address the contributions of Sheldon Refuge to the biodiversity of the Great Basin. There is a need to address public concern about feral horse and burro populations that negatively impact refuge habitats.

There is a need to analyze public use programs for the Refuge System's "Big Six" uses and to determine what improvements or alterations should be made in the pursuit of higher quality programs. The Big Six wildlife-dependent uses are hunting, fishing, wildlife observation, photography, environmental education, and interpretation (See Section 1.4.3 for more on the Big Six uses.)

There is also a need to determine whether and how Sheldon Refuge should continue to offer camping and other non-wildlife-dependent uses, including horseback riding, rock collecting, and off-highway vehicles (OHVs). There is a need to address strategies to better prevent use of refuge lands for illegal uses including off-road use and poaching. Finally, there is a need to describe the steps that should be taken to better protect cultural resources.

1.3 Content and Scope of Plan

This CCP provides guidance for management of refuge habitats and wildlife and administration of public uses on refuge lands and waters. An outline of the key information in the CCP follows.

- An overall vision for Sheldon Refuge and the role in the local ecosystem (Chapter 1).
- Updated and revised management direction in the form of goals and objectives for specific conservation targets and public use programs, as well as strategies for achieving the objectives (Chapter 2).
- A description of the conservation targets, their condition and trends on Sheldon Refuge and within the local ecosystem, a presentation of the key desired ecological conditions for sustaining the targets, and a short analysis of the threats to each conservation target (Chapter 2).
- A description of the physical, biological, and social environments that exist within Sheldon Refuge (Chapters 3, 4, and 5).
- An overview of Sheldon Refuge's public use programs and facilities, a list of desired future conditions for each program, and other management considerations (Chapters 2 and 5).
- An inventory of Sheldon Refuge wilderness resources, including a recommendation of Refuge lands suitable for wilderness designation (Appendix F).
- Compatibility determinations for existing and planned public and economic uses (Appendix D).
- An outline of the projects, staff, and facilities needed to implement the management direction (Appendix E).

A list of species known or suspected to occur on Sheldon Refuge, with information about their state and Federal conservation status (Appendix B).

1.4 Planning and Management Guidance

The U.S. Fish and Wildlife Service, an agency within the Department of Interior, is the principal Federal agency responsible for conserving, protecting, and enhancing fish, wildlife and plants and their habitats for the continuing benefit of the American people. The Service manages the 96-million-acre National Wildlife Refuge System, which encompasses 545 national wildlife refuges, thousands of small wetlands, and other special management areas.

Refuges are guided by various Federal laws and executive orders, Service policies, and international treaties. Fundamental are the mission and goals of the National Wildlife Refuge System (NWRS or Refuge System) and the designated purposes of the refuge unit as described in establishing legislation, executive orders, or other documents establishing, authorizing, or expanding a refuge.

Key concepts and guidance of the Refuge System derive from the National Wildlife Refuge System Administration Act of 1966 as amended (16 U.S.C. 668dd-668ee), the Refuge Recreation Act of 1962 (16 U.S.C. 460k-460k-4), as amended, Title 50 of the Code of Federal Regulations, and the Fish and Wildlife Service Manual. The National Wildlife Refuge System Administration Act is implemented through regulations covering the National Wildlife Refuge System, published in Title 50, subchapter C of the Code of Federal Regulations. These regulations govern general administration of units of the Refuge System.

1.4.1 U.S. Fish and Wildlife Service Mission

The mission of the Service is "working with others, to conserve, protect, and enhance fish and wildlife and their habitats for the continuing benefit of the American people." National natural resources entrusted to the Service for conservation and protection include migratory birds, endangered and threatened species, inter-jurisdictional fish, wetlands, and certain marine mammals. The Service also manages national fish hatcheries, enforces Federal wildlife laws and international treaties on importing and exporting wildlife, assists with state fish and wildlife programs, and helps other countries develop wildlife conservation programs.

1.4.2 National Wildlife Refuge System

The National Wildlife Refuge System is the world's largest network of public lands and waters set aside specifically for conserving wildlife and protecting ecosystems. From its inception in 1903, the Refuge System has grown to encompass 545 national wildlife refuges in all 50 states, and waterfowl production areas in 10 states, covering more than 96 million acres of public lands. More than 36 million visitors annually fish, hunt, observe, and photograph wildlife, or participate in environmental education and interpretive activities on these national wildlife refuges.

1.4.3 National Wildlife Refuge System Mission and Goals

The mission of the Refuge System is "to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations

of Americans" (National Wildlife Refuge System Administration Act of 1966, as amended)(16 U.S.C. 668dd-668ee).

Wildlife conservation is the fundamental mission of the Refuge System. The goals of the National Wildlife Refuge System, as articulated in the Mission Goals and Purposes Policy (601 FW 1) are to:

- Conserve a diversity of fish, wildlife, and plants and their habitats, including species that are endangered or threatened with becoming endangered.
- Develop and maintain a network of habitats for migratory birds, anadromous and inter-jurisdictional fish, and marine mammal populations that is strategically distributed and carefully managed to meet important life history needs of these species across their ranges.
- Conserve those ecosystems, plant communities, wetlands of national or international significance, and landscapes and seascapes that are unique, rare, declining, or underrepresented in existing protection efforts.
- Provide and enhance opportunities to participate in compatible wildlife-dependent recreation (hunting, fishing, wildlife observation and photography, and environmental education and interpretation).
- Foster understanding and instill appreciation of the diversity and interconnectedness of fish, wildlife, and plants and their habitats.

Management of Sheldon Refuge is directed, in large part, by the legislation that created and established purposes for Sheldon Refuge and by the goals described later in this chapter. However, other laws, regulations, and policies also guide the management of Sheldon Refuge. This section identifies the acts and policy guidance that are integral in the development of this CCP.

1.4.3.1 Legal Guidance

Operation and management of Sheldon Refuge is influenced by a wide array of laws, treaties, and executive orders. Among the most important are the National Wildlife Refuge System Administration Act, as amended by the National Wildlife Refuge Improvement Act, the Refuge Recreation Act, and the General Mining Act of 1872. These acts are described briefly in Appendix J along with other acts and legal guidance that influence management of Sheldon Refuge.

1.4.3.2 Policy Guidance

Programmatic guidance and policy documents provide additional direction for the management of national wildlife refuges throughout the System. These documents include the following:

- Fish and Wildlife Service Manual chapters
- Director's orders
- National policy issuances
- Handbooks
- Director's memoranda
- Regional directives

Among the more important policies relating to management of Sheldon Refuge are Service policies for biological integrity, diversity, and environmental health; compatibility; and wilderness

stewardship. These policies are described briefly in Appendix J along with other important policies and guidance that influence management of Sheldon Refuge.

1.4.4 Refuge Management Direction

A number of previous planning efforts have been completed for Sheldon Refuge. These various plans provide the current management direction for Sheldon Refuge. This CCP will substantially revise or replace this existing management direction to reflect revised and updated Service policies and guidelines, new resource information and research findings, and to address issues identified through the scoping process.

The Sheldon National Wildlife Refuge Renewable Natural Resources Management Plan Final Environmental Impact Statement (referred to here as simply the Sheldon Natural Resource Plan) was completed and released to the public on August 18, 1980. The plan was a detailed and valuable document covering location, history, environment, resources, administration, land status, agreements and permits, and management direction.

In addition, several smaller "step-down" plans (plans addressing one program or resource) have been developed for Sheldon Refuge including:

- Virgin Valley Winter Grazing Plan and Environmental Assessment (amended the Sheldon Natural Resource Plan) (1989)
- Fisheries Management Plan (1990)
- Western Juniper Control Project Plan and Environmental Assessment (2001)
- Feral Horse and Burro Management Plan (amended the Sheldon Natural Resource Plan) (2008)
- Fire Management Plan (2009)

With the exception of the Fire Management Plan, the Final Record of Decision for the Sheldon Refuge CCP/Environmental Impact Statement (EIS) will supersede the previous planning decisions and management direction listed above in their entirety. The Fire Management Plan will be updated to reflect any additional or revised management direction included in the CCP/EIS Final Record of Decision.

1.4.5 Future Step-down Management Plans

The CCP will be revised every 15 years or earlier if monitoring and evaluation determine that changes are needed to achieve Sheldon Refuge purposes, vision, goals, or objectives. The CCP provides guidance in the form of goals, objectives, and strategies for refuge program areas but may lack some of the specifics needed for implementation. Step-down management plans will therefore be developed for individual program areas, as needed, following completion of the CCP. Step-down plans require appropriate NEPA compliance. The following step-down management plans will be revised or completed in accordance with the CCP management goals, objectives, and strategies following the Final Record of Decision:

- Minerals and Mining Management Plan
- Wilderness Stewardship Plan
- Transportation Management Plan

- Visitor Services Plan
- Law Enforcement Plan
- Cultural Resources Management Plan
- Cold-water Fisheries Management Plan
- Habitat Management Plan
- Integrated Pest Management Plan

1.5 Refuge Establishment, Refuge Purposes, Refuge Goals

The purpose for which a refuge was established or acquired is of key importance in refuge planning. Purposes must form the foundation for planning and management decisions. The purposes of a refuge are specified in or derived from the law, proclamation, executive order, agreement, public land order, donation document, or administrative memorandum establishing, authorizing, or expanding a refuge, refuge unit, or refuge subunit.

Unless the establishing law, order, or other document indicates otherwise, purposes dealing with the conservation, management, and restoration of fish, wildlife, and plants, and the habitats on which they depend take precedence over other purposes in the management and administration of any unit. Where a refuge has multiple purposes related to fish, wildlife, and plant conservation, the more specific purpose will take precedence in instances of conflict. When an additional unit is acquired under an authority different from the authority used to establish the original unit, the addition takes on the purpose(s) of the original unit, but the original unit does not take on the purpose(s) of the newer addition.

By law, refuges are to be managed so as to achieve their purposes. When a conflict exists between the System mission and the purpose of an individual refuge, the refuge purpose may supersede the System mission.

Refuge purposes are also the driving force in the development of the refuge vision statements, goals, objectives, and strategies in the CCP and are critical to determining the compatibility of all existing and planned refuge uses. The purposes for Sheldon Refuge have been established through a series of congressional acts, presidential executive orders, and public land orders as follows.

This section includes a list and brief description of the establishing and acquisition authorities for Sheldon Refuge. A comprehensive history of the establishment of Sheldon Refuge is included in Appendix I.

1.5.1 Sheldon Refuge Purposes

"...as a refuge and breeding ground for wild animals and birds..." Executive Order (EO) 5540 dated January 26, 1931

"...set apart for the conservation and development of natural wildlife resources and for the protection and improvement of public grazing lands and natural forage resources..." EO 7522 dated December 21, 1936

"...to conserve (A) fish or wildlife which are listed as endangered species or threatened species....or (B) plants..." 16 U.S.C. 1534 (Endangered Species Act of 1973)

"...for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." 16 U.S.C. 715d (Migratory Bird Conservation Act)

1.5.1.1 Establishing and Acquisition Authorities

Migratory Bird Conservation Act of 1929, as amended (16 U.S.C. 715-715r):

> "…for use as an inviolate sanctuary, or for any other management purpose, for migratory birds…" and "…to conserve and protect migratory birds in accordance with treaty obligations…and other species of wildlife found thereon, including species that are listed…as endangered species or threatened species, and to restore or develop adequate wildlife habitat"

Charles Sheldon Wild Life Refuge, Nevada (EO 5540, January 26, 1931):

> "…reserved and set apart for…use…as a refuge and breeding ground for wild animals and birds.…"

Enlarging Charles Sheldon Wildlife Refuge, Nevada (EO 7364, May 6, 1936):

> "…in order to effectuate further the purposes of the Migratory Bird Conservation Act …withdrawn from settlement, location, sale, entry, or other form of appropriation and reserved and set apart…as an addition to the existing Charles Sheldon Wildlife Refuge…."

Charles Sheldon Antelope Range, Nevada (EO 7522, December 21, 1936):

> "…withdrawn from settlement, location, sale, or entry and reserved and set apart for the conservation and development of natural wildlife resources and for the protection and improvement of public grazing lands and natural forage resources…;" and "…the natural resources therein shall be first utilized for the purpose of sustaining in a healthy condition a maximum of three thousand five hundred (3,500) antelope, the primary species, and such nonpredatory secondary species in such numbers as may be necessary to maintain a balanced wildlife population…."

National Wildlife Refuge System Administration Act of 1966, as amended (16 U.S.C. 668dd-668ee), including the Game Range Act of 1976 (Public Law 94-223, 90 Stat. 199):

> "…for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans"

Nevada—Prior Amendment of Executive Order No. 7522; Prior Revocation of Public Land Order No. 5497; Consolidation of Charles Sheldon Antelope Range and Charles Sheldon Wildlife Refuge; Change of Name to Sheldon National Wildlife Refuge; Clarification of Administration and Management Under National Wildlife Refuge System Administration Act (Public Land Order [PLO] 5634, April 25, 1978):

> Consistent with, "The Act of February 27, 1976 (Public Law 94-223, 90 Stat. 199) [a.k.a. the Game Range Act] which amended…the National Wildlife Refuge System Administration Act of 1966 …the Charles Sheldon Antelope Range, shall be administered by the Secretary of the Interior exclusively through the United States Fish and Wildlife Service…;" and "The

> operation and administration of the Charles Sheldon Antelope Range, including grazing…is now being administered, in accordance with the National Wildlife Refuge System Administration Act…;" and "…the lands and interests in land comprising the Charles Sheldon Wildlife Refuge…and the adjoining Charles Sheldon Antelope Range…are hereby consolidated into one administrative unit…designated and known as the Sheldon National Wildlife Refuge"

Mineral Withdrawal of a Portion of the Sheldon National Wildlife Refuge; Nevada (PLO 6849, April 15, 1991):

> "…withdraws approximately 445,766 acres of the Sheldon National Wildlife Refuge…from mining location…to protect the wildlife habitat and unique resource values of the refuge lands"

1.5.2 Refuge Vision Statement

Sheldon National Wildlife Refuge will foster a strong land ethic and provide scientific leadership through collaboration with a diverse network of partners and utilize the highest principles of conservation. Sheldon Refuge will promote opportunities for people to actively seek and discover natural and cultural treasures in the vast and rugged high desert characterized by solitude, abundant wildlife, and wildlands free from human influences. Management will focus on Sheldon Refuge's wild character, biological integrity, and contribution within the larger landscape of the Great Basin as driven by natural ecological processes. As a result, Sheldon Refuge will perpetuate its unique cultural history and critical role in the preservation and study of the sagebrush-steppe ecosystem with its diverse and vital native species.

1.5.3 Refuge Management Direction: Goals

1.5.3.1 Habitat and Wildlife Goals

Goal 1: Manage feral horse and burro populations consistent with the purposes for Sheldon Refuge, the National Wildlife Refuge Improvement Act, national wildlife refuge policy, and to protect and preserve a diverse assemblage of native plant and wildlife species, habitats, and naturally functioning systems characteristic of the Great Basin Ecosystem.

Goal 2: Protect, maintain, and restore sagebrush-steppe and associated upland communities characteristic of the Great Basin Ecosystem.

Goal 3: Restore, protect, and maintain the structure and function of riparian and aquatic habitats characteristic of the Great Basin Ecosystem.

Goal 4: Protect unique and rare habitats, wildlife, and communities.

Goal 5: Using an integrated approach, prevent, control, or eliminate non-native species that threaten Sheldon Refuge resources.

Goal 6: Collect information and create partnerships necessary to support adaptive management decisions at a landscape scale.

1.5.3.2 Fire Management Goal

Goal 7: Provide an active fire management program.

1.5.3.3 Public Use Goal

Goal 8: Provide visitors of diverse interests and abilities with opportunities to experience a variety of quality wildlife-dependent recreational and educational activities on vast, rugged, and remote high desert landscapes. These experiences will enhance visitors' understanding of and appreciation for the unique natural and cultural resources conserved by Sheldon National Wildlife Refuge and the National Wildlife Refuge System.

1.5.3.4 Wilderness Resource Goal

Goal 9: Protect and manage Sheldon National Wildlife Refuge Wilderness Study Areas to maintain wilderness character and values.

1.5.3.5 Cultural Resource Goal

Goal 10: Protect and manage the prehistoric, historic, and paleontological resources of Sheldon Refuge to ensure present and future generations recognize the significance of the area's past.

1.5.3.6 Law Enforcement Goal

Goal 11: Reduce illegal and unauthorized activities on Sheldon Refuge.

1.6 Relationship to Other Ecosystem Planning Efforts

When developing a CCP, the Service considers the goals and objectives of existing national, regional, and ecosystem plans; state fish and wildlife conservation plans; and other landscape-scale plans developed for the same watershed or ecosystem in which the refuge is located. Where appropriate, the CCP is expected to be consistent with the existing plans and assist in meeting their conservation goals and objectives (602 FW 3.3). This section summarizes some of the key plans reviewed by members of the core team while developing the CCP.

1.6.1 State Plans

The Nevada Department of Wildlife (NDOW) recently completed the Nevada Wildlife Action Plan (Wildlife Action Plan Team 2006), which incorporates the agency's special expertise in the management and conservation of Nevada's native wildlife and habitats. The Nevada Wildlife Action Plan is designed to provide scientific support for CCP development, input on impact analyses, and support for implementation of management actions. The Action Plan identifies species of conservation priority throughout Nevada. Species identified in the Action Plan that are known to occur within Sheldon Refuge are identified in Appendix B. Partnerships and close coordination between NDOW and the Service are key to incorporating the Nevada Wildlife Action Plan into the CCP process. As NDOW updates the Action Plan, the Service will update the species list in Appendix B as appropriate.

Other NDOW plans include the Nevada Partners in Flight, Nevada Management Plan for Mule Deer, Big Game Status, Elk Species Management, Bat Conservation, Pronghorn Antelope Ecology, Management and Conservation, and Greater Sage-grouse Conservation.

1.6.2 Migratory Bird Plans

Birds of Conservation Concern (USFWS 2002a): Based on the efforts and assessment scores of three major bird conservation efforts (Partners in Flight, the U.S. Shorebird Conservation Plan, and the North American Waterbird Conservation Plan), this report identifies, by Service region and by Bird Conservation Region, the bird species most in need of conservation attention.

Partners in Flight (PIF), Sheldon Refuge Plan: The primary goal is to ensure long-term maintenance of healthy populations of native landbirds. Specific management activities and strategies are recommended.

North American Waterfowl Management Plan: The North American Waterfowl Management Plan, signed by the United States and Canada in 1986 and by Mexico in 1994, provides a strategy to protect North America's remaining wetlands and to conserve waterfowl populations through habitat protection, restoration, and enhancement. The plan contains population goals for several species and groups of species by season or life stage. The plan was updated in 2004 with an emphasis on strengthening the biological foundation, using a landscape approach and expanding partnerships. Additional strategic guidance was provided in a 2004 update, with specific population objectives by species. Implementation of this plan is accomplished at the regional level by partnership, within 11 Joint Venture areas. The Sheldon Refuge is located within the area of the Intermountain West Joint Venture. The document, 2004 Strategic Guidance (North American Waterfowl Management Plan, 2004), a 15-year plan, does contain species-specific population objectives as a step-down from the North American Waterfowl Plan and evaluations of whether the continental population is currently short or over the target. There are also flyway goals for production by species. The Sheldon Refuge is recognized as one of 67 areas of continental significance to waterfowl, but the plan did not target population objectives for wintering or migratory waterfowl by area.

Pacific Flyway Plans: Flyway management plans are the products of Flyway Councils, developed to help state and Federal agencies cooperatively manage migratory game birds. These plans typically focus on populations. The Pacific Flyway Council has prepared 26 management plans to date in either draft or final form (Pacific Flyway Council 2010). The following flyway management plans pertain to Sheldon Refuge and the CCP:

- Canada Geese: Lesser and Taverner's, Pacific Western, Rocky Mountain, Western, Depredation Control.
- Greater White-fronted Geese: Pacific, Tule.
- Snow Geese: Wrangel Island Lesser, Western Canadian Arctic Lesser Ross' Geese.
- Swans: Pacific Trumpeter, Rocky Mountain Trumpeter, Western Tundra, Eastern Tundra.
- Sandhill Cranes: Pacific Coast, Central Valley.
- Mourning Dove: National Mourning Dove Plan.

Intermountain West Regional Shorebird Conservation Plan (Oring et al. 2006): According to this plan, the Intermountain West is North America's most important inland area for maintaining the continent's shorebird population. The plan identifies major shorebird issues in the region and

outlines regional goals and objectives in the areas of habitat management, monitoring and assessment, research, outreach, and planning. Key issues identified in the plan include water quality and quantity; maintenance and enhancement of populations of long-billed curlew (*Numenius americanus*), mountain plover (*Charadrius montanus*), and upland sandpiper (*Bartramia longicauda*); depredation of eggs and young; regional coordination, agriculture-shorebird interface; and wintering sites. Concern ranking scores are provided for each of the 34 shorebird species breeding or moving through the region. Species ranked as critically important include western snowy plover (*C. alexandrines*), black-necked stilt (*Himantopus mexicanus*), American avocet (*Recurvirostra americana*), long-billed curlew, long-billed dowitcher (*Limnodromus scolopaceus*), and Wilson's phalarope (*Steganopus tricolor*).

1.7 Planning and Issue Identification

1.7.1 Description of the Planning Process

A core planning team, consisting of the Sheldon-Hart Mountain Refuge Complex project leader, deputy project leader, natural resource planner, biologist, fire management officer, and the Sheldon Refuge manager began developing the CCP in 2007. A list of core planning team members and their experience is located in Appendix K. An extended team assisted in development of the CCP, particularly in providing comments at key milestones. The extended team consisted of various professionals from other Federal agencies, NDOW, and within the Service.

Early in the planning process, the extended planning team considered other planning efforts (see Section 1.6) and cooperatively identified the top priority species, groups, and communities for Sheldon Refuge. These priorities were also called conservation targets, and most of the biological emphasis of the CCP is focused on protecting and restoring these targets.

Planning for compatible wildlife-dependent public uses and rock collecting centered on developing goals, objectives, and strategies for secondary supporting uses and facilities such as vehicle access, campground facilities, and water developments.

Public scoping began in spring and summer of 2008. Scoping meetings were held in Lakeview, Oregon, Winnemucca, Nevada, and Denio, Nevada, in May 2008 and Alturas, California, and Reno, Nevada, in June 2008. Public commentary was also solicited through distribution of three planning updates to more than 4,000 individuals on the Sheldon Refuge mailing list and meetings with key stakeholder groups. A number of comments and suggestions were made through this process, which informed further development and refinement of the CCP. Public involvement is further discussed in Appendix A.

An internal draft was distributed to Service Region 1 reviewers, members of the extended team, NDOW, and Oregon Department of Fish and Wildlife (ODFW) representatives. In addition, a consultation meeting was held with the Summit-Lake Paiute Tribal Council to discuss the preliminary alternatives and resource concerns. All changes that were requested and all the resulting changes that were made to the CCP were documented.

1.7.1.1 Planning Issues

The following major issues were identified and expressed by the public, various constituents, and Service staff, and have been analyzed and addressed during CCP development.

- **Feral Horses and Burros:** Management of feral horses and burros has been identified as the most important issue affecting the ability of the Service to fulfill the purposes for Sheldon Refuge. A detailed environmental assessment was prepared (USFWS 2008a), which described a number of direct adverse impacts to biological integrity, diversity, and environmental health within Sheldon Refuge from feral horses and burros (Photo 1.1). These impacts from populations of approximately 800 horses and 90 burros were determined not likely to be significant over the short term until the CCP for Sheldon Refuge could be completed and include long-term management direction for feral horses and burros within Sheldon Refuge. As part of the CCP it was necessary for the Service to evaluate impacts from continued management of approximately 800 horses and 90 burros over the long term in addition to other options for long-term management consistent with Service policy, the mission of the Refuge System, and the purposes for Sheldon Refuge. In addition, it was necessary for the Service to consider the full range of available methods and tools for accomplishing the objectives within the management direction.

Photo 1.1 Damaging effects from feral horses and burros (as shown outside the fence exclosure in the left side of the photo) are well documented within Sheldon Refuge (Photo Gail Collins).

- **Juniper Encroachment:** Over the past hundred years or so, western juniper has been steadily encroaching on large areas of sagebrush-steppe habitat in the western United States (Photos 1.2 and 1.3). This encroachment is the result of grazing management, which has reduced understory vegetation, and fire management, which has increased the density of juniper and further reduced understory vegetation and the natural influences from fire. There is concern that these effects are reducing the amount and quality of habitat for important wildlife such as pronghorn, Greater sage-grouse, mule deer (*Odocoileus hemionus*), and

pygmy rabbit within Sheldon Refuge, and that these impacts could increase if additional management action is not taken.

Photo 1.2 West entrance to Sheldon Refuge in 1961.

Photo 1.3 The expansion of western juniper has occurred in recent times. The expansion into the lower elevation slopes in the western portion of Sheldon Refuge (shown at the center of this 2001 photo) occurred within 40 years.

- **Wildland Fire:** Past fire management has successfully extinguished the majority of lightning-caused fires or significantly reduced the intensity, and size of such fires leading to several habitat changes such as juniper encroachment discussed previously. At the same time, the frequency of fire has increased within certain habitats through prescribed burning (Photo 1.4). This past approach to fire management has resulted in an increasing amount of vegetation and increasing risk for fires burning more intensely and over larger areas of sagebrush habitat than historically would have occurred. This issue is further complicated by grazing from feral horses, the potential for cheatgrass invasion following fire, and the safety risks and hazards associated with attempting to maintain or restore a more natural fire regime. There is a need to explore other options for using fire to meet habitat management objectives and in turn meeting wildlife management objectives for Sheldon Refuge while at the same time maintaining public safety and an acceptable level of risk.

Photo 1.4 Prescribed fire is now more frequently used to manage meadow habitats within Sheldon Refuge.

- **Invasive Species:** In addition to feral horses and burros, and widespread cheatgrass invasion following fire, a number of other invasive plants and animals either currently occur or are known to already be in areas near Sheldon Refuge (Photo 1.5). Presently there is no systematic or strategic effort to identify, control, or remove these species before they become widespread and very difficult or impossible to manage. There is a need for the Service to identify specific strategies for minimizing the impacts from species already occurring within Sheldon Refuge and to greatly reduce the potential for such species occurring in the future.

Photo 1.5 Disturbance from regular grading along road shoulders spreads and creates ideal growing conditions for many non-native invasive plants such as Russian thistle, *Halogeton*, and cheatgrass.

- **Sport Fishing:** There are three primary areas managed for sport fisheries within Sheldon Refuge. Continuing to maintain these fisheries has been raised as an issue due to water being impounded and not available to downstream wildlife habitats; the time, money, and other resources needed for maintenance and repairs, which detract from other higher priority wildlife management projects and programs; and because the current practice of periodically restocking non-native rainbow trout (*Salmo gairdneri*) is incompatible with Service policy.

  Several non-native species of warm-water fish were historically stocked to the Dufurrena Ponds in the Virgin Valley. These ponds continue to provide fishing opportunities, but the ponds are not restocked, and the likelihood that these fish could escape into Thousand Creek or Virgin Creek is considered very low. However, occasional flooding does require maintenance of the ponds and creates conditions where fish could escape into adjacent streams.

  Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*; native to nearby areas) are periodically stocked to Catnip Reservoir, but the reservoir has become shallow through siltation and the earthen dam is beginning to fail. To maintain this fishery, trout will need to be periodically restocked, Catnip Reservoir will need to be dredged, and the dam will need to be repaired or replaced at the considerable cost of several million dollars.

  Big Spring Reservoir is currently dry, but in wetter years it was restocked with rainbow trout, which is preferred by some anglers because it is more vigorous, hardy, faster growing, and ultimately more sporting to catch than the locally indigenous Lahontan cutthroat or redband trout (*Oncorhynchus mykiss gairdnari*). However, restocking non-native fish to waters within a national wildlife refuge to provide sport-fishing opportunity is incompatible with Service policy.

- **Designated Campgrounds:** Overnight camping within Sheldon Refuge is allowed only at designated campgrounds or in the backcountry by Special Use Permit. Due to the remoteness

and size of Sheldon Refuge, overnight camping is allowed to facilitate and support wildlife-dependent uses such as fishing, hunting, wildlife observation, and photography which many visitors would not be able to participate in otherwise. While the number of designated campgrounds has diminished, the remaining semi-primitive and primitive campgrounds are located at or near springs and affect riparian areas through trampling, water pollution, and the disturbance and displacement of wildlife from these important water sources.

Virgin Valley Campground has been developed and includes several outhouses, potable water, fire rings, and a bathhouse and swimming area heated by geothermal springs (Photo 1.6). These amenities make the campground the most popular destination within Sheldon Refuge, and the level of use during the summer often exceeds capacity, causing overcrowding, user conflicts, and unauthorized use of adjacent areas outside the campground. A large proportion of visitation and use of the Virgin Valley Campground is associated with commercial mining of precious opal at mining claims scattered throughout Virgin Valley. There is concern that the non-wildlife-dependent use associated with mining is causing conflict with other visitors participating in higher priority, appropriate wildlife-dependent uses.

The Service needs to consider options for the long-term management of camping within Sheldon Refuge that will minimize impacts to important habitats and at the same time facilitate public use and enjoyment of the fish and wildlife resources it seeks to conserve.

Photo 1.6 Virgin Valley Campground is the most popular recreation site within Sheldon Refuge, but its popularity is mostly related to the developed hot springs and nearby opal mining opportunities—not wildlife-dependent recreation (Photo Gail Collins).

- **Wilderness Review:** Currently 341,500 acres within Sheldon Refuge have been proposed by the President for wilderness designation by Congress. Consistent with Service policy, Sheldon Refuge will continue to manage all proposed wilderness as wilderness until Congress takes action on the original 1974 proposal. However, this same policy also requires

a wilderness review be conducted as part of this CCP. The wilderness review identifies lands and waters that meet the minimum criteria for wilderness, evaluates those areas identified to determine if they are suitable, and then determines if those suitable areas should be recommended for designation as wilderness.

Sheldon Refuge considered a range of alternatives for potential wilderness recommendations that would be consistent with other management objectives and strategies, potential future management needs and activities, and long-term conservation of fish, wildlife, and their habitats. Given the current wilderness proposal for the majority of lands within Sheldon Refuge, an "all wilderness alternative" and a "no wilderness alternative" were determined not to be within a reasonable range of alternatives for this CCP.

- **Public Access, Roads, and Transportation:** Over time, hundreds of miles of primitive motorized routes and trails have been pioneered throughout Sheldon Refuge (Photo 1.7). In addition, several maintained roads have also been established across Sheldon Refuge and are maintained under agreement, permit, or right-of-way with the respective county and state agencies. This existing network of roads, routes, and trails is traveled by high clearance four-wheel-drive vehicles, but primarily by four-wheelers, motorbikes, or other OHVs. This use has resulted in adverse impacts to wildlife, habitats, cultural and historic resources, wilderness character, and primitive recreation opportunities. Despite the fact that many publications, brochures, and maps show these routes and trails, the Service has not officially designated these areas open to motorized use as required by Executive Order 11644 and 50 CFR 27.31. Through this CCP the Service seeks to minimize damage to soils, harassment of wildlife, or significant disruption of wildlife habitats, or other existing wildlife-dependent recreational uses.

1.7.1.2 Issues Outside the Scope of the CCP

A number of issues were raised during scoping which are considered to be outside the scope of the CCP. These issues were not analyzed during the CCP process.

- **Allowing Livestock Grazing:** All assignments of Special Use Permits and privileges for commercial livestock grazing were purchased by a private organization at fair market value in 1994. At the request of the owner of these assignments, all associated grazing privileges were canceled by the Service in 1995. For this reason Sheldon Refuge cannot issue permits for commercial livestock grazing unless such use is determined necessary to fulfill the purposes for Sheldon Refuge and the management objectives in this CCP.

- **Mining Management:** A renewal of the 1991 Public Land Order for withdrawal of the mineral estate from location of mineral claims is being completed outside the scope of the CCP because of its short time requirements for filing. A framework for managing mining claims, mining operations, access to valid claims, and regulations specific to Sheldon Refuge is being explored with Service resource managers, experts, and the USFWS Solicitor's office (which provides legal guidance and advice) because of its complex nature and the longer timeframe expected for its completion. This framework and regulations will be represented in a Minerals Management Plan to be developed for Sheldon Refuge following completion of the Sheldon CCP.

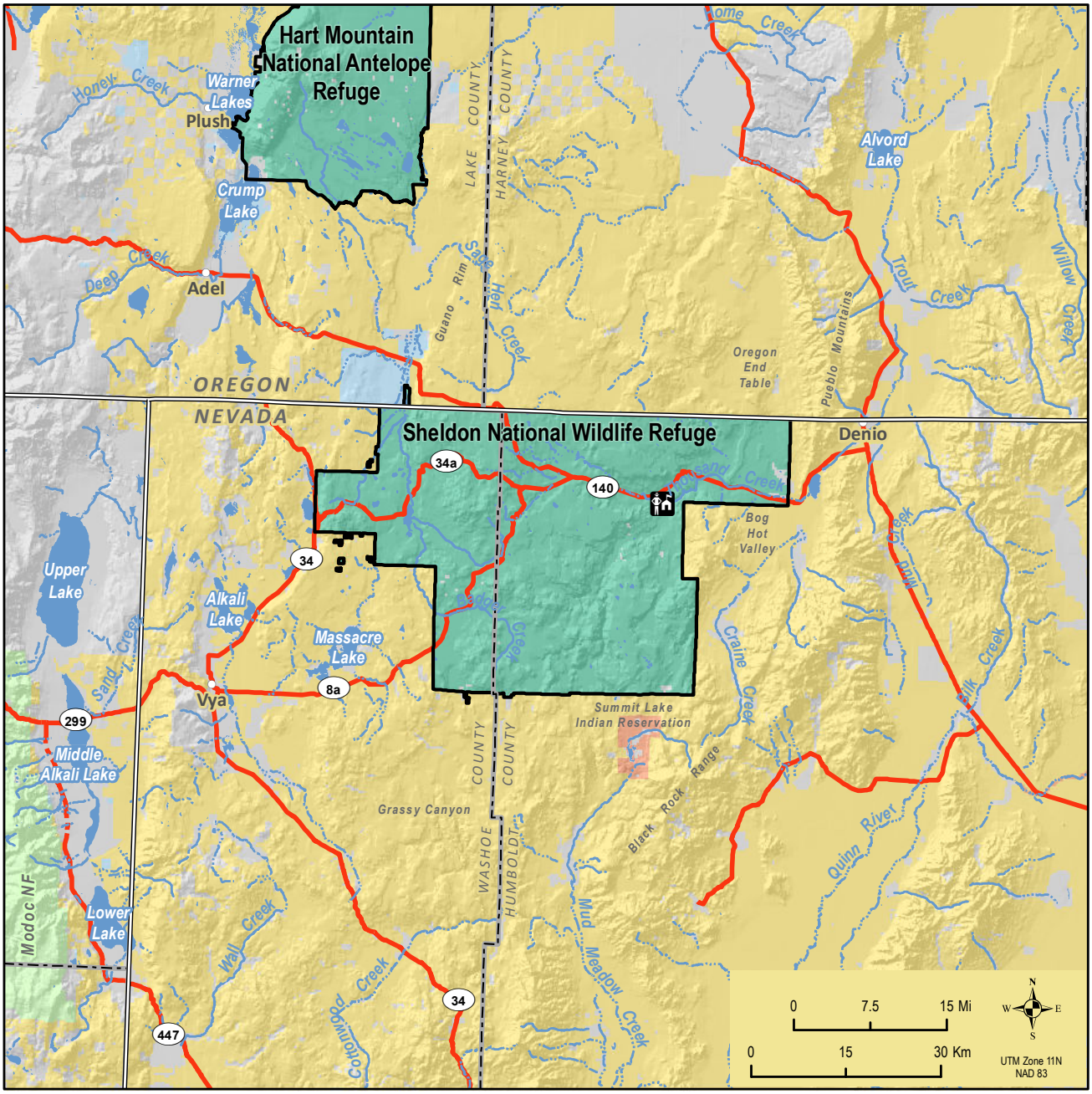
Photo 1.7 Hundreds of miles of four-wheel drive routes and trails are located throughout Sheldon Refuge, with the highest concentration in Virgin Valley for access to mining prospects and claims (Photo Gail Collins).

- **Withdrawing Public Lands between Sheldon and Hart Mountain National Wildlife Refuges from Public Domain to be Included in the Refuge System:** Sheldon Refuge is working to develop partnerships with the Bureau of Land Management (BLM), private landowners, and state agencies to research habitat use by wildlife and conduct habitat improvements between and around the two refuges.

1.8 Plan Amendment and Revision

Service policy directs that Sheldon Refuge review the CCP annually to assess the need for change. We revise the CCP when significant new information becomes available, when ecological conditions change, or when the need to do so is identified during the review. If major changes are proposed, public meetings may be held and new environmental assessments and environmental impact statements may be necessary. Consultation with appropriate state agencies, tribal governments, and the public would occur during any future revisions. Full review and revision of the CCP will occur every 10 to 15 years or more often if necessary.

Figure 1.1 Sheldon National Wildlife Refuge Location

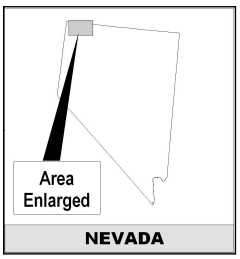


LEGEND

- Refuge Headquarters
- Sheldon NWR Approved Boundary
- County Boundary
- State Line
- Intermittent Stream
- Perennial Stream
- Highway
- City/Town

Land Ownership

- Bureau of Indian Affairs
- Bureau of Land Management
- State Lands
- US Fish and Wildlife
- US Forest Service
- Private/Unclassified



Produced by USFWS Region 1
Refuge Information Branch
Portland, Oregon
Map Date: 11/6/2011
File: 10-064-1.mxd

The back sides of map pages are blank to facilitate map readability.

Chapter 2. Management Direction

2.1 Overview

A general description of the management direction of this CCP is presented below. This description is followed by a table that is organized by goal with details about the management direction (Table 2.1).

2.1.1 Management Directions Considered but Not Evaluated in Further Detail

A number of approaches to the issues raised during scoping were considered, but were not analyzed in further detail. The reasons these approaches were not analyzed further as part of the CCP process are listed below:

Eliminating the Virgin Valley Campground: The campground can be brought to public use standards and incorporate wildlife-related activities (e.g., educational kiosks and interpretative programs), as presented in the CCP.

Eliminating Rock Collecting: Rock collecting has previously been found to be a compatible use within Sheldon Refuge. During the scoping process for this CCP, both the Service and the public expressed concerns about unintentional collection of cultural artifacts and vertebrate fossils, as well as vehicle trespass associated with rock collecting. After an initial evaluation, Sheldon Refuge found the use currently does not conflict with wildlife-dependent uses of Sheldon Refuge, and a range of management actions will likely be effective in reducing or eliminating unintended resource impacts.

Leaving Horses and Burros Unmanaged: This was analyzed in the 2008 Horse and Burro Management Environmental Assessment and was determined to be contrary to Service statutes, policy, and refuge purposes.

Lethal Control as a Last Resort to Meet Horse and Burro Population Objectives: In developing the CCP, comments suggested including lethal control as an option of last resort should other methods prove ineffective. After further consideration, the Service determined the use of lethal control will be unnecessary to meet horse and burro population objectives and could have other unintended and potentially negative consequences. As a result, the inclusion of such an option was unnecessary for a reasonable range of alternatives.

Allowing Wilderness Therapy Concessionaires: Because this use has previously been found incompatible with refuge purposes, it was not considered.

Developing a Trail through Thousand Creek Gorge: Important biological resources within Thousand Creek Gorge have repeatedly been identified as being sensitive to human disturbance or development. Wildlife surveys have identified rare and sensitive species within the gorge that would likely be adversely affected by increased public use or access. The CCP's approach to public access, including trails, will have less impact on sensitive wildlife and plant resources.

Recommending No Areas for Wilderness Designation, or Recommending All Suitable Areas for Wilderness Designation: Because approximately 341,500 acres of Sheldon Refuge have been

proposed for wilderness designation and have been managed for wilderness character since 1974, the consideration of an alternative in detail that would recommend no lands for wilderness designation is contradictory to previous wilderness studies, has not been determined necessary for continued management of Sheldon Refuge, and is considered unreasonable. However, the final wilderness proposal for Sheldon Refuge included key areas not originally recommended, and as a result some management actions and activities have not been implemented or allowed to occur as intended. Consideration of an alternative in detail that would recommend all 388,802 acres of the refuge determined suitable for wilderness study would also be inconsistent with the original refuge wilderness recommendation and current management direction, which recognizes a need for certain management activities, habitat manipulation, and mechanized use in key areas of the refuge.

Opening Sheldon Refuge to Sport Hunting of Additional Wildlife Species: Sport hunting of pronghorn, California bighorn sheep, mule deer, chukar (*Alectoris graeca*), California quail (*Lophortyx californicus*), Greater sage-grouse, geese, ducks, and coots consistent with state and Federal regulations has been determined to be a compatible wildlife-dependent public use within Sheldon Refuge. Additional wildlife species such as coyote (*Canis latrans*), bobcat (*Felis rufus*), or mountain lion (*Felis concolor*) may be utilized for sport hunting or trapping within a National Wildlife Refuge (50 CFR 31). However, the populations and wildlife requirements for these additional species have not been determined and are insufficient to determine what level of sport hunting, if any, would be compatible with the mission of the Refuge System and the purposes for Sheldon Refuge. We anticipate information gathered to meet management objectives identified in this CCP will be sufficient to make such a compatibility determination in the future.

2.1.2 Management Direction

Sheldon Refuge will manage for a natural mosaic of Great Basin habitat types and the native species that depend on them. A broad range of management tools will be available for application including prescribed and natural fire, mechanical treatment, and water management as necessary to meet native wildlife life history requirements. In many cases, management will restore, maintain, or mimic natural ecosystem processes. Habitat for rare or sensitive species and other native flora and fauna will be maintained, or where appropriate, restored, including shrub-steppe, riparian, wetland, woodland, grassland, and cliff-talus habitats. Sheldon Refuge will increase efforts to control, reduce, and remove feral, invasive, exotic, and noxious non-native species. Wildlife-dependent public uses will be highlighted with opportunities for hunting, fishing, wildlife observation, photography, interpretation, and environmental education maintained or improved from present conditions.

Integrated Pest Management (IPM) Strategies: In accordance with 517 DM 1 and 7 RM 14, an IPM approach will be utilized, where practicable, to eradicate, control, or contain pest and invasive species (herein collectively referred to as pests) on Sheldon Refuge. IPM will involve using methods based upon effectiveness, cost, and minimal ecological disruption, which considers minimum potential effects to non-target species and the refuge environment. Regional management direction for implementing IPM strategies has been adopted as part of this CCP (Appendix O). Refuge staff will continue to work with cooperators to develop pesticide use proposals consistent with this IPM guidance. Mechanical, biological, chemical, and physical methods are commonly used techniques to combat invasive and encroaching plants in a variety of habitats. Biological and chemical control methods are also being investigated. Pesticides may be used where physical, cultural, and biological methods or combinations thereof are impractical or incapable of providing adequate control, eradication, or containment. If a pesticide is needed on Sheldon Refuge, the most specific (selective)

chemical available for the target species will be used unless considerations of persistence or other environmental and/or biotic hazards would preclude it.

Pesticide use proposals will be prepared and approved before any herbicide is used within Sheldon Refuge. Pesticide use proposals require site-specific analysis, evaluation of chemical profiles, and evaluation of likely environmental effects. Based on scientific information and analyses documented in chemical profiles, herbicides will be approved for use on Sheldon Refuge lands where the chemical profiles provide scientific evidence that potential impacts to Sheldon Refuge's biological resources and physical environment are likely to be only minor, temporary, or localized in nature, and will be of relatively low risk to non-target organisms as a result of low toxicity or short persistence in the environment.

However, pesticides may be used on Sheldon Refuge lands where substantial effects to species and the environment are possible (exceed threshold values) in order to protect human health and safety (e.g., mosquito-borne disease).

Maintenance and Updating of Existing Facilities: Periodic maintenance and updating of Sheldon Refuge buildings and facilities will be necessary. Maintenance and updating of facilities is necessary for safety and accessibility and to support staff and management needs and is incorporated in the Service Asset Maintenance Management System.

Coordination with Tribal, State, and County Governments: Regular communication with Native American Tribes that are affected or that have an interest in the management of Sheldon Refuge will continue to occur. Tribes that Sheldon Refuge will coordinate and consult with on a regular basis regarding issues of shared interest include the Burns Paiute Tribe, Fort Bidwell Paiute Tribe, Cedarville Rancheria Paiute Tribe, Fort McDermitt Paiute and Shoshone Tribe, and Summit Lake Paiute Tribe.

Similarly, the Service will continue to maintain regular discussions with Washoe and Humboldt county commissioners, the State of Nevada, and to a lesser degree Lake County and the State of Oregon. State agencies include Nevada Department of Wildlife (NDOW), Oregon Department of Fish and Wildlife, and Nevada Department of Transportation. Key topics for discussion will include road maintenance, wildlife monitoring, big-game management, hunting and fishing seasons and regulations, and endangered species management.

Partnerships and Volunteer Opportunities: Sheldon Refuge will actively seek opportunities for partnerships with other agencies and organizations that share a common vision and goals for Sheldon Refuge and the resources that the refuge conserves. We view opportunities for groups and individuals to actively participate in resource conservation through volunteer activities as a vital component of natural resource stewardship, public appreciation for Sheldon Refuge, and support for future refuge management.

Participation in Planning and Review of Regional Development Activities: The Service will actively participate in planning and studies for ongoing and future off-refuge industrial development, contamination, and potential concerns that may adversely affect refuge resources, wildlife, and habitats. The Service will cultivate working relationships with pertinent county, state, and Federal agencies to stay abreast of current and potential developments, and will utilize outreach and education as needed to raise awareness of refuge resources and dependence on the local environment.

Refuge Economic Uses: Economic uses within Sheldon Refuge include rights-of-way for power lines, access to private lands and construction projects, highways, and gravel pits for highway maintenance. These rights-of-way have been found appropriate and compatible with the purposes for Sheldon Refuge, and appropriate permits have been issued for their use. It is the policy of the Service to discourage the types of uses embodied in right-of-way requests (340 FW 3.3). Future economic uses will be authorized by permit only if the use is determined to contribute to, and be compatible with, the purposes for Sheldon Refuge or the Refuge System (50 CFR 29).

Management of Areas Proposed for Wilderness Designation: In 1974 the President submitted a proposal to Congress for designation of certain lands within Sheldon Refuge as wilderness under the Wilderness Act of 1964, but Congress has taken no action on this proposal. Under Service policy these lands are considered proposed wilderness areas and are managed as wilderness until such time as Congress takes additional action. This CCP includes a recommendation to change the current wilderness proposal, but the Final Record of Decision for the Sheldon Refuge CCP/EIS will have no effect on the management or location of areas currently proposed for wilderness designation. Under the CCP these areas will continue to be managed as wilderness.

Areas managed for wilderness values under the CCP will include those currently proposed for wilderness designation and additional areas for wilderness study as part of the 2009 Sheldon Refuge Wilderness Review (Appendix F). As a result, a larger portion of Sheldon Refuge (424,360 acres)[1] will be managed for wilderness character in the short term.

Under the CCP the areas recommended for wilderness designation by Sheldon Refuge are somewhat different in location and configuration than those currently proposed, but the total area recommended is essentially the same (approximately 341,500 acres under the current proposal versus approximately 341,495 recommended under the CCP). Because the previous recommendation for wilderness designation has been approved, and submitted to Congress, the Service cannot alter or adjust the current wilderness proposal. If the new recommendation under the CCP is forwarded through the wilderness proposal process and approved by Congress, it is anticipated that the management direction would have three important differences from current management over the long term.

First, areas recommended under the CCP would have less evidence of human development and disturbance and therefore appear more natural overall than areas currently proposed.

Second, areas recommended are those where fewer repeated management activities and intrusions (e.g., habitat manipulations, mechanized equipment, motorized vehicles, temporary structures, etc.) are expected to be necessary for restoring and maintaining biological integrity, diversity, and environmental health; fulfilling the primary purposes for Sheldon Refuge; and accomplishing the mission of the Service when compared with current management.

Third, the recommendation includes areas that provide the best opportunities for solitude and primitive and unconfined recreation. At the same time, the CCP's recommendation does not include those areas that have traditionally received the greatest amounts of public use and historically had

[1] Acreage figures, which include proposed wilderness areas, differ slightly from the 1974 proposal due to more precise mapping techniques used for calculations in the Sheldon CCP.

higher densities of vehicle routes (most of which remain apparent today and continue to be used illegally by vehicles for recreation and for Sheldon Refuge administrative purposes).

Under the CCP, the overall quality of the wilderness resource (as measured by naturalness, untrammeled character, opportunity for solitude, and opportunities for primitive or unconfined types of recreation) is expected to be greater than under the current proposal.

Develop Appropriate Step-down Plans: A series of step-down plans will be developed following completion of the CCP. These include, but are not limited to the Minerals and Mining Management Plan, Wilderness Stewardship Plan, Transportation Management Plan, Visitor Services Plan, Law Enforcement Plan, Cultural Resources Management Plan, Fisheries Management Plan, Habitat Management Plan, and Integrated Pest Management Plan.

Implementation Subject to Funding Availability: Actions will be implemented over a period of 15 years as funding becomes available. Project priorities are in Appendix E.

Management of Feral Horses and Burros: The management direction will improve habitat conditions and create consistency with existing policy, the mission of the Refuge System and the Service, and the purposes for Sheldon Refuge by removing all feral horses and burros. Implementation of the CCP will require the removal of at least 200 horses and 20 burros each year to completely remove horses and burros within five years. Methods for gather and removal will continue to include helicopter and horseback gathers, followed by shipment to private facilities for adoption or fertility control and release back onto Sheldon Refuge. Sale or auction could be implemented if these methods for removal prove to be ineffective. Once horses and burros are removed, it is anticipated the condition of native habitats throughout Sheldon Refuge will improve, resulting in significant long-term benefits to fish, wildlife, plants and wildlife-dependent public uses.

Management of Habitats: The primary habitat management action under the CCP will be the removal of feral horses and burros from Sheldon Refuge. Other actions will rehabilitate and restore a variety of sites and small areas to improve habitat conditions. In the short term, fence exclosures will be constructed to mitigate impacts from horses and burros, but will not be necessary over the long term following removal of horses and burros and habitat recovery. Abandoned livestock water developments will be removed from springs throughout Sheldon Refuge. In addition spring, springbrook, playa, wet meadow, and stream habitats throughout Sheldon Refuge will be restored to more natural conditions.

Up to nine designated campgrounds will be relocated and some road segments realigned. These actions are expected to reduce erosion and impacts to sensitive riparian areas, but will not change the size, general location, or types of developments currently found at these campgrounds.

Other habitat management actions such as the use of prescribed fire, mowing of sagebrush, thinning of western juniper, and thinning of vegetation adjacent to mountain mahogany under the CCP will be similar to those under current management. However, under the CCP, greater emphasis will be placed on the removal of western juniper where it is encroaching upon sagebrush habitats. These actions will occur primarily in the western portions of Sheldon Refuge.

Management of Public Uses: The CCP's management direction will continue to provide wildlife observation and photography opportunities throughout most of Sheldon Refuge and will continue coordination of fish and wildlife harvest seasons and limits with NDOW. One difference from

current management will be the replacement of non-native trout in Big Spring Reservoir and Virgin Creek with trout indigenous to the region (i.e., Lahontan cutthroat trout or redband trout). Replacement will occur gradually through periodic stocking and is not anticipated to affect the quality of recreational fishing opportunities.

The CCP will expand existing opportunities and provide new opportunities for wildlife-dependent public uses primarily through the expansion, relocation, and construction of public use facilities and the conversion of some historic structures for public use. The most substantial changes are expected to result from the relocation and enlargement of the visitor contact station, improvement of campground facilities, development of an accessible interpretive trail, the creation of a self-guided auto tour route, and improved signing of routes open to vehicle use. Overall, facilities provided under the CCP will expand the range of recreation opportunities both within Sheldon Refuge and throughout the Region by providing additional developed and accessible opportunities when compared with the remote, undeveloped and primitive opportunities typical throughout the region and under current management.

A new visitor contact station will be constructed to replace the existing visitor contact space of about 100 square feet co-located with the Sheldon Refuge Office (Dufurrena). The new facility will be larger, will be located along Highway 140 to provide more convenient access, and will be regularly staffed with volunteers and employees (see Figure 5.1 for approximate location). These changes are expected to greatly increase opportunities and quality of environmental interpretation and outreach when compared with current management.

A self-guided auto tour route will be designated for visitors traveling along Highway 140 and along primary routes connected to Highway 140. The route will provide site-specific information to enhance wildlife viewing opportunities, increase environmental education and knowledge of Sheldon Refuge, and complement other opportunities in the region such as the Barrel Springs Back Country Byway and the historic Applegate-Lassen Emigrant Trail. Information for the auto tour route will be provided primarily through the visitor contact station, the internet, or other off-site media with only the minimal signage necessary along the route itself. Along shorter and more developed portions of the route (i.e., Virgin Valley), some on-site interpretive signs and vehicle pullouts will be constructed.

Additional facilities such as new campsite amenities (i.e., picnic tables and accessible fire rings or barbeque grills), potable water, shade structures, kiosks, and dedicated volunteer sites will be constructed at Virgin Valley, Catnip Reservoir, and Big Spring Reservoir campgrounds (see Figure 5.1). These facilities will provide developed camping opportunities that are not commonly available within Sheldon Refuge or the region. However, these improved facilities will only be sustainable over the long term through campsite fees to support volunteers, maintenance, and replacement.

Improved gravel roads within Sheldon Refuge will be maintained more frequently. All routes open to the public use of vehicles will be adequately signed and marked. As part of the CCP, some existing primitive unmaintained routes be closed to public use of motorized vehicles to protect various refuge resources.

Management action will be taken to reduce impacts from other existing routes (see Figure 2.1). The CCP also identifies key routes that will be re-opened to public vehicle use should the revised wilderness recommendation be approved (see following paragraph). When combined with the Sheldon Refuge proposal to adjust the location and configuration of wilderness area boundaries, the

management direction will result in vehicle access to more areas of the refuge and about the same amount of area to be managed for wilderness values when compared with current management (see Figure 2.1). In addition, visitors will be required to register all OHVs for use on refuge roads and routes designated open to vehicle use. It is anticipated these actions will improve the quality of the transportation system and deter vehicle violations while requiring only minimal law enforcement presence.

The CCP identifies specific routes that will be re-opened to motorized use should the wilderness recommendation be approved. Additional existing routes could be re-opened if, after an evaluation of the public use benefits, resource impacts, and appropriate NEPA documentation, it is determined such use will not interfere with or detract from the purposes for Sheldon Refuge and will not adversely affect the natural, aesthetic, or scenic values of the refuge (EO 11644).

Management of Cultural and Historic Resources: More information will be gathered about prehistoric, historic, and paleontological resources than under current management. Consequently, the level of protection and the quality of interpretation will increase as new sites are discovered and more complete information becomes available. Overall, the increased law enforcement, protection of sites, and in some cases restoration will result in better long-term preservation of historic resources. The value of some structures determined not to have historic significance will continue to be preserved through conversion to public or administrative use.

Table 2.1 Summary of Management Direction

Issue	Management Direction
Habitat Management	
How will the refuge manage and maintain wildlife habitats?	Maintain percentage of habitats within management objective thresholds (Percentage thresholds presented for each habitat are based primarily on Service estimates of effects associated with feral horse and burro management and the amounts of each habitat type that could be restored given available resources.) • At least 60% of big and low sagebrush-steppe and shrubland, salt desert scrub, and greasewood flats habitats. • At least 80% of montane sagebrush-steppe, mountain big sagebrush/ bitterbrush habitats. • At least 60% of semi-desert grassland, and Great Basin wildrye habitats. • At least 60% of emergent marshes and wet meadow habitats. • 85%-95% of cliff, canyon, talus slope, and barren land habitats. • At least 50% of deciduous woodland and shrublands habitat. • 80%-95% of mountain mahogany and western juniper woodlands.
	Improve habitat conditions by removing all feral horses and burros within 5 years.
	• Control horse and burro populations through gathers, adoption, sanctuary, and contraception. • Control populations through sale or auction only if other control methods are impractical or ineffective.
How will the refuge manage western juniper and sagebrush encroaching into other habitats?	Use mechanical treatments to remove juniper and sagebrush from 1,500 acres per year.

Issue	Management Direction
How will the refuge restore emergent marshes and wet meadows for the benefit of native wildlife?	Resume mechanical treatments and prescribed fire on 1,200 acres per year following removal of horses and burros.
How will the refuge restore and rehabilitate developed springs, springbrooks, and stream habitats?	• Remove developments and restore 45%-65% of springs and at least 60% of stream habitat. • Relocate designated campgrounds and access routes. • Realign vehicle routes and use erosion control structures, vegetation planting, etc. to rehabilitate stream headcuts. • Rehabilitate at least one mile of Virgin Creek.
How will the refuge manage playa habitats?	Restore at least 20% of playa habitats.
How will the refuge manage reservoirs and artificial marsh habitats?	Maintain 434 acres (see Objective 3d).
How will the refuge manage artificial wet meadow habitats?	Maintain 1,700 acres (see Objective 3e).
How will the refuge manage artificial water sources (guzzlers)?	Maintain 18 guzzlers.
How will the refuge protect mountain mahogany and western juniper woodlands?	Use mechanical treatments and prescribed fire in adjacent habitats and around mountain mahogany stands to reduce fuel loads and protect stands from future wildland fire.
How will the refuge protect rare and sensitive plants, wildlife, and microbiotic soil crusts?	Increase inventory and monitoring in collaboration with partners.
Weed Management	
How will the refuge control invasive non-native plants (weeds)?	• Treat 1,000 acres per year, primarily along road corridors and newly detected populations • Conduct systematic weed inventories.
Wildland Fire Protection and Restoration	
How will the refuge protect life and property and restore habitats adversely impacted by wildland fire?	• Maintain fire suppression capabilities. Base all responses to wildland fire on an evaluation of risk to firefighters and public safety and the circumstances under which the fire is occurring. • Develop natural fuel breaks utilizing existing features and natural fire. • Use mowing and cutting to extend or connect natural fuel breaks. • Conduct active restoration and rehabilitation. • Use only native seed and plants for restoration.
Public Use Management	
How will the refuge manage hunting?	• In coordination with Nevada Dept. of Wildlife, allow a limited harvest of certain game species consistent with population objectives. • Permit up to 10 commercial operators to guide and outfit hunters.
How will the refuge manage fishing?	• Allow sport fishing and restock reservoirs with trout indigenous to the region (not rainbow trout).
How will the refuge manage wildlife observation and photography?	• Provide basic information to visitors. • Develop brochures, interpretive trails, and off-refuge opportunities.
How will the refuge manage rock collecting?	• Allow limited rock collection. • Increase law enforcement and visitor information.

Issue	Management Direction
How will the refuge provide visitor facilities?	• Replace the Sheldon Refuge Headquarters with Headquarters and Visitor Contact Station along Hwy 140. • Build additional kiosks, trails, and interpretive sites. • Increase development and collect fees at developed campgrounds. • Relocate up to nine semi-primitive and primitive campgrounds to reduce resource impacts.
How will the refuge manage access for public use?	• Allow motorized vehicle use on 300 miles of existing roads and routes, and propose an additional 25 miles be re-opened for vehicle use if the wilderness recommendation is approved. • Increase maintenance of primary access roads. • Improve road information signs, brochures, and maps. • Improve marking of closed roads and routes on the refuge. • Mark and sign open roads and routes on the refuge. • Re-route and realign 12 miles of roads and routes to avoid or minimize resource impacts. • Close duplicate routes. • Designate an auto-tour route. • Require registration for off-highway vehicles. • Allow backcountry camping by Special Use Permit. • Allow horseback riding.
Wilderness Recommendations	
What areas will the refuge recommend for wilderness designation?	Recommend 341,495 acres for designation—excluding some areas currently proposed, but including other areas.
Historic and Cultural Resources	
How will the refuge protect and use historic and cultural resources?	• Minimum inventory, protection, and restoration of historic and cultural resources necessary. • Historic buildings used for administrative purposes only. • Increase inventory and protection of historic and cultural resources. • Restore up to three additional historic buildings. • Allow public use of selected historic buildings.

2.2 Goals, Objectives, and Strategies

2.2.1 Goal 1: Manage feral horse and burro populations consistent with the purposes for Sheldon Refuge, the National Wildlife Refuge Improvement Act, National Wildlife Refuge policy, and to protect and preserve a diverse assemblage of native plant and wildlife species, habitats, and naturally functioning systems characteristic of the Great Basin Ecosystem.

Objective 1a: Feral Horse and Burro Populations
Remove all feral horses and burros from Sheldon Refuge within five years of the final decision for the CCP in order to reduce feral horses and burros to a population level that is consistent with Refuge System policy and the purposes for which Sheldon Refuge was established, and that allows for the attainment of refuge biological goals and objectives.
Strategies Applied to Achieve Objective
With partners, maintain wildlife-friendly fence along Sheldon Refuge boundary to prevent entry of wild horses or burros from surrounding BLM Herd Management Areas (HMAs).
Investigate and monitor impacts of feral horses and burros to habitats and wildlife.
Populations controlled through gathers, adoption, sanctuary, and contraception.
Populations controlled through sale or auction only if other control methods are impractical or ineffective.
Work with BLM to remove wild horses that enter Sheldon Refuge from surrounding HMAs.
Rationale: The U.S. Fish and Wildlife Service (USFWS) Refuge Manual 7 RM 6 states horse and burro populations will not be maintained on Sheldon National Wildlife Refuge, will be removed in accordance with 50 CFR 30.12, and are defined as feral when roaming on certain refuge lands in the western United States (including Sheldon Refuge). As described in Chapter 4, the presence of feral horses and burros has caused significant adverse impacts to the ecological integrity of Sheldon Refuge. These impacts have reduced the health and function of native habitats necessary to support priority species such as pronghorn and Greater sage-grouse as well as a number of other wildlife and plant species. Removal of feral horses and burros will likely result in substantial recovery and restoration of ecological health, natural processes, and natural conditions throughout much of Sheldon Refuge, and has been identified as the most important management strategy necessary for the achievement of refuge purposes, goals, and objectives. Fences considered "wildlife-friendly" can be constructed using a variety of methods and materials. The most basic and common type is a modified barbed-wire fence with a smooth bottom strand of wire at sufficient height from the ground to allow passage of pronghorn. Additional devices such as flagging or reflectors can be used to make the wires more visible and reduce the risk of injury to birds and other wildlife. More expensive types of fence built with wood or steel posts and rails also allow passage for pronghorn, are more visible and durable than wire, and can withstand greater snow accumulation. Sheldon Refuge will continue to employ a variety of fence types and devices to prevent movement of horses and minimize impacts to wildlife. Based upon recent supply and demand for horse adoption, it is likely auction of some animals will be necessary to meet the population management objective. Auction will only be used as a last resort if other strategies for removal are shown to be impractical or ineffective. Stipulations for auction agents will be similar to the requirements regarding facilities, knowledge, skills, and abilities for adoption agents. These

stipulations are included in Appendix H, Standard Operating Procedures for the control of horses and burros within Sheldon Refuge. Implementation of the CCP has also been determined necessary to fully implement Objectives 2a, 2b, 3a, 3b, 3c, 4a, 4b, 4c, 4d, 4e, and 5a. See also Sections 4.1.1 and 4.2.

2.2.2 Goal 2. Protect, maintain, and restore sagebrush-steppe and associated upland communities characteristic of the Great Basin Ecosystem.

Objective 2a: Conserve sagebrush-steppe communities representative of historic Great Basin habitats (see Figures 4.2, 4.3, and 4.4)

Big sagebrush steppe: Protect and maintain at least 60% (80,000 acres [2]) of basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*) habitat for the benefit of a diverse assemblage of native species including migratory birds (e.g., sage thrasher [*Oreoscoptes monatus*]), mammals (e.g., pygmy rabbit), and other sagebrush-obligate species on Sheldon Refuge. The desired condition for basin big sagebrush habitat is characterized by the following:

- 5%-30% canopy cover dominated by mature (11-50 inches tall) basin big sagebrush
- <10% western juniper cover and <4 trees/acre density
- Deep friable soils suitable for burrowing
- <10% invasive plant cover

Big sagebrush shrubland: Protect and maintain at least 60% (80,000 acres **[see footnote 2]**) of Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) habitat for the benefit of a diverse assemblage of native species including resident and migratory birds (e.g., Greater sage-grouse) and other sagebrush-obligate species on Sheldon Refuge. The desired condition for Wyoming big sagebrush habitat is characterized by the following:

- 10%-20% canopy cover (above snow) dominated by mature Wyoming big sagebrush
- 10-40 inches for sagebrush height
- 15%-20% cover of native bunchgrasses and forbs
- <10% invasive plant cover (e.g., cheatgrass)
- Presence of microbiotic crust with appropriate abiotic conditions

Low sagebrush shrubland and steppe: Protect and maintain at least 60% (20,000 acres) of low sagebrush (*Artemesia arbuscula*)shrubland and steppe habitat for the benefit of a diverse assemblage of native species including resident and migratory birds (e.g., Greater sage-grouse), mammals (e.g., pronghorn), and other sagebrush-obligate species on Sheldon Refuge. The desired condition for low sagebrush habitat is characterized by the following:

- >20% canopy cover dominated by mature (<30 inches tall) low sagebrush
- >20% native perennial grass and forb cover
- <10% western juniper cover and <4 trees/acre density
- <10% invasive plant cover
- Presence of microbiotic crust with appropriate abiotic conditions

[2] This acreage figure includes both big sagebrush steppe and big sagebrush shrubland habitat types, which are not differentiated in the satellite imagery used for the calculation.

- Minimal human disturbance

Salt desert scrub and greasewood flats: Protect and maintain at least 60% (20,000 acres) of salt desert scrub and greasewood flat habitat for the benefit of a diverse assemblage of native species including migratory birds (e.g., loggerhead shrike [*Lanius ludovicianus*]), mammals, and reptiles on Sheldon Refuge. The desired condition for salt desert scrub and greasewood flat habitats is characterized by the following:

- <25% canopy cover of mature, tall (>3 feet tall) shrubs including greasewood (*Sarcobatus vermiculatus*), shadscale saltbrush (*Atriplex confertifolia*), or winterfat (*Krascheninnikovia lanata*) with patchy distribution
- <20% native herbaceous cover
- >20% bare ground[3]
- <10% invasive plant cover.
- Minimal human disturbance

Strategies Applied to Achieve Objective

Investigate/research potential management strategies to maintain these habitats.

Where appropriate, utilize mechanical or prescribed fire treatments to create conditions protective from wildfire.

Minimize ground-disturbing activities and management activities that disturb the soil surface (e.g., grading of road shoulders or use by OHVs).

Rationale: These communities were naturally subjected to relatively infrequent and unpredictable disturbances including severe drought (approximately every 70 years), flooding (approximately every 100 years), and fire (approximately every 35 to 1,000 years), depending on composition. It is generally agreed that the thresholds included in the objective when applied across the habitat type reflect healthy natural conditions necessary to support dependent fish and wildlife species. This includes priority species such as pronghorn, Greater sage-grouse, and a host of other dependent wildlife (see wildlife and habitat matrix in Appendix B). By managing habitats within the stated objective thresholds, the necessary ecological integrity will be provided to maintain diverse, healthy wildlife populations within the natural range of variability. Because disturbance is a widely variable component of these habitats, many of these communities are being protected from large-scale natural fire until wildfire management actions can be identified. Currently, the precise conditions of habitats throughout Sheldon Refuge have not been quantified, but based on the results of vegetation surveys and site visits, the primary factors currently influencing habitat conditions within Sheldon Refuge are feral horses and burros.

We anticipate that implementation of the management direction to remove all feral horses and burros from Sheldon Refuge within five years will be the primary and most significant action responsible for progress toward achieving our stated management objective to enhance, protect, and maintain at least 60% of sagebrush-steppe habitat. The precise conditions of habitats throughout Sheldon Refuge have not been quantified, but based on the results of vegetation surveys, site visits, and ongoing research projects, the primary factors currently influencing habitat conditions within Sheldon Refuge are feral horses and burros. Other management actions toward achieving our objective include creating fire breaks, as well as the early detection, rapid response, and control of invasive species.

[3] The upper limit of bare ground will vary considerably within this habitat type but would not be great enough to meet the "largely unvegetated" criteria which defines the cliff, canyon, talus slope, and barren lands habitat type (see Goal 4).

Other benefiting species: Greater sage-grouse, Brewer's sparrow, sage sparrow, bald eagle, ferruginous hawk, white-throated swift, western burrowing owl, and loggerhead shrike; Merriam's shrew, Preble's shrew, sagebrush vole, kit fox, pygmy rabbit, and mule deer; and desert horned lizard and pygmy short-horned lizard have been identified as Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006).

Supporting references for the objective thresholds: Altman and Holmes 2000; California Partners in Flight (CalPIF) 2005; Connelly et al. 2000; Connelly et al. 2004; Crawford 2008; Larrucea and Brussard 2008; Miller et al. 2005; Nachlinger and Tiehm 1996, Neel 1999; O'Gara and Yoakum 2004; Weiss and Verts 1984.

Photo 2.1 Sagebrush-steppe and shrubland habitats cover more than 50% of Sheldon Refuge and provide necessary habitat for many wildlife species, including Greater sage-grouse.

Objective 2b: Restore montane sagebrush-steppe and associated plant communities (see Figures 4.2, 4.3, and 4.4)

Montane sagebrush steppe: Enhance, protect, and/or maintain the natural condition and processes in **more than 80% (146,000 acres)** of late-successional mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) habitat for the benefit of a diverse assemblage of native species including birds (e.g., Greater sage-grouse) and other sagebrush-obligate species on Sheldon Refuge. Mountain big sagebrush habitat is characterized by the following:

- 15%-25% canopy cover of mature (15-31 inches tall) mountain big sagebrush
- Range of bitterbrush (*Purshia* spp.) canopy cover
- ≥25% native bunchgrass and forb cover (>7 inches tall)
- <10% western juniper cover and <4 tree/acre density
- <10% invasive plant cover

Mountain big sagebrush/bitterbrush complex: Enhance, protect, and/or maintain natural condition and processes throughout the mountain big sagebrush/bitterbrush complex for the benefit of a diverse assemblage of native species including resident and migratory birds and mammals (e.g., mule deer) on Sheldon Refuge. This habitat complex is characterized by the following:

- 15%-25% canopy cover of mountain big sagebrush (15-31 inches tall)
- >10% canopy cover of bitterbrush
- ≥25% cover of native bunchgrasses and native forbs (>7 inches tall)
- <10% canopy cover of trees with western juniper density <4 trees/acre
- <10% cover of invasive plants (e.g., cheatgrass)

Strategies Applied to Achieve Objective

Use wildland fire to allow for changing objectives as the fire moves across the landscape. Response will be determined by an evaluation of risks and the circumstances under which the fire is occurring.

As a priority, emphasize mechanical control of encroaching western juniper to mimic natural disturbance and restore an average of 1,500 acres of habitat per year.

Investigate and apply other appropriate restoration techniques for degraded mountain big sagebrush, bitterbrush, and Great Basin wildrye sites in addition to mechanical or prescribed fire treatments.

Rationale: Previous grazing regimes, fire suppression, and ongoing utilization by feral horses and burros have severely degraded a proportion of these habitats and converted a significant portion of formerly bunchgrass-dominated stands (i.e., Great Basin wildrye) to shrub-dominated habitats. Historically, these communities were naturally subjected to relatively frequent disturbances including fire, insects, disease, winter kill, rodent outbreaks, and drought. A reduction in disturbance events has increased encroachment into these communities from western juniper (e.g., into mountain big sage stands) or shrubs (e.g., into Great Basin wildrye stands). The crowns of larger juniper trees often limit grass and other vegetative growth beneath them, thereby reducing the fuel necessary to carry fire into the tree, fireproofing the crown and stem (Agee 1993; Gedney et al. 1999). As a result, fire can no longer be used to restore natural ecological condition or function where encroaching juniper is essentially fireproof.

It is generally agreed that the thresholds included in the objective, when applied across the habitat type, reflect healthy natural conditions necessary to support dependent fish and wildlife species. This includes priority species such as pronghorn, Greater sage-grouse, and a host of other dependent species (see wildlife and habitat matrix in Appendix B). By managing habitats within the stated objective thresholds, the necessary ecological integrity will be provided to maintain diverse, healthy wildlife populations within the natural range of variability. Precise conditions of habitats throughout Sheldon Refuge have not been quantified, but based on the results from vegetation surveys and site visits, the primary factors currently influencing habitat conditions within Sheldon Refuge are feral horses and burros and long-term suppression of natural fire. Additional management for removal of encroaching sagebrush and western juniper that mimics natural disturbance (i.e., wildfire) is intended to restore a mosaic of plant communities and seral stages needed to support shrub-steppe and semi-desert grassland dependent species across a larger supporting landscape. The Service estimates western juniper is encroaching upon 8,000 to 10,000 acres of sagebrush habitat located primarily in the western portion of Sheldon Refuge (see Section 4.2.7.2). The objective of removing an average of 1,500 acres per year will allow for annual variability in accomplishments, while still meeting the overall stated objective for restoration of sagebrush-steppe habitats during the lifetime of the plan.

We anticipate that implementation of the CCP's strategies to remove all feral horses and burros from Sheldon Refuge within five years will be the primary and most significant action responsible for progress toward achieving our stated management objective to enhance, protect, and maintain at least 80% of montane sagebrush-steppe habitat. The precise conditions of habitats throughout Sheldon Refuge have not been quantified, but based on the results of vegetation surveys, site visits, and ongoing research projects, the primary factors currently influencing habitat conditions within Sheldon Refuge are feral horses and burros.

Other benefiting species: Greater sage-grouse, ferruginous hawk, and mule deer have been identified as

Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006).

Supporting references for the objective thresholds: Connelly et al. 2000; Cox et al. 2009; Griffith and Peek 1989; Main and Coblentz 1996; Miller et al. 2005; O'Gara and Yoakum 2004.

Objective 2c: Restore semi-desert grasslands and steppe communities (see Figures 4.2, 4.3, and 4.4)

Restore, protect, and/or maintain more than 60% (22,000 acres) semi-desert grassland and steppe habitats for the benefit of a diverse assemblage of native species including resident and migratory birds (e.g., western burrowing owl), mammals, and reptiles on Sheldon Refuge. This semi-desert grassland habitat is characterized by the following:

- Sparse (<40%) to moderately dense (>40%) native grass and forb cover
- <15% native shrub cover
- 40%-70% bare ground cover
- <10% invasive plant cover

Great Basin wildrye: Restore, protect, and/or maintain all Great Basin wildrye (*Leymus cinereus*) habitat for the benefit of a diverse assemblage of native species including migratory birds, mammals (e.g., pronghorn), and reptiles on Sheldon Refuge. This habitat is characterized by the following:

- >40% cover of native grasses (e.g., Great Basin wildrye) and native forbs
- <5% cover of native shrubs
- <10% cover of invasive species

Strategies Applied to Achieve Objective

Use wildland fire to allow for changing objectives as the fire moves across the landscape. Response will be determined by an evaluation of risks and the circumstances under which the fire is occurring.

As a priority, emphasize removal of encroaching sagebrush to mimic natural disturbance and restore Great Basin wildrye habitat.

Rehabilitate stream channel headcuts by reducing impacts from feral horses and burros and vehicle use, placement of structures, planting shrubs or other vegetation, or using other reliable methods to restore hydrogeological processes and function and to stabilize soils.

Investigate and apply other appropriate restoration techniques for degraded Great Basin wildrye sites in addition to mechanical or prescribed fire treatments.

Rationale: Previous grazing regimes, fire suppression, and ongoing utilization by feral horses and burros have severely degraded a proportion of these habitats and converted a significant portion of formerly bunchgrass-dominated stands (i.e., Great Basin wildrye) to shrub-dominated habitats. Historically, these communities were naturally subjected to relatively frequent disturbances including fire, insects, disease, winter kill, rodent outbreaks, and drought. A reduction in disturbance events has increased encroachment into these communities from sagebrush in adjacent areas.

It is generally agreed that the thresholds included in the objective, when applied across the habitat type, reflect healthy natural conditions necessary to support dependent fish and wildlife species. This includes priority species such as pronghorn, Greater sage-grouse, and a host of other dependent species (see wildlife and habitat matrix in Appendix B). By managing semi-desert grassland, steppe, and Great Basin wildrye habitats within the stated objective thresholds, the necessary ecological integrity will be provided to maintain diverse, healthy wildlife populations within the natural range of variability. Precise conditions of habitats throughout Sheldon Refuge have not been quantified, but based on the results from vegetation surveys and site visits, the primary factors currently influencing habitat conditions within Sheldon Refuge are feral horses and burros and long-term suppression of natural fire. Additional management for removal

of encroaching sagebrush that mimics natural disturbance (i.e., wildfire) is intended to restore a mosaic of plant communities and seral stages needed to support semi-desert grassland dependent species across a larger supporting landscape.

We anticipate that implementation of the CCP's strategies to remove all feral horses and burros from Sheldon Refuge within five years will be the primary and most significant action responsible for progress toward achieving our stated management objective to enhance, protect, and maintain at least 60% of semi-desert grasslands and steppe habitat. The precise conditions of habitats throughout Sheldon Refuge have not been quantified, but based on the results of vegetation surveys, site visits, and ongoing research projects, the primary factors currently influencing habitat conditions within Sheldon Refuge are feral horses and burros.

Other benefiting species: Greater sage-grouse, short-eared owl, and western burrowing owl; kit fox and mule deer; and desert horned lizard, pygmy short-horned lizard, and long-nosed leopard lizard have been identified as Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006).

Supporting references for the objective thresholds: Altman and Holmes 2000; Connelly et al. 2000; Cox et al. 2009; Griffith and Peek 1989, Klute et al. 2003; Main and Coblentz 1996; Miller et al. 2005; O'Gara and Yoakum 2004; Steffen and Anderson 2006.

Photo 2.2 Natural fire is one of the primary tools for managing sagebrush habitats within Sheldon Refuge.

Photo 2.3 Prescribed burning is one of the primary tools for managing sagebrush habitats within Sheldon Refuge.

Photo 2.4 Mowing is one of the primary tools for managing sagebrush habitats within Sheldon Refuge.

Photo 2.5 Cutting of juniper is one of the primary tools for managing sagebrush habitats within Sheldon Refuge.

2.2.3 Goal 3. Restore, protect, and maintain the structure and function of riparian and aquatic habitats characteristic of the Great Basin Ecosystem.

Objective 3a: Emergent Marshes and Wet Meadows (see Figure 4.2)
Emergent marshes and wet meadows: Manage more than 60% (2,000 acres) of wet meadow habitat for the benefit of a diverse assemblage of native species including resident and migratory birds (e.g., shorebirds, passerines, and Greater sage-grouse), mammals, amphibians, and invertebrates. These habitats are defined by the following attributes: • Seasonally flooded meadows or shallow freshwater floodplains • <5% cover of tall, dense deciduous shrubs or, where shrubs are present, an interspersion of deciduous shrub patches and herbaceous openings where neither is <25% or >70% of the total cover of the area • ≤90% cover of native herbaceous species (e.g., sedges [*Carex* spp.], rushes [*Juncus* spp.]) • <10% cover of encroaching sagebrush in transitional zones • <10% cover of invasive plants (e.g., Russian olive [*Elaeagnus angustifolia*], cheatgrass [*Bromus tectorum*])
Strategies Applied to Achieve Objective
Where appropriate use mechanical treatments or prescribed fire to mimic natural disturbance, reduce litter, and increase herbaceous vigor.
Within five to 15 years (following removal of horses and burros), resume mechanical treatments and prescribed fire on a maximum average of 1,200 acres per year.
Investigate and employ wetland restoration techniques (e.g., gabions, plantings, bank stabilization).
Remove water control structures, diversions, or other developments that alter natural hydrology.

Reduce disturbance by relocating designated campgrounds and re-routing roads.

Rationale: Wet meadow habitats are of high importance for conservation of biodiversity and priority species and provide habitat for approximately 80% of all species representative of the Great Basin. Wet meadows are among the most altered and impacted habitats on Sheldon Refuge as a result of water development, prior grazing regimes, and current utilization by feral horses and burros. In addition, these sites are impacted by recreational camping use. Currently precise conditions of habitats throughout Sheldon Refuge have not been quantified, but based on the results from vegetation surveys and site visits, the primary factors currently influencing habitat conditions within Sheldon Refuge are feral horses and burros and long-term suppression of natural fire. Until horse and burro population management objectives are reached, the continued use of prescribed fire and mechanical treatments within these habitat types is not necessary and may be detrimental. Once horse and burro grazing is removed, management activities to restore natural fire or to mimic the effects of natural fire will resume where necessary to achieve habitat objectives.

We anticipate that implementation of the CCP's strategies to remove all feral horses and burros from Sheldon Refuge within five years will be the primary and most significant action responsible for progress toward achieving our stated management objective to enhance, protect, and maintain at least 60% of emergent marsh and wet meadow habitat. The precise conditions of habitats throughout Sheldon Refuge have not been quantified, but based on the results of vegetation surveys, site visits, and ongoing research projects, the primary factors currently influencing habitat conditions within Sheldon Refuge are feral horses and burros.

Other benefiting species: Greater sage-grouse, northern pintail, canvasback, cinnamon teal, American avocet, black-necked stilt, long-billed curlew, willet, greater sandhill crane, Forster's tern, black tern, western snowy plover, least sandpiper, grebes, bald eagle, ferruginous hawk, Swainson's hawk, short-eared owl, bobolink, willow flycatcher, rufous hummingbird, and mountain quail; Preble's shrew, Merriam's shrew, vagrant shrew, mule deer, California bighorn sheep, hoary bat, spotted bat, and little brown myotis; and numerous species of gastropods have been identified as Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006).

Supporting references for the objective thresholds: Altman and Holmes 2000; Connelly et al. 2000; Littlefield 1995; Littlefield and Ivey 2002; Neel 1999; Paige and Ritter 1999.

Objective 3b: Springs, Springbrooks, and Streams (see Figure 4.2)

Spring, springbrooks, and streams: Manage springs, springbrooks, and stream habitats for the benefit of a diverse assemblage of native species including birds, mammals, amphibians, fish, and endemic invertebrates on Sheldon Refuge. These habitats are defined by the following attributes:

- Water temperatures ranging from cold (<75˚F) to thermal (>86˚F)
- Substrates dominated by vegetation, with associated boulders, fines, sand, cobble, or gravel
- Stabilizing bank vegetation
- <10% invasive plant cover

Cold perennial springs: Restore (where necessary), protect, and maintain 45%-65% (65-95) of cold, perennial springs and associated springbrooks on Sheldon Refuge for the benefit a diverse assemblage of native species including desert fish (e.g., Alvord chub [*Gila alvordensis*]), birds, mammals, amphibians, and endemic invertebrates on Sheldon Refuge. These habitats are characterized by the following:

- Perennial
- Water temperatures <86°F

- Presence of benthic and free-swimming organisms
- Vegetative cover
- <10% cover of invasive plants

In-channel habitat: Restore (where necessary), protect, and maintain more than 60% (125 miles) of in-channel habitat within cold-water streams for the benefit of a diverse assemblage of native species including desert fish (e.g., Sheldon tui chub [*Gila bicolor eurystoma*]), amphibians, and endemic invertebrates on Sheldon Refuge. This in-channel habitat within cold-water streams is characterized by the following:

- Water temperatures <78°F
- Soft-bottom sediments
- Stabilizing bank vegetation (e.g., rushes)
- <10% cover of invasive plants

Strategies Applied to Achieve Objective

With assistance from NDOW and other partners, assess and prioritize water developments and develop management prescriptions including removal and active restoration or rehabilitation to restore natural conditions to springs over the next 10 to 15 years.

Reduce disturbance by relocating designated campgrounds and re-routing roads.

Protect from new introductions of non-native fish and amphibians. Examine potential to control existing non-native populations.

Rationale: Springs, springbrooks, and streams are rare in the Great Basin, support rare or unique endemic species, and are important sources of water for wildlife. On Sheldon Refuge, most of the hydrologic processes at these sites have been materially altered by livestock use and by previous water development efforts for livestock, including spring boxes, dams, diversion canals, pipelines, troughs, and dug-out water catchments. In addition, these sites are impacted by recreational visitors, introduced non-native fish, and exotic amphibian species (e.g., guppies [*Poecilia reticulata*] and bullfrogs [*Rana catesbeiana*]). Restoration efforts related to the objective could include a wide range of methods, tools, and techniques, which are determined by individual site characteristics including soils, the percentage of native vegetation present, the type of existing development, and the amount of ground disturbance necessary to remove the development. Because the majority of locations for these water sources are within proposed wilderness, the most likely range of tools and techniques to be used has been evaluated through the Minimum Requirements Analysis (MRA) included in Appendix G.

In some cold water stream reaches, management for cobble and gravel stream bottoms to support salmonid (Lahontan cutthroat, redband and/or Alvord cutthroat) spawning may be appropriate as long as such management does not conflict with the needs of endemic species. Our priority is management for native species (e.g., Sheldon tui chub, amphibians, and endemic invertebrates), but we will not be converting natural cobble and gravel stream bottoms to soft-bottom sediment. In cooperation with NDOW, we will identify stream reaches where management for cobble and gravel bottoms is appropriate and does not conflict with management objectives for Sheldon Refuge.

Past habitat restoration efforts within Sheldon Refuge have been successful in restoring more natural conditions in only a few years. By comparison, observation of habitat exclosures indicate that without active management, natural recovery of these habitats will take several decades—and in some cases may not occur at all. The combination of removal and complete restoration of the most heavily damaged areas will be the quickest and most certain method of restoring natural function and condition to these habitats necessary to fulfill the purposes for Sheldon Refuge.

We will retain the majority of existing water sources until horse and burro populations are significantly reduced. Timeframes presented in the strategies allow for removal of horses and burros prior to completing restoration. We recognize that trade-offs may exist for any management action and that restoration efforts benefitting some species may be detrimental to others. For these reasons, we will further evaluate and review removal of specific water developments and restoration efforts before individual projects are initiated.

We anticipate that implementation of the CCP to remove all feral horses and burros from Sheldon Refuge within five years will be the primary and most significant action responsible for progress toward achieving our stated management objective to enhance, protect, and maintain at least 45%-56% of cold perennial spring habitat and at least 50% of in-channel stream habitat. The precise conditions of habitats throughout Sheldon Refuge have not been quantified, but based on the results of vegetation surveys, site visits, and ongoing research projects, the primary factors currently influencing habitat conditions within Sheldon Refuge are feral horses and burros.

Other benefiting species: Rufous hummingbird, mountain quail, Lewis' woodpecker, willow flycatcher, Cassin's finch, northern goshawk, Swainson's hawk, and bald eagle; and Preble's shrew and vagrant shrew; and numerous species of gastropods have been identified as Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006).

Supporting References for the Objective thresholds: Dunham et al. 1999; Gerstung 1986; Herbst 1996; Tubb 1980, USFWS 1995; Williams and Bond 1981.

Photo 2.6 Springs, springbrooks, and stream habitats represent a small portion of Sheldon Refuge but are extremely important for biological health, integrity, and diversity.

Objective 3c: Playas, Salt Flats, and Mudflats

Ephemeral wetlands: Manage more than 20% (1,400 acres) of ephemeral wetland habitat (e.g., playa, salt flat, mudflat) for the benefit of a diverse assemblage of native species including migratory birds (e.g., shorebirds), invertebrates, amphibians, and reptiles on Sheldon Refuge. Natural characteristics of these habitats are defined by the following:

- Alkaline and saline to hypersaline water quality with depths ranging from saturated soil to 4 feet
- Unvegetated to sparsely vegetated (e.g., shrubs, saltgrass (*Distichlis spicata*), other herbaceous cover)
- Associated habitats include fringes surrounding salt flats, mudflats, and playas of shrubs interspersed with native bunchgrasses (total cover <25%)
- <10% cover of invasive plants (e.g., cheatgrass)
- Facilitates natural processes; saturates via overland flow or groundwater discharge
- Shallow swales with basin topography

Strategies Applied to Achieve Objective

With assistance from NDOW and other partners, assess and prioritize playas and develop management prescriptions including removal and active restoration or rehabilitation to restore at least 20% of playas to natural conditions within 15 years.

Conduct and monitor management experiments to determine appropriate restoration techniques of natural hydrologic function. Apply techniques to additional acres if successful.

Minimize recreational and management activities that disturb the soil surface (e.g., OHV use).

Rationale: Ephemeral wetlands such as playas, salt flats, and mudflats provide habitat for a diverse assemblage of native and desert aquatic species adapted to life in ephemeral, saline, or geothermal habitats, thus, contributing to biodiversity in the Great Basin. On Sheldon Refuge, most of the hydrologic processes at these sites have been materially altered by previous water development efforts for livestock, specifically dug-outs. This has affected the natural ecological processes (e.g., rates of evaporation) and has likely impacted the physical, chemical, and biological condition at these sites; consequently, wildlife that depend on these sites have also been impacted. In addition, these areas are impacted by OHV use, which contributes to soil erosion, soil compaction, and vegetation removal.

Playas are rather complex, highly alkaline but poorly understood basin ecosystems (up to a few hundred acres in size within Sheldon Refuge) that depend on periodic shallow flooding. When flooded, these habitats teem with invertebrates, which have sometimes remained dormant for many years. This rich aquatic life provides valuable forage for migratory birds. Deep depressions or "dug-outs" were excavated in many playas throughout Sheldon Refuge to concentrate water for livestock. Because the water is concentrated in the dug-out area, the playa no longer floods with water and the ecological integrity of the habitat has been lost. Many ecologists assert that once the alkaline layers of the playa have been altered by excavation, restoration may not be possible. Strategies to restore at least 20% of these playas habitats for the benefit of migratory birds and other wildlife are probably realistic, but allowing these habitats to recover naturally over time would occur very slowly, if at all.

We will retain the majority of existing water sources until horse and burro populations are significantly reduced. Timeframes presented in the strategies allow for removal of horses and burros prior to completing restoration. We recognize that trade-offs may exist for any management action and that playa restoration efforts benefitting some species may be detrimental to others. For these reasons, we will further evaluate and review removal of specific water developments and playa restoration efforts before individual projects are initiated.

Other benefiting species: American avocet, black-necked stilt, cinnamon teal, eared grebe, Forster's tern,

black tern, Franklin's gull, least sandpiper, long-billed dowitcher, red-necked phalarope, long-billed curlew, northern pintail, snowy egret, western snowy plover, and willet have been identified as Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006).

Supporting references for the objective thresholds: Dechant et al. 2002; Floyd et al. 2007.

Objective 3d: Artificial Emergent Marshes and Reservoirs (see Figure 4.2)

Manage 434 acres including Catnip Reservoir, Big Spring Reservoir, Dufurrena Ponds, and other existing managed ponds and emergent marshes for the benefit of migratory birds (e.g., wading birds and waterfowl), fish (e.g., Lahontan cutthroat trout) and native amphibians on Sheldon Refuge. The desired state of these habitats is characterized by the following:

- Diverse array of native wetland plants including emergents (e.g., cattail [*Typha* spp.], bulrush [(*Scirpus* sp., *Schoenoplectus* spp.]), sedges, and moist-soil plants (e.g., smartweed [*Polygonum* spp.])
- 30%-90% native residual vegetation with a diverse array of native wetland plants including emergents, sedges, and moist soil plants
- Water depths of 9-10 inches in emergent plant zone
- >50% cover of open water (>3 feet in depth) with native submergent plants (e.g., pondweeds [*Potamogeton* spp.])
- <10% invasive plant cover (e.g., Canada thistle [*Cirsium arvense*], cheatgrass, pepperweed [*Lepidium* spp.])

Strategies Applied to Achieve Objective

Maintenance of artificial habitats primarily for fish, wildlife, and plants and secondarily to provide wildlife-dependent public use opportunities.

Actively maintain the dam and dredge the 22-acre Catnip Reservoir to provide sufficient water depth for Lahontan cutthroat trout.

Actively maintain the headgate and dam for the 212-acre Big Spring Reservoir to impound available water for migratory birds and trout.

Actively maintain headgates, culverts, and dikes at Dufurrena Ponds to retain water for approximately 193 acres of artificial pond, wetland, and wet meadow habitat.

Remove structures and restore Pond 13 (7 acres) to natural conditions.

Control emergent vegetation and maintain early successional communities in artificial ponds including mechanical removal, disking, prescribed fire, and herbicides.

Manage disturbance and impacts associated with recreational use.

Rationale: Because of altered hydrology and continued degradation of many of the natural wetlands and water sources on Sheldon Refuge, these artificial environments can provide important habitats for native fish and wildlife. In addition, these artificial habitats provide recreation opportunities.

Currently Catnip Reservoir provides suitable habitat and a potential source of genetic stocks for federally threatened Lahontan cutthroat trout populations in areas surrounding Sheldon Refuge. However, the reservoir continues to fill with silt, and the dam impounding Catnip Reservoir has been compromised by burrowing animals and is leaking progressively increasing amounts of water. In order to maintain sufficient water to support this fishery, Sheldon Refuge will need to conduct substantial maintenance and dredging in the near future. Cost estimates for dredging and repairs are approaching $3 million and will only increase the longer action is delayed.

Other benefiting species: Clark's grebe, western grebe, eared grebe, common loon, canvasback, redhead, northern pintail, cinnamon teal, western snowy plover, least sandpiper, long-billed dowwitcher, red-necked phalarope, Forster's tern, black tern, American white pelican, Franklin's gull, least bittern, black-necked

stilt, American avocet, long-billed curlew, short-eared owl, bald eagle, ferruginous hawk, peregrine falcon, bobolink, greater sandhill crane, and willet; and little brown myotis have been identified as Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006).

Supporting References for the Objective thresholds: Dunham et al. 1999; Littlefield 1995; Littlefield and Ivey 2002; USFWS 1995.

Photo 2.7 Artificial emergent marshes, reservoirs, and the Dufurrena Ponds (shown here) continue to be maintained to benefit migratory birds and support wildlife-dependent public uses.

Objective 3e: Artificial Wet Meadows (see Figure 5.1)

Manage 1,700 acres of seasonal wetland–wet meadow habitat complex for the benefit of wildlife and migratory birds (e.g., pronghorn and waterfowl) at Swan Lake Reservoir and IXL Ranch on Sheldon Refuge. The desired state of these habitats are characterized by the following:

- Diverse array of native wetland plants including emergents (e.g., cattail, bulrush), sedges, and moist-soil plants (e.g., smartweed)
- 30%-90% native residual vegetation with a diverse array of native wetland plants including emergents, sedges, and moist-soil plants
- <10% invasive plant cover (e.g., Canada thistle, cheatgrass, pepperweed)

Strategies Applied to Achieve Objective

Maintenance of artificial habitats primarily for fish, wildlife, and plants and secondarily to provide wildlife-dependent public use opportunities.

Operate and maintain Swan Lake Reservoir and impoundment dam to provide approximately 1,200 acres as a vital source of moisture for quality late summer pronghorn forage.

Secondary to management for Swan Lake, maintain water control infrastructure at IXL Ranch and release surplus water from Swan Lake Reservoir to provide approximately 500 acres of migratory bird stop-over habitat.

Manage disturbance and impacts associated with recreational use.

Rationale: Because of altered hydrology and continued degradation of many of the natural wetlands and water sources on Sheldon Refuge, these artificial environments can provide important habitats for native fish and wildlife. In addition, these artificial habitats provide recreation opportunities.

The purposes for Sheldon Refuge are to serve as a refuge and breeding ground for wild animals and birds, for the conservation and development of natural wildlife resources and for the protection and improvement of natural forage resources. Efforts to maintain the existing facilities at both IXL Ranch and Swan Lake further these purposes by maintaining waterfowl resting and breeding habitat at IXL Ranch and important pronghorn forage areas at Swan Lake. The 1960s-era water control infrastructure at IXL Ranch was reconstructed in cooperation with Ducks Unlimited, NDOW, and the Nevada Waterfowl Association to provide waterfowl habitat. IXL Ranch was historically flooded by water held within Swan Lake and Catnip reservoirs but is currently dependent upon quantity and periodicity of runoff water. The priority is to retain water in Swan Lake Reservoir to benefit habitats directly associated with Swan Lake itself. Water retained in Swan Lake Reservoir provides habitat for summering pronghorn moving off of fawning grounds, and Swan Lake provides a vital source of quality forage as the water naturally evaporates into late summer and fall.

Other benefiting species: Clark's grebe, western grebe, eared grebe, canvasback, redhead, northern pintail, cinnamon teal, western snowy plover, least sandpiper, long-billed dowwitcher, red-necked phalarope, Forster's tern, black tern, American white pelican, Franklin's gull, least bittern, black-necked stilt, American avocet, long-billed curlew, short-eared owl, bald eagle, ferruginous hawk, peregrine falcon, Swainson's hawk, bobolink, greater sandhill crane, and willet; and Preble's shrew, Merriam's shrew, vagrant shrew, mule deer, California bighorn sheep, hoary bat, spotted bat, and little brown myotis have been identified as Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006).

Supporting references for the objective thresholds: Altman and Holmes 2000; Dechant et al. 2002; Dunham et al. 1999; Floyd et al. 2007; Littlefield 1995; Littlefield and Ivey 2002; Neel 1999; Paige and Ritter 1999; USFWS 1995.

Photo 2.8 Guzzlers have been constructed for bighorn sheep and to increase numbers of chukar for hunting.

Objective 3f: Artificial Water Sources
Maintain the function of 18 other artificial water developments to support the protection and maintenance of other natural habitats.
Strategies Applied to Achieve Objective
In cooperation with NDOW, maintain existing wildlife water guzzlers.
Within five years of the final decision for the CCP, annually prioritize and repair at least 10% of non-functioning artificial water source developments necessary to fulfill Sheldon Refuge purposes.
Evaluate the benefits and consequences of intensively managed water developments versus restoring natural hydrological processes.
Rationale: Guzzlers were constructed at various locations within Sheldon Refuge under the assumption that artificial sources of freestanding water are necessary for healthy populations of chukar, bighorn sheep, and other wildlife. An increasing number of studies have demonstrated that wildlife will utilize these water sources when available and they may provide some benefit (Arizona Desert Bighorn Sheep Society 2004; AZGFD 2004; USFWS 2002b, 2007a), but that they are not biologically necessary for bighorn, mule deer, pronghorn, and other native wildlife, which are well adapted to the dry arid climate of Sheldon Refuge (Cain et al. 2008; Monson 1968, Seton 1937, O'Connor 1939, Phelps 1974, Nowak and Paradiso 1983, Beale and Smith 1970, and Reynolds 1984 as cited in USFWS 1998a). Furthermore, the past construction of water impoundments for commercial livestock grazing has likely created more sources of freestanding water throughout Sheldon Refuge and the surrounding landscape than has existed at any time in the past several hundred years, and the construction of any additional artificial sources of freestanding water is not necessary for maintaining healthy wildlife populations or natural ecological conditions. We will consider constructing additional water developments for wildlife if monitoring data or other resource information are provided, are supported by science, and demonstrate that water developments are biologically beneficial and would achieve the purposes and management goals and objectives of Sheldon Refuge (including goals and objectives for wildlife, public uses, and wilderness where applicable). Existing structures are unlikely to cause additional adverse impacts to wilderness character, and future maintenance will be completed by volunteers and in cooperation with NDOW. Therefore, these permanent structures will be allowed to remain within the proposed wilderness areas while higher priority habitat improvement strategies (removal of feral horses and burros, restoration of springs, etc.) are implemented. By annually prioritizing and completing regular maintenance and repairs for at least 10% of water developments, we will ensure that all developments receive maintenance within the next 15 years. More regular and routine maintenance should reduce or at least delay the need for more extensive and costly repairs or complete replacement.

2.2.4 Goal 4. Protect unique and rare habitats, wildlife, and communities.

Objective 4a: Cliffs, Canyons, Talus Slopes, and Barren Lands (see Figure 4.5)
Cliff, canyon, talus slope, and barren lands: Protect and maintain the ecological integrity of 85%-95% (8,500-9,000 acres) of cliff, canyon, talus slope, and barren land habitats for the benefit of a diverse assemblage of native species including mammals (e.g., California bighorn sheep, American pika [*Ochotona princeps*], bats), migratory birds (e.g., prairie falcon [*Falco mexicanus*]), reptiles, and talus-slope dependent plants (e.g., rattlesnake stickweed [*Hackelia ophiobia*]) on Sheldon Refuge. The desired characteristics of these habitats are as follows: • Well-sheltered crevices, cavities, bluffs, high walls, and rocky ledges and slopes • Largely unvegetated (widely scattered native trees and shrubs) • <4 western juniper trees/acre under <150-year age class with a long fire-return interval and an

absence of understory fuels
- <10% cover of invasive plants (e.g., cheatgrass)
- Minimal human disturbance

Strategies Applied to Achieve Objective

Conduct treatments to control encroaching western juniper, including mechanical removal and prescribed fire.

Evaluate acceptable types of wildlife-dependent public uses and manage to minimize impacts.

Conduct baseline surveys to identify wildlife and plant resources that need further inventory, monitoring, and/or research. Primary focus will be bats, reptiles, amphibians, and rare plants.

Actively seek additional funding through partnerships and grants to research and monitor these areas.

Rationale: Cliffs, canyons, talus slopes, and barren lands, including volcanic tuff habitats, are sparsely scattered and add to the topographic diversity of Sheldon Refuge. These areas provide important habitat for a host of wildlife species, including many that are particularly sensitive to human disturbance, but in general appear to be stable and in good condition. It is generally agreed the thresholds included in the objective, when applied across the habitat type, reflect healthy natural conditions necessary to support dependent fish and wildlife species. This includes priority species such as American pika, California bighorn sheep, mountain lion, bobcat (*Felis rufus*), a number of bat and reptile species, and many other dependent species (see wildlife and habitat matrix in Appendix B). By managing habitats within the stated objective thresholds, the necessary ecological integrity will be provided to maintain diverse, healthy wildlife populations within the natural range of variability. Currently precise conditions of habitats throughout Sheldon Refuge have not been quantified, but based on the results from vegetation surveys and site visits, the primary factors currently influencing habitat conditions within Sheldon Refuge are feral horses and burros and long-term suppression of natural fire.

We anticipate that implementation of the CCP to remove all feral horses and burros from Sheldon Refuge within five years will be the primary and most significant action responsible for progress toward achieving our stated management objective to enhance, protect, and maintain 85% to 95% of cliff, canyon, talus slope, and barren land habitat. The precise conditions of habitats throughout Sheldon Refuge have not been quantified, but based on the results of vegetation surveys, site visits, and ongoing research projects, the primary factors currently influencing habitat conditions within Sheldon Refuge are feral horses and burros.

Other benefiting species: Ferruginous hawk, peregrine falcon, bald eagle, black rosy finch, and white-throated swift; little brown myotis, western small-footed myotis, long-eared myotis, pallid bat, spotted bat, American pika, mule deer, and California bighorn sheep; and desert horned lizard and Great Basin collared lizard have been identified as Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006).

Supporting references for the objective thresholds: Altman and Holmes 2000; Demarchi 2004; Miller et al. 2005.

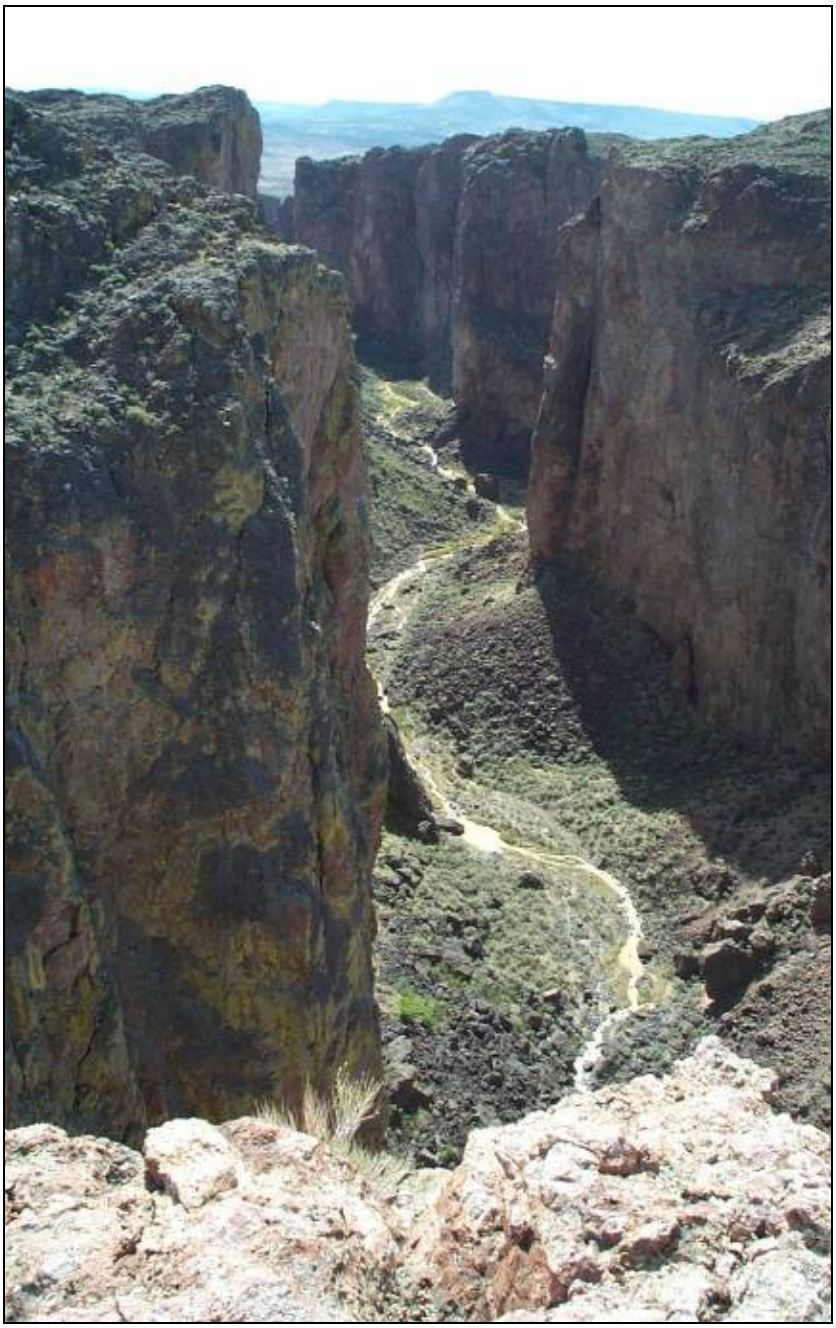


Photo 2.9 The dramatic cliffs along Thousand Creek Gorge provide habitat for raptors, bats, and other dependent wildlife.

Objective 4b: Deciduous Woodlands and Shrublands (see Figure 4.6)

Deciduous woodlands and shrublands: Restore (where appropriate) and maintain more than 50% (>140 acres) of all deciduous woodland and shrubland habitat including aspen stands (*Populus* spp.), for the benefit of a diverse assemblage of native species including migratory birds (e.g., yellow-breasted chat [*Icteria virens*]), mammals, and amphibians on Sheldon Refuge. The desired state of riparian woodland is characterized by the following:

- Patchy shrub layer dominated by deciduous shrubs interspersed with openings of native herbaceous species
- 30%-80% canopy cover of mature (3-12 feet tall) woody vegetation
- <10% invasive plant cover

Aspen stands: Restore (where appropriate) and maintain all aspen stands for the benefit of a diverse assemblage of native species including resident and migratory birds (e.g., woodpeckers, raptors), mammals, and amphibians on Sheldon Refuge. The desired condition of aspen stands can be characterized by the following habitat attributes:

- Range of successional stages including early and mid-to-late
- Small (<10 inches dbh [diameter at breast height]), medium (>10 inch dbh), to large aspen trees (>20 inches dbh)
- 40%-80% tree canopy closure
- >1.5 live trees/acre
- >1.5 snags/acre
- Naturally fragmented patches
- Understory shrub cover ranging from present (>10% cover; aspen seedlings, willow [*Salix* spp.] alder [*Alnus* spp.], chokecherry [*Prunus virginiana* var. *melanocarpa*], currant [*Ribes* spp.], snowberry [*Symphoricarpos* spp.], *Ceanothus* spp.) to absent (<10% understory shrub cover)
- <10% cover of invasive plants

Strategies Applied to Achieve Objective

Allow wildfire, but emphasize treatments such as cutting, thinning, and prescribed fire to mimic natural disturbance regimes and control encroaching western juniper and sagebrush.

Fence for grazing protection and plant native species to restore woody vegetation.

Inventory, assess, and prioritize restoration potential of individual stands.

Rationale: On Sheldon Refuge, many of these communities occur within isolated snowpockets, although others are dependent upon a natural hydrologic regime, including annual to episodic flooding. While these habitats represent a very small percentage of the entire refuge, they are essential for maintaining ecological integrity. Throughout the northern Great Basin region, the protection and restoration of aspen and other deciduous woodland habitats have been identified as necessary long-term conservation strategies. Fire is an important factor in facilitating the long-term presence and health of riparian woodlands across the landscape. A determination will be made as to where this community type historically occurred within Sheldon Refuge, what species were represented, and, if feasible and necessary, where supplemental plantings may accelerate recovery of the system. Overgrazing has removed most younger shoots and stems from areas of deciduous woodland and shrubland habitats and if not addressed could lead to extirpation of aspen stand clones. Currently precise conditions of habitats throughout Sheldon Refuge have not been quantified, but based on the results from vegetation surveys and site visits, the primary factors currently influencing habitat conditions within Sheldon Refuge are feral horses and burros and long-term suppression of natural fire. It is expected that even under the CCP's management direction for the removal of feral horse and burros, protective temporary fencing will be necessary to prevent severe overgrazing, which would take many years to naturally recover, or which could require active restoration to fully recover.

Once horse and burro management objectives are reached, protective fences will be removed.

We anticipate that implementation of the CCP to remove all feral horses and burros from Sheldon Refuge within five years will be the primary and most significant action responsible for progress toward achieving our stated management objective to enhance, protect, and maintain at least 50% of deciduous woodland and shrubland habitat. The precise conditions of habitats throughout Sheldon Refuge have not been quantified, but based on the results of vegetation surveys, site visits, and ongoing research projects, the primary factors currently influencing habitat conditions within Sheldon Refuge are feral horses and burros.

Other benefiting species: Bald eagle, northern goshawk, Swainson's hawk, rufous hummingbird, Cassin's finch, willow flycatcher, mountain quail, Lewis' woodpecker; mule deer, Preble's shrew, vagrant shrew, little brown myotis, long-eared myotis, and western small-footed myotis have been identified as Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006).

Supporting references for the objective thresholds: Altman and Holmes 2000; Daw and DeStefano 2001; Miller et al. 2005; Neel 1999; Squires and Ruggiero 1996.

Objective 4c: Mountain Mahogany and Western Juniper Woodlands (see Figures 4.5 and 4.7)

Mountain mahogany woodlands: Protect and maintain 80%-95% (7,200-8,600 acres) of mountain mahogany woodlands for the benefit of a diverse assemblage of native species including resident and migratory birds (e.g., raptors) and mammals (e.g., mule deer) on Sheldon Refuge. These mountain mahogany woodlands are characterized by the following:

- Discrete bands of mature mountain mahogany trees found on slopes, ridges, rimrock, and canyons
- Limited to higher elevations
- 10%-55% mature stand canopy cover
- <10% cover of invasive plants

Western juniper woodlands: Protect **80%-95% (3,900-4,600 acres)** of late-successional (i.e., old-growth) western juniper woodlands for the benefit of a diverse assemblage of native species including resident and migratory birds (e.g., landbirds, raptors) and mammals (e.g., mule deer) on Sheldon Refuge. Mature western juniper woodlands are characterized by the following:

- Mature western juniper trees (>200 years old; >20 in dbh, >30 feet tall)
- Range of young western juniper trees for recruitment (>3 inches dbh, <9 feet tall)
- Range of western juniper canopy closure (<1% to >50% cover)
- Range of midstory shrub canopy cover (<40% to 80%)
- <10% cover of invasive plants
- Generally situated in "fireproof" locations (e.g., rocky outcroppings, bare areas, talus slopes)

Strategies Applied to Achieve Objective

Protect existing stands from fires that would cause major adverse impacts and other large-scale disturbances.

Conduct mechanical treatments and prescribed fire in areas adjacent to woodlands to reduce fuel loads.

Restore woodlands after stand-replacing fire or other large-scale disturbance (e.g., native seeding and planting).

Rationale: Mountain mahogany and late-successional western juniper stands provide unique and often irreplaceable biological and ecological values. All stands of mountain mahogany are sensitive to stand-replacing fire, do not easily resprout after fire, and are difficult to establish from seed. Late-successional western juniper stands also naturally occur in areas protected from fire, and large-scale fires are historically

rare. Because of decreased seedling establishment in older juniper stands, the maintenance of some early and mid-successional western juniper stands are important for recruitment and will be provided through the following: as a fringe around late-successional stands and from recruitment within existing stands. It is generally agreed the thresholds included in the objective, when applied across the habitat type, reflect healthy natural conditions necessary to support dependent fish and wildlife species. This includes priority species, such as mule deer, and a host of other dependent species (see wildlife and habitat matrix in Appendix B). By managing habitats within the stated objective thresholds, the necessary ecological integrity will be provided to maintain diverse, healthy wildlife populations within the natural range of variability. Precise conditions of habitats throughout Sheldon Refuge have not been quantified, but based on the results from vegetation surveys and site visits, the primary factors currently influencing habitat conditions within Sheldon Refuge are feral horses and burros and long-term suppression of natural fire.

Thresholds for juniper tree size identify structural characteristics preferred by the assemblage of native species using the mature juniper habitat type. Late-successional western juniper is associated with a variety of soils, land forms, and plant associations. Communities typically occupy productively-low rock outcrops and soils that are shallow, rocky, and high in clay or sand. Characteristics that are further used to identify individual late-successional juniper trees include an unsymmetrical canopy that is rounded, spreading, sparse, and containing dead limbs. In addition, the bark becomes deeply furrowed, fibrous, and reddish in color. Older trees will also have limited terminal leader growth on branches in the upper reaches of the tree canopy (Miller et al. 2005).

On Sheldon Refuge, approximately 83% of mountain mahogany stands sampled are estimated to have been established after 1900 (Gruell 1995). This dramatic increase in density and distribution has been attributed to fire exclusion (Gruell 1995) and historical livestock grazing, which diminished competing grasses. Current concerns with mountain mahogany are that many stands are dominated by older trees with crowns that are practically unreachable to wildlife for browse and little recruitment of new plants; if natural fire were to re-enter these stands in their current overgrown conditions, it is likely most or all mountain mahogany will be killed by the intense heat, and these areas will be lost as valuable wildlife cover, forage, and nesting habitat. Mountain mahogany does not easily resprout after burning, and it is difficult to establish from seed. Factors that may limit natural seedling establishment include the presence of mountain mahogany litter that inhibits seed germination, competition for water and soil resources, and browsing of seedlings (see summary by Ibáñez et al. 1999). On Sheldon Refuge, these habitats are considered in overall fair to good condition, but the proactive management that is part of the CCP's management direction is needed to create fuel breaks and perform prescribed burning around mountain mahogany stands to provide protection from future wildfire.

We anticipate that implementation of the CCP to remove all feral horses and burros from Sheldon Refuge within five years will be the primary and most significant action responsible for progress toward achieving our stated management objective to enhance, protect, and maintain at least 80%-95% of mountain mahogany and western juniper woodland habitats. The precise conditions of habitats throughout Sheldon Refuge have not been quantified, but based on the results of vegetation surveys, site visits, and ongoing research projects, the primary factors currently influencing habitat conditions within Sheldon Refuge are feral horses and burros.

Other benefiting species: Northern goshawk, ferruginous hawk, mountain quail, Lewis' woodpecker, olive-sided flycatcher; montane shrew, vagrant shrew, mule deer, hoary bat, and long-eared myotis; and pygmy short-horned lizard have been identified as Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006).

Supporting references for the objective thresholds: Altman and Holmes 2000; CalPIF 2005; Miller et al. 2001; Miller et al. 2005; Neel 1999.

Photo 2.10 Unlike western juniper, mountain mahogany stands are not expanding and are susceptible to fire.

Objective 4d: Rare and Sensitive Plants
Identify, maintain, and expand the populations of rare and sensitive plant taxa.
Strategies Applied to Achieve Objective
Conduct periodic monitoring and conduct inventories on a site-by-site basis in response to project proposals and management activities.
Routinely conduct inventories in areas not yet surveyed for rare plant species and periodically monitor known sites.
Actively seek additional funding through partnerships and grants for research.
Rationale: The Sheldon Refuge population of grimy ivesia (*Ivesia rhypara* var. *rhypara*) represents 86% of the known individuals within Nevada and 85% of all globally known plants. Rattlesnake stickweed has been documented occurring at the base of steep gorge walls, in rocky areas below the walls, and occasionally along ledges in the rock walls on Sheldon Refuge. This species is considered limited in its distribution and a potential species of concern. The population on Sheldon Refuge was the largest documented to date and at that time represented 96% of the total known individuals. Rose biscuitroot (*Lomatium roseanum*) is another rare plant documented within Sheldon Refuge. These examples illustrate the amount of knowledge that can be gained through basic inventory efforts included as part of Objective 4d, which can then be used to make more informed management decisions to better conserve plants and their habitats within Sheldon Refuge.

Objective 4e: Microbiotic Soil Crusts
Inventory microbiotic crust and protect from conflicting public use and land management practices.
Strategies Applied to Achieve Objective
Conduct periodic monitoring and conduct inventories on a site-by-site basis in response to project proposals and management activities.
Conduct inventories to document range and condition of microbiotic crust to provide information for adaptive management.

Minimize ground-disturbing activities and management activities that disturb soil surfaces.
Actively seek additional funding through partnerships and grants for research.
Rationale: Biological soil crusts (i.e., microbiotic crusts) are an integral component of rangeland soils; however, little is known regarding its current condition across Sheldon Refuge. Protection from livestock, OHVs, and other disturbances can assist in the recovery of these communities, resulting in an increase in the percentage of soil surface covered with crust, and conversely a decrease in the percentage of bare soil.

Objective 4f: Rare, Sensitive, and Key Indicator Wildlife Species
Inventory and monitor federally listed species, rare and sensitive species (e.g., prairie falcons), and indicator and/or sagebrush-obligate species (e.g., pronghorn, Greater sage-grouse, pygmy rabbit, and American pika).
Strategies Applied to Achieve Objective
Evaluate existing research and monitoring data to identify scientific information gaps and priority research needs.
Actively seek funding, grants, and partnerships to conduct research and monitoring.
Conduct habitat and wildlife inventories to fill scientific information gaps.
Prepare an inventory and monitoring plan for priority species using standardized protocols.
Rationale: Inventory and monitoring of listed, sensitive, and indicator species is critical to conserving the biological integrity, diversity, and environmental health of Sheldon Refuge. Inventory and monitoring is required to assess the effects of management actions, to both prevent adverse effects to wildlife species and to assess whether Refuge objectives are being met.

2.2.5 Goal 5. Using an integrated approach, prevent, control, or eliminate non-native species that threaten Sheldon Refuge resources.

Objective 5a: Noxious Weeds and Other Invasive Plants
Control, reduce, and, where possible, eliminate noxious weeds and other highly invasive plant species from Sheldon Refuge. Treat 1,000 acres per year (includes all habitat types).
Strategies Applied to Achieve Objective
Implement a more proactive approach by emphasizing treatment along road corridors, early detection and eradication of small infestations, and long-term containment/control of large infestations.
Implement a systematic inventory and monitoring program to measure changes in invasive plant populations over time and responses to management activities.
Aggressively control small populations of noxious weeds and other highly invasive non-native plants using a variety of methods and tools—primarily reseeding and planting, mowing and other mechanical methods, and the use of herbicides.
Slow the spread of well-established and/or large populations of invasive plants (i.e., cheatgrass) by limiting the amount of prescribed burning and other disturbance in highly susceptible areas and through reseeding and planting following fire and other disturbances.
Increase public awareness and participation in control efforts through directed outreach, education, and volunteer events.
Increase voluntary use of certified weed-free feed by visitors through education. Require weed-free feed if pack stock are determined to be a continued source of invasive plants introduced to Sheldon Refuge.
Discontinue grading along road edges within Sheldon Refuge, which promotes the spread and persistence of invasive plants.

Rationale: While noxious weeds and other non-native plants are not as widespread when compared with surrounding areas, these plants are degrading habitats for native fish, wildlife and plants within Sheldon Refuge. Without increased efforts to detect and control newly introduced non-natives plants and at least control existing plants, impacts are expected to become much worse. Effective management of these plants will require Sheldon Refuge to dedicate additional staff, funding, and resources for quicker detection followed by a wide variety of control methods and tools—even within wilderness areas managed for naturalness and primitive character.

Effective control of noxious weeds and other invasive plants requires the ability to use the widest range of tools and techniques available at the proper time and with the correct application. The range of tools and techniques to implement Objective 5a within the eight proposed wilderness areas were evaluated through a Wilderness Minimum Tool Analysis (see Appendix G). Actions to implement the objective in areas of Sheldon Refuge not proposed as wilderness could include the full range of tools and techniques available, but will most commonly include mechanical mowing and herbicides.

The Region 1 IPM Strategies have been evaluated and are adopted and incorporated in this CCP by reference (see Appendix O). These IPM strategies include guidance for the preparation of pesticide use proposals required by the Service. Evaluations conducted in preparation of each pesticide use proposal will ensure that those chemicals approved for use have no more than minor, short-term adverse effects on the environment. Implementation of the CCP has also been determined necessary to fully implement Objectives 2a, 2b, 3a, 3b, 3c, 4a, 4b, 4c, 4d, and 4e.

Objective 5b: Harmful and Invasive Wildlife
Manage, control, or remove fish and wildlife populations that may be detrimental to Sheldon Refuge resources or public safety.
Strategies Applied to Achieve Objective
Take no management action for self-sustaining, non-native species determined to have negligible impact to native species or habitats (see strategy for Objective 8a).
Investigate techniques to mitigate impacts from non-native species determined to be detrimental to a native species or habitats.
Replace non-native trout with native substitutes if viable (see strategy for Objective 8b).

Rationale: Several non-native wildlife species have been introduced to Sheldon Refuge, including largemouth bass (*Micropterus salmoides*), white crappie (*Poxomis annularis*), pumpkinseed sunfish (*Lepomis gibbosus*), yellow perch (*Perca flavescens*), rainbow trout, guppy, bullfrog, California quail, chukar, Hungarian (gray) partridge, and potentially beaver (*Castor canadensis*). Some of these species can have significant impacts to native wildlife and habitats (e.g., guppy, bullfrog), while the effects of others are more benign (e.g., California quail). As populations expand, some species may cause adverse effects on habitat biodiversity, habitat connectivity, and plant community stability; facilitate the expansion of non-native invasive species; become a nuisance to the general public; and/or increase threats to public safety. Adverse effects can also include displacement and predation of other wildlife species, as well as disease transmission.

Current Service policy does not allow for the introduction of species on refuges outside of their historical range unless it is essential for the survival of the species. However, no action is required to reduce or eradicate self-sustaining populations of non-native, noninvasive species unless those species interfere with the accomplishment of refuge purposes or objectives (601 FW 3). The continued presence of non-native rainbow and rainbow hybrid trout within Sheldon Refuge will interfere with Objective 8b, and these non-native fish will be replaced with fish indigenous to the region (e.g., Lahontan cutthroat trout and/or redband trout).

2.2.6 Goal 6. Collect information and create partnerships necessary to support adaptive management decisions at a landscape scale.

Objective 6a: Watershed Restoration
Within five years of the final decision for the CCP, conduct an assessment and initiate restoration of the Virgin Creek watershed, restoring 1 or more miles of Virgin Creek habitat.
Strategies Applied to Achieve Objective
Conduct a health and function assessment of watersheds for determination of restoration priorities.
Develop a watershed restoration plan to include identification and priority areas for restoration.
Assess topographic and hydrological variables and determine the impacts of mining and water development activities in the Virgin Valley.
Following removal of horses and burros, begin efforts to restore and rehabilitate habitat along Virgin Creek.
Rationale: A number of watersheds on Sheldon Refuge have been significantly altered and/or degraded by development, including water diversion, mining activities, invasive species, livestock grazing, and contaminants. Virgin Valley in particular has undergone dramatic alteration due to mining activities and intense grazing by livestock (including feral horses and burros). Long-term soil and water retention are directly affected by vegetative ground cover and soil compaction, which, in turn, increase surface runoff, stream sedimentation, and erosion. A key factor in improving deteriorated riparian areas is understanding the balance between watershed condition and riparian health. Restoration efforts will be largely ineffective as long as feral horses and burros remain within Sheldon Refuge. Until these animals are removed from Sheldon Refuge and Virgin Valley, no active restoration work will take place.

Objective 6b: Wildlife Population Dynamics
Determine key population characteristics of priority species and develop management actions.
Strategies Applied to Achieve Objective
Initiate additional monitoring and/or research to determine population trends, distribution, and migratory patterns (where applicable) for priority species including pronghorn, Greater sage-grouse, and other sagebrush-obligate species.
Investigate appropriate and compatible management actions to mitigate limiting factors.
Apply adaptive management actions to maintain or restore declining or extirpated populations.
Evaluate requirements and potential for restoration of native desert trout.
Evaluate impacts of public use on native wildlife and associated habitats. Implement seasonal area closures as appropriate.
Rationale: Many of the priority wildlife species that occupy Sheldon Refuge have ranges that extend beyond refuge lands, including pronghorn, mule deer, California bighorn sheep, mountain lion, bobcat, coyote, Greater sage-grouse, and a long list of migratory birds. Pronghorn management provides an example of how adaptive management strategies can be applied to meet this objective. In the mid- to late 1990s there was concern that pronghorn populations within the nearby Hart Mountain Refuge were at risk of decline. Early data from studies initiated at that time suggested predators were responsible for the majority of pronghorn fawn mortality. However, pronghorn fawn survival improved coincidentally with suspension of livestock grazing and release from a drought. Planned predator control efforts were postponed indefinitely. Both the Hart Mountain Antelope Refuge and Sheldon Refuge

pronghorn populations have since substantially increased (Collins 2008a), and current data indicate populations are within normal ranges of population variability. This indicates predation was not likely the primary limiting factor. Indeed, additional data have since demonstrated that both the fawn's date of birth and previous summer's precipitation are highly important factors in pronghorn fawn survival (Whittaker 2008).

This example illustrates the complexity of wildlife management and how refuge management has constantly adapted through additional investigation and monitoring that identified likely explanations for changes in pronghorn fawn survival other than predation. Sheldon Refuge intends to implement further study of pronghorn migration, population trends, and predator-prey interactions to create a more complete understanding of factors influencing this priority wildlife species so that future management can continue to adapt.

Organizations and individuals have requested the Service open Sheldon Refuge to the sport hunting and trapping of additional wildlife species (i.e., coyote, mountain lion, and bobcat) consistent with Nevada state hunting regulations. However, the lack of population monitoring data for these species raises a number of conservation concerns. Sport hunting combined with removal of predators from areas adjacent to Sheldon Refuge is ongoing, and it is uncertain what effects, if any, these control efforts have had upon populations which depend upon Sheldon Refuge. The collection of baseline predator population trends, distribution, and movements along with refuge-specific predator-prey interaction studies will allow Sheldon Refuge to make an informed decision as to whether sport hunting of predators is compatible with the Refuge System mission and the purposes for Sheldon Refuge.

There is also the potential to assist in the recovery of locally extirpated species, such as Alvord cutthroat trout and Columbia sharp-tailed grouse, or other species affected by climate change and threats to the sagebrush ecosystem. Sheldon Refuge will collect data to inform future decisions for the management of wildlife populations within natural densities and levels of variation, including naturally fluctuating population cycles, while ensuring that densities of endangered or otherwise rare species are sufficient for maintaining viable populations. A range of tools will be used, including:

- Aerial or ground surveys to estimate numbers, population trend, and/or sex/age composition
- Tracking studies, including radio and satellite marking to estimate distribution and ranges
- Habitat availability and food habit studies
- Predator-prey interaction studies
- Disease monitoring
- Genetic viability estimates
- Standard management techniques that increase/decrease population numbers (e.g., reintroductions, contraception, removal of individuals, supplemental seeding or stocking)

Photo 2.11 Additional research is needed to determine population trends, distribution, and migratory patterns for key species such as pronghorn (Photo Gail Collins).

Objective 6c: Adaptive Management
Monitor habitat conditions, treatments and projects to evaluate effectiveness, and inform future management decisions—i.e., adaptive management.
Strategies Applied to Achieve Objective
Continue to establish monitoring photopoints for prescribed fire habitat treatments.
Conduct periodic riparian assessments.
Continue periodic vegetation mapping.
Continue to monitor the condition of springs.
Maintain research partnerships to monitor habitat treatment and wildfire effects.
Using a systematic approach, implement quantitative monitoring to evaluate short- and long-term effects of natural and prescribed fire.
Implement monitoring to evaluate results from habitat restoration experiments.
Rationale: Past inventory and monitoring of habitat treatment projects within Sheldon Refuge have been inconsistent. For areas where monitoring has been conducted, the level of detail and quantifiable results are generally not sufficient to inform future management actions. A more systematic and quantitative approach is necessary to provide the information necessary to measure management effectiveness and support defensible management decisions.

Objective 6d: Research
Seek partnerships for landscape-level research and conservation projects.
Strategies Applied to Achieve Objective
Develop a conservation planning partnership with cooperative agencies and other groups.
Seek funding to implement projects to achieve common wildlife and habitat objectives in partnership with others.

Seek partnerships and coordinate research on sagebrush-steppe ecosystem to provide information for management actions.
Work with cooperators to investigate the interactions of environmental stress factors, patterns of climate change, wildlife and ecosystem responses, and management actions in the Great Basin.
Create a catalogue of habitat monitoring sites within Sheldon Refuge.
Rationale: The sagebrush-steppe landscape extends across large portions of 11 states in the Intermountain West, but very little of the sagebrush biome remains undisturbed or unaltered from its condition prior to European settlement. Therefore, many of the challenges facing Sheldon Refuge are also issues at the larger landscape scale across the Great Basin (e.g., western juniper encroachment, invasive species expansion, horse management, energy development). Partnership development with other Federal agencies, state agencies, local working groups, and concerned citizens is vital to implementing priority habitat restoration and adaptive management at a larger scale. Coordination among land managers is likely the only way conservation can be accomplished for species with shifting ranges as a result of potential climate change.

Objective 6e: Land Protection
Seek and develop partnerships for land protection efforts.
Strategies Applied to Achieve Objective
Develop partnerships to purchase Sheldon Refuge inholdings from willing sellers.
Consider outholding management options in partnership that are consistent with refuge policies and regulations.
Seek partnerships and evaluate opportunities for land exchanges in support habitat protection and refuge purposes.
Rationale: The Service is responsible for managing the fish and wildlife resources of Sheldon Refuge to benefit current and future generations of Americans. The Service does not, however, own nor have management authority over all of the land within the administrative boundary of Sheldon Refuge. As such, activities on private lands can affect resources on adjacent refuge habitats. Land acquisition and exchange are habitat protection methods that aid the Service in achieving its management objectives (i.e., recovery, restoration, enhancement) for species where habitat loss or degradation is a major cause of decline or where buffers are needed to protect sensitive areas. Partnerships with inholding owners could accomplish several habitat goals, such as invasive species control, fire suppression, or habitat improvements. Inholding development also has the potential to increase Service management costs due to expenses for surveys or fencing, or result in degradation of conservation value for surrounding lands.

Photo 2.12 Development of private inholdings indirectly affects the surrounding area of Sheldon Refuge (Photo Gail Collins).

2.2.7 Goal 7. Provide an active fire management program.

Objective 7a: Fire Protection
Conduct fire management for the protection of life, property, and the enhancement of Sheldon Refuge resources.
Strategies Applied to Achieve Objective
Maintain a fire suppression program capable of performing aggressive initial and extended attack on natural fires.
Use risk evaluation processes to determine most efficient, safe, and cost-effective fire response.
Review, update, and execute cooperative fire suppression agreements with interagency cooperators.
Maintain public safety, protect property, and create defensible space around structures and other important resources by removing vegetation through prescribed burning, mowing, thinning, or other methods.
Develop fuel breaks using past burn locations, riparian zones, age breaks with vegetation, and natural fire as wildfire management allows.
In addition to other methods, use mechanical means (e.g., cutting and mowing) to develop fuel breaks.
Complete an MRA to determine what activities and equipment generally prohibited will be appropriate for fire suppression within proposed wilderness and wilderness study areas (WSAs).
Rationale: Although a natural process that shaped Sheldon Refuge ecosystem, natural fire can be a threat to the safety of the public, and natural and cultural resources, as well as the continued existence of the present ecosystem. The historical natural fire regime has been altered by human influences (e.g., fire suppression, historical cattle grazing, non-native invasive species, and development). In some areas characteristic fire-return intervals are now much longer as a result of fire suppression and the loss of fine fuels to livestock grazing. The introduction of livestock grazing and exclusion of natural fire have contributed to expansion and density of juniper and big sagebrush. Without natural disturbance, much of the sagebrush-steppe is in a late seral stage. Natural fire now has the potential to burn more intensely, more

rapidly, and over larger areas than if overgrazing and continued fire suppression had not occurred—making fire management more difficult. Under some circumstances, these sorts of natural fires can completely eliminate an existing native plant community. Fires can foster the spread and density of unwanted, non-native invasive species, primarily cheatgrass, which further alters the natural fire regime. Having adequate fire suppression resources available to contain and extinguish natural fires before they become large and burn under undesirable conditions is critical to the long-term preservation of the natural, cultural, and native biological resources of Sheldon Refuge.

In a wildfire emergency involving the health and safety of people, we may authorize the use of motorized vehicles and equipment, mechanical transport, or aircraft without conducting the usual MRA. Authorizations are typically requested on a case-by-case basis as each emergency arises. However, conducting an MRA to identify and approve in advance the circumstances under which certain vehicles, equipment, mechanical transport, or aircraft will be authorized could avoid dangerous delays and confusion during wildfire emergencies.

Meeting Objective 7a includes natural and prescribed fire strategies under habitat management Objectives 2a, 2b, 3a, 3d, 4a, 4b, 4c, 5a, and 6c.

Objective 7b: Emergency Stabilization and Rehabilitation
Implement emergency stabilization and rehabilitation of fire and fire suppression impacts.
Strategies Applied to Achieve Objective
Use heavy equipment only on existing roads and routes except where necessary for the protection of life or property.
Implement emergency stabilization and rehabilitation actions following fires causing major adverse impacts, including soil stabilization, cultural resource inventory and protection, non-native species control, native grass and shrub seeding and planting, grazing control, and effectiveness monitoring.
Coordinate closely with fire teams during and after large fire events to ensure Sheldon Refuge priorities are incorporated into stabilization and rehabilitation plans.
Use native, site-appropriate seed genetically similar to plants within Sheldon Refuge for stabilization and rehabilitation activities. Non-native seed may be used in limited circumstances for small areas, when obtaining native seed in not possible or where the likelihood of native seed germination and establishment is not likely to meet habitat management objectives.
Work with partners and cooperating agencies to develop seed sources.
Rationale: Fires that burn outside the historical range of intensity, size, severity, and frequency could threaten native plant communities, facilities, and cultural resources on Sheldon Refuge. Associated fire suppression activities further contribute to resource damage. Utilizing appropriate emergency stabilization and rehabilitation techniques following a fire is critical to reduce long-term negative effects of fire and fire suppression. Service policy to maintain biological integrity, diversity, and environmental health directs that we use native seed sources for ecological restoration, which is also consistent with managing for natural wilderness character. However, we expect that the use of non-native seed under specific and limited circumstances may be necessary to meet our habitat objectives; however, we will maintain the management priority to use native seed whenever possible—especially for large-scale rehabilitation efforts and within proposed wilderness.

Photo 2.13 Aerial seeding is one technique to give native plants an edge over invasive weeds after a fire.

2.2.8 Goal 8. Provide visitors of diverse interests and abilities with opportunities to experience a variety of quality wildlife-dependent recreational and interpretive activities on vast, rugged, and remote high desert landscapes. These experiences will enhance visitors' understanding of and appreciation for the unique natural and cultural resources conserved by Sheldon National Wildlife Refuge and the National Wildlife Refuge System.

Objective 8a: Recreational Hunting (Waterfowl, Upland Birds, and Big Game)
In coordination with NDOW, annually review and set hunting harvest regulations that provide high-quality recreation opportunities.
Strategies Applied to Achieve Objective
Continue to coordinate with NDOW to set tag limits and conduct surveys to monitor population trends for big game, waterfowl, and upland game birds.
Rationale: Hunting is a very popular activity and a priority, compatible, wildlife-dependent public use within Sheldon Refuge. Hunting within Sheldon Refuge is managed to emphasize the quality of the recreational experience (as defined by Service policy) rather than maximize harvest. Season dates, bag limits, and number of harvest tags for mule deer, pronghorn, California bighorn sheep, and Greater sage-grouse, are managed by the State of Nevada in coordination with Sheldon Refuge staff. Chukar and California quail harvest is allowed, per State regulation, in all areas open to hunting while waterfowl hunting is allowed in only a few areas on Sheldon Refuge. Because hunting activities are managed cooperatively with the State of Nevada, ongoing coordination is required to ensure that hunter numbers and restrictions are consistent with Sheldon Refuge purposes, biological goals and objectives, and standards for recreation quality. Wildlife species such as coyote, bobcat, or mountain lion may be utilized for sport hunting or trapping within a national wildlife refuge (50 CFR 31). However, the populations and wildlife requirements for

these species have not been determined, and existing data are insufficient to determine what level of sport hunting or trapping, if any, would be compatible with the mission of the Refuge System and the purposes for Sheldon Refuge. We anticipate information gathered to meet Objective 6b will be sufficient to make such a compatibility determination in the future.

Objective 8b: Cold-water Recreational Fisheries (see Figure 5.1)

Manage cold-water fisheries consistent with Service policy and habitat management objectives to maintain high-quality semi-primitive recreation opportunities.

Strategies Applied to Achieve Objective

Within five years of the final decision for the CCP, develop a cold-water fisheries plan.

Maintain Lahontan cutthroat trout in Catnip Reservoir.

Replace rainbow trout with Lahontan cutthroat, Alvord cutthroat, or redband trout in Big Spring Reservoir.

Replace non-native trout species in Virgin Creek with regionally indigenous trout fishery.

Rationale: Fishing is a priority, compatible, wildlife-dependent public use on Sheldon Refuge. Historically, management of cold-water fish on Sheldon Refuge has been conducted by NDOW with minimal involvement by refuge staff. NDOW has proposed to replace the current Lahontan cutthroat trout population in Catnip Reservoir (Independence and Pilot Peak strain Lahontan cutthroat trout) with the Quinn River/Blackrock strain of Lahontan cutthroat trout. The Quinn/River Blackrock strain is a rare strain that is native to the Quinn River and Blackrock watersheds in northwest Nevada. Currently, there are only a few remaining populations of this strain existing in approximately five streams located just east of Sheldon Refuge. The overall population size of this strain is fairly low and thus, ongoing recovery efforts are complicated. It will be beneficial to have a large, stable population of this strain in the event other populations are compromised. Once this population of Lahontan cutthroat trout is established, NDOW will capture juvenile trout and transport them to recovery streams as needed.

Lahontan cutthroat trout in Catnip Reservoir are outside the historical range of Lahontan cutthroat trout and are managed consistently with a special rule under Section 4(d) of the Endangered Species Act, which authorizes the taking of these trout in accordance with state law. This enables the public to harvest trout from Catnip Reservoir under a state fishing license and researchers to collect trout under a state scientific collection permit.

We will conduct periodic restocking in cooperation with NDOW to maintain recreation fishing opportunities at Big Spring Reservoir and to avoid hybridization by stocking a single species or strain. However a put-and-take stocking program for Big Spring Reservoir would not be consistent with Service policies. Sheldon Refuge will continue to consult with NDOW to determine the appropriate cold-water fishery to retain at Catnip and Big Spring reservoirs.

Photo 2.14 When water is available, Big Spring Reservoir and Campground are popular destinations for Nevada anglers.

Objective 8c: Warm-Water Recreational Fisheries
Provide opportunity for high-quality warm-water fishing at Dufurrena Ponds 19 and 20 and McGee Pond consistent with habitat management objectives.
Strategies Applied to Achieve Objective
Maintain artificial ponds and facilities to allow for a recreational warm-water fishing opportunity (see also Objective 3d).
Establish a kiosk and/or brochure to educate the public about native desert fishes and invertebrates, and risks associated with spreading exotic species.
Rationale: Dufurrena Ponds 19 and 20 and McGee Pond are extremely popular with northern Nevada anglers. These ponds provide opportunities to catch non-native warm-water species such as large-mouth bass, white crappie, pumpkinseed sunfish, and yellow perch. The fish populations in these ponds are currently isolated from the Thousand Creek/Virgin Creek system, and do not require regular restocking by NDOW. These populations can be allowed to remain under Service policy.

Objective 8d: Wildlife Observation and Photography
Within five years of the final decision for the CCP, prepare and implement a visitor services plan that addresses refuge public uses and facilities, including facilities for wildlife observation and photography.
Strategies Applied to Achieve Objective
Publish and periodically update a general information brochure for Sheldon Refuge.
Develop a site plan for the Virgin Valley and Highway 140 focus area.
Develop educational brochure to provide self-guided observation opportunities.
Develop at least one interpretive trail with wildlife observation decks and other opportunities.
Implement seasonal area closures for sensitive species and habitat protection.
Develop off-refuge wildlife viewing opportunities (e.g., remote web-based cameras, web postings of Sheldon Refuge wildlife projects).
Rationale: Most public use within Sheldon Refuge focuses on hunting, fishing, and rock collecting—similar to public use of surrounding public lands. Refuge staff have noted that relatively few visitors understand the mission of the Service or appreciate the differences between the purposes for Sheldon

Refuge and those of surrounding BLM lands. The development of wildlife observation and photography opportunities and related environmental interpretation will bring visitor attention to these differences and promote compatible wildlife-dependent recreation opportunities, which are lacking not only within Sheldon Refuge, but throughout the region as well. The addition of observation decks and trails in specific locations will enhance the public's opportunity to see key representative species; however, other visitors may feel that these physical improvements are not necessary and could potentially take away from the overall primitive recreational experience. In addition, these improvements have the potential to affect wildlife behavior and can be detrimental to some species.

Objective 8e: Environmental Education
Within five years of the final decision for the CCP, develop volunteer and partner support to promote an outdoor education program.
Strategies Applied to Achieve Objective
Use volunteer support and partnerships to develop outdoor education curriculum and programs to support local youth education opportunities.
Seek partnerships with non-profit agencies to provide an environmental education coordinator.
Rationale: Environmental education has been an underutilized program at Sheldon Refuge; however, it is a priority, wildlife-dependent public use under the National Wildlife Refuge System Administration Act, as amended, and a key mechanism to establish support for Sheldon Refuge. Through on-site programs demonstrating wildlife needs and requirements, visitors will learn how to practice proper wildlife viewing etiquette and the importance of our management actions in maintaining wildlife populations. Off-site education curriculum and programs could build a connection with local and remote schools.

Objective 8f: Visitor Facilities (see Figure 5.1)
Within five years of the final decision for the CCP, develop a site plan to identify public facilities and infrastructure that will improve visitor services.
Strategies Applied to Achieve Objective
Develop a site plan for the Virgin Valley and Highway 140 focus area that improves the visitor experience.
Relocate and reconstruct Sheldon Refuge visitor contact station from Dufurrena to Highway 140. Install additional kiosks, trails, and interpretive sites if determined to be needed.
Install additional kiosks, trails, and interpretive sites if determined to be needed.
Rationale: The CCP's overall interpretive philosophy strategy for the Sheldon Refuge is to maintain the "untouched" wild nature of Sheldon Refuge and limit signage and interpretation to preserve that character. At present, overall interpretive use is low, so impact is also presumed to be low. However, there is opportunity to design an environmental program that fosters recreation/education opportunities for the public, and long-term understanding of the National Wildlife Refuge System and the importance of conservation. Currently, the main visitor contact is at the Sheldon Refuge Office (Dufurrena). Replacement of this facility with a Refuge Headquarters Office and visitor contact station may better serve refuge visitors and motorists on Highway 140 while providing education and interpretation about the Sheldon Refuge. Also, a more focused visitor contact presence could mitigate some visitation issues with additional orientation potentially being performed by volunteers, partners, or other agencies.

Objective 8g: Public Participation and Support
Foster partnerships and develop public participation opportunities.
Strategies Applied to Achieve Objective
Increase recruitment of volunteers and implement additional volunteer projects.

Develop additional facilities to support resident volunteers and volunteer projects.
Promote development of a "coalition of partners" to help meet Sheldon Refuge conservation goals.
Develop a volunteer cadre and/or provide additional Sheldon Refuge staff to facilitate public outreach.
Rationale: Sheldon Refuge does not currently have an officially recognized Friends Group but is working to establish a coalition of partners to include a variety of non-profit organizations. The formation of a Sheldon Friends Group will benefit Sheldon Refuge through advocacy, volunteerism, contributions to local economies, and direct links to surrounding communities as well as regional and national associations. Currently there are limited facilities available, but there may be additional opportunities to provide housing by improving existing and developing new facilities (e.g., trailer pads, hookups) for camp hosts and other volunteers. In addition, increased recruitment efforts at schools and universities, and among conservation groups, as well as general postings on the Sheldon Refuge web site and on www.volunteer.gov, may generate additional interest.

Objective 8h: Developed Camping (see Figure 5.1)
Provide developed camping opportunities at the Virgin Valley Campground to support wildlife-dependent public uses.
Strategies Applied to Achieve Objective
Define and post the Virgin Valley Campground boundary, and designate and physically define campsites.
Raise quality standards at Virgin Valley Campground and convert to a fee campground.
Develop interpretive signs for the public.
Rationale: While camping is not a priority wildlife-dependent public use on Sheldon Refuge, as defined in the Refuge Improvement Act, it does directly support priority wildlife-dependent uses such as hunting, fishing, wildlife observation, and photography. Recent increased use of the Virgin Valley Campground is attributed to visitation at neighboring private opal mines. During peak seasons, overcrowding and user conflicts are of concern, as well as overflow into areas immediately adjacent to the campground resulting in further environmental impacts. For example, the riffle beetle, a rare, endemic invertebrate, inhabits the outfall of the hot springs pool that terminates in McGee Pond several yards away. Additionally, exotic, non-native species have been introduced by the public into the springs including guppies, bullfrogs (both adults and tadpoles), and warm-water fish. Service policy provides guidance to protect habitat, cultural resources, and compatible wildlife related recreation. As popularity increases, it is essential to effectively manage this area to ensure that the appropriate information is relayed to visitors and that camping remains a high-quality experience (as defined by Service policy) for visitors participating in wildlife-dependent recreational uses. Campground improvements to define and designate campsites will eliminate visitor confusion, reduce impacts to vegetation and historic resources, and improve law enforcement consistency. Campsite registration and fees for overnight use will improve the level of maintenance for existing facilities, and enhance visitor education and outreach through volunteer campground hosts. A campsite fee structure based on length of stay is expected to eliminate site competition, but maintain opportunities for long-term use for visitors willing to pay the higher fees. Implementation of strategies for public use of historical structures included under Objective 10a will also provide opportunity for developing overnight public use within the Refuge.

Objective 8i: Semi-primitive and Primitive Campgrounds (see Figure 5.1)
Provide semi-primitive and primitive-vehicle-accessible camping opportunities at designated sites in support of wildlife-dependent public uses.

Strategies Applied to Achieve Objective
Delineate campground boundaries to eliminate sprawl.
Develop additional amenities at Big Spring and Catnip Reservoir campgrounds and convert to fee campgrounds.
Relocate up to nine campgrounds to minimize impacts to sensitive riparian habitats and cultural resources (see also strategy for Objectives 3a and 3b).
Rationale: Currently, there are five semi-primitive and seven primitive campgrounds designated on Sheldon Refuge; however, these campgrounds have no clear boundaries and individual campsites have no formal delineation. Additionally, refuge camping areas lack natural barriers that limit vehicle traffic, posing disturbance threats to sensitive riparian areas and cultural sites. Vegetation and cultural resources are most vulnerable to the impacts of undefined camping. The physical impacts of camping can be unsightly and are inconsistent with the natural setting desired on Sheldon Refuge. The majority of scoping comments received were in support of moving campgrounds out of sensitive areas and providing enhanced facilities at the developed Virgin Valley Campground.

Objective 8j: Primitive Camping
Provide opportunities for permit-only primitive backcountry camping in support of wildlife-dependent public uses and to maintain primitive character and outstanding opportunities for solitude.
Strategies Applied to Achieve Objective
Require Special Use Permits for all overnight use outside designated campgrounds.
Increase public awareness of primitive backcountry camping opportunities and natural features to minimize pressure on current developed and semi-primitive campgrounds.
Monitor number of backcountry permits issued and develop more comprehensive regulations if use exceeds appropriate thresholds for solitude (which will be established though monitoring of existing use and visitor surveys).
Rationale: At present, permit-only primitive backcountry camping is considered underutilized, and the program could be further developed to alleviate pressure on existing developed, semi-primitive, and primitive campgrounds. This will provide visitors with a sense of solitude and an enhanced appreciation for the vast landscape. Backcountry camping is consistent with wilderness policy and established WSAs on Sheldon Refuge, and provides a compatible camping alternative in support of wildlife-dependent public uses. Overnight backcountry use will be maintained at a low level that does not cause readily apparent environmental impact and preserves outstanding opportunities for solitude.

Objective 8k: Horseback Riding
Provide horseback riding opportunity in support of wildlife-dependent public uses.
Strategies Applied to Achieve Objective
Allow horseback riding throughout Sheldon Refuge under current regulations.
Allow horseback access to the backcountry for overnight use outside of established campgrounds.
Monitor use by horseback riders and develop more comprehensive regulations if use increases.
Rationale: Recreational horseback riding is not considered a wildlife-dependent public use; however, it does support priority wildlife-dependent uses such as hunting and wildlife observation. Other than travel on foot, horseback riding is the only form of non-mechanized transportation into Sheldon Refuge's wilderness backcountry. Horseback riding on Sheldon Refuge has historically occurred in small numbers, and estimates of current refuge use from incidental observation are less than 10 horseback groups per year. The current level of use is believed to have very little impact on refuge habitats. If monitoring determines

that there are impacts related to use of springs, introduction or spread of noxious weeds, or conflict with other public uses is occurring, Sheldon Refuge will establish thresholds for impacts from horseback riding and regulate as necessary to maintain a compatible level of use.

Objective 8l: Rock Collecting
Provide opportunities for rock collecting which are compatible with refuge purposes, goals, and other public uses.
Strategies Applied to Achieve Objective
Continue to allow the surface collection and removal of up to seven pounds of rock per person, per day.
Develop outreach materials to educate the public about appropriate rocks for collection, acceptable collection methods, and potential conflicts with other Federal regulations.
Increase law enforcement to maintain fewer than five violations related to rock collecting per year.
Rationale: While not a priority, wildlife-dependent public use, collecting rocks and minerals on Sheldon Refuge is a pre-existing compatible use that has become popular with some visitors and that Sheldon Refuge has the authority to authorize. The public can surface-collect up to seven pounds of material per day, which includes petrified wood, opal, and agate. Refuge brochures currently promote this activity and a compatibility determination was prepared and last updated in 1999. However, rock collecting can cause conflict with the Archaeological Resources Protection Act and the National Historic Preservation Act (NHPA) enforcement because individuals engaged in rock collecting, either knowingly or unknowingly, may also illegally collect cultural or historic resources (e.g., arrowheads and fossils). While violations associated with rock collecting are suspected to occur on Sheldon Refuge, it is unknown how many violations occur or if a sufficient number of violations are inadvertent or unintentional that violations could effectively be reduced through additional regulation or permit. The CCP's adaptive management strategy will more accurately document where and why violations occur and adjust refuge outreach efforts accordingly.

Objective 8m: Vehicle Access
Allow off-highway vehicle (OHV) access in support of wildlife-dependent public uses on roads open to vehicle traffic.
Strategies Applied to Achieve Objective
Allow OHVs refuge-wide on roads designated open to vehicle traffic.
Require OHV operators without a certificate of operation under Nevada Revised Statute 490.080 to register their vehicle(s) with Sheldon Refuge and limit use to only wildlife-dependent recreation on roads designated open to public use of vehicles.
Rationale: OHV use is an accepted mode of transportation on roads only open to vehicle traffic in support of compatible wildlife-dependent public use; recreational use of these vehicles is not. However, current limitations and restrictions on the use of OHVs on Sheldon Refuge are neither well-communicated nor enforced. In addition, illegal OHV use within proposed wilderness areas and WSAs is a management concern as is damage caused to roads and adjacent habitats during wet conditions. Illegal off-road travel to retrieve game and to access remote areas for recreational use is also a growing concern because of increasing damage to fragile habitats in the High Desert. Reducing the number of OHV violations and damage to natural resources is necessary to ensure the use remains compatible with the purposes for Sheldon Refuge and the Wilderness Act. For three reasons—the remoteness and rugged terrain of Sheldon Refuge, the small number of law enforcement officers, and the inability to positively identify individual OHVs for law enforcement purposes—requiring OHV users obtain Special Use Permits is one of the only practical ways to both inform the public and effectively enforce existing regulations.

Objective 8n: Transportation Management
Within three to five years of the final decision for the CCP, develop and adopt a transportation management plan (see also Figure 2.1). **Public Access and Transportation:** Manage a network of roads, routes, and trails to provide access for compatible wildlife-dependent public uses consistent with recognized Recreation Opportunity Spectrum Setting descriptions for Primitive, Semi-Primitive Nonmotorized, Semi-Primitive Motorized, Roaded Natural, and Rural categories (see Appendix L). **Other Access and Transportation:** For roads and routes currently closed or not designated open to general public use, authorize access and transportation for administrative use necessary to implement management goals and objectives and for special uses such as mining claims, mill site claims, private lands, power line rights-of-way, and other non-public uses on a case-by-case basis by Special Use Permit. Special Use Permits will determine reasonable routes, modes, and frequency for transportation consistent with applicable laws, regulations, and policies.
Strategies Applied to Achieve Objective
Develop a brochure with a detailed transportation map and road policy.
Implement seasonal road closures on routes open to public travel to reduce soil erosion and wildlife impacts.
Designate vehicle routes open to public use that are determined to have minimal or no impacts to wildlife and wildlife habitat or impacts that can be minimized through management actions such as re-routing, placement of culverts, and construction of waterbars, and that also provide access determined necessary to support wildlife-dependent public uses (approximately 300 miles, plus an additional 25 miles that would be re-opened contingent upon wilderness proposal). Designate other routes necessary to support Sheldon Refuge operation and administrative needs (see Figure 2.1).
Convert Kinney Camp access route to a pedestrian trail to support environmental interpretation and wildlife observation (see Figure 2.1).
Identify and place signs indicating roads and routes open to public use and the use of mechanized equipment and vehicles. Inform Sheldon Refuge visitors that all unmarked roads and routes are closed to public entry and use.
Increase signage and develop an auto tour route adjacent to Highway 140.
Increase the frequency of maintenance on improved roads.
Rehabilitate and naturalize closed, abandoned, or illegal roads and routes using methods that require minimal disturbances over the shortest distance necessary.
Rationale: Vehicle access is important to support wildlife-dependent public uses on Sheldon Refuge, but a large number of routes have appeared over time as a result of mineral prospecting, ranching, fire suppression, and trespass. In addition, there is a need to allow access and transportation along other existing roads and routes for valid existing rights and uses. Sheldon Refuge is interested in providing for a variety of visitor experiences and access means, including vehicular, horseback, and pedestrian access. At present, there are several hundred miles of roads on Sheldon Refuge used by motorized vehicles, many of which are duplicative (i.e., they lead to the same destination), routed through sensitive ecological or cultural areas, or were not specifically opened for public uses and consequently have been closed. Within the Virgin Valley area alone, more than 120 miles of routes have been established through prospecting and mining. These routes are located in highly erodible soils, often cross seasonal drainages at unsuitable locations or without adequate construction, and provide little or no access necessary for wildlife-dependent public uses. Consequently, authorizing use of these routes on a case-by-case basis through a Special Use Permit may be appropriate, but there is no need to designate these routes open for general public use. Road status (open, closed, or administrative) should be based on a combination of administrative needs (including fire protection); habitat, wildlife, and wilderness concerns; cultural and historical resource

protection; safety considerations; current public use program and anticipated changes; and maintenance capability. Roads open to vehicular traffic should be classified by vehicle capability, seasonal conditions, and long-term maintenance standards and needs.

A comprehensive evaluation of the road network was completed for the entire network of roads and motorized routes throughout Sheldon Refuge. Each route was evaluated using three sets of criteria:

1) Public Use criteria included associated wildlife-dependent uses; access to specific destinations; the presence of alternate routes in close proximity or to the same destination; conflicts with other uses; law enforcement difficulties and issues associated with vehicle access; natural appearance and revegetation of the route; and hazards to public safety from current route condition.

2) Resource Impact criteria received more weight in the evaluation than did Public Use criteria and included erosion and other soil impacts; damage to riparian habitats and other rare, unique or sensitive habitats (see Goal 4); disruption, disturbance, or harassment of wildlife; and impacts or disturbance to known sites of cultural, historic, or religious importance. The evaluation included impacts from use of the route itself and from activities associated with use of the route.

3) Access and Transportation criteria included function of the route as a collector for other routes; as a route connecting to other existing roads outside the refuge; and as a route providing access to trailheads or key points of access to non-motorized portions of the refuge.

The final determination for vehicle routes included only those routes that had no net adverse impact or only slightly net adverse impacts that could be acceptably reduced through intensive management actions such as route realignment; culverts, waterbars, or other water control structures; or seasonal closure.

Photo 2.15 The majority of vehicle routes within Sheldon Refuge are primitive and not suitable for two-wheel drive (Photo Aaron Collins).

Objective 8o: Commercial Outfitting and Guiding
Within one year of the final decision for the CCP, develop and implement a Commercial Hunting Outfitter and Guide Operations Plan.
Strategies Applied to Achieve Objective
Review qualifications and issue five-year Special Use Permits for up to 10 commercial operators to guide and outfit hunters.
Rationale: Commercial hunting guides often provide opportunities for hunters who would not be able to participate otherwise, and these guides increase the probability that less experienced hunters can enjoy a safe and successful opportunity which might be available only once in their lifetime. Sheldon Refuge encourages family oriented sport hunting consistent with promoting positive hunting values and hunter ethics. The hunting program at Sheldon Refuge emphasizes quality hunting experiences, which includes less crowding, less competition, fewer conflicts between hunters, relatively undisturbed wildlife, greater hunter safety, and less interference from or dependence on mechanized aspects of the sport. Commercial guiding activities authorized on refuge lands will contribute to these principles under established Special Use Permit conditions. Through a wilderness MRA, Sheldon Refuge has determined no more than 10 commercial guide operations will be needed to provide necessary services to the public. Due to the large proportion of lands currently proposed for wilderness designation, the maximum number of 10 permits will apply to the entire Sheldon Refuge. Guides will compete for five-year Special Use Permits through a prospectus system based upon determination of which submitted proposals best meet criteria established by the Service and Sheldon Refuge, and which provide the best quality services to the public. Permits for guides in good standing could be renewed for one additional five-year period without competition.

Objective 8p: Administrative Facilities
Within five years of the final decision for the CCP, develop and implement a facilities plan to identify buildings and structures necessary to support refuge operations and enhance visitor services.
Strategies Applied to Achieve Objective
Relocate Sheldon Refuge administrative offices to Highway 140.
Construct additional quarters and facilities to support increased staffing and volunteers necessary to implement the CCP.
Rationale: To fully implement the CCP, additional facilities will be necessary to accommodate more volunteers and increased staffing. The current administrative offices for the Sheldon Refuge are located in a small mobile home trailer and are barely adequate for year-round operations. Maintaining the existing facilities will require remodeling and is expected to become increasingly more expensive due to the type and age of the trailer. The most efficient and cost-effective option to meet all needs is to construct a new facility along Highway 140 to accommodate both administrative and public use needs.

Photo 2.16 The Sheldon Refuge Office cannot accommodate the visiting public and the necessary office space.

2.2.9 Goal 9. Protect and manage Sheldon National Wildlife Refuge Wilderness Study Areas to maintain wilderness character and values.

Objective 9a: Wilderness Study Areas
Manage WSAs to protect wilderness character.
Strategies Applied to Achieve Objective
Manage approximately 424,360 acres identified as WSAs and/or proposed wilderness area[4] for naturalness, wildness, and opportunities for solitude or primitive and unconfined recreation.
Determine the minimum administrative action necessary within the proposed wilderness areas and WSAs.
Implement management actions and activities consistent with final and approved minimum tool decisions and analyses for gathering of horses and burros; inventory, monitoring, and study of large mammals; removal of abandoned commercial livestock developments; restoration and rehabilitation of springs and playas; thinning and removal of expanding juniper; maintenance of guzzlers; and weed control (see Appendix G).
Rationale: As part of the wilderness review, the Service determined that 388,772 acres on Sheldon Refuge satisfy the minimum criteria for wilderness and merit further evaluation as WSAs. These WSAs were further evaluated to determine their suitability for wilderness designation as part of the CCP. The remaining 50,405 acres were not found to meet the minimum criteria but were previously proposed for wilderness designation. Service policy (see 610 FW 4) also directs that WSAs are to be managed so as to not adversely affect wilderness character until completion of the wilderness review and, if appropriate, action by Congress. In addition, those areas proposed in 1974 for designation as wilderness will continue to be managed as wilderness until further action by the President and/or Congress. If and when the President proposes to Congress that the WSAs recommended by the Service be designated as wilderness,

[4] Acreage figures that include proposed wilderness areas differ slightly from the 1974 proposal due to more precise mapping techniques used for calculations in the Sheldon Refuge CCP.

those proposed wilderness areas will be managed as wilderness in accordance with Service Policy 610 FW 1. Current Service policy for the management of proposed WSAs was completed after the 2001 MRA for juniper treatment within Sheldon Refuge. To ensure consistency with current policy, a minimum requirement decision and analysis including an MRA needs to be completed for management activities planned within these areas.

Objective 9b: Wilderness Recommendations
Identify and recommend areas suitable for wilderness designation.
Strategies Applied to Achieve Objective
Recommend approximately 341,495 acres for wilderness designation which best coincide with habitat management objectives and existing public uses (includes approximately 266,903 acres currently proposed, see Figure 2.2).
Rationale: Consistent with the Wilderness Stewardship Policy (610 FW 1), Sheldon Refuge conducted a wilderness inventory and study in association with development of this CCP. Based upon this inventory and study, Sheldon Refuge proposes 341,495 acres be recommended for wilderness designation. This recommendation is included as Appendix F. The Big Mountain, Sage Hen Hills, Gooch Table, Fish Creek Mountain, Rye Creek, Round Mountain, Catnip Mountain, Big Spring Table, Railroad Point, Alkali Peak, Hell Creek, Guano Creek, Massacre Rim Contiguous, Sheldon Contiguous Inholdings, Fish Creek Table-Little Catnip, Bateman, and Tenmile WSAs have been determined to be suitable for wilderness designation. These recommendations are preliminary administrative determinations that will receive further review and possible modification by the director of the USFWS, the Secretary of the Interior, and/or the president of the United States. Congress has reserved the authority to make final decisions on wilderness designation.

2.2.10 Goal 10. Protect and manage the prehistoric, historic, and paleontological resources of Sheldon Refuge to ensure present and future generations recognize the significance of the area's past.

Objective 10a: Historic Structures (see Figure 5.1)
Within 10 to 15 years of the final decision for the CCP, complete an inventory of historic structures and determine appropriate level of protection and preservation.
Strategies Applied to Achieve Objective
Maintain necessary law enforcement measures.
Develop a Cultural Resources Management Plan.
Record all historic structures as Sheldon Refuge facilities for the purposes of asset and property management, evaluating historic priority, and maintaining Federal compliance.
Inventory and protect all sites through the use of partnerships, rehabilitate two to three of the most important structures, interpret one site (e.g., Kinney Camp or Virgin Valley Ranch), and collect an oral history.
Collect new information on historic resources.
Make some structures (i.e., Little Sheldon Civilian Conservation Corps Overlook Cabin or Badger Mountain Work Cabin) available for overnight rental, improve other structures for Sheldon Refuge use, and collect an oral history.
Rationale: Most historic structures within Sheldon Refuge are associated with late nineteenth and early twentieth century homesteading and ranching, or the Civilian Conservation Corps (CCC) activities between 1935 and 1941 (see Table 5.1). Historic structures (with the exception of historic buildings at the Alkali

Ranch) have had initial basic evaluations and surveys, but detailed inventories and collection of historic data have not been completed. These sites contain wood, stone, or concrete buildings and structures, as well as buried historic artifact deposits. The effects of weather and vandalism on them are increasingly evident with the passage of time. Visitors value these sites and often visit them. The highest priority structures will be rehabilitated.

An untapped and important resource, which needs to be utilized as soon as possible, is the oral history, which can record information from long-time residents of the area and descendants of original settlers. With the continued passage of time, this rich history is forgotten or lost.

Both the Kinney Camp and Virgin Valley Ranch sites provide the best opportunities for interpretation. Both are relatively accessible to the public and could easily be incorporated into the auto tour route. The Virgin Valley Ranch is near wet meadow and riparian habitats and provides waterfowl and other wildlife viewing opportunities. Kinney Camp has several historic buildings and unique corral construction, with more opportunities for solitude and less evidence of modern developments, which help to recreate the historic setting for interpretation.

Photo 2.17 The historic Kinney Camp homestead is centrally located to other public uses within Sheldon Refuge.

Photo 2.18 The Overlook Cabin at the west entrance to Sheldon Refuge is representative of work done by the Civilian Conservation Corps.

Objective 10b: Interpretation of Prehistoric Cultural Resources
Use partnerships to opportunistically inventory, evaluate, stabilize, and interpret prehistoric cultural resources.
Strategies Applied to Achieve Objective
Conduct inventory, evaluation, and protection for Federal compliance at active refuge management sites.
Develop and conduct a systematic inventory, evaluation, and protection plan for approximately 10% of Sheldon Refuge.
Interpret and educate the public on prehistoric resources, emphasizing first peoples, prehistoric land, and resource use.
Establish inventory and research program with universities and/or scientific organizations.
Exchange information and coordinate planning with Tribes, historical institutions, and other preservation partners for research, interpretation, and protection of cultural resources.
Rationale: Sheldon Refuge is rich with prehistoric cultural sites. They include rock art, lithic scatters, material quarries, resource utilization sites, and village sites. The two largest threats to archaeological sites at Sheldon Refuge are feral horses and disturbance associated with public use. Looting of archaeological and historic sites has been a serious problem for decades on Sheldon Refuge. To address these challenges the first need is to inventory and research a sample of the archaeological sites of Sheldon Refuge, particularly at places that sustain high use by the public or feral horses. Once the information potential and specific management needs of the resources have been identified, an implementation plan can be prepared to recover scientific data, stabilize erosion, protect cultural information, and interpret cultural resources for the public. Due to current staffing levels and higher priorities for any additional future staffing and programs, accomplishment of the strategies identified for this objective will be primarily through partnerships and agreements with other agencies and organizations.

Photo 2.19 Petroglyphs scattered throughout Sheldon Refuge remind visitors of the region's earliest inhabitants.

Objective 10c: Paleontological Resources
Use partnerships to opportunistically inventory, evaluate, protect, and research paleontological resources.
Strategies Applied to Achieve Objective
Provide protection measures to ensure that important paleontological resources are not adversely impacted.
Establish inventory and research program with universities or scientific organizations to identify, map, and research paleontological resources.
Inventory and assess paleontological collections.
Rationale: Preliminary studies carried out in the 1980s identified rich and diverse paleontological resources on Sheldon Refuge, primarily in the lacustrine deposits of Virgin Valley and the Thousand Creek basin. Limited excavation and collection of specimens by several universities occurred during this time. There was also a large expedition in the early 1900s. Since then little information has been gathered to identify and research the extent and importance of these resources.

Objective 10d: Partnerships
Develop partnerships opportunistically to help document and record cultural resources.
Strategies Applied to Achieve Objective
Establish inventory and research program with university or scientific programs.
Work with local historical societies to research historic records and capture oral histories.
Inventory and assess cultural resource collections.
Initiate projects similar to Passport in Time projects conducted on National Forests.
Rationale: Limited funding of the cultural resources program on Sheldon Refuge has, at present, mainly kept the program at a very basic level of site identification and compliance with Section 106 of the NHPA during active Refuge management projects. Only a small portion of Sheldon Refuge has been inventoried extensively and had sites recorded appropriately. Future increases in funding at Sheldon Refuge will be directed toward projects more directly related to the conservation of fish, wildlife, plants, and their habitats. Therefore, accomplishment of objectives for the protection and management of historic, prehistoric, and paleontological resources could realistically be accomplished through continued development of partnerships.

Objective 10e: Tribal Coordination and Consultation
Coordinate and consult with Tribes on natural and cultural resource protection.
Strategies Applied to Achieve Objective
Annually coordinate with staffs of Tribes.
Share cultural resource information between Tribes and Sheldon Refuge.
Establish Native American Graves Protection and Repatriation Act protocol and develop Memorandum of Understanding for handling inadvertent discoveries.
Coordinate with tribal cultural resource programs to identify and plan for management of significant sites.
Rationale: Although Sheldon Refuge has had direct consultation and meetings with the Northern Paiute Tribe in the past, it is important that communication and consultation become more regular and systematic on issues of shared interest. In partnership with local Tribes (e.g., Summit-Lake Paiute, Fort McDermott, Fort Bidwell, Burns-Paiute, and Cedarville Rancheria), Native American Graves Protection and Repatriation Act protocol and procedures for handling inadvertent discoveries of human remains, burial objects, and sacred objects need to be addressed.

2.2.11 Goal 11. Reduce illegal and unauthorized activities on Sheldon Refuge.

Objective 11a: Law Enforcement
Within five years of the final decision for the CCP, develop a Law Enforcement Plan.
Strategies Applied to Achieve Objective
Work with partners to develop educations materials to avoid illegal activities.
Increase both law enforcement patrols and regular staff presence to reduce unauthorized or illegal activities.
Provide training for staff to recognize and deal effectively with specialized violations.
Rationale: Illegal and unauthorized uses that occur on Sheldon Refuge presently include illegal OHV use, camping outside of designated areas, poaching, archaeological theft, vandalism, and theft of refuge signs. Illegal uses persist partly because of the lack of public knowledge and support, as well as limited law enforcement capability. Currently the Sheldon Refuge Manager also serves as a law enforcement officer, and one full-time officer is assigned to both Sheldon and Hart Mountain refuges. Due to the vast area to patrol, additional law enforcement is necessary for adequate coverage.

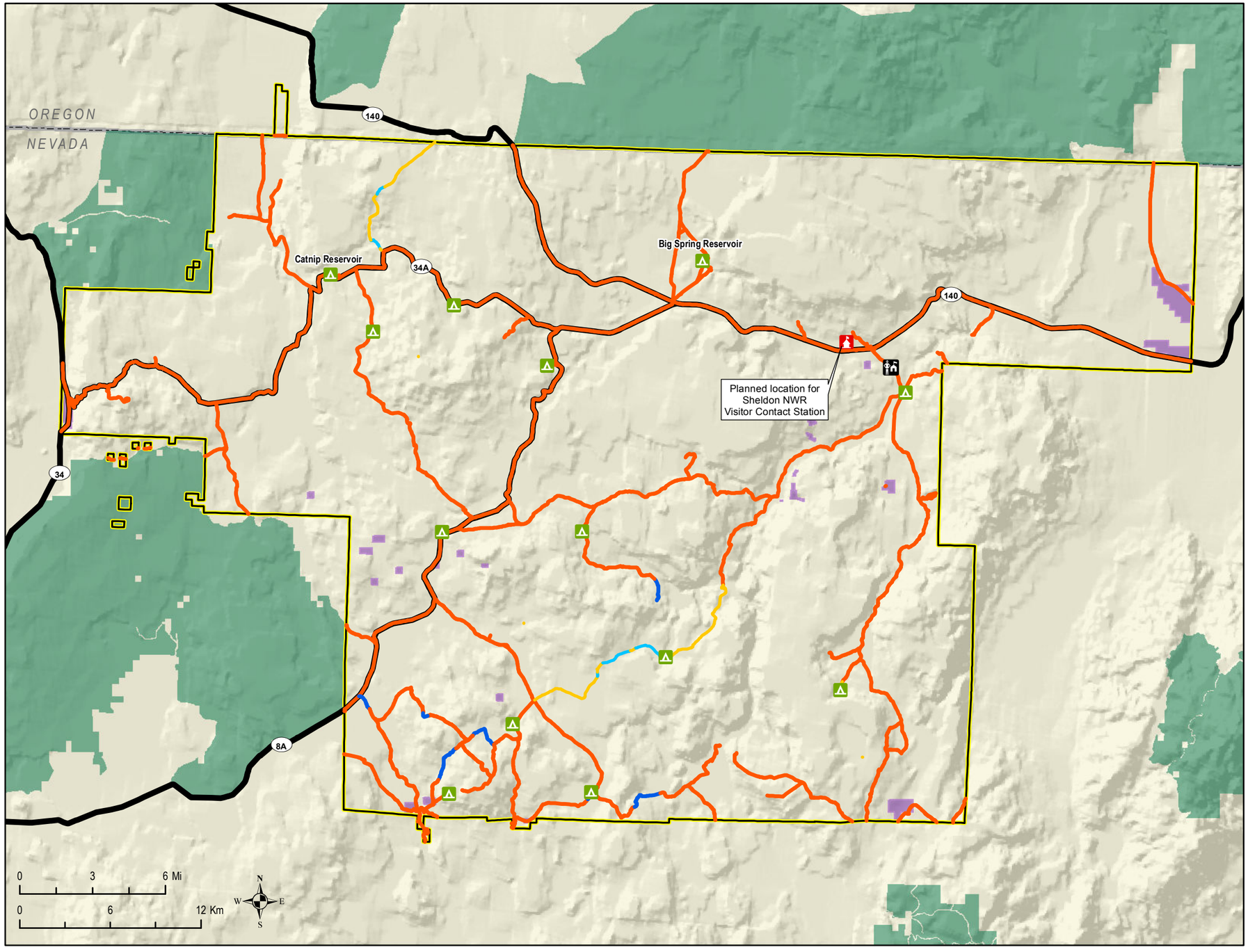
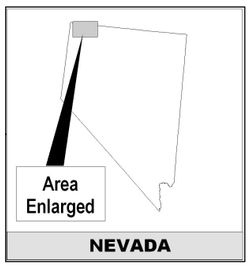


Figure 2.1
Public Vehicle Access for
Sheldon National Wildlife Refuge

LEGEND

- Approved Refuge Boundary
- Private Lands (Inholdings)
- BLM Wilderness Study Areas
- Refuge Headquarters
- Planned Visitor Contact Station
- Refuge Campgrounds
- Public Vehicle Routes
- Public Vehicle Routes (to remain closed pending wilderness designation)
- Rehabilitate or Relocate
- Rehabilitate or Relocate (to remain closed pending wilderness designation)
- Highways



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Portland, Oregon
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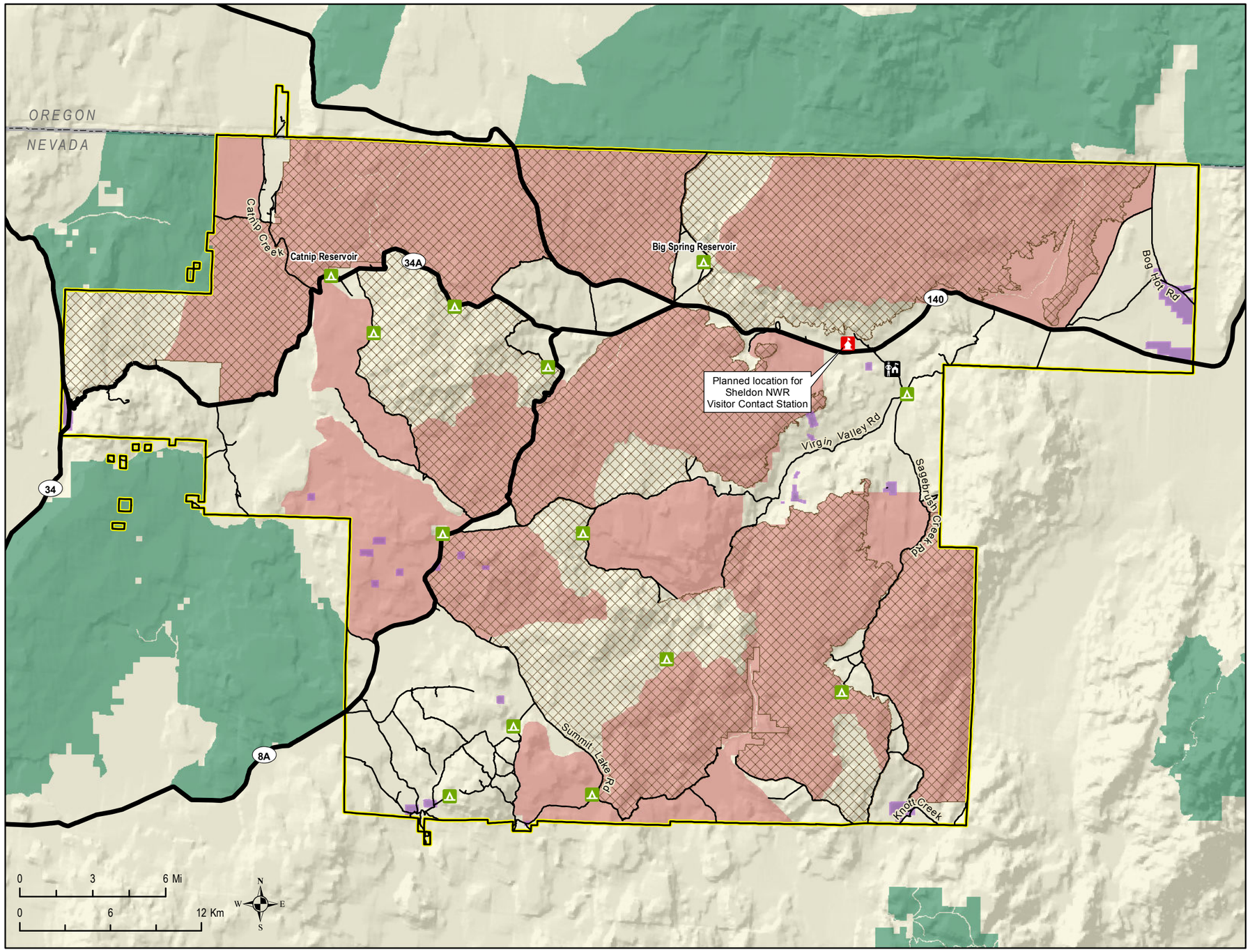
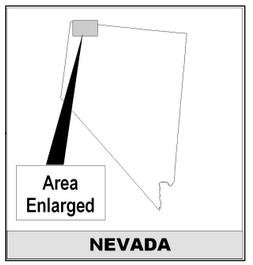


Figure 2.2
Wilderness Recommendations

LEGEND

- Approved Refuge Boundary
- Private Lands (Inholdings)
- Refuge Headquarters
- Planned Visitor Contact Station
- Refuge Campgrounds
- Current Proposed Wilderness Areas
- Recommended Wilderness Areas
- BLM Wilderness Study Areas
- Highways
- Existing Vehicle Routes



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Chapter 3. Physical Environment

3.1 Geographic and Ecosystem Setting

3.1.1 Great Basin Ecosystem

The Great Basin Ecosystem is defined by sagebrush-steppe, salt desert shrub, and pinyon-juniper woodland habitats and the various other fish and wildlife species which live within those habitats. This ecosystem encompasses a portion of the Columbia Basin Plateau in eastern Oregon and southern Idaho as well as the Great Basin Region extending from the Sierra Nevada Mountains in eastern California, across most of Nevada north of the Mojave Desert, to the Rocky Mountains in western Utah. The Great Basin Ecosystem, comprising three ecoregions—the Columbia Plateau, Great Basin, and Wyoming Basins—supports the majority of sagebrush in North America (Suring et al. 2005a).

The majority of Sheldon Refuge falls within the Great Basin, and secondly, Columbia Plateau ecoregions. Sheldon Refuge is dominated by expansive communities of sagebrush steppe. Approximately 111 million acres of the northern intermountain region in the United States are classified as true sagebrush steppe, which predominantly consists of a sagebrush shrub component with an understory of native bunchgrasses and forbs (West 1999). The sagebrush-steppe ecosystem now constitutes one of North America's most imperiled and neglected ecosystems (Dobkin and Sauder 2004; Mac et al. 1998; Noss and Peters 1995).

3.2 Climate

Variability is a natural part of the climate system and has occurred throughout the earth's history driven by complex interactions among the earth's solar orbit, atmospheric CO_2 concentrations, continental ice sheets, ocean circulation, and other factors (see summary by Inkley et al. 2004). However, it is widely accepted by the scientific community that the earth is now undergoing a period of rapid climate change at a rate that has the potential to result in abrupt changes in ecosystems and mass species extinctions (Inkley et al. 2004; USFWS 2008b). Increasing surface and water temperatures; rising sea-level; melting sea ice and glaciers; changing precipitation patterns; growing frequency and severity of storms; and increasing ocean acidification are among the many climate-driving changes observed to date (USFWS 2008b). In addition, climate change may magnify the influences of other threats to ecosystem conservation on national wildlife refuges, including habitat loss and fragmentation, changes in water quality and quantity, and increased transportation corridors (Scott et al. In Review). As summarized by Scott et al. (In Review), the current threats to the National Wildlife Refuge System potentially exacerbated by climate change include invasive non-native species, plant and animal disease, urbanization and increased economic pressure, altered hydrological regimes, sea level rise, extreme weather events, and regime shift (entire ecological communities transformed from historical conditions, either latitudinal or altitudinal).

Specific to the Great Basin, documented climate changes have occurred during the past 100 years, including 1) region-wide warming; 2) increase in precipitation; 3) decline in snow pack; and 4) earlier spring arrival (Chambers 2008). Region-wide warming, while widespread, has varied across the region (Wagner 2003). Minimum temperatures have increased more than maximum temperatures, and the variability in inter-annual temperatures has declined. As a result, the

probability of very warm years has increased and very cold years declined (Chambers 2008). Since the 1950s, annual precipitation across the Great Basin has increased 6%-16%. Variability between years has also increased, with a heightened probability of extreme high-precipitation years (Chambers 2008). Trends in the April 1st snow pack have been declining at most monitoring sites in the Great Basin. Elevation and mean winter temperature have a strong effect on snow pack, with the warmest sites exhibiting the largest losses (Chambers 2008). Finally, the timing of spring snowmelt-driven streamflow is now approximately 10 to 15 days earlier than in the mid-1900s, including an increase in variability between years in spring flow (Baldwin et al. 2003; Stewart et al. 2004).

Although future climate is impossible to accurately predict, the comparison of various climate models and extensive analysis has led to some generally accepted predictions for the next 100 years (see discussion by Inkley et al. 2004). The degree of future climate change will depend on the increase of CO2 by 2100 and will vary in the Great Basin due to large differences in topography (Chambers 2008). Warming is projected to increase between 2 and 5˚C (3.6 to 9˚F) over the next century for Western ranges (Cubashi et al. 2001). There is greater variability among models for projected precipitation changes (Inkley et al. 2004), and average projected changes across the West are near zero (Cubashi et al. 2001). However, losses in snow pack are likely to continue and even accelerate (Mote et al. 2005). Most watersheds in the Great Basin exhibit high natural variability in unregulated streamflow (Hurd et al. 1999), and this variability may increase (Chambers 2008). Climate trends that lead to changes in hydrology will have a large effect on wetlands and other shallow water bodies (Scott et al. In Review). One scenario for western stream flows are changes in the current seasonal proportionality of flows: increased winter flow; reduced and earlier spring peaks; and reduced summer and fall flows (Chambers 2008). Water resources in these arid regions are already in high demand and changes or decreases in water availability will exacerbate competition for water between wildlife, urban centers, agriculture (Hurd et al. 1999), and livestock. Plant invaders, including annual grasses (e.g., cheatgrass), perennial forbs, and woody species may be advantaged by higher levels of CO2. In addition, grazing by cattle on refuges in arid regions may exacerbate the effects of drought stress and aid in the spread of exotic species (Scott et al. In Review); grazing by feral horses and burros is likely to have similar impacts. Some suggest that grazing may also interact with climate-driven vegetation changes to further alter plant communities and wildlife habitat in these areas (Donahue 1999).

Naturally occurring climate cycles impact the life cycles and demographics of both individual wildlife species and certain relationships among species (see Kim et al. 2008). Potentially more important for ecosystems and wildlife than projected climate change are changes in variability and extremes (Inkley et al. 2004). Models predict more hot extremes and fewer cold extremes; reduced day and night temperature differences as nighttime temperatures raise more than daytime temperatures; decreased relative humidity; and increased heat indices (Brown et al. 2004; Inkley et al. 2004). These factors will likely extend fire seasons, with more fires occurring earlier and later than is currently typical, thereby increasing the total area burned in some regions (McKenzie et al. 2004). If climate change increases the variability and length of time for extreme fire weather, larger and more severe fires could be expected (Chambers 2008). The effect of unusually wet years on fuel accumulation will be especially important in dry, sparsely vegetated areas such as desert grass and shrublands (Kipfmueller and Swetnam 2000). In more arid portions of the Great Basin, the frequency and extent of fire is likely to be higher in years with better growing conditions (high fall, winter, and spring precipitation) and as a result of fuel accumulation the previous growing season (Westerling et al. 2006). Progressive invasion by cheatgrass, expansion of pinyon-juniper species, and increases in tree density are likely to result in increases in fire frequency and severity (Link et al.

2006; Miller et al. In Press). Infectious diseases and insect outbreaks could also increase under several different warming scenarios (Logan 2006), placing other species at risk.

As temperature and rainfall patterns change, some species will likely benefit and others may not (Inkley et al. 2004). For example, inhabitants of high elevation zones may experience shrinking habitats and local extinctions may occur among mammalian, avian, and butterfly species (Murphy and Weiss 1992); amphibians and reptiles in these areas may be at particular risk (see Inkley et al. 2004). Localized species which are limited in their distribution and do not migrate will also likely be some of the most highly impacted. For a sampling of species-specific examples see Epps et al. (2004), Beever et al. (2008), Kim et al. (2008), and Zakharov and Hellmann (2008). Of particular interest for Sheldon Refuge, simulations indicate that the potential range of big sagebrush (*Artemisia tridentata*), a dominant and vital species in the area, may shift northward in response to increases in the mean temperature of the coldest month accompanied by a significant contraction of its current range (Shafer et al. 2001). Others predict that the most shrubland losses in the United States will occur in the Great Basin, where the potential for increased precipitation will lead to the replacement of shrubs by savannas; savannas have been simulated to increase by more than 50% under several warm scenarios (Bachelet et al. 2001).

Overall, range shifts in plants are likely to depend upon factors including soil types, migratory pathways, seed dispersal mechanisms, and pollinator availability. Shifts by wildlife are likely dependent upon availability of migration corridors, suitable habitats, and concurrent movement of forage and prey. Further complicating these potential shifts will be other landscape changes such as roads, urban development, and habitat fragmentation, all of which can present significant barriers to species range shifts (Inkley et al. 2004).

3.3 Hydrology

3.3.1 Water Resources

Water resources within Sheldon Refuge are typical of the closed watersheds in the Great Basin—with no outlet to an ocean. Streams, ponds, and playas within these watersheds are intermittent and typically dry during the summer months. There are also numerous wetlands and springs within Sheldon Refuge. These water resources support wetland communities that make up a small fraction of the land area of Sheldon Refuge. Despite the small size they are crucial oasis for the majority of wildlife on Sheldon Refuge. Numerous artificial water resources have been created throughout Sheldon Refuge in the form of reservoirs, stock ponds, guzzlers, and pit reservoirs

Sheldon Refuge water supply is dependent on the accumulation of snow during the winter months. The size of the winter snowpack, and its persistence into the early summer, determines how much water will accumulate in playas and reservoirs and how much will flow through the creeks.

3.3.1.1 Streams/Creeks

In general streams at Sheldon Refuge are small, often less than 5 feet wide. Year-round flow is not common except in reaches near springs or areas where the water table is close to the ground surface. Badger Creek is the only stream system within Sheldon Refuge for which hydrologic data have been collected (USGS 2010a). These data were collected by the U.S. Geological Survey (USGS) between 1963 and 1973 and are probably characteristic of most streams within Sheldon Refuge. As shown in

Figure 3.1.A, surface water has been relatively common during snowmelt runoff, between March and June, but typically dry for the remainder of the year. Nearly 75% of the days for which flows in Badger Creek were above 0 cubic feet per second (cfs) occurred between March and June (Figure 3.1.B). Stream gage data collected at Mahogany Creek (USGS 2010b; Figure 3.2A), located just south of Sheldon Refuge, show a similar pattern for the percentage of days where stream flow exceeded 0 cfs with about 65% of all runoff occurring between March and July during snowmelt runoff (Figure 3.2.B).

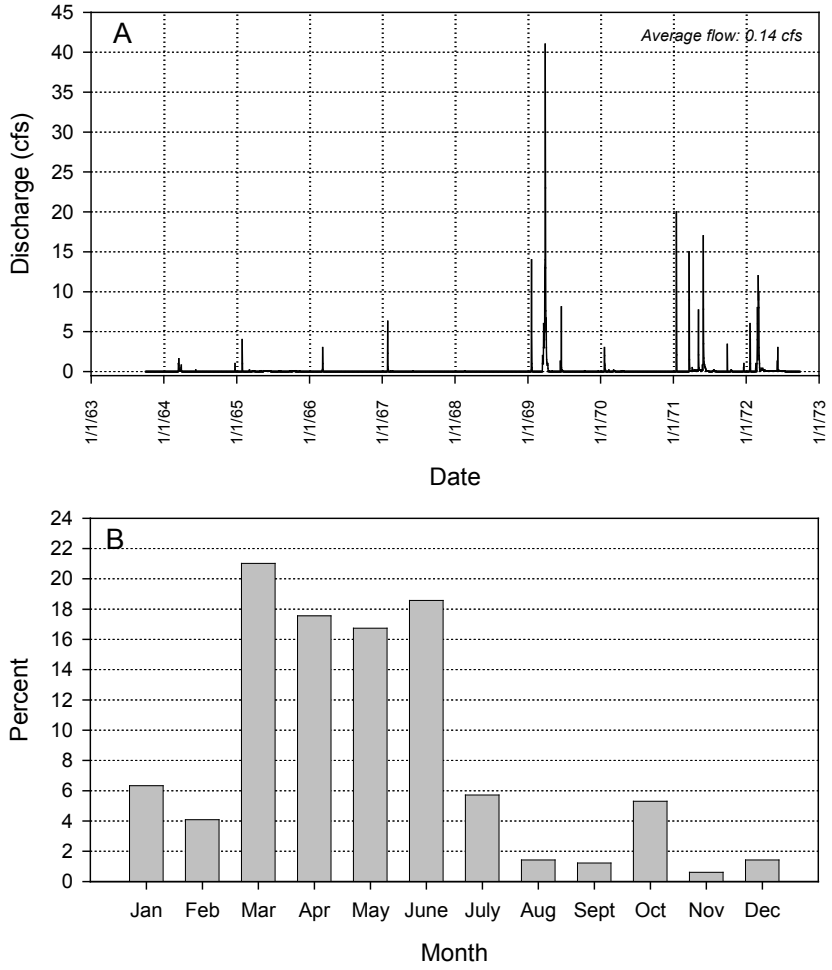

Figure 3.1 A) Mean daily discharge at USGS gaging station on Badger Creek 1963-1973. B) Percentage of days in the Badger Creek gage record where flow exceeded 0 cfs, organized by month.

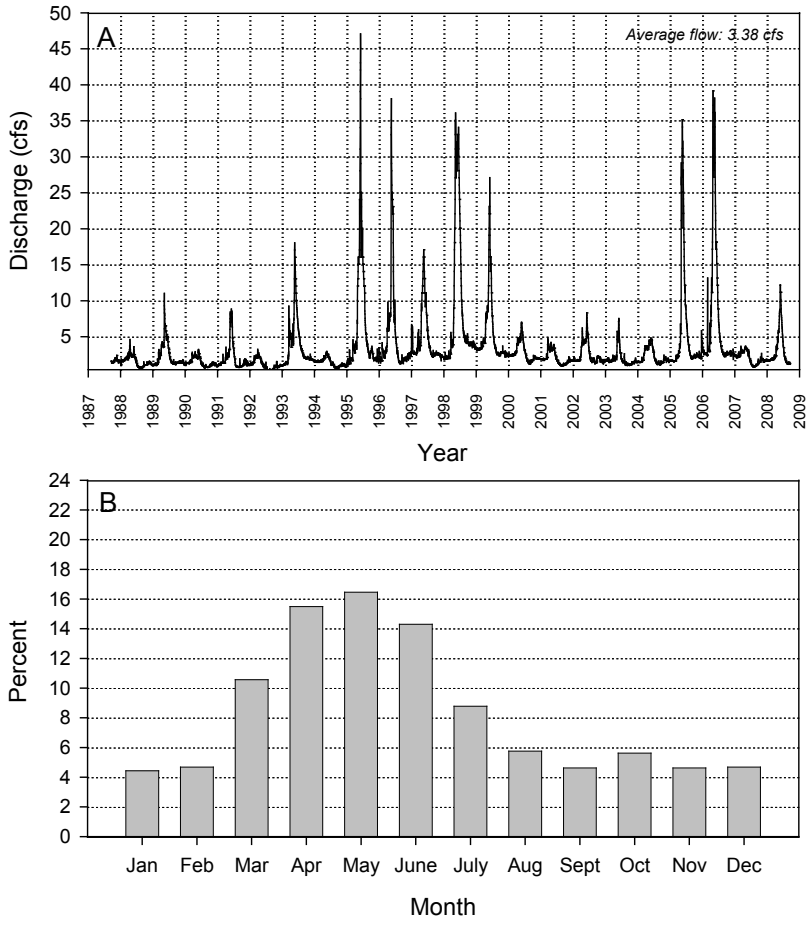

Figure 3.2 A) Mean daily discharge at Mahogany Creek USGS gaging station 1987 to present. B) Percentage of days in the Mahogany Creek gage record where flow exceeds 2 cfs, organized by month.

The Virgin Creek/Thousand Creek watershed is the largest stream system within Sheldon Refuge (Photo 3.1). Virgin Creek flows year-round along most of its length and supports extensive wet meadow and riparian habitat in the Virgin Valley. Although many other creeks on Sheldon may flow continuously during the snowmelt period, year-round flow is only found in the vicinity of springs or in areas where the water table is close to the ground surface.

3.3.1.2 Springs/Seeps

A spring "is a place where ground water flows from rock or soil onto the ground surface" (Wilson and Moore 1998). There have been 130 springs identified on Sheldon Refuge concentrated in the western and southern portions of Sheldon Refuge (Collins 2009). These springs are important because they are often the only year-round water source for streams and wetlands. A spring's aquifer is analogous to a stream's watershed. With Sheldon Refuge it is believed the aquifers for springs above 6,000 feet in elevation have different water sources than those at lower elevations.

More than 50% of springs within Sheldon Refuge are above 6,000 feet in elevation (Figure 3.3). The aquifers for these springs are very likely localized, relatively small, and receive most of their flow

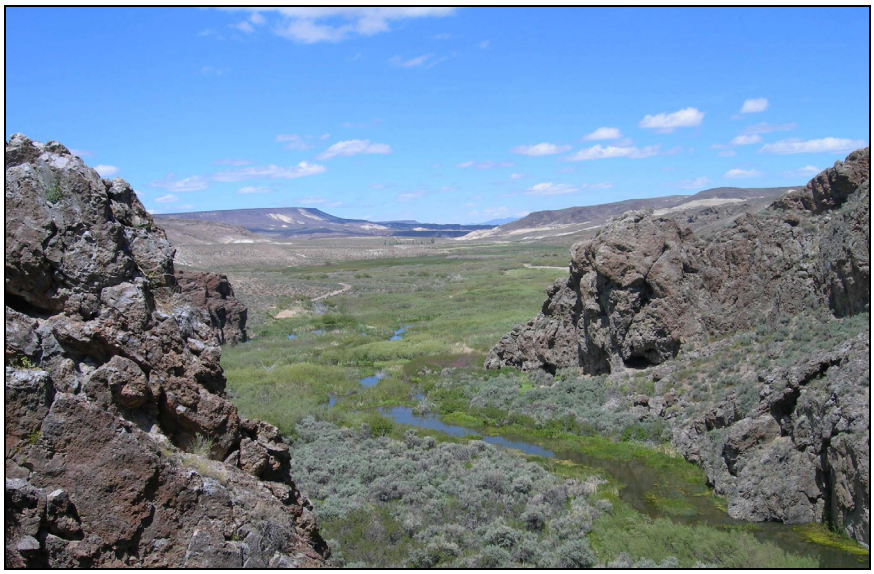

Photo 3.1 Nearly the entire Virgin Creek watershed is within Sheldon Refuge.

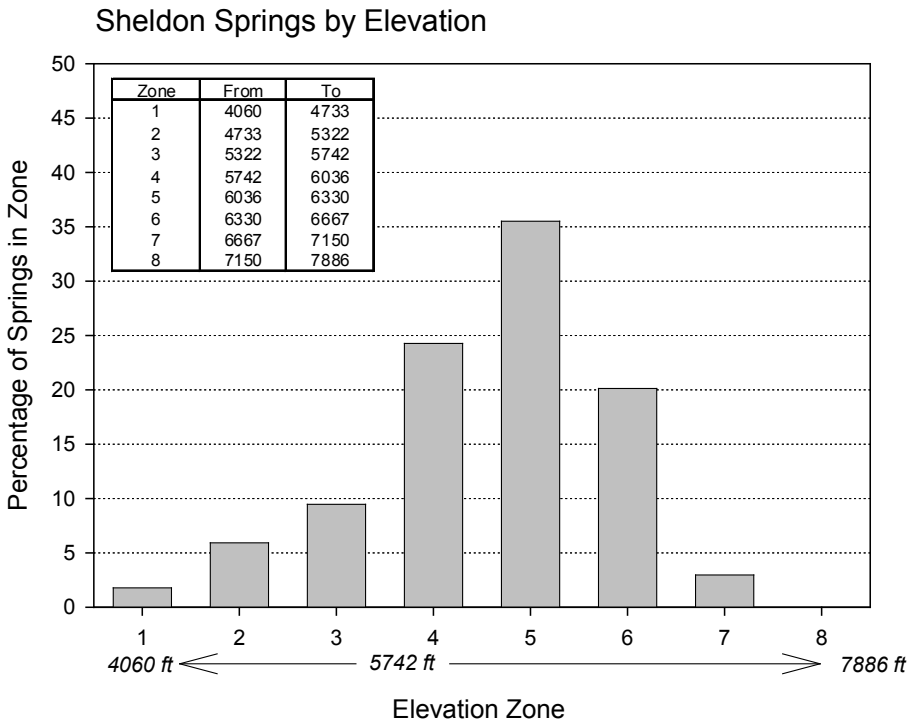

Figure 3.3 Percentage of springs found in different elevation zones on Sheldon National Wildlife Refuge.

from annual snowmelt. These characteristics cause flow to be highly variable throughout the year as snowmelt water travels only a relatively short distance before being forced onto the ground surface—leaving little flow at the spring later in the year. This dependence on snowmelt and annual precipitation makes these higher elevation springs much more susceptible to changes in climate and local weather patterns.

For springs at lower elevations, aquifers are generally much larger, collect larger amounts of water, and have much more consistent flow throughout the year as water gradually percolates through a permeable rock such as fractured basalt and travels longer distances before eventually being forced onto the ground surface by an impermeable rock such as the volcanic tuff layers commonly found within Sheldon Refuge (Photo 3.2). The distribution of springs on Sheldon Refuge suggests this scenario is plausible. Nearly 78% of the mapped springs are found between 5,700 and 6,700 feet, which is comparable to the elevation where most tuff deposits are exposed (USGS 1984).

Photo 3.2 Lower elevation springs like the one shown are commonly found at the bottom of draws and small canyons.

3.3.1.3 Water Improvements

Early pioneers in the Sheldon area quickly recognized that successful agriculture required irrigation during the summer months. These settlers built most of the region's large reservoirs to help ensure water was available through July, August, and September. By the time Sheldon Refuge was established, the biggest reservoirs (Catnip, Big Spring, and Swan Lake) were already built. Early management activities on Sheldon Refuge focused on additional development of water resources to increase year-round water for wildlife. Ponds were dug in seeps, spring flow diverted to watering troughs, and stock ponds built. Although these activities have been common since the 1930s there is debate about how effective these activities are for wildlife (Broyles 1995).

There have been 183 water improvements identified on Sheldon Refuge (Figure 3.4). These improvements include reservoirs, stock ponds, pit reservoirs, gabions, diversion canals, and water control structures. Figure 3.4 also includes digitized boundaries of lakes, ponds, and reservoirs.

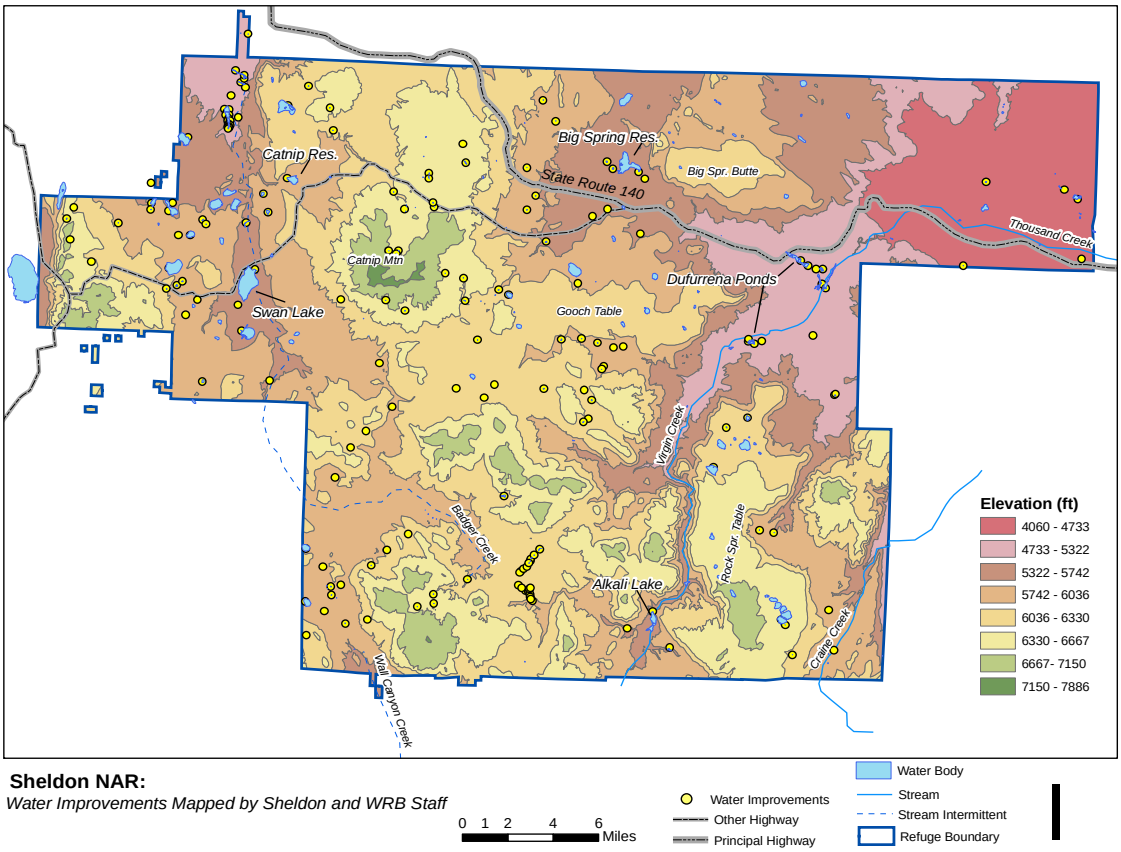

Figure 3.4 Mapped water improvements and USGS National Hydrography Dataset water bodies on Sheldon Refuge.

Note: Water improvement data should be considered draft until field verified.

Reservoirs

Reservoirs on Sheldon Refuge support fishery resources as well as habitat for waterfowl and wildlife. The largest are presented in Table 3.1.

Table 3.1 Twelve Largest Reservoirs on Sheldon Refuge

Name	Acres	Name	Acres
Swan Lake*	643	Big Spring*	249
Rye Patch*	109	Alkali	85
Catnip*	73	Racetrack*	31
Bog Hot	22	Dufurrena 21*	21
Dufurrena 20*	15	Dufurrena 13*	14
Dufurrena 19*		Rock Springs Table*	

Acreages were derived from data in the USGS National Hydrography Dataset. Bog Hot is located on a private inholding and Dufurrena 13 is being re-configured. Reservoirs marked with an asterisk are inventory dams according to USFWS Dam Safety.

Catnip Reservoir, Big Spring Reservoir, and the Dufurrena Ponds typically hold water year-round. The remaining reservoirs fill seasonally or may only have water in them during multi-year wet

periods. The USFWS Dam Safety program has identified 10 inventory dams on Sheldon Refuge. Inventory dams are higher than 6 feet and store more than 20 acre-feet of water (see Table 3.1).

Fifty-two of the water improvements in Figure 3.4 have been identified as dams impounding water. Most of these are in fact small check dams or dikes less than 10 feet high built using soil and rock from upslope to create what is commonly referred to as a stock pond.

Stock ponds

Stock ponds are typically earthen dams built across ephemeral drainages or depressions. These small reservoirs are intended to capture snowmelt runoff and create a watering place that will persist into summer. Ponds form behind these check dams in the spring and early summer but will usually be dry by mid-summer. Seventy water improvements in Figure 3.4 are identified as stock ponds.

Guzzlers

Guzzlers are water improvements built to provide an additional water source for wildlife where none existed before. These contraptions collect precipitation and divert it into a water storage tank. Water in the tank is fed into a small drinking trough that wildlife can access. There are 18 guzzlers identified on Sheldon Refuge. Of these, 12 are designed for chukar and six are designed for bighorn sheep. Most of these are built and maintained by NDOW.

Playas/pit reservoirs

Playas are natural depressions where water collects in the spring and early summer. Water is typically less than 6 inches deep and present during snowmelt runoff or after larger rain events. These features are usually dry each summer and may not have water in them for several years. Early settlers and refuge staff developed many playas by excavating large pits in them (Photo 3.3). These pits hold water longer in the summer and at greater depths than undisturbed playas. Twenty-two water improvements shown in Figure 3.4 are pit reservoirs in playas. Although there are other playas on Sheldon Refuge they have not been identified as having pit reservoirs in them.

Photo 3.3 Excavated catchments or dugouts like the one shown were constructed in the middle of playas to concentrate water for livestock use (Photo Aaron Collins).

3.3.1.4 Wetland Resources

Wetlands at Sheldon occur wherever there is permanent water.

Wet meadows

Wet meadows are found in the valleys adjacent to the larger streams on Sheldon Refuge. They are typically associated with streams and springs that flow year-round, such as Virgin and Thousand creeks. Small wet meadow communities (<3 acres in size) are found in the vicinity of high elevation springs and seeps.

Wet meadows are defined as areas that may flood with surface water for portions of the year and the water table is within 10 feet of the ground surface, year-round. The vegetation community is dominated by wetland plant species such as sedges and rushes. Ranchers historically grazed cattle in these areas and today overuse by feral horses and burros is damaging many of these meadows. Meadows with extensive grazing suffer from soil compaction, vegetation removal, and headcutting. Headcuts occur where surface water runoff initiates sudden downward soil erosion. Once this type of erosion becomes established an incised drainage channel forms, lowering the water table and drying the adjacent meadow habitat.

Riparian communities

Riparian habitat is an important resource for wildlife on Sheldon Refuge. These communities are associated with year-round water in creeks and some of the larger springs. Vegetation is dominated by willows and stands of aspen or cottonwood.

Like any habitat near a permanent water supply many of Sheldon Refuge's riparian communities were grazed when cattle were allowed on Sheldon Refuge. Today, feral horses and burros continue to impact these areas by removing vegetation and compacting soil (USFWS 2007b). Beaver introduced into the Virgin Creek watershed in the 1950s led to destruction of some of the aspen forests there. Today, beaver dams in the Virgin Creek drainage have helped create thick stands of willows.

Open water marsh

Marshes are usually associated with human-made impoundments. The Dufurrena Ponds and the IXL wetland impoundments are examples of this habitat type. Cattail and bulrush (tule) are the dominant wetland vegetation although willows can become established in these areas too. Virtually all of these communities are associated with human-made or beaver-built impoundments.

3.3.1.5 Groundwater Resources

Groundwater resources in the Sheldon area were investigated by Sinclair (1963a, 1963b) for the State of Nevada. It appears that there have not been any other significant investigations of groundwater resources on Sheldon since then.

Sinclair (1963b) concluded that most groundwater in the area is found in the unconsolidated sands and gravels (alluvium) that have accumulated in Sheldon Refuge's valleys. He speculated that a groundwater barrier exists at the head of Thousand Creek Gorge. Groundwater "backs up" upstream of this barrier, helping keep the water table near the ground surface in the Virgin Valley. The high

water table in the valley maintains wetland habitat and perennial flow in Virgin Creek. Similar hydrogeologic conditions may exist in other valleys with permanent water.

The Virgin Valley and other valleys like it have enough water in them to support some groundwater production. However, these basins are not large enough to support development beyond local domestic uses. Groundwater development for municipal or industrial uses would quickly deplete groundwater resources in the local valley-fill aquifers and lead to drying nearby wet meadow, riparian, and stream ecosystems.

At the present it appears that groundwater development on Sheldon is limited to domestic production primarily in the Virgin Valley Mining Area. Well log records from Nevada Department of Water Resources identify 12 wells that have been drilled within Sheldon Refuge, 10 of which are located in the Virgin Creek/Thousand Creek watershed.

The current scale of groundwater development does not appear to be affecting water resources in the Virgin Valley. However, if development increases, water resources could be impacted quickly. Groundwater development in the Virgin Valley Mining Area is a more direct threat to water resources than development outside Sheldon Refuge. Groundwater pumping from alluvial deposits in the Virgin Valley would lower the water table and reduce the extent of permanent, year-round Virgin Creek flow.

3.3.1.6 Water Supply and Climate Change

The water supply for all water resources on Sheldon Refuge is dependent on the accumulation of snow during the winter months. Runoff and precipitation patterns (see Figures 3.1 and 3.2) indicate snow accumulation and subsequent melting determines how much water will infiltrate into groundwater aquifers, accumulate in reservoirs, and the extent of year-round flow in refuge creeks.

3.3.2 Water Quality

A review of Environmental Protection Agency (EPA) online data (EPA 2010) indicates there are no Total Maximum Daily Load or National Pollutant Discharge Elimination System violations in the vicinity of Sheldon Refuge.

Most of Sheldon Refuge is uninhabited with very little development. The greatest concentration of infrastructure on Sheldon Refuge is in the Virgin Valley Mining Area in the form of roads, houses, and mining operations. There is a threat of sediment runoff into wetlands and ponds from adjacent mining operations and roads during storm events.

3.3.3 Water Rights

Water in Nevada is considered a resource of the State. The State grants individuals, corporations, municipalities, and government agencies the right to use the State's water.

Sheldon Refuge's size and remoteness protects most of the identified water resources inside Sheldon Refuge. Because, the headwaters of the largest streams are inside Sheldon Refuge there is little chance upstream users can divert water from stream resources. High elevation springs are fed by local aquifers inside Sheldon Refuge boundary and above potential groundwater development areas.

A review of water right files in the Service's Water Resources Branch office and State of Nevada's water right database identified 139 possible water rights or Federal reserve water right claims within the boundaries of Sheldon Refuge, the majority of which are either appropriative or reserved water rights belonging to the Service. Three water rights are not held by the Service and are located on private inholdings.

Water rights within Sheldon Refuge are associated with springs, streams, wetlands, wells, reservoirs, ditches and canals. Of particular interest in the CCP is the management of certain reservoirs and associated aquatic and riparian habitats. A more detailed discussion of other water rights within Sheldon Refuge is included in the Sheldon National Wildlife Refuge Water Resource Assessment Report (Wurster 2009).

3.3.3.1 Reservoirs and Water Rights

Forty-four of the water improvements identified in Figure 3.4 are identified as dams and 71 are identified as stock ponds. Of the 183 water improvements, 28 are associated with an existing appropriative water right Place of Use (Table 3.2).

Two (Alkali and Big Spring) of the 18 reservoirs have storage rights associated with them. The others do not have rights to store water but there are rights to use water from those reservoirs to irrigate fields and water stock. Fortunately, in Nevada the right to use water from a reservoir confers the right to store water in that reservoir (Palmer 1993).

Three reservoirs in Table 3.3 are found on inholdings or inside the Virgin Valley Mining Area. These include a small dam in the vicinity of Bog Hot Springs and a small check dam on Badger Creek at the Kennedy Property.

Table 3.2 Named Reservoirs and Stock Ponds within 750 Feet of an Appropriative Water Right Place of Use

Reservoir/Stock Pond Name	Reservoir/Stock Pond Name
Alkali Lake	Big Spring Reservoir
Catnip Reservoir	Campground Pond
Dufurrena Pond 19	Dufurrena Pond 20
Dufurrena Pond 21	Dufurrena Pond 22
IXL North Impoundment A	IXL North Impoundment B
North Lake	Rye Patch Reservoir
Sheep Pen Reservoir	Smith Lake
Swan Lake	South Lake
Stock Pond at Catnip Springs	Swan Mountain Reservoir

Table 3.3 Reservoirs, Stock Ponds, and Pit Reservoirs with Prepared Federal Reserve Water Right Claims

Reservoir Name	Reservoir Name	Reservoir Name	Reservoir Name
Andy's Reservoir	Balzedar	Beside 34A	Big Basin #3
Buzzard's Roost	Celia	Middle Center	Center
Chukar	Gunsight	Highway 140	Hobble Spring #2
Hobble Spring #3	Horse Lake	Jog	Little Lake
Lower Jacobs	Middle Jacobs	Mud Spring	North Onion Lake
North Sagehen	North Swan Creek	Nut Mountain	Perlite

Reservoir Name	Reservoir Name	Reservoir Name	Reservoir Name
Racetrack Springs	Rainbow	Rock Springs Table	Round Mtn. Lake
Section 18	Section 8	Sidehill Spring	South Onion Lake
South Swan Creek	Swan Lake Trench	The Knob	Unnamed #1
Unnamed #2	Unnamed #3	Upper Jacobs	Upper Wall Canyon
West Boundary			

3.4 Topography

The entire Sheldon Refuge is located between 4,230 and 7,300 feet in elevation, with more than 12 mountain tops over 6,500 feet. The topography of Sheldon Refuge is characterized by large expanses of high basalt plateaus or "tables" and broad mountains separated from one another by valleys and canyons. The most dramatic of these canyons is Thousand Creek Gorge with cliffs dropping more than 450 vertical feet from the basalt table rim (Photo 3.4). Located in the eastern portion of Sheldon Refuge, Thousand Creek itself flows into the dry Bog Hot Valley which is at the lowest elevation of Sheldon Refuge. Catnip Mountain with its broad ridges is deceptively the highest point within Sheldon Refuge at 7,292 feet. The western portion of Sheldon Refuge differs somewhat with more typical mountain and valley topography including Yellow Peak, which drops abruptly from its 7,191 foot summit to the bottom of Long Valley 1,600 feet below.

Photo 3.4 Both the mouth of Thousand Creek Gorge and the flat-topped finger of Railroad Point in the distance are characteristic of Sheldon Refuge topography (Photo Gail Collins).

3.5 Geology/Soils

Soils in Sheldon are semi-arid, very young, and poorly developed. The soils are largely a result of lake sedimentation, volcanic activity, and water erosion. Chemical and biological soil development processes, such as rock weathering, decomposition of plant materials, accumulation of organic

matter, and nutrient cycling proceed slowly in this environment. Soil recovery processes are also slow; therefore, disruption of soil can lead to long-term changes in ecology and productivity. In many areas, natural or geologic erosion rates are too fast to develop distinct, deep soil horizons. The soils of Sheldon Refuge are complex and diverse.

Management practices may affect soils' ability to maintain productivity by influencing disturbances such as displacement, compaction, erosion, and alteration of organic matter and soil organism levels. When soil degradation occurs in semi-arid, high desert regions, natural processes are slow to return site productivity. Prevention of soil degradation is far more cost-effective and time-effective than remediation or waiting for natural processes. Any activities that remove vegetative cover increase the erosion rate. Some soils are particularly vulnerable to soil erosion. If the surface layers of these soils are washed or blown away, the productivity potential is lost for a geologic time span (BLM 2003).

The following soils map unit descriptions are excerpted from the Sheldon National Wildlife Refuge Renewable Natural Resources Management Plan (USFWS 1980).

The Rolling Hills map unit occurs in mountainous terrain and foot slopes of prominent hills from 6,000 to 6,500 feet in elevation. Soils are moderately deep to deep and stony or gravelly on the surface. Erosion hazard is moderate. About 71,598 acres or 12% of Sheldon is covered by this unit.

The Rockland map unit occurs around 6,000 feet elevation in small clumps or strips on rocky ridges and similar mountainous areas where bedrock outcrops occur. Soils on this unit are shallow to moderately deep over basalt bedrock and are stony and gravelly throughout. Erosion hazard is slight to moderate. This unit occupies about 4,200 acres or 0.7% of Sheldon Refuge.

The Stony Terrace and Claypan Terrace map units occur on gently sloping tablelands around 5,600 feet elevation. These units often occur in association; with the soils of stony terrace being very stony on the surface and the soils of claypan terrace having gravelly loamy surface layers. Stony terrace occupies 93,500 acres or 16% of Sheldon while claypan terrace occupies 100,000 acres or 17% of Sheldon Refuge.

The Arid Rolling Hills map unit occurs on nearly level to rolling areas from 4,300 to 5,400 feet elevation. Soils of this unit are shallow, very stony, and have a moderate erosion potential. This unit occupies 63,900 acres or 11% of Sheldon Refuge.

The Arid Loamy Terrace map unit occurs on nearly level to gently sloping basin terraces from 4.500 to 5,500 feet elevation. The soils are gravelly throughout with a hardpan or cemented gravel at 18 inches. Erosion hazard is slight. About 95,927 acres or 17% of Sheldon is covered by this unit.

The Snow Pockets map unit occurs on north facing slopes where snowdrifts form and persist after snow is gone from the general terrain. Slope gradient is from 15% to 60% and elevation is above 6,000 feet.

The Mountain Swale map unit occurs in mountainous terrain as narrow alluvial fans in the bottom of drainages and as small basin-like depressions in the uplands. Elevation is about 6,000 to 7,000 feet. Soils are loamy, deep and very gravelly, and erosion hazard is slight. Only 201 acres of this unit occur on Sheldon in isolated patches.

The Poorly Drained Bottom map unit occurs as nearly level bottoms in basins having large or mountainous watersheds and is usually associated with perennial springs. Elevation is 4,500 to 6,500 feet. Surface soil layers are black; subsoils are very gray and mottled due to poor drainage. A restrictive layer usually occurs at three to four feet which retains the water table. Hazard for gully erosion is high. There are only 444 acres of meadow on Sheldon Refuge.

The Rolling Hills and Juniper South Exposure map units occur on prominent hills, ridges, plateaus, and south facing slopes with a 2% to 50% gradient. Elevation is about 4,300 to 6,000 feet. Soils are stony to very stony throughout the profile and are usually shallow over basalt bedrock. Erosion is slight. These two map units cover 820 acres on Sheldon Refuge.

The Aspen Grove map unit occurs near some springs on Sheldon but the areas are very small. Soils of this unit have thick, dark colored surface layers with loamy and gravelly subsoils. Erosion hazard is slight.

Riparian areas occur along Hell, Virgin, Catnip, and Fish creeks and some spring sites. The soil is easily eroded.

The Virgin Valley Hills are a unique geological and physiographic area. It is typified by lacustrine deposits, steep truncated slopes and butte caps of igneous rock. The soil is extremely fragile and erodible. About 34,208 acres or 6% of Sheldon is in this area.

3.6 Environmental Contaminants

A number of sites within Sheldon Refuge have been evaluated for environmental contaminants, including lead-based paint, volatile organic compounds (VOCs), and soil contaminants from past mining activities.

In 2001 lead paint screening was conducted for 16 sites, which included a number of structures and buildings. Samples indicated elevated levels of lead from one small building at the Little Sheldon Headquarters/Work Station. Also in 2001, 17 measurements were taken to detect VOCs, with no positive results.

Soil samples collected in 2001 indicated a moderate threat from lead contamination associated with buildings at the IXL Ranch, the Little Sheldon Headquarters/Work Station, and the Virgin Valley Ranch. Mercury contamination at an abandoned mining site along Hell Creek was determined to pose a relatively low threat (USFWS 2001a).

3.7 Land Use

Within Sheldon Refuge are a relatively small amount of private lands, including inholdings and patented mining claims. These inholdings and patented claims are entirely surrounded by public lands and as a result, some have permits for vehicle access, electric transmission lines, and other uses which affect Sheldon Refuge.

The vast majority of lands surrounding Sheldon Refuge are public lands managed by the BLM. As multiple-use public lands, a wide variety of land uses occur on surrounding BLM lands. Uses include mining, grazing, high-voltage electrical transmission lines, natural gas transmission

pipelines, geothermal energy development, wind energy development, OHV recreation, conservation of historic landmarks and trails, and wilderness preservation. Other surrounding lands include the Paiute-Summit Lake Reservation, and various private ranches.

3.7.1 Valid Existing Rights, Rights-of-Way, and Easements

3.7.1.1 Rights-of-Way

Both permanent and temporary rights-of-way exist for State of Nevada Highway 140, for a private overhead electrical line extending from the eastern boundary of Sheldon Refuge to various properties and mining claims in the Dufurrena area, and for access to a private inholding in the western portion of Sheldon Refuge.

3.7.1.2 Access to Private Inholdings

There are seven separate parcels of privately owned land which are within and completely surrounded by lands managed by Sheldon Refuge. As a result, access to these parcels must be granted by Sheldon Refuge in the form of a Special Use Permit to allow reasonable access for use of those lands. As part of the initial wilderness review and study completed for Sheldon Refuge in 1974, an inventory of motorized routes throughout the entire Refuge was completed. At that time no motorized route existed to any of the seven inholdings.

Since 1974, motorized access along a designated unmaintained route has been authorized by the Service to only one parcel, and continues to be allowed under a valid Special Use Permit. Motorized access has not been authorized to the two inholdings located within the Alkali Peak Proposed Wilderness Area or the four remaining inholding parcels south of Fish Creek Table.

3.7.1.3 Easements

There are no existing easements within Sheldon Refuge.

Chapter 4. Biological Environment

This chapter addresses the biological resources and habitats found on Sheldon Refuge. However, it is not an exhaustive review of all species and habitats. The chapter begins with a discussion of biological integrity, as required under the Refuge Improvement Act. The bulk of the chapter is then focused on the presentation of background information used in development of the management goals, objectives, and strategies of this CCP. Background information includes a description, location, condition, and trends of associated wildlife or habitats, and stresses and sources of ecological stress (collectively, "threats").

4.1 Biological Integrity, Diversity, and Environmental Health Analysis

The landscapes that make up Sheldon Refuge extend across large portions of 11 states in the Intermountain West, but very little of the sagebrush biome remains undisturbed or unaltered from its condition prior to European settlement (West 1996). These cold-desert rangelands, the so-called western rangelands, were considered more complex and biologically rich less than 150 years ago than at present (Dobkin and Sauder 2004). The sagebrush-steppe ecosystem as a whole now constitutes one of North America's most imperiled and neglected ecosystems (Dobkin and Sauder 2004; Mac et al. 1998; Noss and Peters 1995) due to profound influences of livestock grazing. Agriculture and herbicide use, mining, energy development, power line and natural gas corridors, and the expansion of road networks have also fragmented landscapes or completely eliminated sagebrush from extensive areas; these changes may have pushed these sagebrush systems in some areas beyond ecological thresholds for recovery (see Dobkin and Sauder 2004). Across the Great Basin, this has resulted in alteration of plant community composition and soils, changes to the natural fire regime, and spread of exotic plant species (Bock et al. 1993b; Fleischner 1994; Miller and Rose 1999; Rotenberry 1998; Saab et al. 1995; Yensen 1981; Young 1994; Young and Sparks 2002). More than 60% of the remaining sagebrush steppe now has either exotic annual grass in the understory or has been completely converted to non-native annual grasslands (West 2000). In addition, more than 90% of the region's flowing waters and their associated riparian habitats have been compromised by livestock and agricultural development (Chaney et al. 1990; Ohmart 1994).

As detailed by Vale (1975), early writings by the first Europeans exploring the northern Intermountain West described pristine vegetation visually dominated by vast stands of sagebrush; grass was generally confined to wet valley bottoms, moist canyons, and mountain slopes (also see Welch 2005). However, sagebrush was long considered by land managers to be an undesirable shrub and subsequently reduced throughout its range in western North America (see summary by Welch 2005). Prior to the end of World War II, most treatment of sagebrush was by mechanical methods such as plowing, chaining, and disking, although fire and heavy grazing pressure had been used in some areas prior to mechanical control. After the mid-1940s, use of herbicides, primarily 2,4-D, became a widespread tool in reducing the abundance of sagebrush (and inadvertently many other shrubs and forbs) (see Baker et al. 1976; Svejcar 1997), with the basic premise that sagebrush was competing for nutrients, water, and space with more desirable grasses preferred by livestock (Baker et al. 1976; Dobkin and Sauder 2004). There is anecdotal evidence that small areas on Sheldon Refuge were treated (Deming 1959). But as early as the 1950s, individuals began to question sagebrush control efforts as a serious threat to the maintenance of populations of sage-grouse, pronghorn, and mule deer, and to identify species of birds (i.e., sage-grouse, sage thrasher, sage

sparrow [*Amphispiza belli*], and Brewer's sparrow [*Spezella breweri*]) that would be adversely affected if sagebrush were eradicated (Baker et al. 1976).

Among land uses, the introduction of livestock and associated habitat alteration have had the most widespread impact on western ecosystems (Bock et al. 1993a; Fleischner 1994; Ohmart 1996). Livestock (i.e., cattle, sheep, and horses) were introduced to the Great Basin rangelands in the mid-1800s and were afforded abundant forage due to centuries of fire disturbance (Gruell 1995). Competition among settlers, plentiful forage, and limited knowledge of range-animal relationships encouraged excessive numbers of livestock when compared to contemporary standards (Gruell 1995; Rouse 1942). Wire fencing, a fundamental livestock management tool, also exacerbated problems attributed to habitat degradation and fragmentation by creating obstacles that inhibited daily and migratory movements of native wildlife species (Fleischner 1994; Harrington and Conover 2006). Across the Great Basin, overgrazing, in combination with alteration of natural fire regimes and climate change, has also resulted in encroachment and habitat conversion of native communities (Miller et al. 2000; Suring et al. 2005b).

These historical land use practices included the area now known as Sheldon Refuge, and overgrazing in this area can be attributed to two separate periods: approximately 1880 to 1940 and 1940 to 1976 (USFWS 1980). The first homesteaders arrived in the area now known as Sheldon Refuge around 1880 and were associated with the cattle and sheep livestock industry (USFWS 1985). Also beginning in the late 1890s and well into the twentieth century, there was a market demand for horses, and there is evidence of campsites on Sheldon Refuge that were selected because of geographical advantages for horse trapping (USFWS 1985). In addition to homesteader activity, Sheldon Refuge was also part of an enormous cattle and land domain of the Miller and Lux Land and Livestock Company, which controlled most of the deeded land within the area. During this period, cattle and horses were the principal livestock grazed (Fallon 1941). The horses occupied the range year-round, while most of the cattle were wintered in nearby Surprise Valley on supplemental hay. In 1926, large numbers of domestic sheep (approximately 20,000) were documented ranging across Sheldon Refuge from April to October each year (Fallon 1941). By the mid-1930s, local managers began to discuss a lack of effective range management and document signs of overuse, including evidence of sheet erosion and degraded range conditions (Fallon 1941; Rouse 1942; Rouse and Fallon 1940; Rush 1936; USFWS 1942). It was believed that range productivity may have been permanently impaired by the loss of topsoil (Rouse and Fallon 1940).

The second period of overgrazing, 1940 to 1976, was defined by uncontrolled cattle and horse grazing with approximately 20,000 Animal Unit Months (AUMs) average use under BLM administration. Unknown numbers of domestic sheep grazed on Sheldon Refuge until at least 1948 (USFWS 1948). It is suspected that domestic sheep were then restricted from Sheldon Refuge sometime after the mid-1950s (USFWS 1952); while the exact date is unknown, it likely preceded the reintroduction of California bighorn sheep in 1968. Uncontrolled grazing is range use with few restrictions as to where, when, or extent of use. As a result, cattle, horses, and sheep could selectively concentrate their utilization in prime forage areas around water sources (USFWS 1980). Anderson and Franzen (1978) found during the mid-1970s that excessive annual utilization during the growing season had resulted in uniformly low vigor of key forage species over much of Sheldon Refuge, and that it was indicative of an unacceptably slow rate of ecological improvement.

The Service assumed grazing responsibility on Sheldon Refuge under the Refuge Administration Act in 1976. Any grazing permits issued subsequent to 1976 were managed in accordance with the Refuge Administration Act, as amended, and associated regulations and policies. As of 1980,

approximately 18,700 cows were grazed on Sheldon Refuge between April and late October by 10 permitees; the season of use paralleled that implemented on adjacent BLM lands (USFWS 1980). Following recommendations in the 1980 Refuge Management Plan (USFWS 1980), livestock grazing was reduced to an approved use of up to 17,721 AUMs and areas for grazing use were restricted. Ecological conditions appeared to be improving by the mid-1980s toward potential natural communities and increased soil stability (Anderson 1984), although issues associated with overuse, both by cattle and feral horses, were still noted into the mid-1990s (St. George et al. 1993). Beginning in the early 1990s, the Conservation Fund, with a grant from the Mellon Foundation, purchased all remaining grazing permits on Sheldon Refuge from willing sellers at fair market value and retired them from use. The last permits were purchased and retired in 1994. As a result, there are no valid claims of grazing rights or privileges on Sheldon Refuge.

Since 1994, Sheldon Refuge has been one of the largest contiguous blocks of land in the Great Basin that is free from domestic cattle and sheep grazing, and apparent ecological conditions have continued to improve. However, feral horses and burros continue to graze uncontrolled on Sheldon Refuge as their population numbers have increased (Collins 2008a), impeding further potential for ecological recovery. Although their numbers have never approached those documented for cattle and sheep, feral horses and burros can affect the landscape in ways different than other livestock; for example, wintering horses and burros remain on the Sheldon Refuge year-round, exerting grazing pressure on native plant communities during times of the year when other livestock would normally receive supplemental feeding (Fallon 1941; Young et al. 1972). Year-round and long-term overuse can result in a systematic weakening and reduction of grasses and forbs, resulting in a loss of species and structural diversity and monotypic stands of less palatable species. For more information on the specific effects of feral horses and burros on habitats within Sheldon Refuge and in the sagebrush ecosystem see USFWS (2008a).

In addition to livestock utilization, associated predator control efforts across the West also altered western rangeland ecosystems. Across the West, wolves, coyotes, mountain lions, other large predators, and many small predators were poisoned, shot, and trapped unremittingly during most of the 1900s (Carrier and Czech 1996). High desert species regarded as competitors with livestock have also been periodically targeted, including wild ungulates (e.g., pronghorn) and small mammals (e.g., ground squirrels [*Spermophilus* spp.], mice) (see Carrier and Czech 1996). On Sheldon Refuge, formal predator control was largely initiated between 1955 and 1967, primarily for coyote and bobcat (McNay 1980), but control efforts also targeted rodents, raccoons (*Procyon lotor*), American badgers (*Taxidea taxus*), porcupines (*Erethizon dorsatum*), and raptors (Deming 1959; Sheldon Refuge files); Sheldon Refuge staff conducted informal predator control efforts at least between 1941 and 1968 (USFWS 1941, 1968). The reduction or elimination of predators over vast areas may have had profound effects on natural rangeland ecosystems. Coyotes, for example, have been suggested to play a keystone role in a multitude of habitats including chaparral, grassland, and wetland ecosystems. Keystone predators have a regulatory effect on medium-sized predators (e.g., badgers, skunks (*Mephitis* spp.), bobcats, foxes (*Vulpes* spp.), ravens (*Corvus* spp.), eagles). Removal of coyotes can therefore result in increased abundance of medium-sized predators, which in turn reduces the abundance and diversity of prey species; alteration of the prey base could have cascading effects throughout the ecosystem (see summary by Henke and Bryant 1999). In addition, coyotes can indirectly impact interactions for species such as sage-grouse. For example, the presence of coyotes reduces the number of mammalian nest predators that prey on sage-grouse eggs (e.g., fox, badger, raven). By also limiting the number of prey species (e.g., jackrabbits [*Lepus* spp.], ground squirrels), coyotes also reduce the number of golden eagles (*Aquila chrysaetos*, a significant predator of adult sage-grouse) and reduce competitors for forage. Indeed, it has been suggested that coyote control

may inadvertently contribute to sage-grouse declines and that a healthy coyote population has the potential to enhance the long-term prospect for many sage-grouse populations (Mezquida et al. 2006). There is currently no open harvest seasons for predator species on Sheldon Refuge, and there is little direct knowledge regarding trends in their populations; however, we can expect that both prey and predator populations have been restored to a more natural equilibrium than previously observed.

As a result of these factors, the ecosystem within and surrounding Sheldon Refuge has undergone dramatic alteration since pre-European settlement times. However, despite these alterations, Sheldon Refuge does remain one of the last, relatively intact representations of the sagebrush-steppe ecosystem in the Great Basin. The five most discernible changes within Sheldon Refuge include 1) continuing disturbance from feral horse and burro activity; 2) influx of invasive and encroaching species, particularly non-native; 3) changes in the natural fire regime; 4) changes in hydrology associated with water developments; and 5) habitat alteration associated with roads and off-highway vehicles, and mining.

4.1.1 Feral Horses and Burros

The release of domesticated animals from captivity into the wild, whether intentional or accidental, has created serious problems for native species on a global scale (Douglas and Leslie 1996). Feral horses and burros are defined as non-indigenous, unbranded, unclaimed descendants of domestic horses and burros which roam free on certain refuge lands in the western United States (7 RM 6.5). Burros and horses, the most common feral species on western rangelands (Douglas and Leslie 1996), occur in substantial numbers on Sheldon Refuge. Burros became feral when domestic animals were released into the wild following the decline of mining, the advent of the railroad, and availability of motorized vehicles (Douglas and Leslie 1996; McKnight 1958). Similarly, horses became feral prior to establishment of Sheldon Refuge as animals escaped or were released from ranches and grazing allotments. The fact that feral horses within Sheldon Refuge descended from domestic animals is well documented. During a horse gather conducted in 1948, at least 74% of the over 2,500 horses removed from Sheldon Refuge were branded. The majority of the remaining horses were attributed to a single grazing operator (USFWS 1948). Further, at least one grazing operator appeared "to have more horses than their license cover[ed]" (Fallon 1941:32), and another was documented to be singularly responsible for 400 horses on the range (four times the number of cattle for that operator; Fallon 1941).

The feral horse population on Sheldon Refuge during the early 1990s averaged 200 to 300 animals as a result of a proactive population control program; without control efforts, the population has substantially increased during recent years to an estimated 1,341 individuals in 2008 (Lubow 2009). In addition, Sheldon Refuge is surrounded by BLM HMAs, and horses may have moved onto Sheldon Refuge from these areas. A more detailed accounting of feral horse and burro population dynamics and impacts to the landscape can be found in Douglas and Leslie (1996) and USFWS (2008a). Recent efforts to control the feral horse and burro populations have been focused on conducting periodic gathers for adoption. Methods used to gather and adopt feral horses from Sheldon Refuge have been thoroughly investigated (USFWS 2008a) and will not be discussed here.

Feral horse and burro herds continue to exert continual grazing pressure on Sheldon Refuge. This grazing pressure has likely resulted in reduced shrub and perennial grass cover, lower species diversity, increased competition with pronghorn and other native grazers, and other documented impacts (Autenrieth 1982; Beever et al. 2003b; Fagerstone and Ramey 1996; Meeker 1979; Salwasser 1980).

Grazing within Sheldon Refuge has played a factor in deciduous woodland decline. The reduction in deciduous woodlands, including aspen, has undoubtedly reduced suitable nesting habitat and availability of nest sites for cavity-nesting species dependent upon large trees; studies have emphasized the importance of snags and live trees with heartwood decay to cavity-nesting birds (Dobkin et al. 1995).

4.1.2 Invasive, Non-Native, Encroaching, and Expanding Species

4.1.2.1 Upland Habitats

Non-native species

It has been long recognized that native plant communities within the big sagebrush–bunchgrass vegetation type are extraordinarily subject to invasion by non-native annual species (Jardine and Anderson 1919 as cited in Young et al. 1972). Approximately 30 species of plants that are introduced, non-native, and often noxious now occur within native vegetation types on Sheldon Refuge (Sheldon Refuge files). Invasive plant species displace native vegetation, altering the composition and structure on vegetation communities, affecting food webs, and modifying ecosystem processes (Olson 1999). The spread of invasive plant species across the Great Basin was likely facilitated by the rapid increase in grazing that resulted from European exploration and settlement in the American West. Invasive plants are most likely to become established where native vegetation has been disturbed (e.g., intensively grazed sites, cabin sites, campgrounds, hiking trails, off-road tracks, roads, and fire suppression lines; see Masters and Sheley 2001). Most invasive plants also need some form of transportation to reach new areas (Trombulak and Frissell 2000). Several potential modes of transportation, or "vectors", continually travel throughout Sheldon Refuge in the form of highway traffic, off-highway vehicles, people, pets, domestic stock, feral horses and burros, wildlife, and firefighting equipment. Changing climates and associated habitat alteration will likely increase opportunities for invasive species to spread because of their adaptability to disturbance (Inkley et al. 2004).

Belsky and Gelbard (2000) identified the following disturbance factors that contribute to plant community vulnerability to invasion: selective grazing of native plants over weed species; trampling vegetation and compacting soils; impacts to biological (microbiotic) soil crusts and mycorrhizal fungi; impacts to soil nitrogen levels; and changes in fire regimes. Feral horses and burros have been found to contribute to many of these factors (USFWS 2008a). Knapp (1996) found that cattle, sheep, and feral horses facilitated cheatgrass spread in the Great Basin. Further, Beever et al. (2007) found that sites with horses tended to have more grazing resistant forbs and exotic plants (particularly cheatgrass) than those areas where horses had been removed 10 to 14 years previously.

Primary non-native, invasive, or noxious upland plants on Sheldon Refuge include cheatgrass, knapweed (*Centaurea diffusa*, *C. maculosa*), kochia (*Bassia scoparia*), hoary cress (*Cardaria draba*), yellow sweetclover (*Melilotus officinalis*), common cocklebur (*Xanthium strumarium*), bull thistle (*Cirsium vulgare*), scotch thistle (*Onopordum acanthium*), and Russian thistle (*Salsola* spp.) Other invasive plants found within Sheldon Refuge that are rapidly invading upland wildlife habitats across the West include medusahead wildrye (*Taeniatherum caput-medusea*), and rush skeleton-weed (*Chondrilla juncea*) (Knick et al. 2003). Currently, the combined invasive species cover is estimated to be less than 1% of the total refuge area (less than 5,750 acres), and substantial occurrences are generally confined to road corridors and other sites of disturbance.

The introduction of cheatgrass to the arid potions of the sagebrush ecosystem has fundamentally and perhaps irreversibly altered the natural fire regime by increasing the frequency and severity of fires (West 1979 as cited in Knick et al. 2005). Cheatgrass alters successional patterns in post-fire plant communities by interfering with native seedling establishment, competing with established perennials for resources, and shortening the interval between fires. Cheatgrass dominance and associated fires reduce populations, diversity, and recovery of biological soil crusts, which affect nutrient cycling, water infiltration, and potential soil erosion (Zouhar 2003). Cheatgrass has also been associated with soil organic matter loss, and changes in its composition and distribution (Norton et al. 2004). Cheatgrass was well established throughout much of its current distribution in the Intermountain West by 1930. However, cheatgrass has rapidly increased its dominance in native plant communities during the past 30 years. Although cheatgrass can colonize regions in the absence of fire, the combination of fire, livestock grazing, habitat management practices, other disturbances, and climate conditions have most rapidly facilitated the heavy dominance by cheatgrass in some sagebrush systems (see summary by Knick et al. 2005). The expansion of cheatgrass is of particular concern to Sheldon Refuge. However, compared with much of the rest of the Great Basin, current cheatgrass infestation on Sheldon Refuge is considered relatively low and primarily confined within travel corridors and other disturbed sites (e.g., mining areas, campgrounds, historic homesteads, burned areas).

Other non-native species that have been introduced to uplands on Sheldon Refuge include California (valley) quail, chukar, and Hungarian (gray) partridge. The impacts of these species to the environment are considered low. California quail have been released throughout northern Nevada and eastern Oregon; 130 quail were first noted on Sheldon Refuge in 1941 and hunting for these birds was first allowed within Sheldon Refuge in 1961, although populations are not considered large (Sheldon Refuge files). Chukar were first introduced to Sheldon Refuge in 1941, and harvest has been allowed since 1961 (USFWS 1971). Little information is available regarding Hungarian partridge; they were first noted on Sheldon Refuge in 1940 but are only occasionally sighted and thought to occur in limited numbers (Sheldon Refuge files; USFWS 1971).

Native and indigenous species

One of the other, most evident changes in vegetation of the Great Basin during the past 120 years has been the expansion of pinyon-juniper woodlands into the sagebrush ecosystem (Miller et al. 2000; Suring et al. 2005a). Over 90% of the existing western juniper woodlands have developed in the last 100 years; only 3%-5% is considered old-growth (Miller et al. 2008; USDI 1990); see Section 4.2.7 for information specific to Sheldon Refuge. Prior to European settlement, juniper was primarily confined to rocky ridges or surfaces with sparse vegetation; however, newly formed juniper woodlands now occupy more productive sites with deep well drained soils (see Miller et al. 2000). Expansion of western juniper coincides with European settlement in this portion of the Great Basin and it has been hypothesized that climate, altered fire frequencies, and grazing in the late 1800s were the primary factors (Miller and Rose 1995). On Sheldon Refuge, western juniper is successionally aggressive and can drastically alter or eliminate the understory component after encroachment. Conversion of sagebrush communities to juniper woodlands places additional stress on the sagebrush-steppe ecosystem that has been severely reduced in area and degraded in quality (Suring et al. 2005a). Juniper expansion is of particular concern because the presence of trees in deeper well-drained soils, where they historically were not abundant, causes increased soil erosion; reduced stream flows; reduced forage production; altered wildlife habitat; changes in plant community composition, structure, and biodiversity; and the replacement of mesic and semi-arid plant communities with woodlands (Miller et al. 2005). The replacement of aspen, riparian, and mountain

big sagebrush communities by western juniper may have detrimental effects on wildlife populations dependent upon these habitats. In summary, low levels of western juniper can be beneficial for many wildlife species but increasing dominance at both the community and landscape levels will result in a general decline in landscape and plant community diversity, resulting in a decline of wildlife abundance and diversity (Miller et al. 2005). Sagebrush encroachment is occurring on some meadow habitats on Sheldon Refuge, most likely as a result of lowered water tables and other factors (see Section 4.2.1).

Deciduous woodland and snowpocket aspen stands are declining in abundance across much of the West (see Dobkin et al. 1995; Heltzel and Earnst 2006), and on Sheldon Refuge as well. Ongoing risk factors for western aspen stands include low aspen densities, little regeneration, and encroaching sagebrush and juniper species (Bartos and Campbell 1998).

There is considerable controversy about whether elk (*Cervus canadensis*) once occupied rangelands of the Great Basin and Desert Southwest, and debate centers on recent transplants of elk and/or colonization by elk into these areas (Wisdom and Thomas 1996). There is evidence that elk originally occupied most grassland biomes throughout western North America, including major portions of the Great Basin and Desert Southwest. However, it has been suggested that a lack of permanent water likely restricted historical elk occurrence in large numbers in the driest portions of these regions; these dry areas, including Sheldon Refuge, presumably are outside the historical range of this species (see Wisdom and Thomas 1996). Elk were considered extinct from Nevada by the end of the nineteenth century (Nevada Department of Wildlife [NDOW] 1997). Between the 1930s and 1990s, elk were released at sites in eastern and central Nevada; their populations are currently expanding (NDOW 1997). To date, individual elk have been only occasionally spotted on Sheldon Refuge.

4.1.2.2 Riparian and Wetland Systems

Non-native, invasive, or noxious plants that occur in riparian areas on Sheldon Refuge include pepperweed (*Lepidium latifolium*, *L. perfoliatum*), saltlover (*Halogeton glomeratus*), Russian olive, Canada thistle, common reed (*Phragmites australis*), and water hemlock (*Cicuta maculate*).

Throughout the semi-arid rangeland, woody species (e.g., *Artemesia* spp.) have expanded into wet meadow systems at the expense of grasses and forbs (see Berlow et al. 2002). Factors influencing this expansion include 1) reduced natural fire frequency due to livestock (including feral horses and burros) grazing of herbaceous species; 2) decreased soil moisture from widespread soil compaction and disturbance from livestock trampling; 3) increased aridity (i.e., lowered water table) from grazing-induced changes in hydrology; 4) changes in the abundance of native wildlife; 5) increased shrub seed dispersal by livestock; and 6) interactions among the above factors (see Berlow et al. 2002).

In addition to invasive or expanding plants, there are species of non-native amphibians and fish which have been introduced to waterways on Sheldon Refuge. Guppies have been released by visitors at several locations on Sheldon Refuge; this species is very adaptable and can occupy a wide range of habitats, particularly warm springs (Williams et al. 1980). Exotic fish establishment is known to have a detrimental effect on native fisheries. For example, the absence of native chubs in Thousand Creek Spring is most likely a result of the introduction and subsequent establishment of guppies (Williams et al. 1980). Rainbow trout were first introduced into Virgin Creek in 1934

(Williams et al. 1980) and subsequently into other areas of Sheldon Refuge, which has resulted in the loss of the native species of Alvord cutthroat trout due to hybridization (Bartley and Gall 1991).

Bullfrogs have also been introduced to areas in Virgin Valley, and the population in the late 1970s was described as large (Storm 1980). Bullfrogs are voracious predators and eliminate native frogs in areas where they are introduced (Storm 1980). The full impact to the native frog populations on Sheldon Refuge both from predation by bullfrogs is unknown. In 2009, chytrid fungus (*Batrachochytrium dendrobatidis*) was documented on Sheldon Refuge (see Section 4.1.3). Chytridiomycosis, a disease caused by the chytrid fungus, is thought to be one of the biggest threats facing amphibian species worldwide; bullfrogs have been proposed as an important vector of the chytrid fungus (Weldon et al. 2004). Section 4.1.3 discusses this disease in more detail.

4.1.2.3 Control Efforts

Already a very significant problem in some areas for native plants and wildlife, invasive species control efforts will be essential, including extensive monitoring and spot control to preclude larger impacts (Inkley et al. 2004). Mechanical and physical methods have been used to combat invasive and encroaching plants in a variety of habitats, specifically in areas with encroaching western juniper. Chemical control methods are also being investigated for herbaceous species, and refuge staff are working with cooperators to develop an Integrated Pest Management Plan and associated pesticide use proposals, where appropriate. Despite recommendations to remove or control invasive animals (e.g., guppies, Storm 1980; bullfrogs, Williams et al. 1980) no attempts have been made to date.

4.1.3 Disease

Emerging infectious diseases pose a serious potential threat to wildlife conservation (Daszak et al. 2000). Greater sage-grouse are highly susceptible to West Nile virus (WNv) infection and once infected, there is little to no chance of survival (Clark et al. 2006). WNv was first confirmed in Greater sage-grouse in 2003 in northeast Wyoming. That year, WNv mortality contributed to a 25% decline in survival of marked birds in Wyoming and Montana (Naugle et al. 2004). Between 2004 and 2008, Greater sage-grouse, passerines, and feral horses were sampled for WNv antibodies on Sheldon and Hart Mountain refuges. To date, all sage-grouse and passerines have tested negative. However, of the feral horse samples tested in 2008 and 2009, 19% and 7%, respectively, tested positive for specific WNv neutralizing antibody (Franson et al. In Review). Specific WNv neutralizing antibodies were first detected in feral horses samples collected at Sheldon Refuge in 2005 when a single horse was found positive. Antibody positive status indicates an exposure to the virus, not necessarily that the animal is capable of transmitting the virus at the time of sampling. To transmit the virus the animal would have to have a virus positive result. To date, it is still widely believed that infected horses cannot infect a mosquito (Dusek 2008). However, a full understanding of the implications of WNv for sage-grouse conservation requires a long-term, coordinated monitoring strategy (Naugle et al. 2005).

In 2009, chytrid fungus was detected in introduced non-native bullfrogs in the Virgin Valley on Sheldon Refuge (Sheldon Refuge files). Bullfrogs have been proposed as an important vector for transmission of the chytrid fungus to native frogs and other amphibians (Weldon et al. 2004). Chytridiomycosis, a disease caused by the chytrid fungus, is thought to be one of the biggest threats facing native amphibian species worldwide (Weldon et al. 2004). Chytridiomycosis has been proposed as the cause of death in frog populations in the rain forests of Australia and Panama and

associated with the decline of frog populations in Ecuador, Venezuela, New Zealand, and Spain (Weldon et al. 2004). The full impact to the native frog populations on Sheldon Refuge, outside of Virgin Valley, from this introduced disease is unknown.

Recently, large die-offs of wintering populations of bats have been documented in the eastern U.S. as a result of white-nose syndrome (WNS). WNS is such named because of a white fungus observed growing on the noses of some infected bats. The disease is not well understood, but one hypothesis is that infected bats arouse from hibernation to attempt to deal with the fungal infection and in doing so prematurely use up all of their fat reserves. The earliest evidence of WNS was documented at a cave in New York in 2006; since then, hundreds of thousands of bats have died. WNS is spread by bat-to-bat contact as well as by humans exploring caves and mines. To date, WNS has not been reported in the western United States; however, it generally accepted that it will eventually spread across many regions of North America (Western Bat Working Group 2009).

Many studies have identified disease as one of the most common factors limiting native and reintroduced bighorn sheep populations in the latter half of the twentieth century (see summary by Cassirer and Sinclair 2007). Disease, primarily bacterial pneumonia, has played an important role in the dynamics of bighorn sheep populations and has been responsible for numerous declines throughout North America; catastrophic all-age disease events are commonly reported in bighorn sheep populations. However, in some cases and even in the absence of a large-scale die-off, chronic or sporadic pneumonia-caused mortality could also be a primary factor limiting population growth (Cassirer and Sinclair 2007).

4.1.4 Changes in the Fire Regime

Fire regimes are the pattern of fire across the landscape and are defined by the combination of the frequency, intensity, severity, and time of year in which natural fire occurs within any particular area over a period of time. Areas within Sheldon Refuge are classified for fire management purposes based upon the frequency in which fires occur and the current condition of vegetation and fuels relative to historical conditions.

Fire is one of the dominant and most visible disturbances in the Great Basin and has played a significant role in shaping the sagebrush-steppe ecosystem of the western United States (Knick et al. 2005; Miller et al. 1994; Pyne 1982; Wright and Bailey 1982; Young et al. 1972); the plants and animals native to the sagebrush steppe evolved under the influence of periodic natural fire. After investigating fire episodes in the Interior Columbia Basin Ecosystem from 1540 to 1940, Barrett et al. (1997) concluded that 4% (4 million acres) of the Columbia Basin sagebrush types burned annually. Historically, fires in the Great Basin shrublands typically produced a mosaic of burned and unburned areas.

The distribution of soils, topography, moisture conditions, and fuels resulted in a mosaic of openings and uneven-aged stands of sagebrush (Connelly et al. 2004; Suring et al. 2005b). However, fire may not be beneficial in all situations to all species or detrimental to all species in all situations (Rose and Miller 1998; Wright and Bailey 1982). Additionally, there is some disagreement on the frequency and spatial scale of fires prior to European settlement (Dobkin and Sauder 2004). Fire is important in the maintenance of forb and grass components, facilitates nutrient cycling, and regulates other ecosystem processes within the sagebrush community (Knick et al. 2005). In the short term, fire generally increases the availability and palatability of herbaceous plants and crown-sprouting shrubs (e.g., rabbitbrush [*Ericameria nauseosa*], chokecherry, snowberry), while materially reducing other

shrub and juniper cover. In the long term, the development of shrubs results in the re-establishment of critical cover (Gruell 1995). Then as sagebrush cover and density increase during succession, cover and density of associated herbaceous plants often decline (Britton and Clark 1985; Gruell 1995; Harniss and Murray 1973; Wright and Bailey 1982).

Prior to European settlement, fires in the Great Basin were believed to have occurred on average every 20 to 200 years (Burkhardt and Tisdale 1976; Houston 1973; Miller et al. 1994), depending on the existing plant community. Use of fire by Native Americans prior to European settlement in southeastern Oregon and northern Nevada has also been suggested, and it has been argued that the nomadic Paiute of eastern Oregon may have used fire on a widespread basis (see Gruell 1995). However, documentation of Native American use of fire is fragmented at best, and there are those that disagree with the overall extent of fire use (see Williams 2002). It is thought that European settlement during the 1850-1870s altered fire occurrence, and the resulting fire exclusion profoundly changed the vegetation composition in the Great Basin. In some areas characteristic fire-return intervals are now much longer as a result of fire suppression and the loss of fire fuels to livestock grazing; in other places, fire-return intervals are dramatically shorter due to the spread and dominance of fire-promoting exotic species, such as cheatgrass (Dobkin and Sauder 2004). The introduction of livestock and exclusion of fire have increased the distribution and density of juniper and big sagebrush across the Great Basin (Miller et al. 1994; Young and Evans 1981) and have resulted in declines in aspen density and regeneration. Prior to European settlement, fires probably created aspen communities with a mosaic of differing age classes, characterized by age classes of less than 60 to 100 years old, with stands over 100 years old being rare (Miller et al. 2001). Mosaics of different seral stages have changed to rather homogenous stands of dense sagebrush with corresponding reductions in herbaceous understory species as a result of fire suppression and livestock influence (Champlin and Winward 1982; Crane and Fisher 1986; Crawford et al. 1992; Goodrich 1999; Hironaka et al. 1983; Kauffman 1990; Tart 1996; Winward 1985; Wright and Bailey 1982; Young 1990).

4.1.4.1 Frequency of Fire within Sheldon Refuge

Following the area's settlement by ranchers and miners, the number of human-caused fires increased, but both these and other lightning-caused fires were aggressively suppressed and extinguished. Between 1935 and the early 1980s all natural fires were aggressively suppressed throughout Sheldon Refuge (USFWS 2009). Beginning in the 1960s and continuing through the 1980s, a limited amount of prescribed burning was conducted within Sheldon Refuge. The use of prescribed burning increased in the late 1980s and continues to be used to achieve a variety of management objectives.

From 1993 through 2004 an average of four natural fires occurred within Sheldon Refuge each year. The number of natural fires within any particular year during the same time period varied from zero to 10. On average, an additional six fires per year were ignited as prescribed fire to achieve habitat management objectives. The number of prescribed fires within any particular year during the same time period ranged from zero to 12 (Figure 4.1).

Documented lightning-caused fires after 1890 have remained relatively small. Excluding the Badger Fire which burned approximately 38,000 acres in 1994 (approximately 6% of Sheldon Refuge), an annual average of 1,659 acres burned by natural fires from 1993 through 2004 on Sheldon Refuge (USFWS 2008a). Prescribed fires have also remained small in size. From 1993 through 2004 the 74 prescribed fires burned an annual average of 327 acres. This average increased from 2005 through

2008 to an average of 1,365 acres; a total of 1,014 acres were burned via prescribed fire in 2009 (NFPORS 2009).

Under current fire management, the frequency of fires has been increasing, particularly prescribed fire, but the average size of an individual fire remains relatively small when compared to presumed natural conditions.

4.1.4.2 Fire Intensity within Sheldon Refuge

Lightning-caused fires within Sheldon Refuge are generally intense, fast-moving fires driven primarily by localized winds. Flame lengths range from 8 to 12 feet, and up to 20 feet in length in steep terrain (USFWS 2008a). In contrast, prescribed fires are usually conducted during the phase of dormancy of perennial grasses, generally after summer cure and prior to green-up, and as a result are less intense.

4.1.4.3 Fire Severity within Sheldon Refuge

Despite the intense nature of fires within Sheldon Refuge, natural fuel conditions throughout much of Sheldon Refuge are discontinuous and light—generally resulting in the potential for rapid fires but with low to moderate severity. Shrubs and other woody plants can be killed or completely consumed by flames of varying intensity, but basal stems of perennial bunchgrasses, and underground plant rhizomes, suckers, and runners are left intact to regrow and sprout the following season. When fuel conditions are above normal, fire intensity and duration can increase to the point all plants are killed or consumed (USFWS 2009).

In the western portion of Sheldon Refuge of mid and higher elevations, natural fuel conditions are generally more continuous and heavy, resulting in the potential for higher severity fires which can completely remove the dominant overstory canopies of western juniper, mountain mahogany, bitterbrush, and sagebrush—resulting in replacement by early successional plant communities.

4.1.4.4 Timing of Fires within Sheldon Refuge

The majority of lightning-caused fires occur from June through September, with some fires occasionally starting as early as mid-May or as late as mid-October. Prescribed fires are typically conducted from September through April, but prescribed fires have been ignited during every month of the year when management prescriptions for ignition have been met.

4.1.4.5 Current Fire Regime within Sheldon Refuge

Clearly existing conditions and management actions do not correspond to a natural fire regime. Past land management practices, including fire suppression, which occurred even before Sheldon Refuge was established, have potentially altered the patterns and types of vegetation and fuel across the landscape. In addition, the paramount importance of safety dictates that prescribed burns are conducted only when strict environmental conditions are met, which are not typical of the hotter, dry, and windy summer conditions of natural fires. Prescribed burning does not mimic natural fire because it generally occurs when conditions are cooler and wetter than during the summer months when lightning-caused fires would typically occur.

Presently, the condition of the fire regime within Sheldon Refuge is characterized as having a high (>66%) departure from historical conditions (USFWS 2009).

4.1.5 Human Disturbance and Habitat Fragmentation

4.1.5.1 Water Developments

Nearly every riparian and aquatic habitat system in Nevada has been altered or modified to some degree from pre-European settlement, through actions such as channelization, construction of dams and diversions, regulation of flows or diversion of flows for agriculture, groundwater depletion, recreational and urban development, de-watering activities (e.g., mining), and the introduction of non-native aquatic species (Wildlife Action Plan Team 2006), and the situation is no different within Sheldon Refuge. Hydrologic processes have been materially altered by previous water development efforts for livestock, including spring boxes, diversions, troughs, canals, dug-outs, and artificial ponds and reservoirs. Water diversions, pumping, and associated groundwater depletion can eliminate riparian habitats entirely because springs and ephemeral streams can easily be pulled underground by removal of a water source (Herbst 1996).

In efforts to enhance the distribution and productivity of livestock and game species, water sources have been built across Sheldon Refuge (see Figure 3.4). Although use of water catchments continues to be a popular management tool in the western United States, the efficacy of such efforts has been questioned and their use is controversial, particularly within wilderness areas (see summary by Cain et al. 2008). On Sheldon Refuge, water catchments or guzzlers have been constructed primarily for the benefit of chukar (a non-native species, see Section 4.1.2) and California bighorn sheep (Wurster 2009). Other modifications and alterations of riparian and aquatic habitats within Sheldon Refuge are the result of hundreds of spring diversions, small and large dams, dug-outs, troughs, and diversion canals. Almost 60% of surveyed sites on Sheldon Refuge were noted as being developed (Collins 2009). Of those developed sites, it was estimated that at least 48% of the structures were either only partially functioning or had already failed (Collins 2009). Repair of these structures must be weighed between the costs of restoration and ecological values. However, it is possible that some riparian systems have been lost entirely or altered so dramatically that they no longer provide the range of habitat opportunities that they would offer if they were not manipulated or otherwise managed (Wildlife Action Plan Team 2006). For example, constructed reservoirs such as Big Spring, Catnip, and Swan Lake are incontrovertible features of the landscape of Sheldon Refuge. Although the creation of these reservoirs necessitated loss of native habitat by inundating riparian habitats, affecting wetlands by altering water availability downstream, and creating habitats which support non-native aquatic and invasive plant species, many now provide significant summering, wintering, and migratory staging sites for waterbirds (Wildlife Action Plan Team 2006).

4.1.5.2 Fences

Currently, Sheldon Refuge has approximately 200 miles of residual allotment fences remaining from historical livestock grazing management. Much of this interior fencing is in extreme disrepair and has become an entanglement hazard for wildlife; efforts are ongoing to remove these hazards. However, one consequence of Sheldon Refuge being surrounded by BLM HMAs is that feral horses and burros may be moving onto Sheldon Refuge from these adjacent lands. This has necessitated additional fencing construction and maintenance along the exterior Sheldon Refuge boundary. Negative impacts of fences can be mitigated by proper design, and current fence construction standards on Sheldon Refuge use BLM wildlife fencing standards for all new fence construction.

4.1.5.3 Habitat Alteration Associated with Roads and Off-highway Vehicle Use

Among the most widespread forms of natural landscape modification landscape during the past century has been the construction and maintenance of roads. To date, more than 550,000 miles of roads have been built on Federal lands to facilitate resource extraction, recreation, and transportation (Havlick 2002). Over 22% of the contiguous United States is estimated to have been ecologically altered by the nation's road network, and that roads in rural areas have the greatest total ecological effect (Forman 2000; Riitters and Wickham 2003). Further, the typical western watershed has more than 20% of its total land area within 0.2 mile of a road, and many have more than 40% (Riitters and Wickham 2003).

Within Sheldon Refuge, vehicle use occurs on approximately 850 miles of road, routes, and trails. This includes unauthorized and illegal use within proposed wilderness areas and other areas closed to vehicle use. Since 1974, route density within Sheldon Refuge has more than doubled from approximately 0.37 mile of route per square mile to roughly 0.84 mile of route per square mile. Improper placement of roads in riparian areas has increased erosion, siltation, disturbance to wildlife, and habitat fragmentation (Ohmart 1996; Wildlife Action Plan Team 2006). Many remote campgrounds and roads are also situated in or near riparian areas, creating additional disturbance.

4.1.5.4 Recreation Uses and Activities

Specific recreational use impacts to riparian and aquatic systems within Sheldon Refuge include bleach and soap added to springs, soil compaction, removal of vegetation and resulting erosion from camping along edges, and manipulation of water flow from installing tubs and water diversions (e.g., Virgin Valley bathhouse). Disturbance, displacement, and habituation of wildlife due to recreation activity have been well documented and studied in other areas (Hammitt and Cole 1987). Other than impacts associated with hunting and vehicle use we presume impacts to wildlife and their habitats from wildlife observation, photography, sport fishing, and interpretation occurring on Sheldon Refuge occur seasonally and are short-term in nature due to the relatively few number of refuge visitors. Hunting is not considered a short-term seasonal use because this activity occurs from August until early February each year, and typically includes overnight camping within Sheldon Refuge. As noted in other sections of this document, we estimate most impacts occur within Virgin Valley where uses and facilities are congregated and at other public use facilities such as semi-primitive and primitive campgrounds.

4.2 Refuge Habitats and Vegetation Types

The Great Basin and Columbia Plateau ecoregions include a variety of distinct habitats and vegetation types. Each habitat type is defined by the relative abundance of associated plant species. The health and function of these habitat types are the foundation upon which management of Sheldon Refuge is based and are therefore very important for developing and implementing future management decisions (Table 4.1).

Table 4.1 Estimated Acres by Landcover Type, Sheldon National Wildlife Refuge, Nevada
(See also Figure 4.2, which displays the location and distribution of these various habitat types.)

Vegetation Types[1]	Habitat Types	Estimated Acres	Percentage of Total Area
Intermountain Basins Big Sagebrush	Big sagebrush steppes and shrublands	133,617	23.898%
Columbia Plateau Low Sagebrush	Low sagebrush shrublands and steppes	133,500	23.877%
Intermountain Basins Greasewood	Salt desert scrubs and greasewood flats	23,669	4.233%
Intermountain Basins Mixed Salt Desert		10,716	1.917%
Intermountain Basins Montane Sagebrush	Montane sagebrush steppes	180,343	32.255%
Northern Rocky Mountain Deciduous Shrub		2,445	0.437%
Intermountain Basins Semi-desert Grassland	Semi-desert grasslands and steppes (including Great Basin wildrye stands)	37,327	6.676%
North American Arid West Emergent Marsh	Emergent marshes and wet meadows	3,511	0.628%
Cattails		172	0.031%
Open Water	Streams and reservoirs (including springs and springbrooks)	455	0.081%
Intermountain Basins Playa	Ephemeral wetlands (includes playas, salt flats, and mudflats)	7,131	1.275%
Barren	Cliffs, canyons, talus slopes, and barren lands		
Intermountain Basins Cliff and Canyon		10,164	1.818%
Rocky Mountain Aspen Forest and Woodland	Deciduous woodlands and shrublands	275	0.049%
Intermountain Basins Mountain Mahogany	Mountain mahogany woodlands	9,009	1.611%
Intermountain Basins Juniper	Western juniper woodlands	4,863	0.870%
Invasive Annual Forbland		857	0.153%
Invasive Annual Grassland		1,054	0.189%
Total area classified (excludes outlier properties)		559,109.18	

[1] Does not include spring and springbrooks habitats, which are too small to be mapped by landcover type.

4.2.1 Sagebrush-steppe and Other Shrubland Habitats

4.2.1.1 Description and Location

Sagebrush is often the dominant shrub on salt-free soils at elevations between 492 and 10,826 feet (Miller and Eddleman 2001). There are five main types of sagebrush or shrubland habitat on Sheldon Refuge: 1) montane sagebrush steppe; 2) big sagebrush steppe (Photo 4.1); 3) big sagebrush shrubland; 4) low sagebrush shrubland and steppe; and 5) salt desert scrub and greasewood flat. This nomenclature generally follows that described in LANDFIRE (2007) and the Southwest Regional Gap Analysis Project (NatureServe 2004). Further detail may also be found in Rogers and Tiehm (1979).

Photo 4.1 Typical sagebrush-steppe habitat within Sheldon Refuge.

Big sagebrush steppe

These stands are dominated by basin big sagebrush (*A. t.* spp. *tridentata*) occurring in deep, friable soils. Other shrubs include rabbitbrush and Wyoming big sagebrush (*A.t.* ssp. *wyomingensis*). Native perennial bunchgrasses and forbs predominate the understory and include bluebunch wheatgrass (*Pseudoroegneria spicata*), Thurber's needlegrass (*Achnatherum thurberianum*), Great Basin wildrye, and Sandberg's bluegrass (*Poa secunda*). The forb component can be diverse with more than 200 species identified over the range of this habitat type in the Great Basin. Native annual forbs may dominate following disturbance.

Big sagebrush shrubland

These stands are dominated by Wyoming big sagebrush. Other shrubs include spiny hopsage (*Grayia spinosa*), basin big sagebrush, and rabbitbrush. Sandberg's bluegrass is the primary herbaceous species; other native species include needle-and-thread (*Hesperostipa comata*), bluebunch wheatgrass, and Great Basin wildrye. Forbs are relatively sparse except following disturbance and include lupine (*Lupinus* spp.).

Low sagebrush shrubland and steppe

These stands are dominated by low sagebrush. Rabbitbrush and bitterbrush also occur. Associated species include Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass, Thurber's needlegrass, squirreltail (*Elymus* spp.), Sandberg's bluegrass, and prairie junegrass (*Koeleria macrantha*). A variety of forbs are usually present including *Phlox* spp., *Lomatium* spp., *Crepis* spp., buckwheat (*Polygonaceae* spp.), and *Lupinus* spp.

Two rare plants are known to occur in this habitat type on Sheldon Refuge: rose biscuitroot and grimy ivesia. The first species, rose biscuitroot, is found in scree and rock fissures overlying clay soils in low sagebrush shrublands. The second species, grimy ivesia has been documented occurring

as a dominant plant in sparsely vegetated gravelly and rocky areas within a matrix of shrublands dominated by low sagebrush and mountain sagebrush (Nachlinger and Tiehm 1996). The Sheldon Refuge population of grimy ivesia represents 86% of the known individuals within Nevada and 85% of all globally known plants (Nachlinger and Tiehm 1996).

Salt desert scrub and greasewood flat

These habitats occur as a mosaic of low shrub communities interspersed with native bunchgrasses on alkaline or moderately saline soils where a relatively high water table is present. Precipitation is also a major factor, and winter moisture accumulation amounts will affect spring plant growth. Some communities are further maintained by intra- or inter-annual flooding cycles followed by extended drought. Common shrubs include greasewood, shadscale saltbrush, fourwing saltbrush (*Atriplex canescens*), silver sagebrush (*Artemesia cana*), winterfat (or whitesage), and spiny hopsage. Common herbaceous species include Indian ricegrass (*Achnatherum hymenoides*), needle-and-thread, saltgrass, squirreltail, sea-blight (*Suaeda torreyana*), and globemallows (*Sphaeralcea* spp.).

Montane sagebrush steppe

These stands are dominated by mountain big sagebrush. Mountain big sagebrush generally occupies moist, productive rolling upland sites. Bitterbrush is a common component of these sites. Other common shrubs include threetip sagebrush (*Artemisia tripartite*) and mountain shrub species (e.g., currant, wild rose [*Rosa* spp.], and snowberry). Herbaceous species include Thurber's needlegrass, Idaho fescue, bluebunch wheatgrass, and Sandberg's bluegrass.

Other associated sagebrush-steppe communities

Biological soil crusts are an integral component of rangeland soils and occur across Sheldon Refuge. These complex assemblages of lichens, liverworts, mosses, cyanobacteria, and algae dominate the uppermost part of the soil surface (Rosentreter and Eldridge 2004). Biological soil crusts provide living cover in environments where soil conditions and high evapotranspiration rates do not support dense vascular plant cover. They reduce soil erosion and enhance nutrient cycling in semi-arid and arid plant communities (see Kaltenecker et al. 1999; Rostentreter and Eldridge 2004).

4.2.1.2 Condition and Trends

Big sagebrush steppe

Basin big sagebrush has a variable mean fire-return interval (<50-150 years). Ecologically significant fires are generally mixed lower severity fires with high severity fires that occur on longer intervals. Periodic drought and insect outbreaks are also factors. Shrub canopy closure of 30%-40% may occur, but it is considered rare. Recently, invasive annual grasses have encroached on patches of varying size. Across the Great Basin, a lack of fire has resulted in a greater proportion of the late-seral closed canopy class than is thought to have occurred historically. Livestock grazing has further increased the proportion of rabbitbrush and decreased native bunchgrass vigor and abundance in all seral stages. On Sheldon Refuge, these habitats are confined to areas of deep soils with adequate moisture and are generally in overall fair condition.

Big sagebrush shrubland

Wyoming big sagebrush habitats historically experienced relatively infrequent fire due to highly variable fire fuels; average fire-return intervals were estimated to be 25 to 100 years (Rose and Miller 1998). Shrub die-offs have occurred, but the causes are largely unknown. Typical canopy cover in this habitat ranges from 8% to 23%; at 12% to 15% cover understory production can begin to decline (Winward 1991). Return of a site following disturbance with a previously high canopy cover (~20%) to a shrub-dominated canopy can take upward of 40 years in drier sites (Winward 1991). In the Great Basin, past overgrazing has allowed invasive annual grasses, mostly cheatgrass, to establish within many of these habitats. In some areas, cheatgrass has contributed to larger and more frequent fires than occurred historically and is resulting in habitat conversion. In addition, grazing has also contributed to an increased density of large shrubs and a reduction in perennial grasses. On Sheldon Refuge, grazing by feral horses continues to be a main concern in these habitats. While encroachment by cheatgrass in disturbed areas is also a concern, these habitats appear to be in overall fair condition.

Low sagebrush shrubland and steppe

Fire in low sagebrush habitats does not carry well and is infrequent under all but extreme conditions. Prior to European settlement, the estimated mean fire-return interval in low sagebrush habitats was 100 to 200 years (Rose and Miller 1998); it is likely that the period of fire suppression has not yet pushed this habitat beyond its historical fire-free interval (Ballard 2002). These habitats regenerate slowly following fire, and prescribed fire treatments in these types of less productive habitats have had mixed results (Rose and Miller 1998). Disturbed low sagebrush habitats are also commonly threatened by invasion from exotic annual grasses, including cheatgrass; invasive plants are less likely to invade undisturbed sites in good condition. Some stands across the Great Basin have seen reductions in large perennial bunchgrasses as a result of past grazing history. On Sheldon Refuge, while grazing by feral horses and burros continues to be a main concern, these habitats appear to be in overall fair to good condition.

Salt desert scrub and greasewood flat

Moisture supporting these intermittently flooded wetlands is usually derived off-site, and they are dependent upon natural watershed function for persistence (Reid et al. 1999). However, the length and severity of drought in the Great Basin has increased since the beginning of the twentieth century. Disturbance events are generally unpredictable and include drought (mean 70 years), flooding (mean 100 years), and fire (mean 150-1,000 years) although stand-replacing fire is rare. Historical overgrazing by livestock on Sheldon Refuge contributed to an increase of shrubs on these sites, and a significant proportion of Great Basin wildrye stands have been converted to greasewood dominated habitats (Photo 4.2). Upland salt desert shrub and greasewood communities are also easily invaded and, in the short term, replaced by cheatgrass and other invasive plant species (e.g., *Halogeton* spp.). In some areas of the Great Basin, the invasion of cheatgrass has altered fire behavior and frequency in these community types. On Sheldon Refuge, ongoing grazing by feral horses and burros precludes restoration.

Photo 4.2 Typical salt desert scrub and greasewood habitat within Sheldon Refuge (Photo Gail Collins).

Montane sagebrush steppe

Mountain sagebrush habitats incur stand-replacing fire every 12 to 15 years on average, ranging from three to 38 years (Miller and Rose 1998). The disturbance pattern largely creates a variety of age classes across the larger landscape ranging from 100 to 5,000 acres in size. Under pre-European settlement conditions, mosaic burns generally killed the above-ground portion of at least 75% of plants (also called topkill) due to the relatively continuous herbaceous layer. These stands also incur periodic mortality due to insects, disease, winter kill, rodent outbreaks, and drought. These disturbances in combination may have significantly reduced the cover of dense stands every 50 to 100 years.

Bitterbrush is a major component of some mountain big sagebrush habitats on Sheldon Refuge and is considered a valuable forage shrub on many ranges occupied by wintering ungulates. Initially, fire exclusion coupled with intensive spring perennial grazing by livestock appeared to favor bitterbrush stand establishment, growth, survival, and increased density (Bunting et al. 1985; Rice 1983; Salwasser 1979). However, livestock overgrazing, senescence, extreme natural fire, and encroachment by big sagebrush has severely reduced bitterbrush abundance across much of its range (Murray 1983; see Ganskopp et al. 2004). Currently, diminished bitterbrush recruitment and reduced vigor are attributed mainly to the absence of disturbance, including fire (Adams 1975; Bedunah et al. 2004; Rice 1983; Roberts et al. 1989; Salwasser 1979). Plant age and vigor in particular can contribute to sprouting responses; shrubs less than five or greater than 60 years old do not sprout well (Martin and Driver 1983; USDA 1999). Other sources of disturbance include periodic defoliation by insects (e.g., tent caterpillar, grasshopper, tussock moth) and disease (e.g., root rot, fungus) (Dryer et al. 2007). However, many species of insects and mites inhabit bitterbrush, several of which are beneficial; bitterbrush is insect pollinated (Dryer et al. 2007).

Fire exclusion in many bitterbrush stands has resulted in increased competition from western juniper and big sagebrush encroachment. Indeed, protection of stands from fire to the point of advanced age,

where excessive fuel has accumulated, plant competition has developed, or the plants have not developed sprouting capability, has led to bitterbrush stands that are increasingly susceptible to fire across the Great Basin (Martin and Driver 1983). In the Badger Mountain area of Sheldon Refuge, natural fire re-occurred in 1994, 1997, and 2000. After the 1994 fire, there was marked recruitment of bitterbrush seedlings on the margins of the burned area (Clements and Young 2006). But the 1997 and 2000 fires in the same area may have eliminated some of the seed source necessary for further shrub recruitment (Clements and Young 2006). On Sheldon Refuge, while grazing by feral horses continues to be a main concern, these habitats appear to be in overall fair condition.

4.2.2 Other Associated Sagebrush-steppe Communities

4.2.2.1 Associated Wildlife

Birds

Bird species whose distribution is closely tied to sagebrush habitats during at least part of the year are considered sagebrush obligates (Braun et al. 1976; Paige and Ritter 1999). Shrubland and grassland birds are declining faster than any other group of species in North America (Dobkin 1994; Paige and Ritter 1999; Saab and Rich 1997). In fact, sagebrush habitats have been identified as one of the top most threatened bird habitats in the United States (American Bird Conservatory 2007). Dobkin and Sauder (2004) documented significantly declining population trends for 16 of the 25 upland bird species considered. In addition, Paige and Ritter (1999) identified 18 bird species associated with sagebrush ecosystems that were of conservation concern. These species represent an important component of the biodiversity of the western United States but have seen little conservation action (Knick et al. 2003). Recently, the three primary passerine species of sagebrush habitats, Brewer's sparrow, sage sparrow, and sage thrasher, have received special conservation status in one or more western states (Knick and Rotenberry 2002; Wildlife Action Plan Team 2006). The status of populations on Sheldon Refuge is unknown.

Greater sage-grouse

Widespread concern for sagebrush-obligate wildlife due to loss of sagebrush habitats has been primarily focused on Greater sage-grouse (habitat distribution shown in Figure 4.3), the flagship game bird of these landscapes (see Dobkin and Sauder 2004). Sage-grouse on Sheldon Refuge have been documented to nest in shrub habitats, including low sagebrush, big sagebrush, and bitterbrush sites (Klebenow and Burkhardt 1982). While shrubs also provide important forage, the importance of forbs and insects in the sage-grouse diet has been well documented (Drut et al. 1994; Evans 1986; Gregg 2006). For example, Huwer et al. (2008) found that increasing forb cover in areas with <20% forb cover may lead to increased chick survival and grouse productivity. For more information on sage-grouse ecology, see Connelly et al. (2004) and CalPIF (2005).

Sage-grouse have been extirpated in British Columbia, Nebraska, New Mexico, Arizona, and Oklahoma (Braun 1991, 1993). Within the core area of their range, sage-grouse populations have dramatically declined (Braun 1998; Wisdom et al. 1998). In 2008, the Western Association of Fish and Wildlife Agencies (WAFWA) conducted new population trend analyses that incorporated an additional four years of data beyond the Connelly et al. 2004 analysis (WAFWA 2008). Although the WAFWA analyses used different statistical techniques, lek counts also were used. WAFWA results were similar to Connelly et al. (2004) in that a long-term population decline was detected from 1965 to 2007 (average 3.1% annually; WAFWA 2008). WAFWA attributed the decline to the

reduction in number of active leks (WAFWA 2008). Across Nevada, annual rates of change suggest a long-term decline for sage-grouse. The statewide population reached a low in the mid-1990s and according to Connelly et al. (2004) did not appear to have changed substantially since that time. In the mid-1980s, a study in an area adjacent to Sheldon Refuge suggested that high harvest rates combined with low annual recruitment were affecting the low density sage-grouse population (Zunino 1987).

Recorded estimates of sage-grouse numbers and population trends have been maintained since 1942 on Sheldon Refuge (USFWS 1971); however, methods were not standardized until the mid-1990s (Collins 2008b). The primary method used to monitor trends in sage-grouse populations within Sheldon Refuge is by conducting helicopter surveys to count the number of male birds annually at designated lek areas during the breeding season. In 2004 the population of sage-grouse within Sheldon Refuge was estimated at 2,896 to 3,475 birds (Sage-grouse Conservation Team 2004). In 2007, 2008, and 2009, a population decrease was noted for Sheldon Refuge, which had shown population increases each year since calculations were first established in 2003 (Collins 2010; Sage-grouse Conservation Team 2007; Sheldon Refuge files).

Hunting for sage-grouse within Sheldon Refuge has been conducted intermittently and for various purposes over the past 50 years. There was no hunting for sage-grouse on Sheldon Refuge between the refuge's establishment in 1931 and 1960. A limited annual sport hunting season was initiated in 1961 (USFWS 1971) but was subsequently closed. In 1995, the Service, in cooperation with the State of Nevada, initiated a limited permit-only hunting season for Greater sage-grouse on the majority of Sheldon Refuge (Collins 2008b; Day 2009) specifically to collect bird wings for use in estimating population productivity and reproduction. Although population trend can be estimated from lek counts alone, production data help determine whether recruitment rates are high enough to sustain a population. Nest success and recruitment of juveniles into the population are usually cited as the most significant parameter influencing sage-grouse population trend (Armentrout et al. 2004). The nest success for 2008 was estimated to be 61%. This was higher than all other areas in the western region of Nevada, which includes Washoe, Humboldt, and Churchill counties. However, the accuracy of this estimate is questionable due to greater susceptibility of immature birds to hunter harvest and concerns related to inadequate sample size. Wing data from birds harvested on Sheldon Refuge are also used to estimate sage-grouse sex and age ratios. Monitoring upland game population trends with sex and age ratios from hunter harvests is a common practice, although recent analyses indicate that the number of samples required to generate precise population estimates currently exceeds the harvest levels of most states (Hagen and Loughin 2008). Questions regarding the ability to conduct meaningful population analysis from hunter-harvested wings have previously been noted for Sheldon Refuge (Klebenow and Burkhardt 1982). Despite the limitations of wing data, they probably provide the only viable means for assessing the effects of management actions on production at the state or local population management unit scale (Sage-grouse Conservation Team 2004).

The hunt on Sheldon Refuge is considered the most conservative in Nevada and is conducted by permit during two separate two-day seasons during September each year. In total, 75 permits are issued, each of which allow a maximum daily harvest of two birds and a maximum possession limit of four birds for a maximum allowable harvest of 300 birds. The average annual harvest reported is 144 birds. NDOW and Sheldon Refuge coordinate the timing and harvest limit of the hunting season(s). All permit holders are required to deposit one wing from each sage-grouse harvested in collection barrels on Sheldon Refuge. In addition, hunters must return a questionnaire to USFWS

stating if they actually hunted, where they hunted, and how many birds they harvested. The compliance rate for returning the questionnaire was 90% in 2001 (Armentrout et al. 2004).

In 2010 the USFWS listed Greater sage-grouse as a candidate species under the Endangered Species Act, meaning that the Service finds that listing the Greater sage-grouse (rangewide) (as a threatened or endangered species) is warranted but precluded by higher priority listing actions. The Service recognizes the need to recover sage-grouse populations throughout the United States to ensure the continued existence and survival of the species. In support of sage-grouse population recovery efforts, 25 birds were translocated from Sheldon Refuge to Washington in 2004, and 22 birds were translocated to California in 2007.

Other birds

Sagebrush-steppe and shrubland habitats on Sheldon Refuge provide important habitat to a range of other bird species. As discussed above, the major sagebrush-steppe obligate passerine species are Brewer's sparrow, sage sparrow, and sage thrasher. In addition, many other birds seasonally occupy shrub-steppe habitats on Sheldon Refuge including vesper sparrow (*Pooecetes gramineus*), horned lark (*Eremophila alpestris*), lark sparrow (*Chondestes grammacus*), loggerhead shrike (*Lanius ludovicianus*), green-tailed towhee (*Chlorura chlorura*), gray flycatcher (*Empidonax wrightii*), Say's phoebe (*Sayornis saya*), western meadowlark (*Sturnella neglecta*), western kingbird (*Tyrannus verticalis*), and white-throated swift (*Aeronautes saxatalis*). Shrub-steppe uplands also provide foraging habitat for raptors, including bald eagle (*Haliaeetus leucocephalus*), long-eared owl (*Asio otus*), ferruginous hawk (*Buteo regalis*), red-tailed hawk (*B. jamaicensis*), and prairie falcon. Of the listed species above, Greater sage-grouse, Brewer's sparrow, sage sparrow, bald eagle, ferruginous hawk, white-throated swift, and loggerhead shrike have been identified as Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006).

Mammals

Pronghorn

Pronghorn (habitat distribution shown in Figure 4.4), a sagebrush-obligate species within the Sheldon and Hart Mountain refuges are migratory, and the populations of these two refuges are thought to intermingle (Pyle and Smith 1990). There have been few accurate total population counts of pronghorn on Sheldon Refuge or adjacent lands; generally efforts have been directed toward herd composition rather than population census. For all survey efforts (composition and census), discrepancies in location and distribution of the population during surveys, differences in the timing and intensity of effort, poor and varied techniques, and lack of available resources have contributed to the complexity of this issue (USFWS 2001b).

Pronghorn were nearly extirpated from North America in the late 1800s by sport and commercial hunting. Following the enactment of protective laws, pronghorn subsequently increased by >3,200% during the twentieth century; they have been second only to deer species in abundance and harvest in the United States (Yoakum et al. 1996). Pronghorn populations have undergone large fluctuations since Sheldon Refuge was established. Three population trends are evident on the Sheldon and Hart Mountain refuges since the 1930s. First, summer numbers gradually declined from a peak in the late 1930s to a low in the mid-1950s. The population then increased in the late 1950s, and was apparently stable between the 1950s and 1970s. Pronghorn increased again in the 1980s (Pyle and Smith 1990). There were recent concerns in the mid- to late 1990s that the population on Hart

Mountain Refuge was at risk of decline (USFWS 2001b). Early data from studies initiated during that period suggested that predators were responsible for the majority of pronghorn fawn mortality and that predator control was necessary for the recovery of the declining population (USFWS 2001b). Ultimately, predator control efforts were postponed indefinitely in part due to an unexpected improvement in fawn survival, and both the Hart Mountain and Sheldon pronghorn populations have since substantially increased (Collins 2008a). This indicates that predation was not the primary limiting factor. Indeed, additional data has since demonstrated that both the fawn's date of birth and previous summer's precipitation are highly important factors in fawn survival (Whittaker 2008). There was no harvest season for pronghorn within Sheldon Refuge between 1936 and 1967. Conservative harvest regulations were implemented in 1968, with an emphasis on quality hunting experiences (Pyle and Smith 1990).

For studies of pronghorn habitat requirements, diet, intra-species interactions, and population dynamics within Sheldon Refuge see Deming (1954), Meeker (1979), McNay (1980), and Maher (1991). Low sagebrush habitats on Sheldon Refuge in particular are important for pronghorn, especially for wintering and fawning. Sagebrush is also an important forage source year-round, with forbs contributing heavily to the diet during the summer. Winter weather severity and spring/summer precipitation strongly influence pronghorn population numbers, trends, production, recruitment, distribution, and seasonal movements (USFWS 2001b).

Mule deer

Mule deer populations (habitat distribution shown in Figure 4.4) have experienced wide fluctuations over the past 60 years due to past land management practices. The current decline of populations throughout the western United States most likely is the result of habitats that have reached optimum levels during and following a period of extreme disturbance. It is unlikely these lands will again support such high historically observed numbers of mule deer (Gruell 1986).

Studies have confirmed that mule deer diets on Sheldon Refuge are dominated by bitterbrush and mountain mahogany (Woodis 1989). Important mule deer fawning habitats on Sheldon Refuge also include mountain big sagebrush and mountain mahogany sites, and the Virgin Valley is important for spring foraging (Burkhardt et al. 1982). Data also indicate that some mule deer summering on Sheldon Refuge migrate off-refuge during the winter (Burkhardt et al. 1982; Sheldon Refuge files). There were no open seasons for deer harvest between 1936 and 1951. By the mid-1950s, mule deer ranges on Sheldon Refuge were noted as being severely overgrazed and attempts were made to reduce the wintering mule deer population by as much as 30% (USFWS 1956). However, in the early 1960s, it was noted that liberal harvest regulations, including either-sex and extended seasons, were potentially impacting Sheldon Refuge's mule deer population outside of the closed areas (USFWS 1962). Currently mule deer hunting is managed to limit take and maximize quality hunting experiences.

Pygmy rabbit

Pygmy rabbits (habitat distribution shown in Figure 4.3) are a sagebrush habitat specialist of heightened conservation concern for which data on distribution, movement, and space use are limited (USFWS 2003). Following declines in Oregon and Washington and a lack of solid information about its status elsewhere, the species was designated as a Federal species of special concern. In 2010, the Service determined that there has been some loss and degradation of pygmy rabbit habitat

range-wide, but not to the magnitude that constitutes a significant threat to the species and that protection under the Endangered Species Act is not warranted.

While the population status of pygmy rabbits on Sheldon Refuge is largely unknown, recent investigations found that pygmy rabbits were still present throughout all of their historical range in Nevada (Larrucea and Brussard 2008). Pygmy rabbits are uniquely dependent on big sagebrush for cover and food, occupying some of the remaining sagebrush steppe in the Great Basin where sagebrush is relatively tall and dense and soils are deep. Dense sagebrush provides thermal cover and protection from predators (see Siegel-Thines et al. 2004). In addition to providing cover, sagebrush dominates the diet of pygmy rabbits throughout the year, with substantial use of grasses and forbs when seasonally available (see summary by Sanchez and Rachlow 2008). There are indications that pygmy rabbits use larger home ranges than expected for their body size, and that their range is influenced by gender, season, and dispersion of resources.

Other mammals

Additional sagebrush-obligate or shrubland mammal species on Sheldon Refuge include kit fox (*Vulpes macrotis*), sagebrush vole (*Lagurus curtatus*), and Great Basin pocket mouse (*Perognathus parvus*). Other mammal species that utilize shrubland habitats on Sheldon Refuge include bobcat, coyote, mountain lion, desert wood rat (*Neotoma lepida*), black-tailed jack rabbit (*Lepus californicus*), Nuttall's (mountain) cottontail (*Sylvilagus nuttallii*), dark kangaroo mouse (*Microdipodops megacephalus*), northern grasshopper mouse (*Onychomys leucogaster*), and Preble's shrew (*Sorex preblei*). Many of the inhabitants of salt-desert scrub, in particular, require burrows for nesting, hunting, predator avoidance, and thermoregulation. Of the listed species, Preble's shrew, sagebrush vole, kit fox, pygmy rabbit, and mule deer are listed as Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006).

Reptiles and amphibians

The main sagebrush-obligate reptile species that occurs on Sheldon Refuge is the sagebrush lizard. Other species found in shrub uplands include collared lizard (*Crotaphytus collaris*), desert horned lizard (*Phrynosoma platyrhinos*), pygmy short-horned lizard (*Phrynosoma douglasii*), western whiptail (*Cnemidophorus tigris*), and striped whipsnake (*Masticophis taeniatus*). The desert horned lizard and pygmy short-horned lizard are listed as Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006).

Amphibians include the Great Basin spadefoot toad (*Scaphiopus intermontanus*). This species is unique in that it occupies arid regions of sagebrush flats and shrublands, breeding in temporary or permanent water bodies. While little is known of their movement capabilities, it is suspected they may move several hundred feet between breeding sites and terrestrial habitats (Hammerson 2005).

4.2.2.2 Threats

Across the Great Basin, human-caused disturbance and habitat fragmentation associated with livestock grazing, fencing, agriculture, mining, urban development, and recreational access are all considered threats. In addition, encroachment of western juniper, expanding invasive plant species, changes in the natural fire regime, disease, and grazing from feral horses and burros are also threats to these habitat types and associated fish and wildlife within Sheldon Refuge.

Shrubs and trees increased with the increasing length of fire-return intervals after the 1870s, and currently a dense shrub or tree layer dominates much of the mountain big sagebrush–bunchgrass communities in much of the Great Basin. Burkhardt and Tisdale (1976) concluded that fire-frequency intervals of 30 to 40 years would be adequate to keep western juniper from invading many sagebrush-grassland communities. As communities cross the threshold and juniper begins to dominate a site, the rapid decline of understory fine and woody fuels greatly reduces the potential for fire to occur (Miller et al. 2001). However, the decline of intact Wyoming big sagebrush–bunchgrass communities in the larger region has generated debate regarding the value and risks associated with using prescribed fire in an attempt to mimic historical fire regimes; in particular, the potential for prescribed fire to promote exotic annual grass invasion. Sites that have transitioned from shrub-steppe to woodland due to encroachment of western juniper may now only burn under severe weather conditions that create crown fires in tree-dominated communities (Knick et al. 2005).

Human disturbance and habitat fragmentation

Anthropogenic influences in shrub-steppe ecosystems have changed the landscape of the Intermountain West (see Section 4.2.1). This includes habitat fragmentation associated with livestock grazing, fencing, agriculture, mining, urban development, and recreational access.

4.2.3 Semi-desert Grasslands and Steppes

4.2.3.1 Description and Location

These habitat types include semi-desert steppes and grasslands characterized by sparse to moderately vegetated mosaic of shrubs and perennial grasses (Photo 4.3). The herbaceous layer is dominated by drought-resistant perennial bunchgrasses including bluebunch wheatgrass, Thurber's needlegrass, Sandberg's bluegrass, Great Basin wildrye, needle-and-thread, and Indian ricegrass. Shrubs include greasewood, spiny hopsage, saltbrush (*Atriplex* spp.), sagebrush, bitterbrush, and rabbitbrush. Nomenclature follows that described in LANDFIRE (2007) and the Southwest Regional Gap Analysis Project (NatureServe 2004).

Photo 4.3 Typical semi-desert grassland habitat within Sheldon Refuge.

4.2.3.2 Condition and Trend

The composition and structure of the semi-arid or desert grasslands of western North America have changed dramatically over the past 150 years. Native brushy or woody species in these communities have increased in density and cover due to changes in local conditions (Van Auken 2000). Causes for shrub or woody plant encroachment in semi-arid grasslands have been much debated. Most often cited as reasons are climate change, chronic high levels of grazing, changes in fire frequency, changes in grass competitive ability, spread of seed by livestock, small mammal populations, elevated levels of carbon dioxide, and combinations of these factors (see Van Auken 2000). Chronic high levels of grazing associated with the introduction of cattle (and likely feral horses and burros) appear to be a primary factor in the conversion of semi-arid grasslands into shrublands or woodlands. However, the mechanisms are still not well understood (Van Auken 2000). At the same time, fire frequency and fire size in these semi-arid grasslands have decreased, resulting in larger and denser stands of woody plants and less grass. There is historical evidence of fires in these systems from the earliest travelers and European settlers, although some argue that there was not enough fuel in these grasslands to carry an extensive fire; today natural fires are rare (see Van Auken 2000).

4.2.3.3 Associated Wildlife

Birds

Semi-desert steppes and grasslands support several breeding bird species including Greater sage-grouse, horned lark, mountain bluebird (*Sailia currucoides*), savannah sparrow (*Paserculus sandwichensis*), vesper sparrow, and western meadowlark. Grasslands also provide foraging habitat for raptors including American kestrel (*Falco sparverius*), ferruginous hawk, golden eagle, long-eared owl, short-eared owl (*Asio flammeus*), northern harrier (*Circus cyaneus*), northern shrike (*Lanius excubitor*), red-tailed hawk, and rough-legged hawk (*Buteo lagopus*). The Greater sage-grouse, ferruginous hawk, short-eared owl, and western burrowing owl (*Speotyto cunicalaria*) are listed as Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006).

Western burrowing owl

Populations of burrowing owls have declined in many portions of their range. The owls are listed as endangered in Canada, a species of National Conservation Concern in the United States, and are listed, or being considered for listing, in many western states (Conway et al. 2008; Klute et al. 2003). The status of the population on Sheldon Refuge is largely unknown. For details of burrowing owl ecology, see Klute et al. (2003).

Mammals

Semi-desert steppes and grasslands on Sheldon Refuge provide habitat for pronghorn, mule deer, kit fox, coyote, bobcat, mountain lion, yellow-bellied marmot (*Marmota flaviventris*), American badger (*Taxidea taxus*), black-tailed jackrabbit, white-tailed jackrabbit (*Lepus townsendii*), Belding's ground squirrel (*Spermophilus beldingi*), Ord's kangaroo rat (*Dipodomys ordii*), and northern grasshopper mouse. Species included as Nevada Species of Conservation Priority are mule deer and kit fox (Wildlife Action Plan Team 2006).

Reptiles and amphibians

Reptiles documented in these habitats on Sheldon Refuge include desert horned lizard, long-nosed leopard lizard (*Gambelia wislizenii*), pygmy short-horned lizard, rubber boa (*Charina bottae*), western whiptail, striped whipsnake, and western rattlesnake (*Crotalus viridis*). The desert horned lizard, pygmy short-horned lizard, and long-nosed leopard lizard are listed as Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006). Amphibians include the Great Basin spadefoot toad, although the distribution of this species is limited by available ponds for breeding.

4.2.3.4 Threats

In addition to feral horses and burros (see Section 4.1.1), human disturbances associated with recreation use and habitat fragmentation from vehicle routes and utility rights-of-way (see Section 4.1.5) are considered threats to these habitat types and associated wildlife within Sheldon Refuge.

4.2.4 Emergent Marshes, Wet Meadows, Streams, Reservoirs, Springs, Springbrooks, and Ephemeral Wetlands

4.2.4.1 Description and Location

Riparian habitats in western rangelands have exceedingly high values for human society, fish, and wildlife. Their resource values far exceed the approximate 0.1% of the land area they cover (Ohmart 1996). These areas serve to trap and stabilize eroded sediments, detoxify compounds, act as phosphorus sinks for soil enrichment, and serve as denitrification areas to provide high water quality (Ohmart 1996). Riparian areas are also the most ecologically productive and diverse of all terrestrial habitats. This results from a variety of physical environments arising from moisture gradients, margins of often highly contrasting vegetation components, and a general mosaic of habitats created by dynamic stream changes (Clary and Medin 1999). Riparian habitats are also particularly important in the arid refuge environment where the presence of water and relatively cool, often shaded conditions provide an ecological importance and diversity far beyond their extent; a large portion of both the flora and fauna in riparian zones exists nowhere else (Clary and Medin 1999; Ohmart 1996). Although many desert aquatic species are adapted to life in ephemeral, saline, or geothermal habitats, prolonged disruption of aquatic environments has resulted in the loss of biodiversity in the Great Basin (Herbst 1996).

On Sheldon Refuge, water is scarce during the summer months, and the most consistent water sources are natural springs and associated springbrooks, the majority of which are located between 5,700 and 6,700 feet in elevation. See Section 3.3 for a more detailed description water sources and hydrology within Sheldon Refuge.

There are four major types of aquatic and riparian habitats on Sheldon Refuge: 1) ephemeral wetlands; 2) emergent marshes and wet meadows; 3) springs and springbrooks; and 4) streams and reservoirs. Nomenclature used generally follows that described in LANDFIRE (2007) and the Southwest Regional Gap Analysis Project (NatureServe 2004). Further detail may also be found in Rogers and Tiehm (1979).

Emergent marshes and wet meadows

These areas are generally broad flat areas that include wet meadows, ponds, fringes around lakes and along slow-flowing streams, and springbrooks (Photo 4.4). Water levels may be stable or fluctuate over a season, and these areas include seasonally flooded meadows or shallow freshwater floodplains. There is generally a diverse array of native wetland plants including emergent plants, sedges, and moist-soil plants. Common vegetation include bulrush (*Scirpus* sp., *Schoenoplectus* spp.), cattail, rushes, sedges, pondweed, pond lily (*Nuphar* spp.), and canarygrass (*Phalaris* spp.). Shrub species, where present, include willow, aspen, and chokecherry (*Prunus* spp.).

Photo 4.4 Typical wet meadow habitat within Sheldon Refuge.

Streams and reservoirs

Stream habitats have water temperatures generally <75˚F, and include flowing water with well-vegetated cover, stable banks free from barriers and diversions, stream velocity breaks, and in relatively silt free, rocky riffle-run areas (Photo 4.5). Substrates range from soft bottom sediments to rocky riffle-run areas. Vegetation found along the reservoirs is generally characterized by species that are tolerant to fluctuations in water levels. Common species found on or near the shores include wedgeleaf dock (*Rumex triangulivalvis*), povertyweed (*Iva axillaries*), spikesedge (*Eleocharis* spp.), and cattail (*Typha latifolia*).

Springs and springbrooks

Ephemeral or perennial freshwater springs and associated springbrooks have a range of water temperatures (<78˚F to >86˚F). Substrates range from boulders and gravel to fines and vegetation and there is generally low to no turbidity. The vegetation found at these sites is very similar to that of riparian communities described earlier. However, unique and rare vegetation communities can be found at some of the thermal springs and may include desert centaury (*Centaurium exaltatum*), alkali pepperweed (*Lepidium dictyotum*), and boraxweed (*Nitrophila occidentalis*).

Ephemeral wetlands

Ephemeral wetlands include shallow swales with basin topography; these barren and sparsely vegetated areas include playas, salt flats, and mudflats (Photo 4.6). These systems hydrate via overland flow or groundwater discharge. The soils are lacustrine or palustrine and alkaline to hypersaline. Herbaceous species include fourwing saltbrush, spiny hopsage, and Great Basin wildrye.

Ephemeral wetlands within Sheldon Refuge consist almost entirely of small, closed basins called *playas*, which collect precipitation and runoff from the surrounding areas. Playas are formed and maintained through a combination of dissolution of subsurface basin material and wind deflation (Gustavson et al. 1995; Osterkamp and Wood 1987; Reeves and Reeves 1996). These processes concentrate salts and clay minerals in playa soils, making them more alkaline, and reduce water infiltration. As a result, playa habitats may become flooded after even a small amount of precipitation. Playas range in size from less than an acre tens of thousands of acres. Most playas within Sheldon Refuge are less than 50 acres in size. Because playa hydrology is determined by localized weather conditions, playas may be flooded seasonally or annually for several consecutive years, or may be dry for a number of years and flooded only rarely. Playa flooding is highly variable and may range from of only a thin film of water to several inches of water. Because playas are closed basins, water remains until it evaporates or infiltrates into the soil. During flooded conditions, typically during spring, playas teem with aquatic invertebrates. These invertebrates provide important forage for migrating birds. As playas begin to dry later in the season, the moist soils support grasses, sedges, and forbs, which provide forage for pronghorn, deer, sage-grouse, and other wildlife. Little research or literature is available related to playa formation and ecology, but for the Southern High Plains region of Texas and New Mexico, Haukos and Smith (2003) stated that because scattered individual playas collectively form the basis for diversity of the region, impairment of the function of an individual playa contributes to the decline of biodiversity across a much larger area than only the impacted wetland. Therefore, successful conservation of playas and associated flora and fauna is dependent upon protection of as many playas as possible in the landscape rather than attempting to identify the best playas and concentrating efforts on a select few wetlands.

Photo 4.5 Typical stream habitat within Sheldon Refuge.

Photo 4.6 Typical playa habitat within Sheldon Refuge (Photo Gail Collins).

Playa habitats support a broad array of bird, amphibian, invertebrate, and plant species. Invertebrates and other aquatic taxa which live in playa wetlands are specially adapted to withstand prolonged dry periods and to then quickly mature and reproduce during brief periods when playas flood. and Smith (2003). Historically, plants in playas were grazed seasonally by many wildlife species, including pronghorn (*Antilocapra americana* Ord), elk (*Cervus elaphus* Linnaeus), and bison (*Bison bison* Hamilton-Smith). Any grazing by wildlife today is generally by small mammals, although pronghorn and deer (*Odocoileus* spp.) continue to forage in grassland playas.

At any point-in-time, species occurrence in playas is dependent on three factors: 1) the composition of the available seed bank (i.e., viable seed in a position within the soil capable of germinating), 2) the environmental conditions of previous years that dictated species presence and replenishment of the seed bank, and 3) the environmental conditions of the current growing season that regulates germination and seedling growth from the seed bank (Haukos and Smith 1993).

4.2.4.2 Condition and Trends

Despite removal of domestic cattle and sheep from riparian areas, grazing by feral horse and burro populations continues to impact the condition of riparian habitats on Sheldon Refuge (USFWS 2008a). Impacts include indirect effects such as reducing plant vigor or eliminating vegetation by grazing and trampling.

Erosion and high levels of turbidity are common water-related issues on Sheldon Refuge (Barnett 2002; Steblein 2007). Most springs and adjacent meadows have been trampled by previous livestock and current feral horse use, resulting in weakened vegetation, erosion, and headcutting. In particular, grazing on Sheldon Refuge has resulted in deterioration of spring-associated meadows and destruction of riparian vegetation (including willows and aspen). Recent surveys of springs on Sheldon Refuge rated approximately 43% of perennial springs as displaying moderate to severe grazing disturbance; feral horses were the most commonly documented ungulate, occurring at 71% of sites surveyed (Collins 2009). In addition, 31 springs surveyed did not meet guidelines for

riparian protection detailed by Chaney et al. (1990): undergoing moderate to severe utilization, affected by uncontrolled season-long grazing by feral horses, and stubble heights <3.19 inches.

Earlier accounts suggested that heavy grazing of Sheldon Refuge meadow habitats was the most serious management problem for Greater sage-grouse (USFWS 1971). While moderate levels of managed, seasonal grazing on Sheldon Refuge appeared to be effective in stimulating forb regrowth on meadows, weedy species were generally more prevalent at sites exposed to moderate to heavy long-term grazing (Evans 1986). Without plants to slow water movement and associated headcutting, the water table has dropped at some sites, and sagebrush, primarily on the periphery, has invaded associated riparian meadows.

Global declines in amphibian populations are perhaps one of the most enigmatic environmental problems of the late twentieth century (Daszak et al. 1999). While some declines are likely due to habitat destruction, others are not associated with obvious environmental factors. Other potential causes include the introduction of predators or competitors, increased ultraviolet irradiation, acidic precipitation, adverse weather patterns, environmental pollution, infectious disease, or a combination of factors (Daszak et al. 1999).

4.2.4.3 Associated Wildlife

Birds

Greater sage-grouse

Summer and fall habitat types utilized by sage-grouse on Sheldon Refuge include both uplands and meadow sites, including ecotones between these types (Klebenow and Burkhardt 1982). After hatching, sage-grouse broods seek out riparian meadows and other moist areas where native broadleaved flowering plants and insects are abundant. See Section 4.2.1 for more information regarding Greater sage-grouse on Sheldon Refuge. On Sheldon Refuge, it has been shown that Greater sage-grouse generally avoid meadow areas where sagebrush encroachment has occurred. (Klebenow and Burkhardt 1982).

Other birds

Aquatic and riparian habitats on Sheldon Refuge provide important habitat for a wide variety of resident and migratory birds. Nevada lies within the Pacific Flyway, the primary seasonal movement corridor for waterbirds migrating west of the Rocky Mountains (Wildlife Action Plan Team 2006). The number of waterfowl that use Sheldon Refuge is not large compared to other areas, although a substantial number use Sheldon Refuge's wetlands during fall migration. While most shorebirds using refuge wetlands are spring and fall migrants, species including American avocet, American bittern (*Botaurus lentiginosus*), killdeer (*Charadrius vociferous*), Virginia rail (*Rallus limicola*), sora rail (*Porzana carolina*), black-necked stilt, long-billed curlew, spotted sandpiper (*Actitis macularia*), willet (*Catoptrophorus semipalmatus*), Wilson's phalarope, and common snipe (*Capella galliango*) are known to nest around permanent water sources. Other common waterbird species that occur seasonally in Refuge aquatic habitats are greater sandhill crane, black-crowned night heron (*Nycticorax nycticorax*), double-crested cormorant (*Phalacrocorax auritus*), Forster's tern (*Sterna forsteri*), black tern (*Chlidonias niger*), western snowy plover, greater and lesser yellowlegs (*Tringa melanoleucus* and *T. flavipes*), sandpipers (least [*Calidris minutilla*], solitary [*T. solitaria*], and western [*C. mauri*]), and grebes (Clark's [*Aechmophorus clarkii*], eared [*Podiceps caspicus*], horned

[*P. auritus*], pied-billed [*Podilymbus podiceps*], and western [*A. occidentalis*]). These habitats also provide foraging areas for a range of seasonally resident and migrating raptors, including American kestrel, bald and golden eagles, ferruginous hawk, northern harrier, rough-legged hawk, Swainson's hawk (*Buteo swainsoni*), short-eared owl, long-eared owl, and western screech owl (*Otus asio*). Passerines also occupy these habitats and include bobolink (*Dolichonyx oryzivorus*), Brewer's blackbird (*Euphagus cyanocephalus*), red-winged blackbird (*Agelaius phoeniceus*), calliope hummingbird (*Stellula calliope*), rufous hummingbird (*Selasphorus rufus*), savannah sparrow, fox sparrow (*Passerella iliaca*), vesper sparrow, and western bluebird (*Sialia mexicana*). Mountain quail (*Oreortyx pictus*) are native to Sheldon Refuge, and although this species has been reported only rarely since the 1960s, it may be occasionally observed within riparian habitats.

Several species of waterfowl also nest on Sheldon Refuge including Canada goose (*Branta canadensis*), canvasback (*Aythya valisineria*), gadwall (*Anas strepera*), mallard (*Anas platyrynchos*), northern pintail (*Anas acuta*), northern shoveler (*Anas clypeata*), redhead (*Aythya americana*), ruddy duck (*Oxyura jamaicensis*), blue-winged teal (*Anas discors*), green-winged teal (*Anas carolinensis*), and cinnamon teal (*Anas cyanoptera*). Limited waterfowl hunting opportunities became available on Sheldon Refuge beginning in 1999, the majority of which occur at the IXL Ranch wetlands, Alkali Reservoir, and Perry Springs (USFWS 1998b). Of the above species, those that are listed as Nevada Species of Conservation Priority include northern pintail, canvasback, cinnamon teal, American avocet, black-necked stilt, long-billed curlew, willet, greater sandhill crane, Forster's tern, black tern, western snowy plover, least sandpiper, grebes, bald eagle, ferruginous hawk, Swainson's hawk, short-eared owl, bobolink, rufous hummingbird, and mountain quail (Wildlife Action Plan Team 2006).

Mammals

Riparian habitats provide critical habitat for a variety of small mammals, including Preble's shrew, Merriam's shrew (*Sorex merriami*), vagrant shrew (*S. vagrans*), water shrew (*S. palustris*), montane vole (*Microtus montanus*), Belding's ground squirrel, and white-tailed antelope ground squirrel (*Ammospermophilus leucurus*). In addition, these habitats provide important foraging areas for California bighorn sheep, mule deer, porcupine, striped skunk (*Mephitis mephitis*), hoary bat (*Lasiurus cinereus*), spotted bat (*Euderma maculatum*), and little brown myotis (*Myotis lucifugus*). Reported occurrences of river otter (*Lontra canadensis*) and muskrat (*Ondatra zibethicus*) have been rare. Seasonally wet areas, particularly associated with playa lakes, are a very important component in pronghorn summer and fall range. Of the above species, those that have been listed as Nevada Species of Conservation Priority include Preble's shrew, Merriam's shrew, vagrant shrew, water shrew, river otter, mule deer, California bighorn sheep, hoary bat, spotted bat, and little brown myotis (Wildlife Action Plan Team 2006).

Beavers

Beaver were released into Virgin Valley in the late 1960s by a local rancher (USFWS 1971); it is unknown if they historically occurred on Sheldon Refuge. By the end of the nineteenth century, beaver populations in North America had been rapidly depleted by overharvesting and removed from many riparian systems (see Svejcar 1997). If they were present on Sheldon Refuge prior to the decline throughout their range, the influence of beavers on the structure and functioning of riparian zones may have been substantial, at both the local and landscape scale.

Fish

Beginning in the early twentieth century, aggressive introduction programs established non-native trout species, including brook (*Salvelinus fontinalis*), brown (*Salmo trutta*), and rainbow trout, in many streams and reservoirs throughout Sheldon Refuge; the majority of those waters still maintain recreational fisheries to this day. Most recent sport-fish management efforts have focused on the conservation and expansion of remaining populations of endemic salmonids such as Lahontan cutthroat trout, while maintaining sport-fishing opportunities through the stocking of non-native trout species in appropriate locations including Big Spring Reservoir.

Lahontan cutthroat trout

Lahontan cutthroat trout were historically native to the major lakes and rivers of the Lahontan Basin of Nevada and California; habitat alteration preceded the listing of this subspecies first in 1973. Because of reduced numbers of this subspecies, individuals have been stocked in Sheldon Refuge reservoirs since 1947 to provide a source for propagation and stocking into other waters (Williams et al. 1980). Catnip Reservoir continues to provide habitat for the federally listed Lahontan cutthroat trout. These trout are managed consistently with a special rule under Section 4(d) of the Endangered Species Act, which authorizes the taking of these trout in accordance with state law. The enables the public to harvest trout from Catnip Reservoir under a state fishing license and researchers to collect trout under a state scientific collection permit. NDOW conducted spawning operation and egg takes at Catnip Reservoir to produce either pure Lahontan cutthroat trout or a hybrid cross with rainbow trout from Big Spring Reservoir for sport-fish management throughout Nevada. Spawning operations and egg takes continued until 2002, when the water level at Big Spring Reservoir declined and rainbow trout eggs were no longer available at Big Spring Reservoir. Since 1959, 6.6 million cutthroat eggs have been taken at Catnip Reservoir (>1.0 million eggs between 1990 and 2001).

Prior to the allowance of sport fishing at Catnip Reservoir in 1998, the Lahontan cutthroat trout population was managed solely as a brood stock source for egg production. The spawning process is usually stressful for the fish and mortality can be high. Therefore, stocking rates were adjusted high to ensure the annual spawning run was robust. Additionally, stocking rates varied because it was uncertain how many Lahontan cutthroat trout Catnip Reservoir could support. Over the years, by comparing relative body condition, biologists were able to determine that ±3,000 fish stocked per year produced the best results.

Currently, it is unknown if Catnip Creek has enough spawning habitat to support a viable population of Lahontan cutthroat trout, regardless of sport-harvest levels. NDOW has documented Lahontan cutthroat trout successfully spawning in the Catnip Creek, but survival rates of the juvenile trout and their contribution the lake's fishery is unknown. In 2011, NDOW plans to initiate a more comprehensive research project to determine the amount of contribution these naturally produced fish have on the fishery and if the fishery could sustain itself without hatchery augmentation. This project will likely take several years to accumulate enough data to make a determination.

Big Spring Reservoir has been periodically stocked with non-native rainbow trout, but due to dry weather conditions and a lack of water, this reservoir has not supported a fishery for several years. Because Big Spring Reservoir is an artificial impoundment, there is no potential spawning habitat, and the fishery, even with water and under optimal conditions, does not provide any spawning habitat. Therefore, it is impossible for this fishery to sustain itself in the absence of hatchery augmentation.

Alvord cutthroat trout

This undescribed subspecies of cutthroat trout is presumed extinct in Oregon and Nevada as a consequence of hybridization with introduced rainbow trout. Rainbow trout were first introduced into Virgin Creek in 1934 (Williams et al. 1980), and any remaining cutthroat trout descendants are likely rainbow trout/Alvord cutthroat trout (*Salmo gairdneri* x *Oncorhynchus clarki*) hybrids (Bartley and Gall 1991).

Chubs

Springs, springbrooks, and streams provide habitat for Alvord and Sheldon tui chubs. The Alvord chub is indigenous to the Alvord Basin of southeastern Oregon and northwestern Nevada. However, this species is limited in its distribution by interspecies competition, and the introduction of guppies has eliminated Alvord chubs from parts of Sheldon Refuge including the Dufurrena and Virgin Valley areas. The Sheldon tui chub is indigenous to Guano Basin of southern Oregon and northern Nevada (Williams and Bond 1981; Williams et al. 1980). The restricted range of this species resulted in its listing at one time as a species of special concern by the American Fisheries Society (Deacon et al. 1979).

Reptiles and amphibians

Species known to occur in suitable riparian and aquatic habitats include Western terrestrial garter snake (*Thamnophis elegans*), Great Basin spadefoot toad, and Pacific treefrog (*Hyla regilla*). The distribution of desert amphibians in the arid environment of Sheldon Refuge is sporadic in association with the distribution of water resources. Isolation of species and subpopulations has resulted in a high level of endemism which makes Nevada's (and the Sheldon Refuge's) populations particularly susceptible to localized habitat alterations, short-term climatic conditions (e.g., drought), and ecological changes (Wildlife Action Plan Team 2006).

Invertebrates

Sheldon Refuge contains a rich diversity of aquatic habitat types and inhabitant invertebrate fauna. Isolated desert springs and stream drainages, geothermal spring systems, and ephemeral playa lakes on Sheldon Refuge have been documented to contain over 200 aquatic invertebrate species, including several undescribed new species, rare and separate populations, and organisms specifically adapted to life in severe and transient desert environments (Herbst 1996).

There are 74 gastropods listed as Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006), the vast majority of which are springsnails (*Pyrgulopsis* spp.). This genus has been documented on Sheldon Refuge although species have not been identified (Herbst 1996). Most springsnail populations are highly isolated because springs and seeps are widely dispersed and disconnected. Their aquatic habitats are rare and sensitive to both drought and water development, and populations are likely declining almost faster than we can learn about them (Wildlife Action Plan Team 2006).

4.2.4.4 Threats

Feral horses and burros, sagebrush encroachment, non-native fish and wildlife, disease, and human disturbances from water developments and recreation uses have been identified as threats to these habitat types and associated fish and wildlife within Sheldon Refuge.

4.2.5 Cliffs, Canyons, Talus Slopes, and Barren Lands

4.2.5.1 Description and Location

These habitats generally include steep cliff faces, bluffs, high walls, narrow canyons, rocky ledges, crevices, and rock outcrops of various igneous, sedimentary, and metamorphic bedrock types (Photo 4.7). They also include areas of unstable scree, desert pavement, scarps, talus slopes, slides, dunes, mines, and gravel pits. These habitats are generally unvegetated to sparsely vegetated with widely scattered trees and shrubs (e.g., *Juniperus* spp., *Artemesia* spp.)

One rare plant, rattlesnake stickweed, has been documented occurring at the base of steep gorge walls, in rocky areas below the walls, and occasionally along ledges in the rock walls on Sheldon Refuge. This species is considered limited in its distribution and a potential species of concern (Nachlinger and Tiehm 1996). The rattlesnake stickweed population on Sheldon Refuge was the largest documented to date and at that time represented 96% of the total known individuals (Nachlinger and Tiehm 1996).

Photo 4.7 Typical talus slope habitat within Sheldon Refuge (Photo Gail Collins).

4.2.5.2 Condition and Trends

Cliffs are unique habitats that lend topographic diversity to homogenous areas. Cliff and canyon habitats are important to wildlife and provide structure for nesting, roosting, denning, shelter from weather, protection from predators, and areas for foraging (Wildlife Action Plan Team 2006). Cliffs benefit wildlife directly by providing shelter and cover, and indirectly by providing food from

adjacent diverse plant communities (Ward and Anderson 1988). Currently, these habitats on Sheldon Refuge, outside of Virgin Valley, appear to be stable and in good condition.

4.2.5.3 Associated Wildlife

Birds

Several species of birds are dependent upon ledges, crevices, or talus slopes for nesting on Sheldon Refuge. Breeding birds include canyon wren (*Catherpes mexicanus*), rock wren (*Salpinctes obsoletus*), cliff swallow (*Petrocelidon pyrrhonota*), rough-winged swallow (*Stelgidopteryx ruficollis*), violet-green swallow (*Tachycineta thalassina*), Say's phoebe, white-throated swift, common raven (*Corvus corax*), golden eagle, and prairie falcon. Other species include black rosy finch (*Leucosticte atrata*), ferruginous hawk, and peregrine falcon (*Falco peregrinus*). Species listed as Nevada Species of Conservation Priority include peregrine falcon, ferruginous hawk, and white-throated swift (Wildlife Action Plan Team 2006).

Mammals

California bighorn sheep

California bighorn sheep (habitat distribution shown in Figure 4.5)are highly dependent upon open habitats in variable, steep, and dissected terrain for escape cover (Hansen 1982). Following their extirpation from Sheldon Refuge in the late 1920s, eight California bighorn sheep were re-introduced from Hart Mountain Refuge in 1968 and were placed into an enclosure at Hell Creek (Thomas 1978; USFWS 1971). By 1975, it was suspected that sheep were escaping the enclosure. The population was estimated to be over 40 individuals in 1981 (Hansen 1982). California bighorn are listed as a Nevada Species of Conservation Priority.

American pika

Although long rumored to be present on Sheldon Refuge, this species was first officially documented in 2009 (habitat distribution shown in Figure 4.5). As summarized by Beever et al. (2008), pikas occur in talus and talus-like habitats across western North America and feed on grasses found near talus slopes and also store vegetation in hay piles among the rocks for overwinter use. Pika may be the most montane-obligate species in the Great Basin. Studies have found a rise in the minimum elevation of pika populations since historic times related to temperature driven distribution; pikas exhibit extreme vulnerability to elevated temperatures suggesting that climate change may be factor in their ecology. Pikas in the Great Basin appear to have undergone significant losses (25% of historical sites) during the last half century (Beever et al. 2003b) and are listed a Nevada Species of Conservation Priority.

Other mammals

Other mammal species occupying these habitats include mountain lion, bobcat, porcupine, yellow-bellied marmot, bushy-tailed woodrat (*Neotoma cinerea*), desert woodrat, least chipmunk (*Tamias minimus*), little brown myotis, fringed myotis (*Myotis thysanodes*), pallid bat (*Antrozous pallidus*), spotted bat, and Townsend's big-eared bat (*Corynorhinus* spp.) Mule deer and pronghorn have also been observed utilizing these types of habitats for protection from wind and sun, and for food on south slopes free from snow (Ward and Anderson 1988). Other species listed as Nevada Species of

Conservation Priority include mule deer, little brown myotis, fringed myotis, spotted bat, and Townsend's big-eared bat.

Reptiles and amphibians

Several species of reptiles require talus slopes and rocky outcroppings, including collared lizard, side-blotched lizard (*Uta stansburiana*), western fence lizard (*Sceloporus occidentalis*), and night snake (*Hypsiglena torquata*).

4.2.5.4 Threats

In addition to threats from disease (see Section 4.1.3), and general threats from feral horses and burros, there are specific threats to American pika and California bighorn sheep, which are almost exclusively associated with cliffs, canyons, talus slopes, and barren land habitat types within Sheldon Refuge. In an evaluation of pika population extirpations (Beever et al. 2003a), it was found that many had occurred in areas open to livestock grazing, although further research was warranted. Feral horses may negatively influence pikas by competing for forage if grazing occurs in areas within 66 to 164 feet of talus. Indirect influences could also include trampling of soils or vegetation, which also occurs with horse grazing (Beever et al. 2003a). In addition, feral burros have been implicated as contributing to declines in bighorn sheep numbers; it has been recommended that burros be removed from areas where they are sympatric with bighorn sheep (Seegmiller and Ohmart 1981).

4.2.6 Deciduous Woodlands and Shrublands

4.2.6.1 Description and Location

These habitats include woodlands along riparian habitats or within snowpockets dominated by shrubs or trees including willow, aspen, currant, wild rose, snowberry, and chokecherry (Photo 4.8). Aspen stands on Sheldon Refuge are mostly associated with snowpockets. They also generally dominant along stream banks in the higher elevations of the western portion of Sheldon Refuge and can also be found in the eastern portion along perennially flowing, protected streams (aspen distribution shown in Figure 4.6). Further detail may be found in Rogers and Tiehm (1979).

4.2.6.2 Condition and Trends

Decades of livestock overuse and exclusion of fire have resulted in extensive loss of woody riparian habitats (particularly aspen stands) and ecologically degraded conditions for much of what remains in the Intermountain West (Dobkin 1994; Fleischner 1994; Heltzel and Earnst 2006; Schier 1975) and likely Sheldon Refuge as well. For example, Wall et al. (2001) reported that three-fourths of aspen communities below elevations of 7,000 feet in the Great Basin have either been replaced, are being replaced, or have establishing populations of western juniper. Fire has been reported to be an important factor in facilitating the long-term presence and health of aspen across the landscape; disease, insects, and native browsing also influence the age structure (see Wall et al. 2001). Historically, total stand replacement in aspen habitats was estimated to occur every 100 years, on average, with smaller disturbances every 16 years (Wall et al. 2001). On Sheldon Refuge, these habitats are considered in overall poor to fair condition.

Photo 4.8 Pockets of aspen and other deciduous trees and shrubs in Sheldon Refuge are most often found in areas where snow drifts during winter, along streams, and at springs as shown here (Photo Aaron Collins).

4.2.6.3 Associated Wildlife

Birds

Deciduous woodlands provide critical habitat for several species occurring on Sheldon Refuge. Known or suspected breeding birds include ash-throated flycatcher (*Myiarchus cinerascens*), dusky flycatcher (*Empidonax oberholseri*), blue-gray gnatcatcher (*Polioptile caerulea*), broad-tailed hummingbird (*Selasphorus platycercus*), calliope hummingbird, rufous hummingbird, Cassin's finch (*Carpodacus cassinii*), lazuli bunting (*Passerina amoena*), Lewis' woodpecker (*Asyndesmus lewis*), northern flicker (*Colaptes auratus*), northern oriole (*Icterus galbula*), Swainson's thrush (*Catharus ustulatus*), warbling vireo (*Vireo gilvus*), MacGillivray's warbler (*Oporornis tolmiei*), orange-crowned warbler (*Vermivora celata*), yellow warbler (*Dendroica petechia*), and tree swallow (*Iridoprocne bicolor*). Other species include willow flycatcher (*Empidonax traillii*), American goldfinch (*Carduelis tristis*), western bluebird, black-headed grosbeak (*Pheucticus melanocephalus*), cedar waxwing (*Bombycilla cedrorum*), yellow-breasted chat, downy woodpecker (*Dendrocopos pubescens*), hairy woodpecker (*D. villosus*), red-naped sapsucker (*Sphyrapicus nuchalis*), and varied thrush (*Ixoreus naevius*). Dobkin and Sauder (2004) documented for the Great Basin significantly declining population trends for five of the 12 riparian bird species considered, which includes many of those listed above. In addition, this habitat also supports populations of raptors including bald eagle, Cooper's hawk (*Accipiter cooperii*), great horned owl (*Bubo virginianus*), long-eared owl, northern saw-whet owl (*Aegolius acadicus*), northern goshawk (*Accipiter gentilis*), northern shrike, osprey (*Pandion haliaetus*), red-tailed hawk, sharp-shinned hawk (*Accipiter striatus*), Swainson's

hawk, and western screech owl. Of these species, bald eagle, northern goshawk, Swainson's hawk, rufous hummingbird, Lewis' woodpecker, willow flycatcher, and Cassin's finch are listed as Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006).

Mammals

Several species of mammal occur in this habitat type, including mountain lion, bobcat, coyote, beaver, porcupine, long-tailed weasel (*Mustela frenata*), ermine (*M. ermine*), Nuttall's cottontail, yellow pine chipmunk (*Tamias amoenus*), fringed myotis, little brown myotis, western small-footed myotis (*Myotis ciliolabrum*), Preble's shrew, and vagrant shrew. In addition, mule deer utilize these habitats for resting and foraging. Of these species, mule deer, fringed myotis, little brown myotis, western small-footed myotis, Preble's shrew, and vagrant shrew are listed as Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006).

Reptiles and amphibians

Deciduous woodlands provide habitat for reptile species including northern alligator lizard (*Elgaria coerulea*) and racer (*Coluber constrictor*). Amphibian species include the pacific treefrog.

4.2.6.4 Threats

In addition to feral horses and burros (see Section 4.1.1), threats to these habitat types and associated wildlife within Sheldon Refuge include changes in the natural fire regime (see Section 4.1.4), and resulting encroachment by sagebrush and western juniper (see Section 4.1.2).

4.2.7 Mountain Mahogany and Western Juniper Woodlands

4.2.7.1 Description and Location

Nomenclature follows that described in LANDFIRE (2007) and the Southwest Regional Gap Analysis Project (NatureServe 2004). Further detail may be found in Rogers and Tiehm (1979).

Western juniper woodlands

The vegetation in western juniper woodlands (habitat distribution shown in Figure 4.5) is characterized by a mature stand of western juniper. Mature stands of western juniper exhibit considerable diversity in structure and composition, varying from open-shrub tree savannas to nearly closed-canopy woodlands. However, tree canopy cover in the majority of stands is usually less than 20%. Ages are usually mixed with little to no recruitment in closed stands. Very old stands usually contain standing and downed dead trees that can persist for several hundred years, especially on dry sites and where downed trees do not come into contact with soil. A key indicator of mature western juniper woodland is the presence of old-growth trees (>130 years in age), dead snags, and recruitment of younger aged trees (Miller et al. 2005). Common understory shrubs include mountain big sagebrush, bitterbrush, and rabbitbrush (Photo 4.9). Other understory associates include Thurber's needlegrass, bluebunch wheatgrass, Sandberg's bluegrass, and prairie junegrass.

Photo 4.9 Typical western juniper habitat within Sheldon Refuge.

Mountain mahogany woodlands

Mountain mahogany woodlands (habitat distribution shown in Figure 4.7) are dominated by curl-leaf mountain mahogany (*Cercocarpus ledifolius* var. *ledifolius*) (Photo 4.10). These stands occupy areas often associated with late-enduring snowbanks and higher elevations to 8,000 feet. Mountain big sagebrush and scattered juniper may also occur. Common associates include Thurber's needlegrass, prairie junegrass, Sandberg's bluegrass, Idaho fescue, and *Lupinus* spp.

Photo 4.10 Typical mountain mahogany habitat within Sheldon Refuge.

4.2.7.2 Condition and Trends

The expansion of western juniper following European settlement is unprecedented. Numerous inventories and studies have demonstrated a rapid expansion of western juniper into adjacent sagebrush habitats since the late 1800s (Miller et al. 2008). This expansion is primarily the result of changes in the natural fire regime, which have allowed juniper to persist, and the removal of fire fuels through grazing by livestock. The distribution of old trees (>130 years old) is generally limited to rocky ridges and low sagebrush communities. Old trees are found only occasionally growing in deeper, well-drained soils such as mountain big sagebrush–grassland communities and are most often absent from aspen communities (Miller and Rose 1995). During the period of juniper expansion, younger trees have filled in between larger old trees creating much higher tree densities than historically occurred (Miller et al. 2008). On Sheldon Refuge, these habitats are overall considered in good condition.

In addition to the estimated 4,863 acres of western juniper habitat, it is estimated between 8,000 and 10,000 acres of habitat within Sheldon Refuge have been, or are in the process of being, encroached upon by western juniper. Currently Sheldon Refuge actively removes western juniper which has expanded into adjacent habitats through the use of prescribed burning and chainsaw thinning. Since 2003, Sheldon Refuge has treated an annual average of 373 acres, primarily to remove encroaching juniper. The number of acres has gradually increased over the same time period, with approximately 1,014 acres treated in 2009 (NFPORS 2009).

Mountain mahogany stands have also exhibited dramatic increases in density and distribution, which has been attributed to fire exclusion (Gruell 1995). Mountain mahogany was further proliferated by livestock grazing which diminished competing grasses. On Hart Mountain and Sheldon refuges, approximately 88% and 83% of the stands sampled, respectively, have been estimated to have been established after 1900 (Gruell 1995). Current concerns with mountain mahogany are that many stands are dominated by older trees with crowns that are practically unreachable to wildlife for browse and little recruitment of new plants. If natural fire were to re-enter these stands in their current overgrown conditions, it is likely most or all mountain mahogany would be killed by the intense heat and these areas would be lost as valuable wildlife cover, forage, and nesting habitat. Mountain mahogany does not easily resprout after burning, and it is difficult to establish from seed. Factors that may limit natural seedling establishment include the presence of mountain mahogany litter that inhibits seed germination, competition for water and soil resources, and browsing of seedlings (see summary by Ibáñez et al. 1999). On Sheldon Refuge, these habitats are considered in overall fair to good condition.

4.2.7.3 Associated Wildlife

Birds

Mature western juniper and mountain mahogany stands provide habitat for a range of breeding bird species including juniper titmouse (*Baeolophus ridgwayi*), black-throated gray warbler (*Dendroica nigrescens*), yellow-rumped warbler (*Dendrocia coronata*), dusky flycatcher, gray flycatcher, fox sparrow, mountain chickadee (*Parus gambeli*), ruby-crowned kinglet (*Regulus calendula*), Townsend's solitaire (*Myaestes townsendi*), and western scrub jay (*Aphelocoma californica*). Western juniper berries (female cones) provide an important source of food for Townsend's solitaires, American robins, mountain bluebirds, cedar waxwings, Steller's jays, and scrub jays (Lederer 1977; Poddar and Lederer 1982; Solomonson and Balda 1977). Western juniper berries are

the sole winter food used by Townsend's solitaires and make most of the American robin's diet throughout the winter (Lederer 1977; Poddar and Lederer 1982).Other species include black-headed grosbeak, chipping sparrow (*Spizella passerina*), golden-crowned kinglet (*Regulus satrapa*), Hammond's flycatcher (*Empidonax hammondii*), MacGillivray's warbler, Nashville warbler (*Vermivora ruficapilla*), northern shrike, olive-sided flycatcher (*Nuttallornis borealis*), pine siskin (*Spinus spinus*), red-breasted nuthatch (*Sitta canadensis*), Townsend's warbler (*Dendroica townsendi*), western bluebird, and western tanager (*Piranga ludoviciana*). These habitats are also important as nesting and resting habitat for migrating raptors, including Cooper's hawk, ferruginous hawk, golden eagle, northern goshawk, great horned owl, northern saw-whet owl, red-tailed hawk, rough-legged hawk, and sharp-shinned hawk. Of these species, northern goshawk, ferruginous hawk, and olive-sided flycatcher are listed as Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006). Old-growth stands differ structurally from post-settlement woodland, including having a greater density of cavities, which significantly influences cavity nesting species.

Mammals

These habitats on Sheldon Refuge provide important thermal cover for mule deer and pronghorn. Mountain mahogany also provides winter forage for big game (Scheldt and Tisdale 1970). Leckenby et al. (1982) concluded that dense stands of trees or shrubs over 5 feet tall provided optimal thermal cover. However, these stands provide minimal food resources. Trainer et al. (1983) reported that pronghorn rarely used western juniper woodlands during the winter or spring in eastern Oregon, preferring more open shrub-steppe communities or stands with only scattered trees. Other species occurring in these habitats include mountain lion, bobcat, porcupine, bushy-tailed woodrat, golden-mantled ground squirrel (*Spermophilus lateralis*), Great Basin pocket mouse, hoary bat, and least chipmunk. Of these species, mule deer and hoary bat are listed as Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006).

Reptiles and amphibians

These stands provide habitat for reptiles including pygmy short-horned lizard and racer on Sheldon Refuge. Pygmy short-horned lizards are listed as a Nevada Species of Conservation Priority (Wildlife Action Plan Team 2006).

4.2.7.4 Threats

Feral horses and burros (see Section 4.1.1) and changes in the natural fire regime (see Section 4.1.4) are considered threats to these habitat types and associated wildlife within Sheldon Refuge.

Old-growth western juniper and mountain mahogany trees provide unique, and often irreplaceable biological and ecological values, such as plant and animal habitat, biodiversity and genetic pools, and long-term climatic records (see Waichler et al. 2001). However, juniper establishment declines with woodland maturity because of a decrease in seedling establishment as shrubs die out and an increase in intra-specific competition (Miller et al. 2000). On some more arid sites, juniper woodland development has also led to desertification and reduction in site productivity and understory (Miller et al. 2000).

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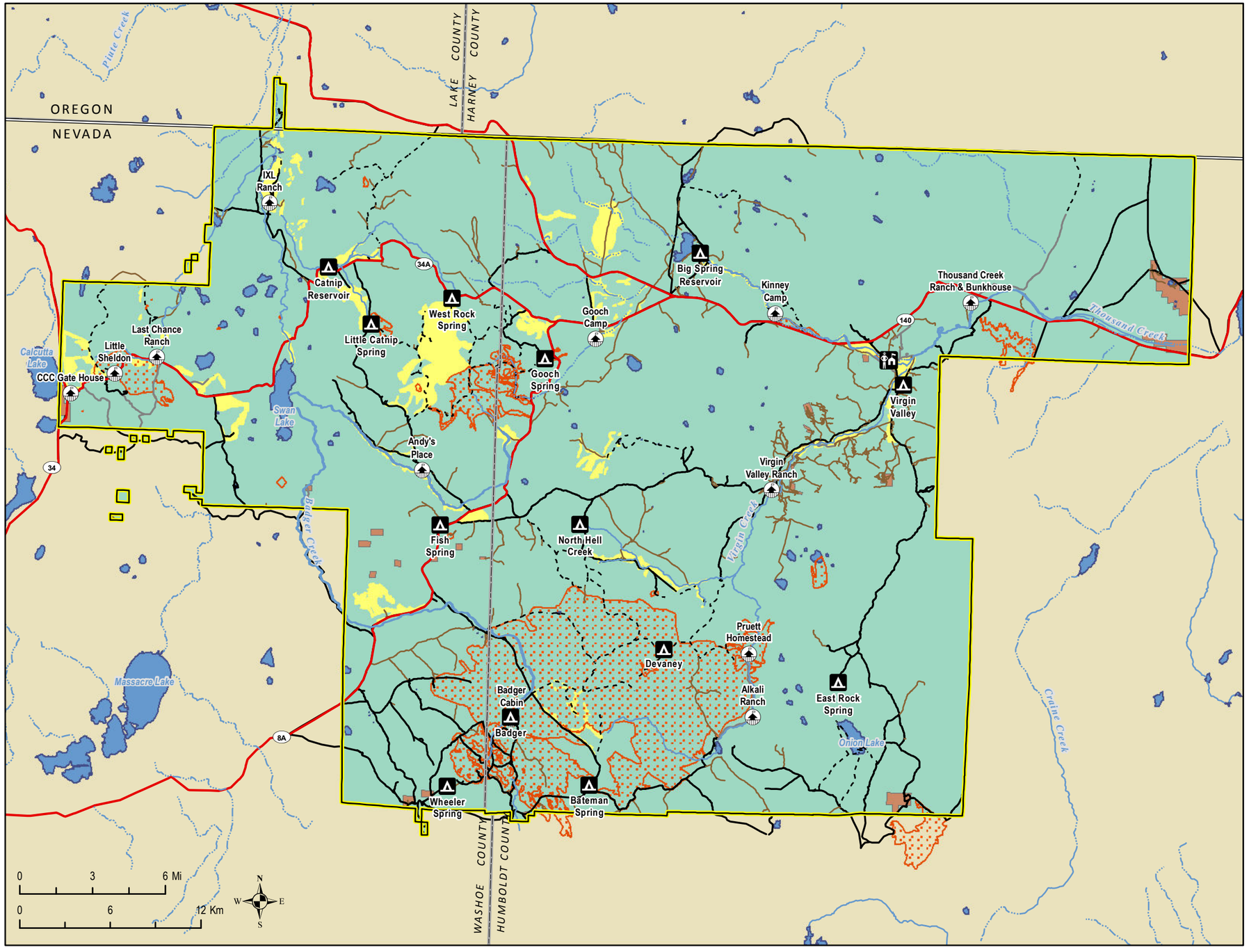
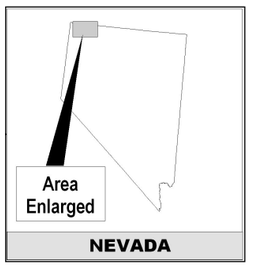


Figure 4.1
Fire History and Fire Protection

LEGEND

- Refuge Headquarters
- Approved Refuge Boundary
- Refuge Ownership
- Private Lands (inholdings)
- Campgrounds
- Sheldon Historic Structures
- Prescribed Fires 1991-2003
- Natural Fires 1985-2003
- County Boundary
- Service Routes
- Closed Routes
- No Vehicles
- Public Vehicle Routes
- State Line
- Highway
- Intermittent Stream
- Perennial Stream
- Lakes and Reservoirs



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Refuge Information Branch
Portland, Oregon
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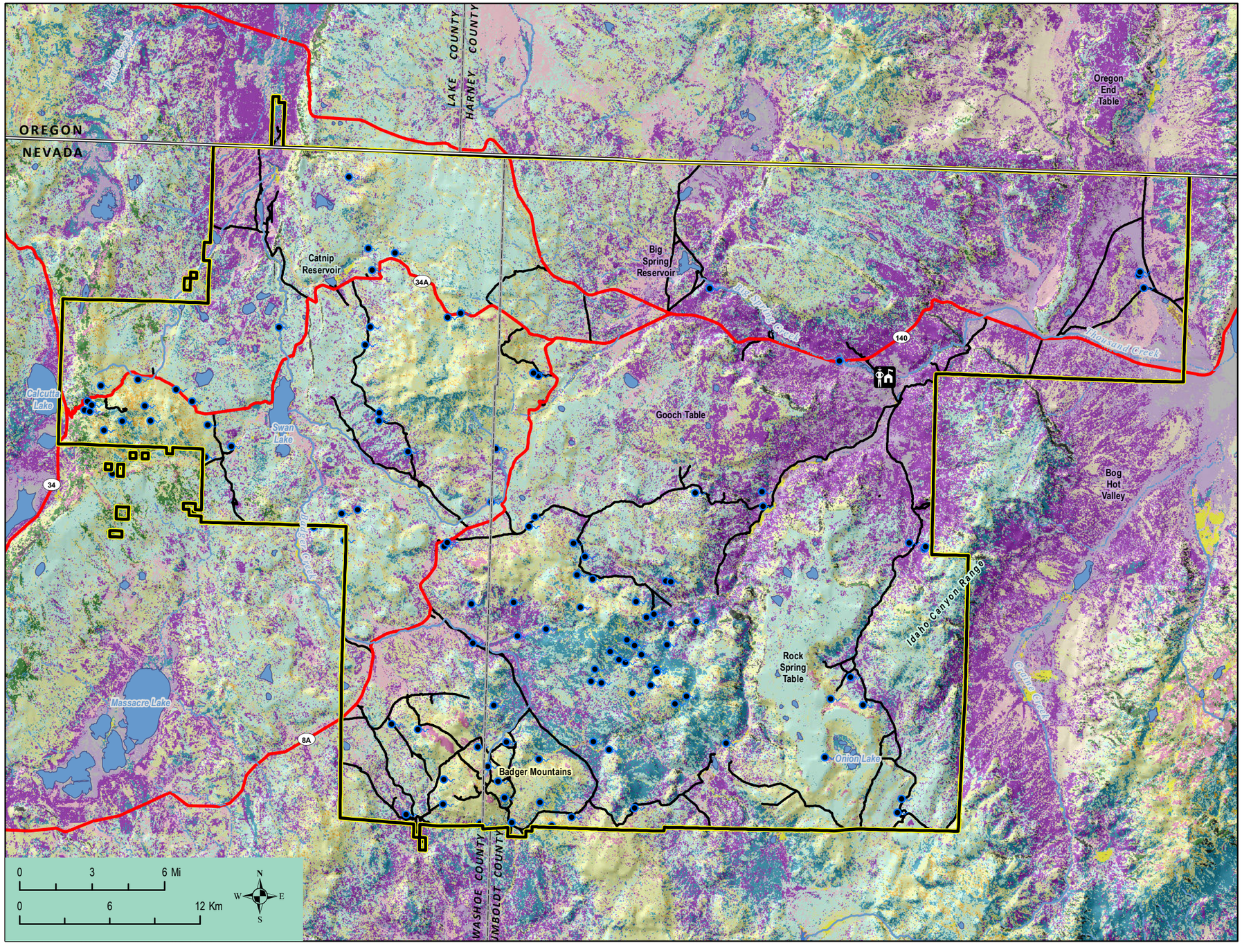

Figure 4.2
Habitat Distribution

LEGEND

- Refuge Headquarters
- Approved Refuge Boundary

Habitat Type

- Aspen
- Basin Big Sagebrush
- Canyon Vegetation
- Emergent Vegetation
- Greasewood
- Juniper
- Low Sagebrush
- Mountain Big Sagebrush
- Mountain Mahogany
- Mountain Shrub
- Perennial Grassland
- Salt Desert
- Sparse Vegetation
- Unclassified
- Water
- Wet Meadow
- Wyoming Big Sagebrush
- Seeps and Springs
- County Boundary
- State Line
- Intermittent Stream
- Perennial Stream
- Highway
- Public Vehicle Routes (clipped to Refuge)

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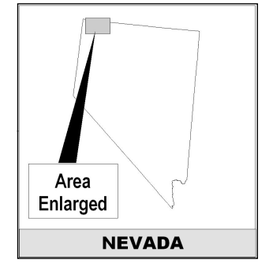

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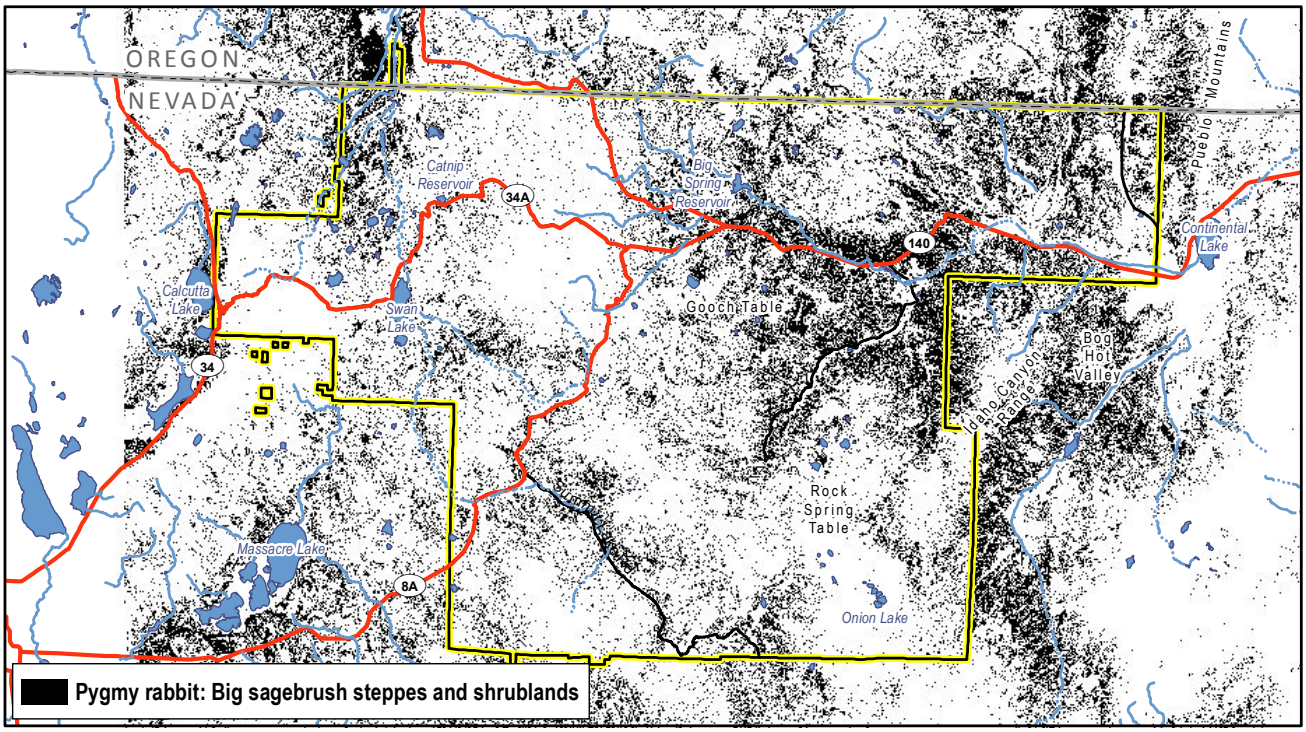
Figure 4.3 Pygmy rabbit and Greater sage-grouse distribution based on habitat



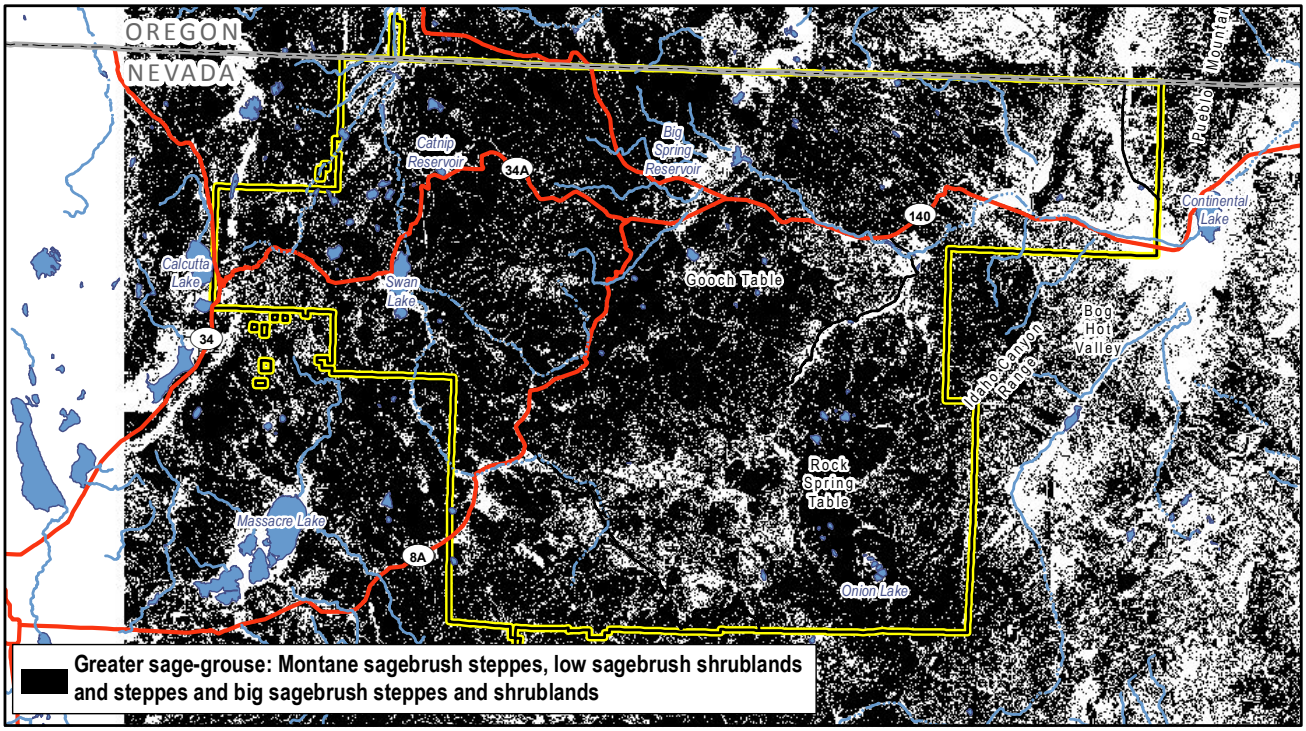


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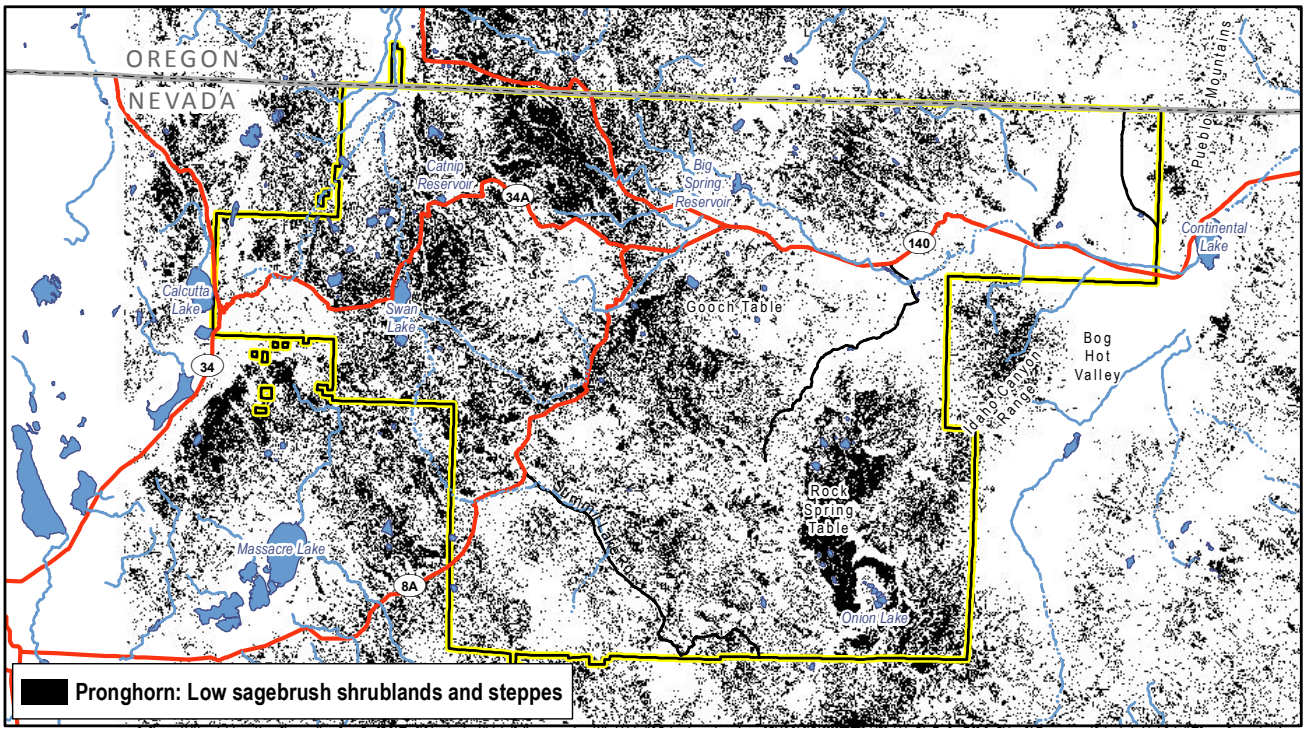
Figure 4.4 Pronghorn and mule deer distribution based on habitat



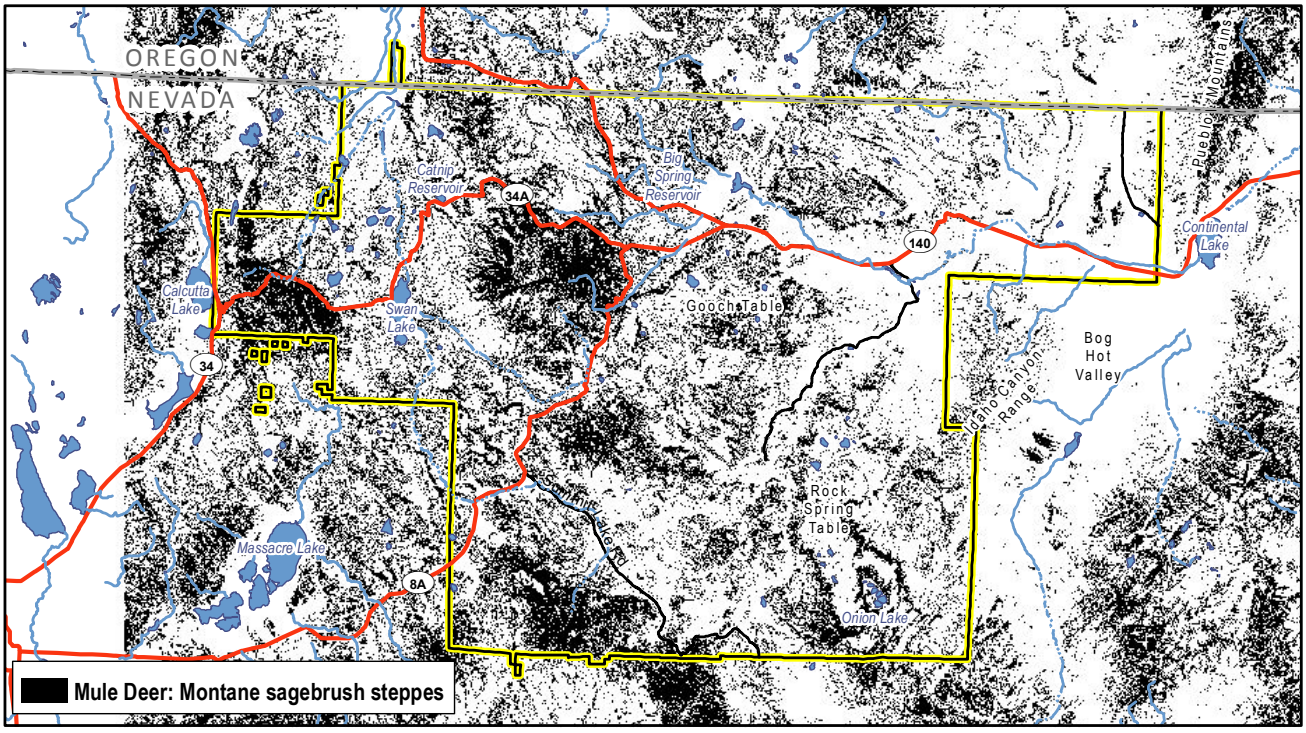


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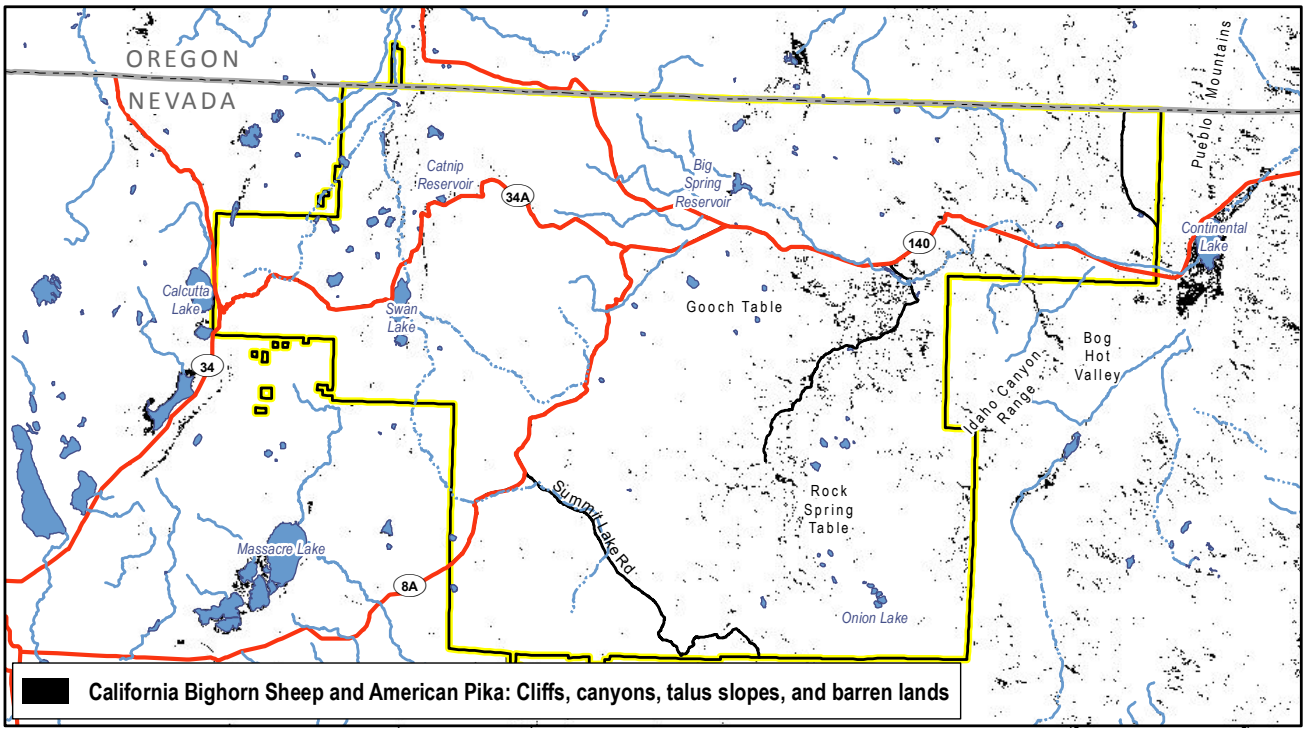
Figure 4.5 California bighorn sheep, American pika, and old-growth western juniper distribution based on habitat



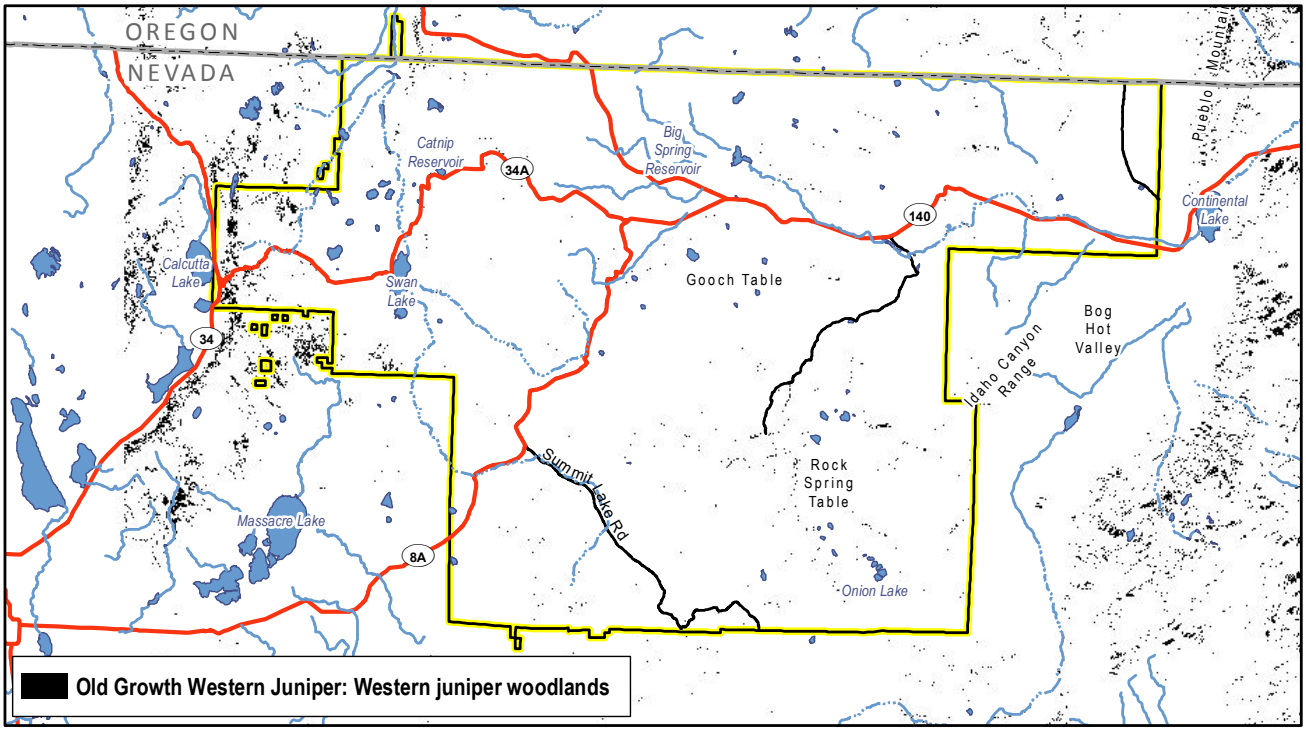


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Figure 4.6 Aspen distribution based on habitat

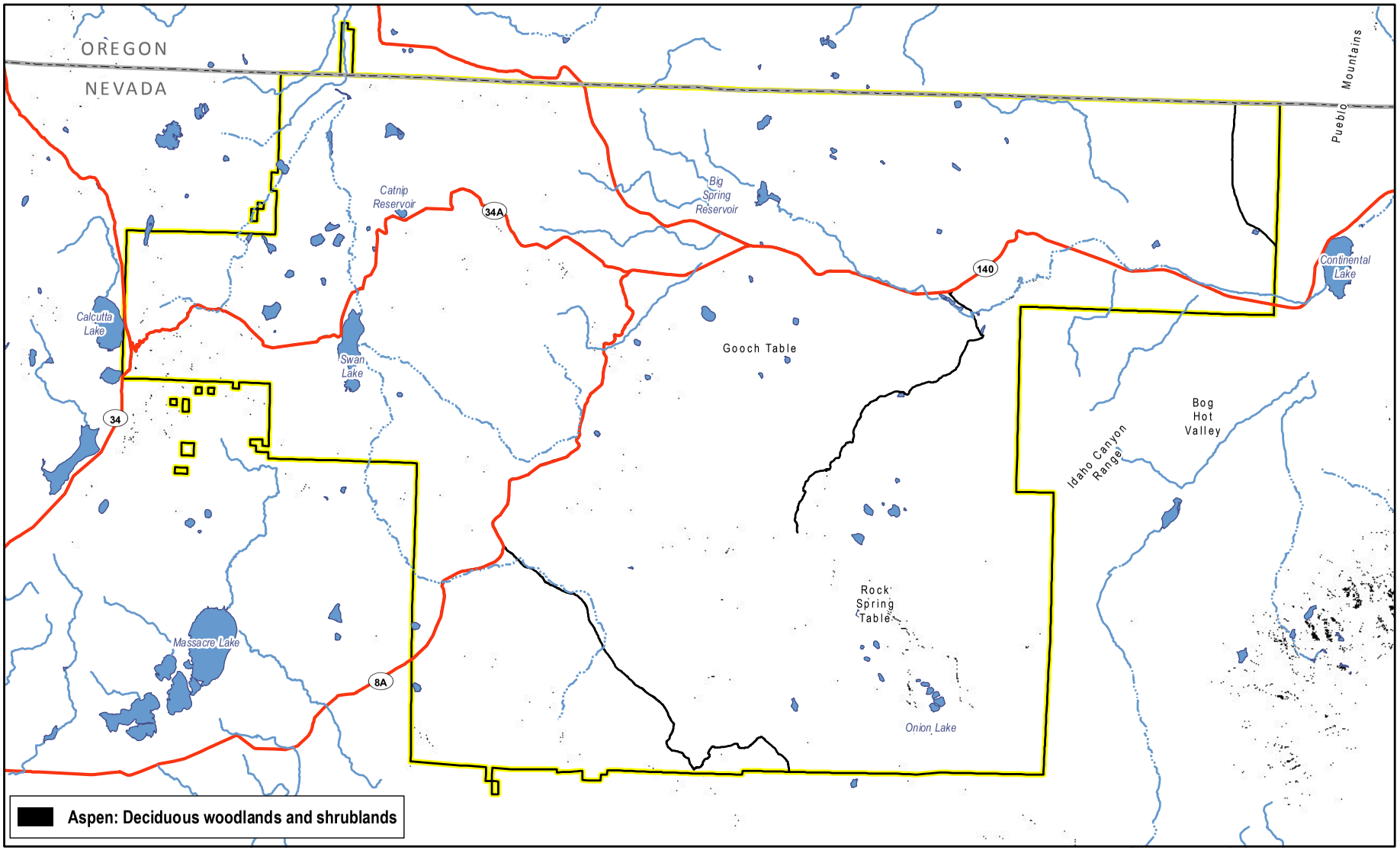

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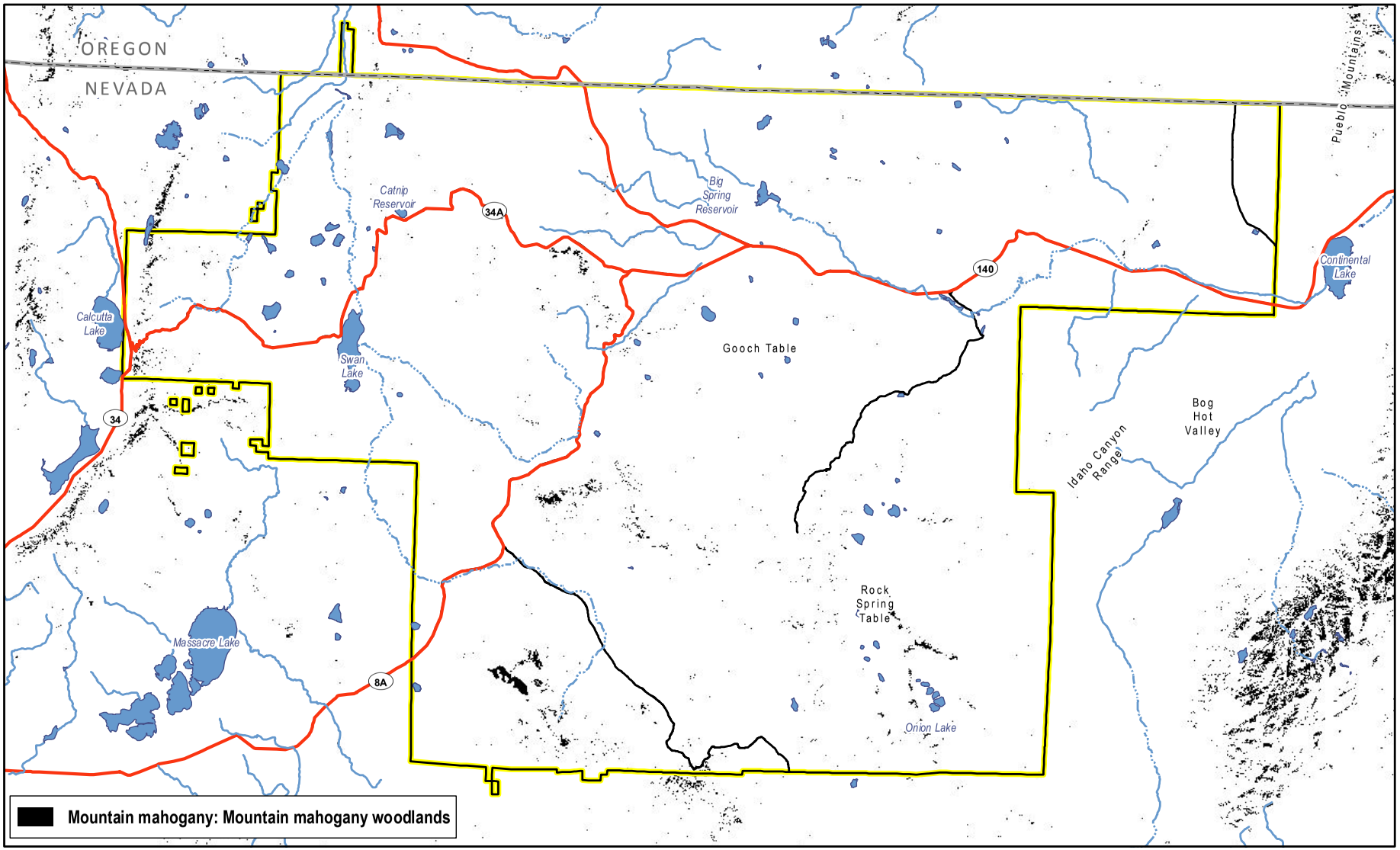
Figure 4.7 Mountain mahogany distribution based on habitat



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Chapter 5. Social and Economic Environment

5.1 Infrastructure and Administrative Facilities

The infrastructure and facilities required to administer Sheldon Refuge are extensive. In addition to a number of buildings, structures, fences, and signs, Sheldon Refuge maintains a system of roads that provides access to administrative facilities and to fish, wildlife, plant, and habitat management and research project sites throughout Sheldon Refuge, and secondarily serves as public use and access.

5.1.1 Administrative Buildings and Structures

There are five primary administrative sites for Sheldon Refuge (Figure 5.1). These include the Sheldon Refuge Office (Dufurrena), the Sheldon-Hart Mountain Refuge Complex Headquarters in Lakeview, Oregon, the Thousand Creek Bunkhouse, the Little Sheldon Headquarters/Work Station, and the Badger Mountain Work Cabin. With the exception of the Complex Headquarters, all of these administrative sites are located on refuge lands.

The Sheldon Refuge Office, in Virgin Valley, consists of an office/visitor contact trailer, a barn and tack shed, two maintenance shops, a horse processing facility which includes a hay shed and corrals, and housing for two full-time employees (Photo 5.1). Currently the Sheldon Refuge Manager and two maintenance staff members are stationed at the Sheldon Refuge Office.

Photo 5.1 The Sheldon Refuge Office at Dufurrena includes residences, maintenance buildings, and a small office (Photo Gail Collins).

The Sheldon-Hart Mountain Refuge Complex Headquarters consist of an office and visitor contact building, a storage shed, a vehicle storage lot, and office space at the Lakeview Interagency Fire Center. Currently the Complex Manager, Deputy Complex Manager, Supervisory Wildlife Biologist, Fire Management Officer, Assistant Fire Management Officer, Prescribed Fire Specialist, Natural Resource Planner and three administrative staff members are stationed at the Complex Headquarters.

The Thousand Creek Bunkhouse is located near Highway 140 and east of the Dufurrena Headquarters. This facility consists of two buildings, which provide seasonal quarters and office space for one Fire Station Supervisor, one Engine Crew member, Biological Technicians, and other various staff members associated with seasonal and short-term refuge research and management projects and programs.

The Little Sheldon Headquarters/Work Station located on Highway 34A near the western boundary of Sheldon Refuge consists of a bunkhouse/office building and a storage shed. These facilities provide seasonal and short-term quarters and office space in support of refuge research and management projects and programs.

The Badger Mountain Work Cabin consists of a small dual-purpose building, which serves as bunkhouse and office space. This building is used as a field camp to support refuge research and management projects on a seasonal or short-term basis.

5.1.2 Management Infrastructure

5.1.2.1 Water Control Structures

A variety of water control structures have been constructed within Sheldon Refuge (see Figure 5.1). Most structures were constructed on private lands prior being included in Sheldon Refuge, or were constructed to support the commercial livestock grazing operations that were permitted by Sheldon Refuge prior to 1994. A discussion of these various water control structures can be found in Chapter 3. Since commercial livestock grazing no longer occurs within Sheldon Refuge, many of these structures have not been maintained and no longer function. Other facilities function but are not currently maintained for refuge management purposes. The water control structures discussed here are those now actively maintained and managed to support administration of Sheldon Refuge.

Swan Lake Reservoir was constructed in 1929 to provide stockwater and irrigation for IXL Ranch. It is now maintained by Sheldon Refuge to provide late summer pronghorn forage. Early spring snowmelt and runoff water is stored and allowed to slowly evaporate—resulting in green palatable forage late in the year after other plants have dried. Excess water flows to the IXL wetlands. A 2002 inspection determined the condition of the Swan Lake Reservoir dam was fair (URS 2002).

The IXL wetlands are a portion of a former ranch. The historic ranch buildings are not used for administrative purposes, but the water diversion dam, canals, headgates, and ponds are maintained to provide seasonal waterfowl habitat.

NDOW maintains 18 water guzzlers for the enhancement of small-game and bighorn sheep populations within Sheldon Refuge. These facilities are authorized to support refuge wildlife management objectives. The remaining facilities and infrastructure within Sheldon Refuge were constructed and historically used to support commercial livestock grazing. This use no longer exists, and the need for these facilities and infrastructure is being evaluated as part of this CCP.

Catnip Reservoir constructed in 1910 to supply irrigation water to IXL Ranch and has a capacity of 243 acre-feet. Today this reservoir is maintained to provide habitat for Lahontan cutthroat trout and secondarily to provide recreational fishing opportunities. Current condition of the dam is considered poor due to seepage (Fox and Clayton 1988). To remain functional, the Catnip Reservoir dam will require substantial repair or replacement at some point in the future.

Water wells are located at the Thousand Creek Work Station, Sheldon Refuge Headquarters at Dufurrena, Virgin Valley Campground, and the Little Sheldon Headquarters/Work Station. A natural spring supplies water to the Badger Mountain Work Cabin.

5.1.2.2 Fencing

Fences and fence exclosures within Sheldon Refuge include a permanent perimeter boundary fence designed to inhibit the movements of horses and cattle while allowing passage of wildlife. A number of small semi-permanent and temporary fence exclosures are maintained within Sheldon Refuge to protect key habitats from overgrazing by feral horses or as part of various habitat research studies and management treatments.

5.1.2.3 Administrative Roads

Roads within Sheldon Refuge used for administrative purposes include roads designated open to general public use, and roads, routes, and trails open only to administrative use by Service employees or by refuge Special Use Permit.

5.1.2.4 Maintained Public Roads

The primary access roads within Sheldon Refuge include Nevada State Highway 140 and County Roads 34A and 8A and the Summit Lake/Badger Road (see Figure 5.1). The 34-mile portion of Highway 140 within Sheldon Refuge is a paved two-lane highway maintained by the State of Nevada Highway Department. The remaining 100 miles of maintained primary routes are gravel roads suitable for two-wheel drive passenger vehicles. County Roads 34, 34A, and 8A include 59 miles of roads, which are cooperatively maintained by Sheldon Refuge and the respective road maintenance crews from Washoe and Humboldt counties. The remaining 41 miles of gravel road are maintained solely by Sheldon Refuge.

The unimproved roads within Sheldon Refuge are not regularly maintained (Photo 5.2), but are repaired on a site-by-site basis to keep them in usable condition or to prevent undue resource damage (i.e., excessive erosion). Administrative routes within the proposed wilderness areas were historically created through vehicle access to range developments, mining claims, habitat rehabilitation projects or fenced exclosures, but are now used almost exclusively to support fire suppression activities and are not maintained or improved. A number of other vehicle routes exist within Sheldon Refuge, but these routes were created by illegal vehicle use and continue to be signed, closed, and rehabilitated as staff time and funding allows.

Photo 5.2 Most roads and routes within Sheldon Refuge like this one are of native materials, have no maintenance, and are suitable only for high-clearance vehicles (Photo Gail Collins).

5.1.2.5 Directional and Informational Signage

Because Sheldon Refuge is so large and remote, directional and information signs provide critical information to visitors. These signs are considered part of the Sheldon Refuge infrastructure and do not provide educational information or an interpretive message. These include several refuge entrance signs, refuge road direction signs, refuge boundary signs (posted primarily on the perimeter refuge boundary fence), designated vehicle route signs, designated campground signs, and closed area/road signs. While the exact numbers are not tracked, it is estimated several hundred signs are located throughout Sheldon Refuge.

5.1.3 Operations and Administration

Approximately $1.68 million annually is required to manage Sheldon Refuge. This includes funds for employee salaries, fire suppression, feral horse and burro management activities, vehicle and facilities operations and maintenance, equipment, supplies, utilities, and a variety of contracts.

Sheldon Refuge is managed by a combination of on-site and off-site staff. The Sheldon Refuge Manager, two maintenance staff members, a fire station supervisor, and a fire engine crew are stationed on Sheldon Refuge at the Dufurrena Headquarters and the Thousand Creek Work Station near Denio, Nevada. The Sheldon-Hart Mountain Refuge Complex Project Leader, Deputy Project Leader, Supervisory Wildlife Biologist, Fire Management Officer, Assistant Fire Management Officer, Prescribed Fire Specialist, Natural Resource Planner, Budget Officer, and two additional administrative staff members are stationed in Lakeview, Oregon, at the Complex Headquarters. Unlike on-refuge staff, these Complex staff members split their time between the two refuges. Salaries and benefits for work conducted on Sheldon Refuge in 2008 was estimated to be $847,000.

Surveys, monitoring, research studies, and other biological projects and programs related to wildlife, fish, and their habitats within Sheldon Refuge require additional funds to pay for aerial survey contracts, equipment, vehicles, and travel. Annual maintenance of roads, administrative buildings, water control structures, boundary fences, campgrounds, signs, and information kiosks also requires additional funds. The combined costs for these activities are $100,000 per year. In addition, volunteers, partners, and cooperating agencies annually contribute labor, transportation, and other assistance.

In addition to employee salaries, approximately $47,000 is spent annually to conduct wildfire suppression operations and for the equipment, maintenance, planning, inventory, operations, and monitoring required to conduct prescribed burning and other habitat treatment projects within Sheldon Refuge.

Management of feral horses and burros is the most expensive program at Sheldon Refuge. Implementation of the current management plan requires the removal of between 160 and 200 animals each year to maintain population levels. Excluding employee salary costs, management of feral horses and burros requires $684,000 annually (Industrial Economics 2010). The majority of these funds pay for the gathering, feeding, transporting, and adoption of the animals. If employee costs for this program are included, the feral horse and burro program consumes well over half the entire annual budget for Sheldon Refuge.

5.1.3.1 Public Access

A range of opportunities for a particular recreation activity can be achieved by combining varying degrees of management presence, interaction with other visitors, the degree of development, and types of access. Access—defined in terms the types of use, modes of transportation, and the level of development and maintenance—can be used to describe recreation settings. Access settings have been broadly categorized for planning purposes as follows: Primitive (areas without developed trails, roads, and vehicles); Semi-primitive non-motorized (areas with developed trails or routes, but without roads or motorized vehicles); Semi-primitive motorized (areas with roads and routes for motorized vehicles, but generally suitable only for ATVs, snowmobiles, or high-clearance four-wheel drive vehicles); Roaded Natural (roads are maintained, may be either native material, gravel or asphalt, and are suitable for most types of vehicles); Rural; and Urban.

Generally, the remoteness of the physical setting within Sheldon Refuge falls into the Semi-primitive Nonmotorized and Semi-primitive Motorized categories. Only two small areas on Big Spring Table and Gooch Table, which are more than 3 miles from a road or motorized route, meet the criteria for a Primitive recreation opportunity setting. A relatively small percentage of Sheldon Refuge, which includes the corridors along Summit Lake/Badger Road, County Roads 34A, 8A, and State Highway 140, would be categorized as Roaded Natural, and the Dufurrena/Virgin Valley area would be considered a Rural recreation opportunity setting where land use and development are readily noticeable and numerous facilities and buildings are evident. The majority of public use occurs within these Roaded Natural and Rural settings. With the exception of a few administrative areas, all public lands within Sheldon Refuge are open to public use and fall into one of these three access settings. There are no areas of Sheldon Refuge within the Urban settings.

As with much of northwest Nevada, public use and recreation activities typically involve a variety of motorized vehicles, especially OHVs. Over the past several decades, more than 400 miles of unimproved motorized routes and trails within Sheldon Refuge have been pioneered by ranchers, mining prospectors, fire suppression crews, staff, and visitors. While many of these primitive routes continue to be used today by visitors, the Service has not evaluated the adverse impacts from these routes to the natural, aesthetic, or scenic values of Sheldon Refuge and has not determined if their location minimizes damage to soils; harassment of wildlife or significant disruption of wildlife habitats, or other existing recreational uses as required by Executive Order 11644. Furthermore, the Service has never officially designated any of these routes open to use by OHVs as required by Executive Order 11644 and 50 CFR 27.31.

Currently visitors can drive to within 4.5 miles of any point on Sheldon Refuge using a variety of roads, routes, and trails (see Figure 2.1). With the exception of 34A, 8A, Dufurrena, and the Summit Lake/Badger Road, Sheldon Refuge conducts the minimum maintenance necessary to keep routes in useable condition and to prevent undue resource degradation. As a result, most routes within Sheldon Refuge require a high-clearance and/or four-wheel drive vehicle and are impassible after heavy rain or snowfall.

The boundaries of the proposed wilderness areas within Sheldon Refuge are primarily defined by adjacent roads and routes. Visitors typically access the proposed wilderness areas along these adjacent boundary roads and routes before taking day trips or short overnight trips into Sheldon Refuge backcountry for hunting and other recreation activities. There are no maintained routes or trails within the proposed wilderness areas, but existing user created trails do provide limited access. The Primitive setting characterizes access within each of the proposed wilderness areas.

5.1.3.2 Public Use Overview

Recreation activities within Sheldon Refuge include hunting for birds and large game, fishing for both cold- and warm-water fish, wildlife observation and photography, and rock collecting. Hunting is the most common of these activities. In addition to the system of roads, routes, and trails within Sheldon Refuge, 12 semi-primitive and primitive campgrounds, one developed campground, a horse corral, reservoirs, a fishing dock, and a number of information signs and kiosks are maintained to support these recreation activities.

Sheldon Refuge provides outstanding opportunities for primitive and unconfined recreation characterized by solitude, remoteness, and a variety of terrain and scenery. These opportunities are recognized by the fact nearly 60% of Sheldon Refuge has been proposed for wilderness

designation—in part due to these outstanding opportunities. Aside from a number of undeveloped primitive roads and semi-primitive campgrounds, Sheldon Refuge is undeveloped and can be experienced in its natural state with little or no evidence of human presence, habitation, or alteration. When compared with other large, primitive, undeveloped areas in the region, it is the almost complete absence of modern human use (primarily ongoing commercial livestock grazing operations) that sets Sheldon Refuge apart.

Annual recreation visits

Sheldon Refuge received approximately 17,000 visitors in 2008, mostly enjoying hunting, fishing, wildlife viewing, camping, and rock collecting. Generally, the majority of visitors in the spring are rock collecting, camping, and wildlife viewing, and the majority of visitors in the fall are hunting. In 2008 there were 4,198 visitors to Sheldon Refuge for the purpose of hunting. An estimated 488 anglers fished at Catnip Reservoir and Dufurrena Ponds in 2007 (which represents nearly all sport fishing within Sheldon Refuge). There are no visitation numbers for the other visitor activities.

Outdoor recreation rates and trends

Overall, recreation visits to Sheldon Refuge have increased in recent decades. It was estimated that in 1974 there were 12,000 visitors to Sheldon Refuge (USFWS 1974). In 2008 it was estimated there were 17,000 visitors.

More recently, the rate of use in Virgin Valley Campground was increasing, until higher gas prices in 2008; hence, due to the remoteness of Sheldon Refuge, visitation decreased notably from 2007 to 2008. Refuge staff also noted a decrease in hunter scouting trips in 2008 prior to the hunting season.

Recreation opportunities in the surrounding area

Commercial operators provide fee-based recreation rock collecting and mining opportunities for precious opal on private lands and patented mining claims in the Virgin Valley area within Sheldon Refuge. Private commercial developed campgrounds are provided in conjunction with these rock collecting opportunities. However, the majority of use at refuge public use facilities in the Virgin Valley area are visitors to these private rock collecting and mining areas.

Sheldon Refuge is surrounded by public lands managed by the BLM, which include WSAs, a national conservation area, and a variety of primitive and semi-primitive facilities which provide a wide range of recreation opportunities including hunting, fishing, camping, rock collecting, horseback riding, hang gliding, bicycle riding, photography, OHV use, and wildlife viewing.

5.2 Wildlife-dependent Recreation and Public Uses

5.2.1 Waterfowl Hunting

Waterfowl hunting is permissible in accordance with NDOW regulations. All of Sheldon Refuge is open to waterfowl hunting except Virgin Valley, the Little Sheldon area, and Big Spring and Catnip reservoirs. There are no official data on the number of hunters. It is estimated that waterfowl hunting draws less than 100 visitors to Sheldon Refuge a year. Harvest statistics are not available for waterfowl hunting. The water control structures near the historic IXL Ranch support waterfowl hunting on Sheldon Refuge.

5.2.2 Upland Bird/Small-game Hunting

All of Sheldon Refuge is open to upland game bird hunting except Virgin Valley and the Little Sheldon area. Upland game birds open to hunting include Greater sage-grouse, chukar, and California quail. There were 40 California quail and chukar hunters in 2007.

Hunting of Greater sage-grouse within Sheldon Refuge is allowed with permits issued from NDOW. Hunting of Greater sage-grouse provides recreation opportunity for up to 150 hunters drawn by lottery from a pool of roughly 400 applicants each year. Sage-grouse hunting within Sheldon Refuge is restricted to two separate two-day seasons in September. Seasons and harvest limits are coordinated by NDOW and Sheldon Refuge to maintain healthy populations and adequate data collection. Harvest levels are currently lower than in past years because harvest limits were reduced from three birds to two, and possession limits were reduced from six birds to four. From 2002 through 2010, a minimum of 1,296 Greater sage-grouse were harvested within Sheldon Refuge (based on the number of wings hunters provided). Harvest ranged from 75 birds in 2007 to 230 in 2004 and averaged 144 birds per year (Collins 2010). Every hunter is required to deposit one wing from each grouse into a collection barrel before leaving Sheldon Refuge. Wings are then examined each year during the annual NDOW wing bee to estimate population productivity and nesting success.

Small-game hunting is not allowed on Sheldon Refuge.

Other than wing collection barrels, there are no facilities specifically in support of these activities.

5.2.3 Big-game Hunting

Big-game hunting is a very popular activity and a priority public use on Sheldon Refuge. There is considerable public support for hunting on Sheldon Refuge. All of Sheldon Refuge is open to big-game hunting except for two large sanctuary areas. The sanctuary areas are Virgin Valley on the east end of Sheldon Refuge and the Little Sheldon area on the western end. Big-game species open to hunting are mule deer, pronghorn, and California bighorn sheep in accordance with NDOW regulations. Sheldon Refuge staff works closely with NDOW to set big-game tag numbers and season dates for the upcoming year. NDOW administers the hunt including tag issuance, data collection, and the preparation of summary reports, which provide excellent hunt participation information for Sheldon Refuge. Because hunting activities are managed cooperatively, ongoing coordination is required to ensure that hunter numbers and restrictions are consistent with refuge purposes, Service policies, and refuge biological goals and objectives. In 2008 there were five California bighorn sheep, 87 pronghorn, and 185 mule deer tags issued. Sheldon Refuge encompasses State hunt management unit number 033.

Sheldon Refuge is managed to provide a quality big-game hunting experience. A lottery system limits the number of harvest tags, which is set to provide a high-quality recreational experience. This system is used in conjunction with phased season openings to reduce overcrowding and disperse hunter activities. Sheldon Refuge is renowned for its big-game hunting and hunters come from throughout Nevada as well as 10 or more additional states each year. Hunt quality is considered high, as measured by the number of animals seen, the quality and health of the animals, the lack of interference from other hunters or refuge users, and the scenic quality and biological integrity of the areas visited while hunting. Sheldon Refuge has a reputation for producing exceptional trophies, and tags are highly sought after.

Demand for commercial guides and outfitters is growing in popularity for non-Nevada resident hunters. Guiding and outfitting within Sheldon Refuge is discussed further under Section 5.3.

There are limited developed camping opportunities on Sheldon Refuge, forcing hunters to camp in close quarters with others. NDOW splits the hunting seasons on Sheldon Refuge to ease the crowding in the campgrounds. This cuts the number of hunters in the field by half for each season. Several of the campgrounds have meat hanging poles, providing the only facilities maintained expressly for this program.

5.2.4 Fishing

Fishing opportunities on Sheldon Refuge are managed in cooperation with NDOW and are characterized by ease of access to remote quiet settings with semi-primitive facilities. Stocking non-native fish has occurred on Sheldon Refuge, although it is not preferred under Service policy. Restocking of fish to Catnip and Big Spring reservoirs continues to occur periodically. Fishing is allowed in the Dufurrena Ponds and Catnip and Big Spring reservoirs (Photo 5.3). The fisheries at these locations are typically described as either cold-water fisheries (i.e., trout) or warm-water fisheries (e.g., bass). There are no current data available for the number of visitors fishing on Sheldon Refuge. In 2007 NDOW estimated that 312 anglers fished Catnip Reservoir and that 176 anglers fished the Dufurrena Ponds (NDOW 2010). The most recent estimate for Big Spring Reservoir was in 1998 when NDOW estimated 1,906 anglers fished this reservoir (NDOW 2010). Fishing is regulated by NDOW in consultation with the Service.

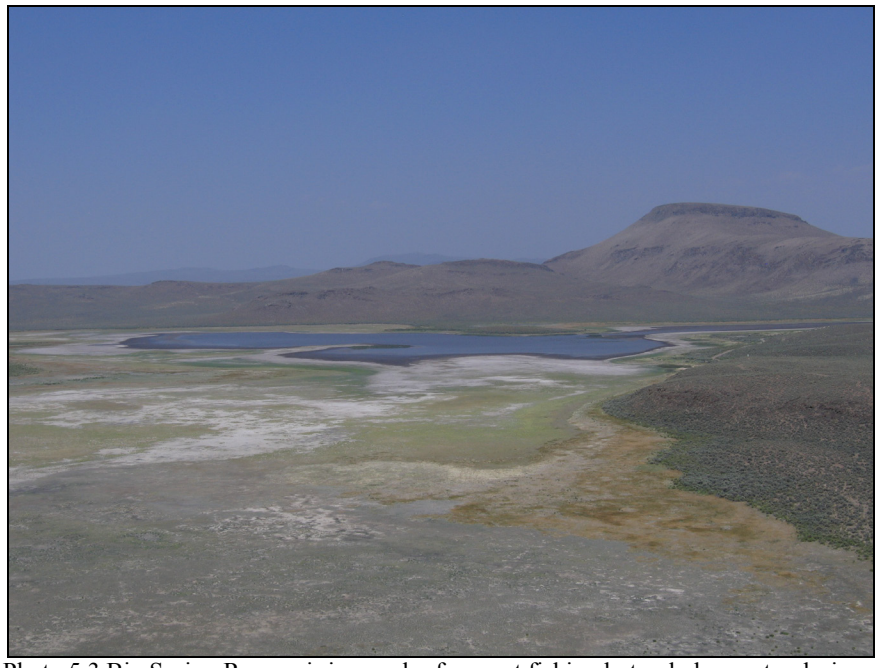

Photo 5.3 Big Spring Reservoir is popular for sport fishing but only has water during certain years.

Big Spring and Catnip reservoirs have facilities in support of fishing; Big Spring Reservoir has a campground and a boat launch, and Catnip Reservoir has a campground. The Virgin Valley Campground is located 1½ miles from Dufurrena Ponds 19 and 20. Dufurrena Pond 20 and McGee Pond have fishing docks that are accessible to people with physical disabilities. The Alvord cutthroat trout, an undescribed subspecies, is considered to be extinct and the population found in Virgin Creek

likely no longer exists in its pure form; however, individuals described as Alvord cutthroat trout-rainbow trout hybrids have been documented within the watershed. Native Sheldon tui and Alvord chubs are not impacted by management of sport fisheries in Big Spring and Catnip reservoirs.

The popularity of fishing on Sheldon Refuge results in visitation which approaches or exceeds campground capacity at some sites during short periods of the summer and fall. Additionally, the stocking of non-native fish to waters within Sheldon Refuge is in conflict with Service Policy 7 RM 10 and 601 FW 3. Fish stocking in conjunction with maintenance and management of existing reservoirs, other water control structures, and campgrounds continues to affect the natural hydrologic systems of various watersheds, associated riparian, wetland, and aquatic habitats, and various aquatic native species.

All opportunities are provided by previous NDOW stocking or periodic restocking of non-native fish species to constructed reservoirs. Catnip Reservoir is located within a closed basin that has no native or indigenous species of trout. Big Spring Reservoir is located within the Alvord Basin, which at one time supported a native subspecies of cutthroat trout. However, due to hybridization with rainbow trout, which were stocked in the 1930s, the pure form of this subspecies has been extirpated. Two species of trout considered indigenous to the region are the Lahontan cutthroat trout, which occurs in the Quinn River Basin (Lahontan Basin drainage) east and south of Sheldon Refuge, and the redband trout which occurs in Columbia River Basin north of Sheldon Refuge. Both Catnip and Big Spring reservoirs are constructed impoundments with limited to no spawning or rearing habitat that would facilitate self-sustaining trout populations large enough to support a recreational fishery (NDOW 2011a). Therefore, to maintain recreation trout fishing opportunities and a quality fishing experience for the public within Sheldon Refuge, periodic restocking of hatchery fish will need to continue. Adjacent or nearby campgrounds accessible by unimproved roads are maintained by Sheldon Refuge. The quality of these opportunities makes fishing on Sheldon Refuge a popular recreational activity in northern Nevada, part of the Great Basin. Fishing opportunities can be further subdivided into warm-water and cold-water fishing opportunities.

5.2.4.1 Warm-water Fishery

Dufurrena Ponds 19 and 20 and McGee are non-native warm-water fisheries that are extremely popular with anglers from northern Nevada. These ponds provide opportunities to fish for large-mouth bass, crappie, sunfish, and yellow perch. The fish populations in these ponds are considered self-sustaining, do not require continual restocking by NDOW, and do not pose a risk to native species. Considering these factors, Sheldon Refuge has made a commitment to maintain the existing fishery.

McGee Pond provides fishing opportunity only for individuals who are age 12 or under, age 65 or older, or disabled. It was most recently stocked with fish in 2006 at the request of refuge staff after it was drained for maintenance. The Biological Integrity Diversity and Environmental Health Policy (601 FW 3) addresses the management of non-native species in Section 3.16 which states: “We require no action to reduce or eradicate self-sustaining populations of non-native, noninvasive species (e.g., pheasants) unless those species interfere with accomplishing refuge purpose(s). We do not, however, manage habitats to increase populations of these species unless such habitat management supports accomplishing refuge purpose(s).” Because these ponds have self-sustaining populations and are popular with fishing residents in northern Nevada, these populations can continue to exist. Currently, these fish cannot enter into the Thousand Creek/Virgin Creek system and establish additional non-native populations. They are separated by meadow complexes that did

not allow passage of fish during a recent 500-year flood event into the Thousand Creek/Virgin Creek system. There is some risk that fish may be transferred to other water bodies on Sheldon Refuge.

5.2.4.2 Cold-water Fishery

Management of cold-water fish on Sheldon Refuge has been conducted by NDOW with minimal involvement by refuge staff. Two popular sport fisheries (e.g., Big Spring and Catnip reservoirs) are supported by NDOW on Sheldon Refuge.

Catnip Reservoir

Catnip Reservoir has been historically used by NDOW as brood stock for the Walker Lake strain of Lahontan cutthroat trout and was opened in 1998 to fishing with a limit of one trout. Although the Lahontan cutthroat trout is a threatened species, the population on Sheldon Refuge is designated as experimental non-essential under an ESA 4D ruling (Sheldon Refuge is outside of this species' historical distribution), and NDOW is allowed to permit harvest in accordance with state laws.

Inspections, done by the Service (in 2002) and by the State of Nevada (in 2006) classified Catnip Reservoir dam as being in an unsafe, non-emergency condition due to heavy seepage. The dam was classified as non-emergency due to the low chance of loss of life in the event of dam failure. The reservoir will eventually need to be drained in order for the dam to be repaired. The reservoir is very shallow due to siltation brought in from its tributaries. Draining the reservoir to repair the dam will allow for some dredging to deepen the reservoir and to restock with Lahontan cutthroat trout.

Big Spring Reservoir

Big Spring Reservoir has been stocked with trout, and the fishing limit is five fish. Big Spring Reservoir is subject to periodic drying and filling depending on precipitation amounts. When the reservoir holds water for several years, the fishing is very good and becomes very popular. However, when the reservoir becomes dry, it is necessary to restock to re-establish the fishery. The current put-and-take program is not consistent with the following Service policies: 7 RM 1.1 (Population Management), 7 RM 10 (Fisheries Resource Management), 7 RM 12 (Propagation and Stocking), or 601 FW 3 (Biological Integrity, Diversity, and Environmental Health). These policies indicate that only stocking of native and indigenous species is acceptable in refuge waters. In addition, the 7 RM 10 policy states that only fingerling/juvenile fish can be stocked as opposed to catchable-size fish. Stocking Big Spring Reservoir with Lahontan cutthroat, Alvord cutthroat, or redband trout, which are considered indigenous to the region, would be more consistent with Service policy in Big Spring Reservoir.

5.2.5 Wildlife Viewing and Photography

Wildlife viewers and photographers are free to roam Sheldon Refuge and use personally provided temporary blinds. Professional photographers currently use Sheldon Refuge and are required to obtain a Special Use Permit. There are not any available data to estimate the number of visitors participating in wildlife viewing and photography (Photo 5.4).

Parts of Sheldon Refuge are very remote and access is limited by the terrain and adverse seasonal conditions. The wilderness character is an important part of the Sheldon's attractiveness.

Sheldon has no facilities managed and maintained specifically for this activity other than a few unimproved areas posted as a place to view wildlife. There are several places on Sheldon Refuge where photography blinds could be placed. The Dufurrena Ponds are one such area and will provide opportunities to photograph many species of wildlife. Another possibility is Swan Lake Reservoir, where many pronghorn congregate during the summer.

Photo 5.4 Although no estimates are available, most people likely participate in wildlife viewing or photography while visiting Sheldon Refuge.

5.2.6 Environmental Education

The remoteness of Sheldon Refuge does not lend itself to many opportunities for environmental education in a traditional format where school children are presented programs on-site. The nearest population centers are Denio to the east and Adel to the west of Sheldon Refuge. Both areas have elementary schools but older children are bused to other areas with larger populations. Both Denio and Adel have populations of less than 200. In the past few years the visitor numbers have ranged from zero to 12.

The current refuge office, a single-wide trailer, does not have the space for an adequate visitor contact station and is not set up to serve as a visitor contact facility. There are no facilities managed or maintained for environmental education.

5.2.7 Interpretation

Sheldon Refuge provides brochures and signs at key visitor contact locations. Sheldon Refuge Complex also maintains a website (http://www.fws.gov/sheldonhartmtn) where current information can be obtained at any time.

Sheldon hosts wildlife viewing tours twice a year: in the spring and fall to volunteer groups. Tours are available on request to the staff; however, refuge staffing is extremely limited. There is no visitor contact station or regular staffing at the Sheldon Refuge Office (Dufurrena).

5.3 Supporting Uses and Facilities

5.3.1 Camping

Camping itself is not a priority public use on Service lands, but because of the size, remoteness, and quality of roads on Sheldon Refuge, it is important in supporting priority uses including fishing, hunting, wildlife observation, and wildlife photography. Camping on Sheldon Refuge is allowed in designated campgrounds or under special backcountry permit with a 14-day camping limit at any one location. There are four types of camping opportunities currently provided on Sheldon Refuge: developed, semi-primitive, primitive, and backcountry/wilderness.

Campgrounds at Sheldon Refuge can be classified as either developed, semi-primitive, or primitive depending upon types of facilities and development and levels of use. Currently, there are 13 campgrounds available to visitors on Sheldon Refuge (see Figure 5.1).

5.3.1.1 Developed Camping

Developed camping opportunities are provided in the Virgin Valley Campground, which is easily accessible year-round for all vehicles, including recreational vehicles (RVs). The campground, located at Dufurrena, offers shade trees, potable water, two vault toilets, 16 picnic tables, 24 fire rings, a bath-house, meat hanging pole, and a hot spring developed for swimming. The campground can hold approximately 100 camping parties on a first-come, first-served basis without designated sites. From 2005 through 2007 an average of 18 campsites were occupied per day during the days surveyed for a seasonal average of 6,573 visitor use days (USFWS Undated Report).

Between mid-May and early September the Virgin Valley Campground is extensively used by individuals collecting rocks and/or mining for opals at nearby commercial mining sites, with visitation highest during June; camping in support of these activities is not an identified priority public use. From mid-August through mid-November, the Virgin Valley Campground is heavily used by hunters. Others stay at the campground to participate in nearby fishing and birding opportunities; however, the number of individuals using the campground to enjoy fishing and birding activities is not known. The proportion of camping to support these uses may be incidental in comparison to mining and hunting activities. At the Virgin Valley Campground individual campsites are not delineated nor is there a reservation or fee system. During peak seasons, overcrowding and user conflicts have been a concern as well as overflow into the surrounding uplands, which may result in further environmental damage. There is also a private developed campground at the Royal Peacock Mine located in the Virgin Valley Mining District, which has RV hookups.

Virgin Valley Campground is situated at the site of a former CCC work camp. The campground has few vegetated areas and is mostly gravel roadway or bare volcanic soil, which naturally has little or no organic matter. The campground is includes Virgin Valley Hot Springs and is immediately adjacent to McGee Pond, both of which are extensively developed and altered habitats.

5.3.1.2 Semi-primitive Camping

The second type of camping opportunity is semi-primitive. Five of the 13 designated campgrounds (Catnip Reservoir, West Rock Spring, Fish Spring, Badger, and Big Spring Reservoir) within Sheldon Refuge are considered semi-primitive and include outhouses, fire rings, meat-hanging poles,

and in the case of Fish Spring and Badger campgrounds, horse corrals. These semi-primitive campgrounds are accessible from primary roads or improved secondary roads suitable for most types of vehicles. The semi-primitive sites are primarily used by hunters, and campsite capacity, in part, limits the number of tag holders that can be accommodated during big-game seasons. Individuals seeking fishing opportunities use campgrounds at Catnip and Big Spring reservoirs.

Catnip Reservoir and Big Spring Reservoir campgrounds are located immediately adjacent to artificial reservoirs. The remaining three semi-primitive campgrounds are all located immediately adjacent to or include wet meadows, spring, or springbrook habitats. Catnip Reservoir and Big Spring Reservoir campgrounds receive the greatest amounts of use and exhibit the greatest amount of impact. The core areas of use at these campgrounds no longer support vegetation, water infiltration is considered low due to soil compaction, and gravel has been placed in some areas to reduce erosion. Most of the remaining semi-primitive campgrounds have moderate amounts of vegetation loss and soil compaction, which is limited to areas adjacent to fire rings and outhouses, but these impacts are generally not continuous throughout the campground.

5.3.1.3 Primitive Camping

Seven campgrounds (Little Catnip Spring, Gooch Spring, North Hell Creek, Wheeler Spring, Bateman Spring, Devaney, and East Rock Spring) are considered primitive campgrounds and have only fire rings or no improvements, are remote, and accessible to four-wheel drive or high-clearance vehicles when road conditions are passable. These primitive campgrounds receive intermittent and low amounts of use, occurring mostly during the hunting seasons (early August through October). All of these campgrounds are located immediately adjacent to or include wet meadows, spring, or springbrook habitats. Three primitive campgrounds (Wheeler Spring, Devaney, and East Rock Spring) also include aspen woodland habitats.

Primitive campgrounds generally exhibit few impacts to vegetation or soils due to low amounts of intermittent use, which occurs during late summer and fall after when most annual and biannual plants have finished growing for the season and when soils are typically drier and more resistant to impact. Some primitive campgrounds have no visible bare ground, and because they are located in meadow habitats, vegetation is generally able to recover from the low amounts of use. Other primitive campgrounds exhibit small areas of bare ground, generally lack forbs that are not resistant to trampling, and in the case of Wheeler Spring, Devaney, and East Rock Springs, exhibit some impacts to aspen trees from soil compaction, root exposure, and cutting.

5.3.1.4 Backcountry/Wilderness Camping

The fourth type of camping opportunity on Sheldon Refuge is considered backcountry or wilderness camping, and use is relatively low at present. This activity requires a backcountry camping permit issued by the Sheldon Refuge Manager. There are currently no limits on the number of permit holders. To date, the majority of visitors utilizing this opportunity are hunters pursuing game on the tablelands, which are generally within the designated WSAs. There is also moderate dispersed use by campers and bathers at Bog Hot Springs. The spring itself is privately owned, but campers on that inholding spill over onto refuge lands.

Restrictions on backcountry camping are few, but currently include no camping within 100 yards of a water source, or within 0.5 mile of a road or vehicle. All trash must be packed out and the permit must be carried by the user as well as a tear-off sheet displayed in his or her vehicle.

Most campgrounds on the Sheldon Refuge are located at or near springs and riparian areas and are primarily used during the hunting season. The proximity of these campgrounds to water could potentially contaminate water sources, and disturb and displace wildlife from critical habitats. Other direct impacts include soil compaction, erosion, and trampling and removal of vegetation. Campfires are a seasonal concern during dry periods when campfires are not allowed, resulting in numerous violations being observed each year. Data regarding camping demographics are generally lacking across the landscape and need to include where, when, how many, duration, and purpose for visiting Sheldon Refuge.

5.3.2 Horseback Riding

Horseback riding has been allowed as a recreational activity on Sheldon for many years. However, there have been less than 10 horseback visitors a year, and as a result, horseback riding is considered a very low impact activity on Sheldon Refuge. Horseback riding gives the public an opportunity to visit remote parts of Sheldon Refuge, and to enjoy the wildlife viewing, solitude, and expansive views that Sheldon Refuge is known for. In addition, visiting Sheldon Refuge via horseback can give the user a sense of history. Pack trips are allowed with a backcountry permit.

Currently, horseback riding is allowed refuge wide except in small areas that are closed to all public entry. The areas closed to horseback riding are the administrative facilities at the Dufurrena subheadquarters, which include the shop area and the horse corrals.

There are very few facilities designed for horseback use; only two of the 12 semi-primitive and primitive campgrounds, Badger and Fish Spring campgrounds, provide facilities for domestic horses. There is a concern that the number of visitors engaging in horseback riding may increase, particularly with hunting guides and their clients. There is also a potential for an increase in horseback riding use with the designation of wilderness.

5.3.3 Bicycling

On Sheldon Refuge, bicycle use occurs but is light. Bicycling is allowed only on roads open to motor vehicles.

5.3.4 Outfitting and Guiding

Several professional guides have permits to guide on Sheldon Refuge. The use of hunting guides is growing in popularity for non-resident hunters; however, the total number of guides is currently limited to 10 annually. On average, between nine and 10 guided hunt permits were issued from 2005 through 2009, each for outfitting and guiding big-game hunters. Guiding is viewed as a commercial use and requires a Special Use Permit from Sheldon Refuge. Hunting guides can provide a valuable service by offering a quality hunting experience for non-resident hunters who are unfamiliar with Sheldon Refuge and high desert hunting conditions. However, Sheldon Refuge has received a number of complaints about guides and associated subguides interfering with other hunters. There is also the perception that spotter aircraft are being used increasingly by guides, in turn disrupting wildlife and the quality of other hunters' experience.

Professional guides are occasionally permitted to provide services in support of other recreational uses such as photography or upland bird hunting. However, the demand and number of requests for these permits are rare and typically issued on a case-by-case basis.

5.4 Other Refuge Uses

5.4.1 Rock Collecting

Collecting rocks and minerals on Sheldon Refuge has long been a popular pastime, and it is currently open to the public. Collection of 7 pounds of rocks a day is allowed anywhere on Sheldon Refuge except on mining claims. Mining on established claims within the Virgin Valley Mining District is not considered rock collecting.

Rock collecting is not allowed under Refuge System regulations or policies, and may be in direct conflict with Refuge System regulations (e.g., 50 CFR 27.61). However, under current refuge policy, the public can collect up to 7 pounds of surface rock per day including petrified wood, opal, and agate. No digging or excavation is allowed outside of the mining district.

5.5 Law Enforcement and Illegal Activities

Illegal uses that occur on Sheldon Refuge include illegal OHV use, camping outside of designated areas, poaching, hunting and fishing violations, archaeological theft, vandalism, and theft of refuge signs. The President's proposal for eight wilderness areas within Sheldon Refuge in 1974 included closing all permanent roads and motorized trails within the proposed areas. However, recurring illegal vehicle use has been a persistent problem throughout Sheldon Refuge. The remoteness, size, existing staffing, and existing funding have made public education and enforcement of these existing closures difficult.

There is also concern that certain segments of the public, intentionally or inadvertently, may be collecting archaeological artifacts that are prohibited from collection by the Archaeological Resources Preservation Act of 1979.

Illegal uses persist partly because of the lack of public support, insufficient public education, and limited law enforcement capability. There is one dual-function officer assigned to Sheldon Refuge and a full-time officer assigned to the Sheldon-Hart Mountain Complex. Due to travel distances, remoteness, and the vast area to patrol, additional law enforcement personnel are necessary.

In 2008, there were three citations issued on Sheldon Refuge: two citations for reckless driving and one citation for operating an ATV on a closed road. There were two cases of abandoned property: a car and a horse.

5.6 Cultural Resources and Historic Properties

Cultural resources are the physical remains, sites, objects, records, oral testimony, and traditions that connect people to our nation's past. They include archaeological and historical artifacts, traditional ecological knowledge, sites, landscapes, sacred locations, and traditional cultural properties. Cultural resources are integral components of the landscape. They tell us how people have used the land and its wildlife. At Sheldon Refuge, cultural resources remind us that human beings had already been part of the web of life for thousands of years before the arrival of Euro-Americans in the mid-1800s.

5.6.1 Native American Cultural History

Archaeological evidence indicates that humans have lived in northern Nevada for at least 12,000 years. Some of the earliest radiocarbon dates of human occupation (nearly 9,000 years ago) have come from Last Supper Cave. However, most of the prehistory of the area is represented by open-air lithic scatters. The Native American cultural history at Sheldon Refuge is based on interpretation of the archaeological record on and near Sheldon Refuge. Several scholars have presented the history and archaeology of the region in detail (e.g., Elston and Earl 1979; Layton 1970; Leach 1988; Smith et al. 1983).

5.6.2 Native American Ethnography and Recent History

Sheldon Refuge occurs in the homeland the *Aga'I'paninadokada* ("fish lake eaters") and *Moado'kado* ("wild onion eaters") Northern Paiute (Raymond 2000). They were a semi-nomadic people who made their living by hunting (pronghorn, bighorn, rabbits, ground squirrels, waterfowl), gathering (roots, berries, seeds), and fishing (trout, suckers, chub). The nuclear family was the principal socio-economic unit (Steward 1938).

Prior to Euro-American incursion into northern Nevada, Northern Paiute families congregated for the winter at lower elevation village sites near dependable water, fuel, and food. The people at the winter villages lived on stored food, supplemented by hunting game, and fishing. With the arrival of spring the Indians harvested wild roots (camas, ipos, bitterroot, biscuitroot) by the bushel. Some were roasted and eaten on the spot while many were dried and stored for the following winter. In summer, the families dispersed to higher elevations following game and the seasonal ripening of plants. In autumn, the families would gather again for communal rabbit and pronghorn hunts. They often held *fandangos,* a sort of harvest celebration where far-flung families met to exchange food and other resources, share information, make acquaintances, form alliances, and find mates. With the first snow of the season, Northern Paiute families reconvened at their winter village locations. (Fowler 1989; Fowler and Liljeblad 1986; Steward 1938; Stewart 1939).

As Euro-American immigrants settled northwestern Nevada, the Northern Paiute began raiding ranches for their livestock while trying to avoid directly fighting with the new arrivals (Layton 1977:244, 1978). Many of the raids appear to have been perpetrated by the same band led by Captain Tom, or Black Rock Tom as he was also known, who was easily identified by his white horse. Black Rock Tom based his operations in the High Rock region, including the Black Rock Range and probably parts of the Sheldon Refuge.

In response to raids and associated casualties, the U.S. Army established several forts in northwest Nevada between 1860 and 1865 to protect the area from Indians and Confederate sympathizers. After a series of deadly skirmishes and retributions eventually ended and the Northern Paiute were removed to nearby reservations and began to assimilate with the new order by working on ranches as cowhands, laborers, and domestic help. Today the Northern Paiute live at Summit Lake Indian Reservation, Fort McDermitt Indian Reservation, Fort Bidwell Indian Reservation, Cedarville Indian Rancheria, and in the towns and ranches that surround Sheldon Refuge.

5.6.3 Euro-American History

5.6.3.1 Early Exploration

The earliest Euro-American exploration of the Sheldon area was led by Colonel C.S. Drew in 1864 in search of a wagon route from Fort Klamath, Oregon, to the Owyhee Mining District in Idaho. Drew's report contains topographic information and information about the Indians, flora, and water sources. In July 1866, Major Robert S. Williamson of the U.S. Army led an exploratory party from Fort McDermitt to Lassen's Meadow in California but found the area to be too sandy and too arid for a decent wagon route (Elston and Earl 1979:35). Under the direction of Andrew J. Hatch, the Office of the U.S. Surveyor General began systematic surveys in the vicinity of Sheldon Refuge in 1872. The maps created from these surveys record old roads between Denio and Virgin Valley, Denio and Cedarville, Virgin Ranch to Denio, and Thousand Creek Canyon to Rock Spring Valley.

5.6.3.2 Nineteenth Century Ranching

Euro-Americans began settling the Sheldon Refuge area in the 1860s. They were attracted to the numerous springs and the grassy meadows for grazing livestock. But the warm season verdure was offset by the long and occasionally harsh winters. Particularly difficult winters in the 1880s decimated livestock herds and many ranches failed. Ranchers sold their properties to the stock raising companies such as Miller and Lux. Between 1886 and 1888, Miller and Lux purchased huge tracts of land and many of the early ranches in northwestern Humboldt County. By 1905, Miller and Lux owned much of northwestern Nevada.

Although cattle ranching remained the primary economic activity of the region in the late nineteenth and early twentieth centuries (Elston and Earl 1979), some ranchers also raised European horse breeds as saddle and working stock for the U.S. Cavalry and the burgeoning population of nearby California (USFWS 1985). George B. Hapgood built ranches at Calcutta Lake and Last Chance Ranch in 1880. Both ranches were geared to diversified livestock production, although for many years a focus of summer activities at Last Chance Ranch was horses (Hapgood 1984 in USFWS 1985:26; Speulda 2002). Starting in 1890, William K. Ebeling built the ranches now known as Dufurrena, Thousand Creek, and Kinney Camp. Buzz Miller, Ebeling's "vaquero boss" in the 1910s, reported that Ebeling ran a mixed outfit including cattle, a few sheep, and predominately horses (Miller 1984 in USFWS 1985:40). Inevitably, horses escaped from these ranches and formed herds that roamed the landscape (Raymond et al. 2007).

Some ranchers capitalized on the growing population of feral horses at Sheldon Refuge by gathering and selling them. In 1891, Eugene Gooch established a livestock operation that was strategically located to gather, trap, and ship feral horses. "Gooch Camp" is located in a narrow canyon between Gooch Table and Catnip Mountain historically known to harbor herds of feral horses.

In 1905, newspaper reporter Allen Bragg visited ranches in Virgin Valley and described the James McGhee ranch as "140 acres of meadow land…a bunch of cattle and horses…the cellar is walled up by flat stone of various colors and products of the valley" (Bragg 1976:44). Another ranch owned by William Ebeling about 2 miles from the McGhee place also had cattle and horses, and a milk house made of the flat rock (Bragg 1976:44). Further up the valley, Miller and Lux owned the ranch at Virgin Valley, along with "nine other ranches in this part of the county along with numerous camps" (Bragg 1976:39-40).

Basque sheep-herder Thomas Dufurrena moved to the Sheldon area from California in 1905. His herd of 40,000 sheep was among the largest operations in the area. He had diversified into cattle ranching by 1911. Dufurrena bought several other ranches in the 1920s and 1930s as drought and the Depression forced many ranchers to sell. By the mid-1930s, most of the ranchers including Dufurrena sold their property to the U.S. Fish and Wildlife Service for inclusion in the Sheldon Refuge.

5.6.3.3 Mining

Prospectors began exploring the Sheldon Refuge area in the 1860s and 1870s. Opals were discovered in Virgin Valley in 1908, and the Virgin Valley Mining District was established in 1909. Private individuals and enterprise have worked the deposits since. The Rainbow Ridge Mining Company, incorporated in 1918, is the only opal mining company that has a significant record. In 1919, the mine produced the largest opal ever found in the United States. It weighed 16.95 troy ounces and was valued at $250,000 (Elston and Earl 1979:39). The gem joined the famed Roebling Collection and was later donated to the Smithsonian Institution in Washington, D.C., where it is on display in the Hall of Gems and Minerals at the National Museum of Natural History. Opal mining continues on Sheldon Refuge to this day.

A large formation of pink and buff sandstone occurs in the Virgin Valley at the confluence of Virgin Creek and Thousand Creek. The stone has been quarried, knapped, and cut for use as a building material since the late nineteenth century. Known today as the Dufurrena Sandstone, blocks from the quarry were used to construct many of the early ranch structures on Sheldon Refuge. From 1935 to 1942 the CCC quarried the sandstone to construct a pool, bridge, pathways, loading dock, and other buildings at their Virgin Valley Camp. In the 1950s, a commercial operation worked the quarry and marketed the stone under the name “Owyheeite.”

A cinnabar mine was located 4 miles southeast of the headquarters, on the south slope of Bald Mountain and was developed in the late 1920s.

With the exception of the area in and around Virgin Valley, the majority of Sheldon Refuge has been formally withdrawn from mineral entry.

5.6.3.4 Creation of the Sheldon Refuge

In the early twentieth century, pronghorn populations in Nevada had plummeted as a result of several years of cold dry weather, unchecked livestock grazing, degraded rangelands, and unregulated hunting. By 1920, conservationists including members of the Audubon Society, the Boone and Crockett Club of New York City, employees of the U.S. Biological Survey (later renamed the U.S. Fish and Wildlife Service), and the State of Nevada raised concerns about the plight of the pronghorn. E.R. Sans, an employee of the U.S. Biological Survey, mobilized prominent members of the conservation movement including Dr. Gilbert Pearson, president of the National Association of Audubon Societies, and Charles Sheldon of the Boone and Crockett Club, to address Nevada’s pronghorn problem (Elston and Earl 1979:39-45).

The Nevada pronghorn conservationists recognized that forage and habitat were essential for the survival of pronghorn populations and observed that non-native animals including sheep, cattle, and feral horses competed for the same forage and habitat as pronghorn. E.R. Sans convinced the group that Hapgood’s Last Chance Ranch would make an ideal pronghorn sanctuary. For 10 years the

conservationists organized, raised money, and lobbied county, state, and Federal governments. Their efforts paid off in 1931 when President Herbert Hoover signed Executive Order No. 7511 purchasing Hapgood's Ranch and establishing the Charles Sheldon National Antelope Range for the conservation of pronghorn antelope and other native wildlife species. Franklin Roosevelt followed with Executive Order No. 7522, enlarging Sheldon Refuge to over 539,000 acres (Elston and Earl 1979:39-45).

5.6.3.5 Civilian Conservation Corps

The Works Progress Administration (WPA) began construction of a refuge office/residence on the west side of Sheldon Refuge, but the WPA was replaced by the CCC in 1935. The CCC efforts at Sheldon were directed toward "improvement and development of the present habitat for wildlife now inhabiting the area, plus development of water resources for migratory waterfowl and other migratory birds" (records of the Civilian Conservation Corps: Record Group 35, Box No. 133).

By 1936, CCC established Camp Sheldon BF-1 on the west side of Sheldon Refuge (Speulda 1995). The camp, named Camp Board Corrals, was in the northern part of Long Valley. From this camp the CCC enrollees built boundary fences, telephone lines, and roads. Their largest effort was constructing the steep west side hill road and entrance sign. They also built an overnight cabin halfway up the grade. The road remains a primary entrance to Sheldon Refuge.

In 1938, the CCC set up a camp in Virgin Valley on the McGee Ranch on the east side of the Sheldon Refuge. An advance U.S. Army crew led the construction effort with help from the CCC enrollees. In addition to the usual bunk, mess, and work facilities, they built a four-table pool hall with a fine sandstone floor, a ping-pong table, barber shop, and a shoe shine stand. They also constructed a 40-by-60-foot stone swimming pool within the camp area which is filled by a steady stream of warm (artesian) water. This historic swimming pool and campground (now called the Virgin Valley Campground) continue to attract visitors to Sheldon Refuge.

The CCC operated out of the Virgin Valley camp for more than three years without a break. They built dikes and ponds and enhanced wildlife habitat in the Virgin Valley. They improved roads, built fence lines, and restored old homesteads making them suitable for refuge employees. The CCC also built "Badger Cabin," a place for refuge workers to overnight in the Sheldon hinterlands. As the prospect of war loomed, the U.S. Army closed the CCC camp and dismantled and removed all the portable buildings in 1941. But the craftsmanship of the CCC endures in the roads, water impoundments, and stonework on cabins that are still in use by the Service.

5.6.4 Current Knowledge of Cultural Resources Sites on Sheldon Refuge

A systematic or comprehensive sample inventory of cultural resources has never been conducted on Sheldon Refuge. Archaeologists have conducted 35 relatively small archaeological surveys covering 5,955 acres or slightly more than 1% of the 575,000-acre Sheldon Refuge. Almost all of the surveys have been carried out in advance of proposed development projects in compliance with Section 106 of the NHPA. Archaeologists have done surveys for refuge maintenance and construction (e.g., fences, guzzlers, roads, and prescribed burns) and to address the impacts of feral horses and rangeland wildfires. Utility companies have stimulated archaeological surveys for pipe and fiber optic lines. The archaeological surveys have recorded 251 cultural resource sites on Sheldon Refuge. These include 211 prehistoric sites, 23 historic building sites, and 17 sites recorded as dual component sites, which contain both prehistoric and historic archaeological deposits. We suspect

that several hundred, if not thousands, of archaeological sites occur on Sheldon Refuge. But vast stretches of Sheldon Refuge have never been examined by archaeologists and even a broad outline of its human prehistory remains mostly unknown.

5.6.4.1 Prehistoric Sites

Among the 251 recorded cultural resources sites on Sheldon Refuge, 211 (84%) are prehistoric sites. Many of the recorded sites occur near water. Perennial springs and streams at Sheldon Refuge were magnets for human occupation throughout the past. The water sources are oases compared to the relatively dry and monotonous landscape beyond them. Although a formal inventory has not been conducted, we suspect that every permanent spring and stream on Sheldon Refuge is bounded by archaeological sites. Springs and stream-side sites are characterized by lithic scatters, fire-affected rock, ground stone tools, and residential features. Few such sites are small, most exceed an acre in size, while several encompass a dozen or more acres around the spring or stream. Some spring and stream-side sites harbor buried cultural deposits in the deeper soil that often characterizes these environments. These archaeological sites offer the challenge and opportunity to sort out multiple periods of human occupation at Sheldon Refuge and describe the cultural changes that mark the different occupations.

Lithic scatters make up the majority (n=188, or 89%) of the known prehistoric sites on Sheldon Refuge. The remaining 23 sites consist of rock art, village sites, caves, rockshelters, rock cairns, hunting facilities, and obsidian quarries. The following sections describe some of the common types of prehistoric archaeological sites on Sheldon Refuge.

Lithic scatters

Lithic scatter refers to a prehistoric archaeological site consisting of stone artifacts and the debris from the manufacture and use of stone artifacts. Flaked stone tools (e.g., projectile points, knives, scrapers) and the waste flakes (a.k.a. debitage) generated from the manufacture of flaked stone tools are the most ubiquitous elements at lithic scatters. The most common toolstone at archaeological sites on Sheldon Refuge is obsidian, but chert, chalcedony, flint, agate, basalt, and jasper are also present. Lithic scatters may contain ground stone stools (e.g., manos, metates, mortars, pestles) but usually in small numbers. Fire-affected rock (a.k.a. fire cracked rock, hearth rocks, oven rocks) may also occur at lithic scatters. Lithic scatters range in size from a few square meters containing about 10 artifacts to several acres in size with thousands of stone artifacts. Lithic scatters are often confined to the surface, but many lithic scatters also contain buried cultural deposits. Some lithic scatters occur in conjunction with other archaeological sites and features described below.

At Sheldon Refuge, the size and complexity of the lithic scatters are governed by their proximity to naturally occurring toolstone and water, as well as elevation. Large and complex lithic scatters generally occur in places with abundant obsidian on low-elevation alluvial plains in well-watered valleys like Virgin Creek and Thousand Creek. Such sites tend to have many flaked stone tools, cultural features such as hearths, ground stone tools, abundant debitage, and good potential for buried archaeological deposits. Absent nearby water and toolstone, archaeological sites tend to be small, lack many tools, and are limited to the surface.

Isolated finds

An isolated find is a lithic scatter of less than 10 items. Isolated finds do not contain buried cultural deposits or other features such as hearths or middens. Isolated finds are common throughout Sheldon Refuge.

Villages

An archaeological village appears as a large lithic scatter with additional evidence of long-term residential occupation such as hearths, house foundations (stone rings, earthen pits, or depressions), and middens (trash dumps containing debris from food, clothing, shelter, and food preparation). Archaeological and ethnographic records have documented winter villages of the Northern Paiute and their ancestors in places surrounding Sheldon Refuge. By analogy, we suspect Native American villages occur at well-watered, low-elevation, sheltered areas on Sheldon Refuge. Although no formal archaeological investigation has been conducted, places like Bog Hot Springs, Virgin Creek Valley, Alkali Reservoir, and the mouth of Thousand Creek Gorge are likely areas where future investigations should be focused.

Caves and rockshelters

Caves and rockshelters are archaeological sites characterized by stone artifacts and often middens that occur in and around the mouths of caves and in sheltered areas among rock outcrops and canyon walls. Caves and rockshelters are often important sites because they preserve better than most archaeological sites a variety of evidence of human occupation for thousands of years.

Last Supper Cave is a large and deeply stratified archaeological site on Hell Creek. It was completely excavated in the 1970s by a team of archaeologists from the American Museum of Natural History, Louisiana State University, and University of Nevada, Reno (Layton 1970). The cave contains an abundance of surface and subsurface deposits, including a large midden, stone tools and debitage, faunal remains, basketry, sandals and other perishable items. Samples have been radiocarbon dated to nearly 9,000 years ago, and the earliest cultural materials within the cave predate 9,000 years ago. The artifacts are from the early Holocene and are relatively abundant. The large artifact and sample collection from the cave has been inventoried, repackaged, and stabilized at the Nevada State Museum, where it is periodically studied by graduate students and other scholars (Lyman 1988). Other similar but smaller caves are known to occur on Sheldon Refuge, but a systematic inventory of them has not been conducted.

Rock art (petroglyphs and pictographs)

Rock art is characterized by markings, either painted (pictographs) or engraved (petroglyphs), on the surface of rock and by geoglyphs (large figures produced by either removing the surface of the ground or alignments of stone on the surface of the ground). Rock art sites are often associated with lithic scatters and other archaeological features and are usually found at places with smooth surfaces of basalt or rhyolite, often at the base of canyons and rimrock. Rock art is located at several locations within Sheldon Refuge, many of which can be easily seen and have little or no evidence of disturbance or vandalism by visitors.

Rock cairns, walls, and rings

Archaeological features built with large cobble- and boulder-sized stones include cairns, walls, and rings. Cairns are stacks of stones built with one or more rocks. Prehistoric cairns can have spiritual connections (Chartkoff 1983; Haynal 2000) and can be distinguished from historical cairns built by hikers and ranchers by their location and apparent antiquity. Prehistoric cairns are often located on rimrock and are often associated with lithic scatters. Prehistoric cairns also often show extensive lichen growth. Short low rock walls in association with lithic scatters are often interpreted as hunting blinds. Rock circles or rings may be house foundations, especially if lithic scatters, artifacts, and/or a midden occur close by. Small rock rings lacking any artifacts are often interpreted as spiritual prayer or vision quest locations.

Quarries

Prehistoric quarries for toolstone are common on Sheldon Refuge. Obsidian occurs naturally on much of the northern half of Sheldon Refuge. Obsidian is widely available at the surface as secondary deposits of pebbles and cobbles, which occur as lag left by the erosion of rhyolite facies. In most cases the prehistoric quarrying simply involved picking up the stone. Prehistoric acquisition and use of obsidian at the source locations is characterized by vast lithic scatters displaying evidence of testing and reducing obsidian cobbles into smaller more portable packages.

Traditional cultural properties

A traditional cultural property (TCP) is a cultural resource whose significance is derived from the role it plays in the traditional and continuing lifeways of a community. TCPs include locations associated with the traditional beliefs of a Native American group about its origins, cultural history, or the nature of the world. TCPs are often locations where a community has traditionally carried out religious, economic, artistic, or other cultural practices important in maintaining its historical identity. According to the Summit Lake Tribe, a TCP exists in the vicinity of 10-mile Spring on Sheldon Refuge.

5.6.4.2 Historic Sites

Among the 251 recorded cultural resources sites on Sheldon Refuge, 23 (16%) are Euro-American historic sites. Many of these occur near water and roads, particularly in and near Virgin Valley and Thousand Creek. There has been no formal effort to find historic-period sites beyond the largest and most obvious early ranches and CCC-era facilities on Sheldon Refuge. The known historic sites can be allocated into one or more themes.

- The Ranching Theme includes sites with one or more of the following features: residence, barn, corral (stone and willow), chicken house, small out-building, bunkhouse, root cellar, road, pasture, fencing, machine shed, and windmill. Features that are outside the ranch complex but relevant to the ranching theme include sheep camps, livestock trails, branding camps, and line camps.

- The Depression-Era (CCC) Theme includes sites with one or more of the following features: road, bridge, culvert, pond, refuge infrastructure, residence/office, overnight cabin, and spike camp.

- The Mining Theme includes sites with one or more of the following features: mine, adit, quarry, haul road, tailing, claim, camp, and quarry equipment (Speulda 2000).

- Miscellaneous historic-period sites small dispersed domestic dumps, dispersed campsites, landing strips, and crash sites.

The principal historic-period sites on record are listed in Table 5.1 and are shown on Figure 5.1. Many sites are considered extremely significant cultural resources, and five have been determined to be eligible or potentially eligible for inclusion in the National Register of Historic Places (Speulda 1998; USFWS 1985).

Table 5.1 Principal Historic Period Sites at Sheldon Refuge

Name	Construction Date	Historic Associations	NRHP Status*
Last Chance Ranch	1890-1910	Early ranching, architecture, early refuge management	Eligible
IXL Ranch	1890s	Early ranching	Not potentially eligible (USFWS 1985)
Gooch Camp Horsetrap (stone corral)	1890s	Early ranching, architecture	Potentially eligible
Kinney Camp/a.k.a. McKenny Ranch (house, barn, chicken house, willow corral, cellar)	1890s-1910s	Early ranching, architecture	Potentially eligible
Dufurrena Ranch (barn, chicken house)	1890s-1910s	Early ranching, architecture	Not potentially eligible (USFWS 1985)
Virgin Valley Ranch (stone buildings and site)	1890s	Early ranching, architecture	Eligible (Speulda 1998)
Alkali Ranch	1910s	Early ranching	Not evaluated
Thousand Creek Ranch (house, barn, chicken house, corral)	1890s-1910s	Early ranching, architecture	Eligible (NVSHPO 2001)
Little Sheldon refuge office and residence	1930s	WPA, CCC, architecture	Potentially eligible
Little Sheldon Overnight Cabin	1930s	WPA, CCC, architecture	Eligible (USFWS 2000)
Badger Cabin	1930s	CCC	Potentially eligible
Virgin Valley Campground (metal warehouse, camp features—excluding bathhouse)	1930s	CCC camp	Potentially eligible

* NRHP Status refers to status under the National Register of Historic Places.

National Register of Historic Places

Established under the NHPA of 1966, the National Register has identified and documented, in partnership with state, Federal, and tribal preservation programs, nearly 77,000 districts, sites, buildings, structures, and objects that are significant in American history, architecture, archaeology,

engineering, and culture. The documentation on each property consists of photographs, maps, and a National Register registration form, which provides a physical description of the place, information about its history and significance, and bibliography. Last Supper Cave is the only site within Sheldon Refuge currently listed on the National Register.

The NHPA also requires that any structure or historic place that is generally more than 50 years old be inventoried and evaluated to determine whether or not it is eligible to be included on the National Register of Historic Places. Sheldon Refuge contains a number of historic resources that are more than 50 years old (pre-1959 for the purposes of this document) and are awaiting evaluation or have already been evaluated and determined eligible, but not yet included on the National Register.

Last Chance, Virgin Valley, and Thousand Creek historic ranches located within Sheldon Refuge have officially been determined eligible for the National Register of Historic Places. Nine other structures within Sheldon Refuge associated with historic ranching or the CCC have not been formally evaluated.

5.6.5 Special Designation Areas

In 1974 the President proposed that Congress designate 341,500 acres of Sheldon National Wildlife Refuge as Wilderness under the 1964 Wilderness Act. Despite the fact this proposal has never been acted upon, it is Service policy that all proposed wilderness areas be managed consistent with policy and guidance for designated wilderness until further action is taken by Congress.

The majority of lands within the proposed wilderness areas appear essentially natural and undisturbed to the casual observer. Exceptions to this level of natural appearance consist of portions of the Big Spring Table, Catnip Mountain, and Alkali Peak proposed wilderness areas, which were developed with water troughs, catchment basins, and primitive vehicle routes for commercial grazing or disturbed by prospecting prior to mineral withdrawal. Other scattered developments to support past commercial livestock grazing and associated undeveloped vehicle trails are visible within the proposed wilderness areas, but very few permanent structures remain, which are used for management purposes. Feral horses and burros and fire suppression have caused more severe impacts to habitat condition and ecological function.

Aggressive fire suppression, prescribed burning, weed control, and grazing both from commercial livestock in the past and presently from feral horses and burros continue to trammel wilderness character. Conditions within most of the proposed wilderness areas have progressed to the point that further management manipulation and intrusion is often determined necessary to prevent further impacts to habitats or to restore natural conditions and ecological function. Other management activities within the proposed wilderness areas include inventory and monitoring, research studies, removal of abandoned fences, and construction of temporary fences to protect springs. These activities are temporary and do not typically result in any long-term trammeling or alteration of wilderness character.

With the exception of a few portions of the proposed wilderness areas near developed campsites and maintained roads opportunities for solitude and primitive and unconfined types of recreation are considered outstanding. Visitors are free to explore and travel throughout Sheldon Refuge and the proposed wilderness areas on foot or by horseback with few regulations or restrictions, and very little contact with refuge staff.

Descriptions and maps depicting the proposed wilderness areas are included in Appendix F.

5.6.6 Social and Economic Conditions

Sheldon Refuge is a large, remote national wildlife refuge in northwest Nevada that also shares a border with and includes a small portion within Oregon and is located less than 30 miles from California. Therefore, the affected social and economic setting for Sheldon Refuge has been identified to include the five counties that include and surround Sheldon Refuge. The five counties are Washoe and Humboldt counties in Nevada, Lake and Harney counties in Oregon, and Modoc County in California. This affected region encompasses a massive land area of 38,995 square miles. For perspective, this region is larger than Maine, Kentucky, Indiana, or South Carolina.

Conversely, the region is one of the most sparsely populated areas in the contiguous 48 states. Total population in 2009 was 459,322 people which equates to a population density of 11.8 people per square mile. However, excluding the 300,214 residents of Reno and Sparks, located in the southernmost portion of the affected region, the population density falls to 4 people per square mile—which is only slightly less than the population density of Wyoming (5.1 people per square mile). Despite the enormous size and sparse population of this region, refuge management and visitation affect the economies of all five counties both directly and indirectly.

U.S. Census data collected in 2000 indicate the industry of arts, entertainment, recreation, accommodation, and food services employed the highest percentage of people in the region. However, this figure is heavily skewed by the economies of Reno and Sparks in Washoe County, Nevada, where casino gambling, winter skiing, and other recreation and entertainment activities dominate the local economy. Excluding Washoe County, the leading employment industry is agriculture, forestry, fishing and hunting, and mining followed by educational, health and social services. Government employment was a significant portion of the regional economy in 2000, employing 14.5% of all workers over 16 years in age throughout the five-county region, and 24.8% of all workers in the four-county area (Washoe County excluded) (U.S. Census Bureau 2000). More recent data indicate that government employment now accounts for a substantially larger percentage of the workforce following the recent economic downturn (Industrial Economics 2010).

It is estimated the management and visitation to Sheldon Refuge contributes directly or indirectly to the employment of 119 people throughout the region, and the total regional economic contribution generated by activities on Sheldon Refuge is estimated at $8.3 million annually (in 2010 dollars) (Industrial Economics 2010). When considering the 575,000-acre size of Sheldon Refuge, the economic contribution would also be estimated at $14 per acre per year. Refuge budgetary expenditures make a significant contribution to the local economy, contributing approximately $5.0 million annually to gross state product (GSP) (value added[1]), or 60% of the quantified regional contribution to GSP. Wildlife observation and wildlife photography are the most common wildlife-dependent recreational activities taking place on Sheldon Refuge, resulting in an estimated 17,900 annual visits. As a result, expenditures associated with wildlife observation and photography are the largest contributor to GSP of the wildlife-dependent recreational activities assessed, contributing $2.5 million to GSP (30%). Annual expenditures associated with 1,691 annual sport hunting days

[1] Value added is considered the final value or revenue, less the value of goods or services purchased to produce the final product or service.

(associated with mule deer, pronghorn, and bighorn sheep hunting) have been found to comprise 5% of current contribution to GSP ($0.4 million), while expenditures associated with 1,122 annual sport-fishing days contribute another 1% ($0.1 million).[2] Revenue payments by Sheldon Refuge to local governments contribute the remaining 5% to GSP ($0.3 million). Expenditures associated with camping have not been expressly quantified but are expected to largely overlap with other wildlife observation and photography expenditures (Industrial Economics 2010).

In addition to quantified benefits associated with Sheldon Refuge management and visitation, Sheldon Refuge provides other nonuse and ecological benefits. In his seminal piece, Krutilla (1967) suggests that "when the existence of a grand scenic wonder or a unique and fragile ecosystem is involved, its preservation and continued availability are a significant part of the real income of many individuals." For example, Freeman (1993) explains that people may gain utility from the knowledge that a natural area is preserved despite the fact that they do not expect to visit that area. Similarly, people may be willing to pay to protect endangered species even though they do not expect to see one of them (Freeman 1993). These values may be motivated by desires to maintain intergenerational equity and the option of future resource use, as well as other factors (Industrial Economics 1998).

Various attempts have been made to quantify nonuse or existence values of natural resources and special areas such as national wildlife refuges. Economists have estimated that every U.S. household would be willing to pay $29 per year to preserve bighorn sheep and $15 per year to preserve Greater sage-grouse (Industrial Economics 2010). Sheldon Refuge is one of the only areas of public land in the United States set aside specifically to conserve species such as California bighorn sheep, Greater sage-grouse, pronghorn, and other priority sagebrush-steppe wildlife species. Even if the more than 100 million households in the United States were only willing to pay $0.10 per year to preserve wildlife within Sheldon Refuge, the value would exceed the estimated $8.3 regional economic contribution from management and use of the Sheldon Refuge for wildlife viewing, photography, hunting, fishing, and other consumptive uses. Other estimates have been derived for habitat types and even entire ecosystems and have ranged from $156 per acre per year to as much as $2,400 per acre per year, but these values are questionable given the uncertainty associated with the assumptions made and the quality of the underlying information and data (Industrial Economics 2010).

[2] Big Spring Reservoir does not currently support sport fishing and is not included in estimates of current contribution to GSP.

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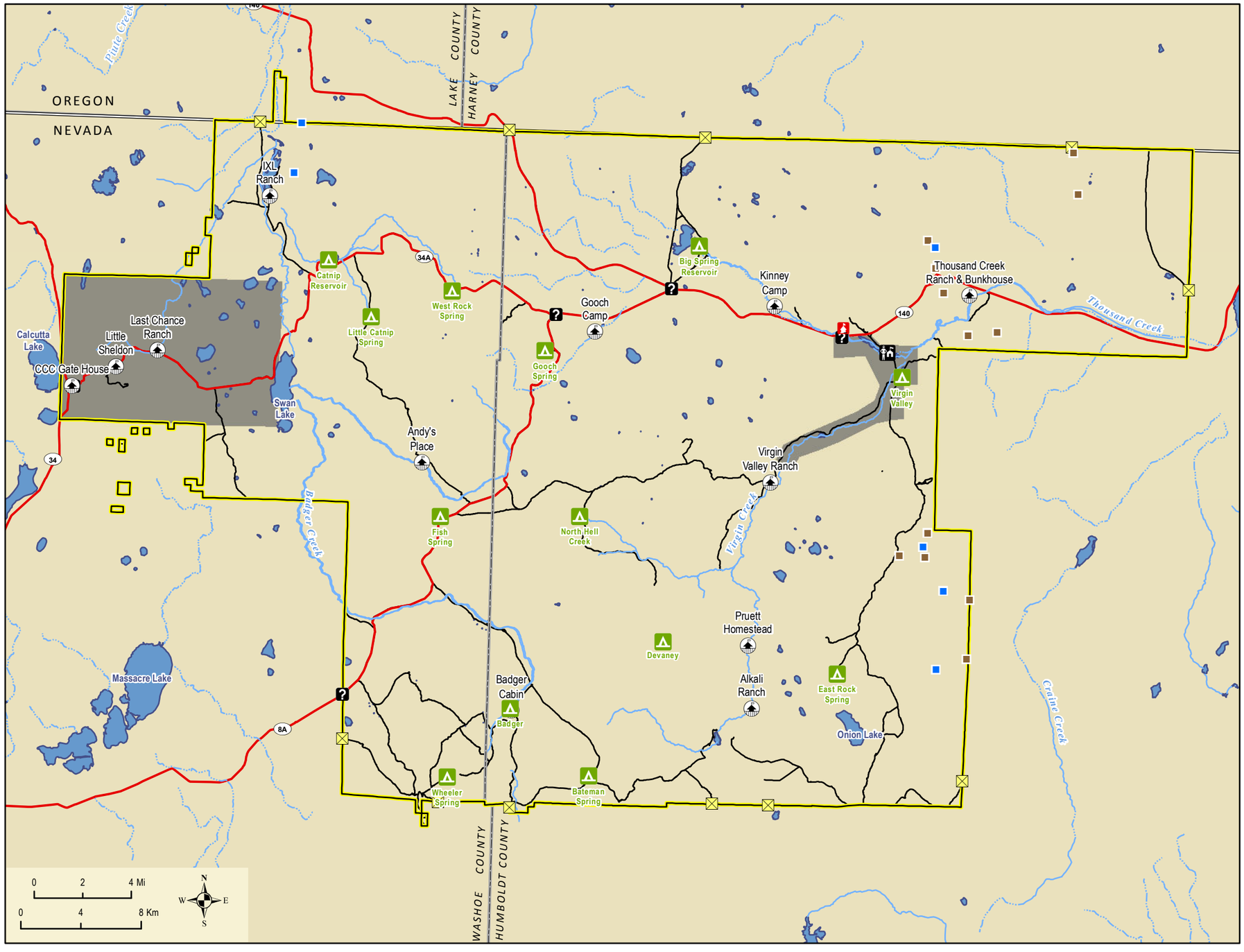
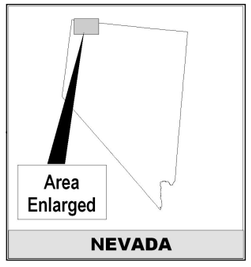


Figure 5.1
Public Use and Facilities

LEGEND

- Approved Refuge Boundary
- Refuge Headquarters
- Planned Visitor Contact Station
- Campgrounds
- Historic Structures
- Wildlife Guzzler (big game)
- Wildlife Guzzler (small game)
- Kiosk
- Sign
- Hunting Not Allowed
- Lakes
- County Boundary
- State Line
- Public Vehicle Routes (clipped to refuge)
- Highway
- Intermittent Stream
- Perennial Stream



Produced by USFWS Region 1
Refuge Information Branch
Portland, Oregon
Map Date: 2/4/2013
File: 10-068-1.mxd

The back sides of map pages are blank to facilitate map readability.

Appendix A. Sheldon National Wildlife Refuge Comprehensive Conservation Plan and Environmental Impact Statement Public Involvement

Public involvement for the Sheldon Refuge CCP/EIS involved a number of announcements, Refuge planning updates, and meetings, both formal and informal. In response to these efforts, Sheldon Refuge received thousands of letters, emails, and phone calls from interested members of the public, non-profit organizations, state government agencies, and other federal agencies. This appendix summarizes the process used to involve the public and other interested parties.

Formal scoping for the CCP/EIS occurred between May 12, 2008, and June 30, 2008. As part of the formal scoping process, Sheldon Refuge issued a notice in the Federal Register and a planning update to notify the affected public of the opportunity to participate in the preparation of the CCP and encourage them to comment on preliminary refuge vision and goals; help identify potential issues, management actions and concerns, significant problems or impacts; and pursue opportunities or alternatives to resolve them (602 FW 3, 3.4(2b)). In addition, public meetings were held in area communities, and several additional meetings were held with the State of Nevada and key stakeholder groups. Following this formal scoping period, Sheldon Refuge contracted with an independent third party to produce a written report and summary of all scoping comments received. The full scoping report is available at the Sheldon Refuge planning webpage or upon written request.

After public scoping the planning team reviewed and evaluated all potential issues, management concerns, and problems and the opportunities to resolve them that the planning team, other Service personnel, partners, and the public identified in order to determine significant issues. The Service defines an issue as: "Any unsettled matter that requires a management decision, e.g., an initiative, opportunity, resource management problem, threat to the resources of the unit, conflict in uses, public concern, or the presence of an undesirable resource condition (602 FW 1 1.6 K)." Significant issues typically are those that are within our jurisdiction, suggest different actions or alternatives, and will influence our decision (602 FW 3, 3.4(3b)).

After significant planning issues were identified, a second planning update for the Sheldon Refuge CCP was distributed to the public in April 2009. This planning update summarized the significant planning issues and scoping comments submitted. A preliminary set of draft management alternatives was developed based on scoping comments, expert opinion, and management policy. These preliminary draft alternatives, including the Service's preferred alternative, were presented to the public in a third planning update in June 2010, and comments from the public were solicited at that time. Following the release of the planning update, additional meetings were held with the State of Nevada and key stakeholder groups. Based upon comments received, Sheldon Refuge modified the preliminary draft alternatives to develop the alternatives presented in the Final CCP/EIS.

Outreach Efforts

Federal Register Notice of Intent to Prepare a CCP—published May 12, 2008

The Federal Register Notice included background information on Sheldon Refuge and preliminary issues with request for scoping comments.

Planning Update #1

The May 2008 Planning Update #1 was made available to USFWS staff and the general public throughout the scoping period, with 450 of 500 hardcopies distributed to Refuge office visitors and partners, scoping meeting attendees, and 66 individuals and 35 organizations on the mailing list. An electronic copy of the Planning Update was available for visitors to the USFWS website (http://www.fws.gov/pacific/planning/main/docs/NV/docssheldon.htm), and the website address was also included in a Dear Interested Party notification email to 2,722 interested parties and USFWS staff members nationwide. The planning update included background information on Sheldon Refuge in addition to the preliminary goals and issues to be considered in the CCP. Information about the CCP process, an invitation to attend four public open house meetings, and a solicitation for comments were also included.

Planning Update #2

The April 2009 Planning Update #2 was mailed to all interested parties and summarized the results of the formal scoping process as part of the NEPA planning process.

Planning Update #3

The June 2010 Planning Update #3 was mailed to all interested parties and outlined the Service's preliminary alternatives for the Sheldon Refuge CCP.

Media Outreach and Press Coverage

A news release, entitled "Sheldon National Wildlife Refuge Kicks Off Comprehensive Conservation Planning with Four Public Open House Meetings," was released on May 5, 2008. The release was sent to a list serve of 45 media contacts and it was also posted on the Service's Region 1 website (accessed at: http://www.fws.gov/pacific/news/2008/SheldonCCPNR.pdf). The news release and associated planning activities resulted in various subsequent media articles.

Scoping Meetings

The scoping meetings began with a PowerPoint presentation giving an overview of Sheldon Refuge and the importance and logistics of the CCP process. Following the presentation, there were four informational tables staffed by refuge employees available to receive public questions.

The informational tables each featured different topics: wildlife and habitat management, public use and facilities, feral horses and burros, and the planning process. Presentations were given by the Project Leader with support from the Deputy Project Leader and Natural Resource Planner. Scoping meeting locations, dates, and times were as follows:

- Lakeview, Oregon, May 14, 2008, 6:00-9:00 pm
- Denio, Nevada, May 21, 2008, 6:00-9:00 pm
- Winnemuccca, Nevada, May 22, 2008, 6:00-9:00 pm
- Alturas, California, June 4, 2008, 6:00-9:00 pm
- Reno, Nevada, June 11, 2008, 6:00-9:00 pm

Meeting Invitations Mailed to Tribal Officials

A letter soliciting input from representatives of five tribes was mailed on September 4, 2008. This letter was mailed on behalf of Paul Steblein to the Burns Paiute Tribe, Fort Bidwell Paiute Tribe, Cedarville Rancheria Paiute Tribe, Fort McDermitt Paiute and Shoshone Tribe, and Summit Lake Paiute Tribe to invite their participation throughout the process.

An email soliciting input from the Summit Lake Paiute Tribe to conduct formal consultation was sent August 6, 2010.

Meetings with Congressional Representatives and Senators or their Aides

Nevada State Legislature, Committee on Public Lands, Lovelock, Nevada, August 22, 2008

- USFWS Participants: Paul Steblein
- Other Participants: Approximately 60 people including citizens and staff from state agencies, federal agencies, and non-governmental organizations

Nevada Congressional Representatives, August 2010

- USFWS Participants: Robin West, Paul Steblein
- Other Participants: Congressman Heller's staff representative, Senator Reid's staff representative

Meetings with State Agency Representatives

Nevada Department of Wildlife (NDOW), Reno, Nevada, March 19, 2008

- USFWS Participants: Paul Steblein, Regional Refuge Chiefs, Field Supervisors, Planning Chief, and Project Leaders for Sheldon-Hart Mountain Refuge Complex and Desert Refuge Complex
- Other Participants: NDOW Director, Deputy Director, and Division Chiefs

NDOW, Reno, Nevada, August 26, 2010

- USFWS Participants: Paul Steblein, Regional Refuge Chiefs, Field Supervisors, Planning Chief, and Project Leaders for Regions 1 and 8, Sheldon-Hart Mountain Refuge Complex, Desert Refuge Complex, Stillwater Refuge, and Ruby Lake Refuge
- Other Participants: NDOW Director, Deputy Director, and Division Chiefs

Meetings with County Representatives

Modoc/Washoe Experimental Stewardship Program, Cedarville, Nevada, May 29, 2008

- USFWS Participants: Paul Steblein
- Other Participants: Approximately 30 people including public land managers and supporting staff, Natural Resource Conservation Service staff, local government officials, ranchers, and small business owners

Humboldt County Supervisor and Commissioners, Winnemucca, Nevada, July 21, 2008

- USFWS Participants: Paul Steblein
- Other Participants: Humboldt County supervisors and commissioners and approximately 20 citizens

Meetings with Federal Agency Representatives

Bureau of Land Management (BLM) District Managers, Lakeview, Oregon, November 7, 2007

- USFWS Participants: Paul Steblein, Sheldon-Hart Mountain staff
- Other Participants: BLM District Managers for Lake County District, Burns District, Winnemucca District, Surprise Valley Resource Area, Oregon State Horse Specialist, U.S. Geological Survey Project Leader for Horse and Burro Research

Meetings with Non-government Organizations

Nevada Bighorn Unlimited and Nevada Wildlife Coalition, Board of Directors, Reno, Nevada, June 10, 2008

- USFWS Participants: Paul Steblein
- Other Participants: Approximately 35 members of both Boards of Directors

Sierra Club, Tioyobe Chapter, Reno, Nevada, June 11, 2008

- USFWS Participants: Paul Steblein
- Other Participants: Three members of Board of Directors

Friends of Nevada Wilderness, Reno, Nevada, June 12, 2008

- USFWS Participants: Paul Steblein
- Other Participants: President of organization

Friends of Sheldon, Winnemucca, Nevada, August 21, 2008

- USFWS Participants: Paul Steblein
- Other Participants: Approximately 20 members, including wildlife sportsmen group members

Friends of Nevada Wilderness, Sierra Club, Nevada Bighorn Unlimited, Nevada Wildlife Coalition, and Safari Club International, Reno, Nevada, August 26, 2010

- USFWS Participants: Paul Steblein and Aaron Collins
- Other Participants: Approximately 60 members from the attending organizations.

Final Comprehensive Conservation Plan and Environmental Impact Statement Public Involvement

Public involvement for the Final CCP/EIS included publication of a Notice of Availability in the Federal Register, a media press release, a Refuge planning update, and meetings with state agencies and local organizations interested in the Draft CCP/EIS.

The Service released the Draft CCP/EIS on September 9, 2011, for formal public review and comment. This comment period closed November 8, 2011. During the formal comment period, the Service received 401 comment responses from 1,709 agencies, organizations, and individuals[1]. Five comments were submitted after the closing date of the comment period.

Key issues raised through comment were those identified in the CCP. The majority of comments expressed support or opposition for a particular alternative, or for particular actions in one or more alternatives.

A summary of the comments received and the Service's response to comments are included in Appendix N.

Federal Register Notice of Availability for the Draft CCP/EIS

The Federal Register notice, published September 9, 2011, included background information on Sheldon Refuge, the planning process, and a summary of alternatives included in the Draft CCP/EIS. Information was provided for public review and comment on the draft document.

Planning Update #4

We mailed a fourth planning update to more than 4,500 interested individuals, organizations, and agencies. This planning update included a description and summary table for the alternatives in the Draft CCP/EIS—including the Service's preferred alternative. The planning update provided information for obtaining a complete copy of the Draft CCP/EIS and for submitting comments.

Direct Mailings

We mailed complete electronic and paper copies of the Draft CCP/EIS to state and federal agencies, the Summit Lake Paiute Tribal Council, congressional representatives in Nevada and Oregon, and local public libraries. Additional copies were mailed to individuals and organizations upon request.

Media Outreach and Press Coverage

We mailed local media a news release announcing availability of the Draft CCP/EIS for public comment and a detailed question-and-answer document related to our proposed actions to address significant issues included in the plan. The press release resulted in at least one article in a local newspaper.

[1] Identical copies of responses were submitted by 1,308 individuals.

Meetings with State Agency Representatives

NDOW

- USFWS Participants: Region 1 Chief of Refuges, Refuge Supervisor, and Chief of Planning and Visitor Services; Sheldon-Hart Mountain National Wildlife Refuge Complex Project Leader, Deputy Project Leader, and Park Ranger/Recreation Planner; Sheldon Refuge Manager
- NDOW Participants: Director, Supervisory Habitat Biologist

Meetings with County Representatives

Humboldt County Commissioners Meeting, Winnemucca Nevada—October 17, 2011

- USFWS Participants: Sheldon-Hart Mountain Refuge Complex Project Leader and Park Ranger/Recreation Planner

Meetings with Non-government Organizations

Lions Club Regular Meeting, Winnemucca Nevada—October, 2011

- USFWS Participants: Sheldon-Hart Mountain Refuge Complex Park Ranger/Recreation Planner

Appendix B. Species List

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Common Name	Scientific Name	Native, Introduced, or Hybrid	Sagebrush-Steppe Habitats[1]	Montane Sagebrush Steppe[2]	Emergent Marshes and Wet Meadows	Springs and Springbrooks	Ephemeral Wetlands[3]	Reservoirs and Other Artifical Riparian Habitats	Deciduous Woodlands and Shrublands (Aspen)	Mountain Mahogany and Western Juniper Woodlands	Cliffs, Canyons, and Barren Lands	Federal Status	Nevada Wildlife Action Plan Status
		A= All life history requirements; B= Breeding; C=Cover; F=Foraging; M=Migrant; N=Nesting/Rearing/Fauning/Lambing; R= Roosting; S=Seasonal; X= Benefiting Species; SCP=Species of Conservation Priority											
Amphibians													
Bullfrog	*Rana catesbeiana*	Int			A	A							SCP
Columbia Spotted frog	*Rana luteiventris*	Nat			X	A		A				Candidate	SCP
Great Basin spadefoot toad	*Scaphiopus intermontanus*	Nat	X	X									SCP
Pacific treefrog	*Hyla regilla*	Nat											SCP
Birds													
American avocet	*Recurvirostra americana*	Nat			N	N	N, M, B, F	N					SCP
American bittern	*Botaurus lentiginosus*	Nat			N	N	X	N					SCP
American coot	*Fulica americana*	Nat											SCP
American goldfinch	*Carduelis tristis*	Nat							X				SCP
American kestrel	*Falco sparverius*	Nat		F	F	F	F	F					SCP
American robin	*Turdus migratorius*	Nat											SCP
American wigeon	*Anas americana*	Nat											SCP
Ash-throated flycatcher	*Myiarchus cinerascens*	Nat							B	X			SCP
Bald eagle	*Haliaeetus leucocephalus*	Nat	F		F	F	F	F	X			Listed Threatened	SCP
Bank swallow	*Riparia riparia*	Nat									X		SCP
Barn swallow	*Hirundo rustica*	Nat											SCP
Belted kingfisher	*Megaceryle alcyon*	Nat											SCP
Black rosy finch	*Leucosticte atrata*	Nat									X		SCP
Black swift	*Cypseloides niger*	Nat											SCP

Common Name	Scientific Name	Native, Introduced, or Hybrid	Sagebrush-Steppe Habitats[1]	Montane Sagebrush Steppe[2]	Emergent Marshes and Wet Meadows	Springs and Springbrooks	Ephemeral Wetlands[3]	Reservoirs and Other Artifical Riparian Habitats	Deciduous Woodlands and Shrublands (Aspen)	Mountain Mahogany and Western Juniper Woodlands	Cliffs, Canyons, and Barren Lands	Federal Status	Nevada Wildlife Action Plan Status
Black tern	*Chlidonias niger*	Nat			S	S	S	S					SCP
Black-billed magpie	*Pica pica*	Nat											SCP
Black-capped chickadee	*Parus atricapillus*	Nat											SCP
Black-crowned night heron	*Nycticorax nycticorax*	Nat			SM	SM	SM	SM					SCP
Black-headed grosbeak	*Pheucticus melanocephalus*	Nat							X	X			SCP
Black-necked stilt	*Himantopus mexicanus*	Nat			N	N	N	N					SCP
Black-throated gray warbler	*Dendroica nigrescens*	Nat								B			SCP
Black-throated sparrow	*Amphispiza bilineata*	Nat											SCP
Blue-gray gnatcatcher	*Polioptile caerulea*	Nat							B	X			SCP
Blue-winged teal	*Anas discors*	Nat			N	N	N	N					SCP
Bobolink	*Dolichonyx oryzivorus*	Nat			X	X	X	X					SCP
Brewer's blackbird	*Euphagus cyanocephalus*	Nat			X	X	X	X					SCP
Brewer's sparrow	*Spezella breweri*	Nat	X	X						X			SCP
Broad-tailed hummingbird	*Selasphorus platycercus*	Nat			X				B				SCP
Brown-headed cowbird	*Molothrus ater*	Nat											SCP
Bufflehead	*Bucephala albeola*	Nat											SCP
California gull	*Larus californicus*	Nat											SCP
California quail	*Lophortyx californicus*	Int											SCP
Calliope hummingbird	*Stellula calliope*	Nat			X	X	X	X	B				SCP
Canada goose	*Branta candensis*	Nat			N	N	N	N					SCP
Canvasback	*Aythya valisineria*	Nat			N	N	N	N					SCP
Canyon wren	*Catherpes mexicaus*	Nat									B		SCP

Common Name	Scientific Name	Native, Introduced, or Hybrid	Sagebrush-Steppe Habitats[1]	Montane Sagebrush Steppe[2]	Emergent Marshes and Wet Meadows	Springs and Springbrooks	Ephemeral Wetlands[3]	Reservoirs and Other Artifical Riparian Habitats	Deciduous Woodlands and Shrublands (Aspen)	Mountain Mahogany and Western Juniper Woodlands	Cliffs, Canyons, and Barren Lands	Federal Status	Nevada Wildlife Action Plan Status
Caspian tern	*Hydoprogne caspia*	Nat											SCP
Cassin's finch	*Carpodacus cassinii*	Nat							B	X			SCP
Cedar waxwing	*Bombycilla cedrorum*	Nat							X				SCP
Chipping sparrow	*Spizella passerina*	Nat								X			SCP
Chukar	*Alectoris graeca*	Nat											SCP
Cinnamon teal	*Anas cyanoptera*	Nat	N	N	N	N		X					SCP
Clark's grebe	*Aechmophorus clarkii*	Nat			S	S	S	S					SCP
Cliff swallow	*Petrocelidon pyrrhonota*	Nat									B		SCP
Common bushtit	*Psaltriparus minimus*	Nat											SCP
Common crow	*Corvus brachyrhynchos*	Nat											SCP
Common egret	*Casmerodius albus*	Nat											SCP
Common goldeneye	*Bucephala clangula*	Nat											SCP
Common loon	*Gavia immer*	Nat						A					SCP
Common merganser	*Mergus merganser*	Nat											SCP
Common nighthawk	*Chordeiles minor*	Nat											SCP
Common poorwill	*Phalaenoptilis nuttallii*	Nat											SCP
Common raven	*Corvus corax*	Nat									B		SCP
Common snipe	*Capella galliango*	Nat			N	N	N	N					SCP
Common yellowthroat	*Geothlypis trichas*	Nat											SCP
Cooper's hawk	*Accipiter cooperii*	Nat							X	N, M			SCP
Curve-billed thrasher	*Toxostoma cirvirostre*	Nat											SCP
Dark-eyed junco	*Junco hyemalis*	Nat											SCP
Dipper	*Cinclus mexicanus*	Nat											SCP
Double-crested cormorant	*Phalacrocorax auritus*	Nat			SM	SM	SM	SM					SCP
Downy woodpecker	*Dendrocopos pubescens*	Nat							X				SCP

Common Name	Scientific Name	Native, Introduced, or Hybrid	Sagebrush-Steppe Habitats[1]	Montane Sagebrush Steppe[2]	Emergent Marshes and Wet Meadows	Springs and Springbrooks	Ephemeral Wetlands[3]	Reservoirs and Other Artifical Riparian Habitats	Deciduous Woodlands and Shrublands (Aspen)	Mountain Mahogany and Western Juniper Woodlands	Cliffs, Canyons, and Barren Lands	Federal Status	Nevada Wildlife Action Plan Status
Dusky flycatcher	*Empidonax oberholseri*	Nat							B	B			SCP
Eared grebe	*Podiceps caspicus*	Nat			S	S	S	S					SCP
Eastern kingbird	*Tyrannus tyrannus*	Nat											SCP
European starling	*Sturnus vulgaris*	Nat											SCP
Ferruginous hawk	*Buteo regalis*	Nat	F	F	F	F	F	F		N	X	Candidate	SCP
Forster's tern	*Sterna forsteri*	Nat			S	S	S	S					SCP
Fox sparrow	*Passerella iliaca*	Nat			X	X	X	X		B			SCP
Gadwall	*Anas strepera*	Nat			N	N	N	N					SCP
Golden eagle	*Aquila chrysaetos*	Nat		F	F	F	F	F		N	B		SCP
Golden-crowned kinglet	*Regulus satrapa*	Nat							X	X			SCP
Gray flycatcher	*Empidonax wrightii*	Nat	S							N, B			SCP
Great blue heron	*Ardea herodias*	Nat											SCP
Great horned owl	*Bubo virginianus*	Nat							X	N			SCP
Greater sage-grouse	*Centrocerus urophasianus*	Nat	N	N, B	X	N	N	N				Candidate	SCP
Greater sandhill crane	*Grus canadensis*	Nat			N,SM	SM	N, S, M, B, F	X					SCP
Greater yellowlegs	*Tringa melanoleucus*	Nat			S	S	S	S					SCP
Green-tailed towhee	*Chlorura chlorura*	Nat	X	X									SCP
Green-winged teal	*Anas carolinensis*	Nat	N	N	N	N							SCP
Hairy woodpecker	*Dendrocopos villosus*	Nat							X				SCP
Hammond's flycatcher	*Empidonax hammondii*	Nat								X			SCP
Hermit thrush	*Cathearus guttata*	Nat											SCP
Hooded merganser	*Lophodytes cucullatus*	Nat											SCP
Horned grebe	*Podiceps auritus*	Nat			S	S	S	S					SCP
Horned lark	*Eremophila alpestris*	Nat	S	B									SCP
House finch	*Carpodacus mexicanus*	Nat											SCP

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House sparrow	*Passer domesticus*	Nat											SCP
House wren	*Troglodytes aedon*	Nat											SCP
Hungarian (gray) partridge	*Perdix perdix*	Nat											SCP
Juniper titmouse	*Baeolophus ridgwayi*	Nat								N, B			SCP
Killdeer	*Charadrius vociferus*	Nat			N	N	N	N					SCP
Lark sparrow	*Chondestes grammacus*	Nat	S										SCP
Lazuli bunting	*Passerina amoena*	Nat			B, N, M				B				SCP
Least sandpiper	*Calidris minutilla*	Nat			X								SCP
Lesser scaup	*Aythya affinis*	Nat											SCP
Lesser yellowlegs	*Trina flavipes*	Nat			S	S	S	S					SCP
Lewis' woodpecker	*Asyndesmus lewis*	Nat							B				SCP
Lincoln's sparrow	*Melospinza lincolnii*	Nat											SCP
Loggerhead shrike	*Lanius ludovicianus*	Nat	S	X						X			SCP
Long-billed curlew	*Numenius americanus*	Nat			B, F	X	X	X					SCP
Long-billed dowitcher	*Limnodromus scolopaceus*	Nat			X								SCP
Long-billed marsh wren	*Telmatodyts palustris*	Nat											SCP
Long-eared owl	*Asio otus*	Nat	F	F	F	F	F	F	X				SCP
MacGillivray's warbler	*Oporornis tolmiei*	Nat							B	X			SCP
Mallard	*Anas platyrynchos*	Nat			N	N	N	N					SCP
Merlin	*Falco columbarius*	Nat											SCP
Mountain bluebird	*Sailia Currucoides*	Nat		B	X					X	X		SCP
Mountain chickadee	*Parus gambeli*	Nat								B			SCP
Mountain quail	*Oreortyx pictus*	Nat				S							SCP
Mourning dove	*Zenaida macroura*	Nat											SCP

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Nashville warbler	*Vermivora ruficapilla*	Nat								X			SCP
Northern flicker	*Colaptes auratus*	Nat							B				SCP
Northern goshawk	*Accipiter gentilis*	Nat							N, R, F	N		Candidate	SCP
Northern harrier	*Circus cyaneus*	Nat		F	F	F	F	F					SCP
Northern oriole	*Icterus galbula*	Nat							B				SCP
Northern phalarope	*Lobipes lobatus*	Nat											SCP
Northern phalarope	*Lobipes lobatus*	Nat					X						SCP
Northern pintail	*Anas acuta*	Nat			N	N	N	N					SCP
Northern saw-whet owl	*Aegolius acadicus*	Nat							X	N			SCP
Northern shoveler	*Anas clypeata*	Nat			N	N	N	N					SCP
Northern shrike	*Lanius excubitor*	Nat		F					X	X			SCP
Olive-sided flycatcher	*Nuttallornis borealis*	Nat							X	X			SCP
Orange-crowned warbler	*Vermivora celata*	Nat							B	X			SCP
Osprey	*Pandion haliaetus*	Nat							X				SCP
Peregrine falcon	*Falco peregrinus*	Nat									X	Listed Endangered	SCP
Pied-billed grebe	*Podilymbus podiceps*	Nat			S	S	S	S					SCP
Pine siskin	*Spinus spinus*	Nat								X			SCP
Plain titmouse	*Parus inornatus*	Nat											SCP
Prairie falcon	*Falco mexicanus*	Nat	F	X							N, B		SCP
Purple finch	*Carpodacus purpureus*	Nat											SCP
Red-breasted nuthatch	*Sitta canadensis*	Nat								X			SCP
Red-breasted sapsucker	*Sphyrapicus ruber*	Nat							X				SCP

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Redhead	*Aythya americana*	Nat			N	N	N	N					SCP
Red-naped sapsucker	*Sphyrapicus nuchalis*	Nat							R, N, F	X			SCP
Redtailed hawk	*Buteo jamaicensis*	Nat	F	F					X	N			SCP
Red-winged blackbird	*Agelaius phoeniceus*	Nat			X	X	X	X					SCP
Ring-billed gull	*Larus delawarensis*	Nat											SCP
Ring-necked duck	*Aythya collalris*	Nat											SCP
Ring-necked pheasant	*Phasianus colchicus*	Nat											SCP
Rock wren	*Salpinctes obsoletus*	Nat									B		SCP
Rough-legged hawk	*Buteo lagopus*	Nat		F	F	F	F	F		N			SCP
Rough-winged swallow	*Stelgidopteryx ruficollis*	Nat									B		SCP
Ruby-crowned kinglet	*Regulus calendula*	Nat								B			SCP
Ruddy duck	*Oxyura jamaicensis*	Nat			N	N	N	N					SCP
Rufous hummingbird	*Selasphorus rufus*	Nat			X		X	X	B				SCP
Rufous-sided towhee	*Pipilo erythophthalmus*	Nat											SCP
Sage sparrow	*Amphispiza belli*	Nat	N	X									SCP
Sage thrasher	*Oreoscoptes monatus*	Nat	N	X									SCP
Savannah sparrow	*Paserculus sandwichensis*	Nat		B	X	X	X	X					SCP
Say's phoebe	*Sayornis saya*	Nat	S								B		SCP
Screech owl	*Otus asio*	Nat											SCP
Sharp-shinned hawk	*Accipiter striatus*	Nat							X	N			SCP
Short-eared owl	*Asio flammeus*	Nat		F	F	F	F	F					SCP
Snow goose	*Chen caerulescens*	Nat											SCP
Snowy egret	*Egretta thula*	Nat			X			X					SCP

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Solitary sandpiper	*Tringa solitaria*	Nat			S	S	S	S					SCP
Song sparrow	*Melospinza melodia*	Nat											SCP
Sora rail	*Porzana carolina*	Nat			N	N	N	N					SCP
Spotted sandpiper	*Actitis macularia*	Nat			N	N	N	N					SCP
Swainson's hawk	*Buteo swainsoni*	Nat		X	F	F	F	F	X	X			SCP
Swainson's thrush	*Catharus ustulatus*	Nat							B				SCP
Townsend's solitare	*Myaestes townsendi*	Nat								B			SCP
Townsend's warbler	*Dendroica townsendi*	Nat								X			SCP
Tree swallow	*Iridoprocne bicolor*	Nat							B				SCP
Turkey vulture	*Cathartes aura*	Nat											SCP
Varied thrush	*Ixoreus naevius*	Nat							X				SCP
Vesper sparrow	*Pooecetes gramineus*	Nat	S	B	X	X	X	X					SCP
Violet-green swallow	*Tachycineta thalassina*	Nat									B		SCP
Virginia rail	*Rallus limicola*	Nat			N	N	N	N					SCP
Warbling vireo	*Vireo gilvus*	Nat							B				SCP
Water pipit	*Anthus spinoletta*	Nat											SCP
Western bluebird	*Sialia mexicana*	Nat			X	X	X	X	X	N			SCP
Western burrowing owl	*Speotyto cunicalaria*	Nat	X	N, B									SCP
Western grebe	*Aechmophorus occidentalis*	Nat			X			A					SCP
Western kingbird	*Tyrannus verticalis*	Nat	S										SCP
Western least bittern	*Ixobrychus exilis hesperis*	Nat			X			X					SCP
Western meadowlark	*Sturnella neglecta*	Nat	S	B									SCP
Western sandpiper	*Calidris mauri*	Nat			S	S	S	S					SCP
Western screech owl	*Otus asio*	Nat			F	F	F	F	X				SCP

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Western scrub jay	*Aphelocoma californica*	Nat								B			SCP
Western snowy plover	*Charadrius alexandrinus*	Nat			S	S	S	S					SCP
Western tanager	*Piranga ludoviciana*	Nat								X			SCP
Western wood pewee	*Contopus sordidulus*	Nat											SCP
Whistling swan	*Olor columbianus*	Nat											SCP
White pelican	*Pelecanus erythrorhynchos*	Nat											SCP
White-crowned sparrow	*Zonotrichia leucophrys*	Nat											SCP
White-faced ibis	*Plegadis chihi*	Nat										Vulnerable	SCP
White-fronted goose	*Anser albifrons*	Nat											SCP
White-throated swift	*Aeronautes saxatalis*	Nat	S								B		SCP
Willet	*Catoptrophorus semipalmatus*	Nat			N	N	N	N					SCP
Willow flycatcher	*Empidonax traillii*	Nat							X				SCP
Wilson's phalarope	*Steganopus tricolor*	Nat			N	N	N	N					SCP
Wilson's warbler	*Wilsonia pusilla*	Nat							N, B				SCP
Wood duck	*Aix sponsa*	Nat											SCP
Yellow warbler	*Dendroica petechia*	Nat							B				SCP
Yellow-bellied sapsucker	*Sphyrapicus varius*	Nat											SCP
Yellow-breasted chat	*Icteria virens*	Nat							N, B				SCP
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	Nat						A					SCP
Yellow-rumped warbler	*Dendrocia coronata*	Nat								B			SCP

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Fishes													
Alvord chub	*Gila alvordensis*	Nat				A							SCP
Alvord cutthroat trout	*Oncorhynchus clarki alvordensis*	Nat				A		A				Extinct / Endangered	SCP
Brown trout	*Salmo trutta*	Int											SCP
Guppy	*Poecilia reticulata*	Int											SCP
Lahontan cutthroat trout	*Oncorhynchus clarki henshawi*	Nat				X		A				Reintroduced /Threatened	SCP
Largemouth bass	*Micropterus salmoides*	Int											SCP
Mosquitofish	*Gambusia affinis*	Int											SCP
Pumpkinseed sunfish	*Lepomis gibbosus*	Int											SCP
Rainbow / Alvord cutthroat trout hybrid	*Salom gairdneri* x *Oncorhynchus clarki*	Hyb						X					SCP
Rainbow trout	*Salmo gairdneri*	Int				X							SCP
Sheldon tui chub	*Gila bicolor eurysoma*	Nat				A		A					SCP
White crappie	*Poxomis annularis*	Int											SCP
Yellow perch	*Perca flavescens*	Int											SCP
Invertebrates (aquatic)													
	Aeschna interrupta nevadensis	Nat				A	X						SCP
	Agabus spp.	Nat				A	X						SCP
	Agapetus sp.	Nat				A	X						SCP
	Ametor scabrosus	Nat				A	X						SCP
	Amphiagrion abbreviatum	Nat				A	X						SCP

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	Apsectrotanypus sp.	Nat				A	X						SCP
	Argia nr. *vivida*	Nat				A	X						SCP
	Argia sp. (nr. *Hyponeura lugens*)	Nat				A	X						SCP
	Arrenurus sp.	Nat				A	X						SCP
	Artemia nr. *franciscana*	Nat				A	X						SCP
	Baetis sp.	Nat				A	X						SCP
	Belonia saturata	Nat				A	X						SCP
	Belostoma bakeri	Nat				A	X						SCP
	Berosus nr. *styliferus*	Nat				A	X						SCP
	Bezzia/Palpomyia sp.	Nat				A	X						SCP
	Branchinecta coloradensis	Nat				A	X						SCP
	Branchinecta gigas	Nat				A	X						SCP
	Brillia sp.	Nat				A	X						SCP
	Buenoa sp.	Nat				A	X						SCP
	Caenestheriella setosa	Nat				A	X						SCP
	Caenis sp.	Nat				A	X						SCP
	Callibaetis nr. *californicus*	Nat				A	X						SCP
	Cenocorixa wileyae	Nat				A	X						SCP
	Ceratopogon sp.	Nat				A	X						SCP
	Ceriodaphnia reticulata	Nat				A	X						SCP
	Chaetocladius nr. *vitellinus group*	Nat				A	X						SCP
	Chaoborus sp.	Nat				A	X						SCP
	Chironomus sp.	Nat				A	X						SCP
	Chrysops sp.	Nat				A	X						SCP
	Cinygmula spp.	Nat				A	X						SCP

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	Cleptelmis addenda	Nat				A	X						SCP
	Clinocera (Hydrodromia) sp.	Nat				A	X						SCP
	Coenagrion/Enallagma sp.	Nat				A	X						SCP
	Colymbetes nr. *rugipennis*	Nat				A	X						SCP
	Coptotomus nr. *longulus*	Nat				A	X						SCP
	Coptotomus sp.	Nat				A	X						SCP
	Corynoneura lobata	Nat				A	X						SCP
	Corynoneura nr. *lacustris*	Nat				A	X						SCP
	Corynoneura scutellata	Nat				A	X						SCP
	Cricotopus nr. *bicintus group*	Nat				A	X						SCP
	Cricotopus sp.	Nat				A	X						SCP
	Cricotopus sylvestris group	Nat				A	X						SCP
	Cricotopus tremulus group	Nat				A	X						SCP
	Cricotopus trifascia group	Nat				A	X						SCP
	Cryptotendipes sp.	Nat				A	X						SCP
	Cypridopsis nr. *vidua*	Nat				A	X						SCP
	Daphnia middendorffiana	Nat				A	X						SCP
	Daphnia nr. *schodleri*	Nat				A	X						SCP
	Daphnia pulex	Nat				A	X						SCP
	Derotanypus sp.	Nat				A	X						SCP
	Diamesa sp.	Nat				A	X						SCP
	Diaphanosoma birgei	Nat				A	X						SCP
	Dicranota sp.	Nat				A	X						SCP
	Dixa sp.	Nat				A	X						SCP
	Dixella sp.	Nat				A	X						SCP
	Dugesia nr. *dorotocephala*	Nat				A	X						SCP

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	Dytiscus nr. *marginicollis*	Nat				A	X						SCP
	Dytiscus sp.	Nat				A	X						SCP
	Enallagma boreale	Nat				A	X						SCP
	Enallagma civile	Nat				A	X						SCP
	Enallagma clausum	Nat				A	X						SCP
	Enochrus nr. *cristatus*	Nat				A	X						SCP
	Enochrus nr. *hamiltoni*	Nat				A	X						SCP
	Epeorus (*Iron*) *albertae*	Nat				A	X						SCP
	Ephemerella infrequens	Nat				A	X						SCP
	Ephydra (*Hydropyrus*) *hians*	Nat				A	X						SCP
	Erpetogomphus (nr. *designatus*)	Nat				A	X						SCP
	Erpobdella punctata	Nat				A	X						SCP
	Eubrianax edwardsi (?)	Nat				A	X						SCP
	Eukiefferiella claripennis group	Nat				A	X						SCP
	Eukiefferiella gracei group	Nat				A	X						SCP
	Eukiefferiella nr. *brehmi*	Nat				A	X						SCP
	Eukiefferiella nr. *pseudomontana*	Nat				A	X						SCP
	Eukiefferiella sp. *undetermined*	Nat				A	X						SCP
	Gammarus lacustris	Nat				A	X						SCP
	Gerris incognitus	Nat				A	X						SCP
	Gerris incurvatus	Nat				A	X						SCP
	Gerris nr. *gillettei*	Nat				A	X						SCP
	Gerris nyctalis	Nat				A	X						SCP
	Gerris remigis	Nat				A	X						SCP
	Glossiphonia complanata	Nat				A	X						SCP

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	Glyptotendipes sp. *Group A (Wiederholm)*	Nat				A	X						SCP
	Gordius sp.	Nat				A	X						SCP
	Graphoderus sp.	Nat				A	X						SCP
	Gumaga sp.	Nat				A	X						SCP
	Gyraulus sp.	Nat				A	X						SCP
	Gyrinus consobrinus	Nat				A	X						SCP
	Haemopis marmorata	Nat				A	X						SCP
	Haliplus robertsi	Nat				A	X						SCP
	Haliplus sp. *undetermined*	Nat				A	X						SCP
	Helisoma sp.	Nat				A	X						SCP
	Helobdella stagnalis	Nat				A	X						SCP
	Helophorus nr. *leconteі*	Nat				A	X						SCP
	Hesperocorixa laevigata	Nat				A	X						SCP
	Hesperodiaptomus eiseni	Nat				A	X						SCP
	Hesperodiaptomus franciscanus	Nat				A	X						SCP
	Hesperodiaptomus nevadensis	Nat				A	X						SCP
	Hesperophylax sp.	Nat				A	X						SCP
	Heterlimnius corpulentus	Nat				A	X						SCP
	Hyallela azteca	Nat				A	X						SCP
	Hydrachna sp.	Nat				A	X						SCP
	Hydrobius fuscipes	Nat				A	X						SCP
	Hydroporus sp.	Nat				A	X						SCP
	Hydropsyche oslari	Nat				A	X						SCP
	Hydroptila sp.	Nat				A	X						SCP
	Hygrotus masculinus	Nat				A	X						SCP

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	Hygrotus nr. *collatus*	Nat				A	X						SCP
	Hygrotus nr. *tumidiventris*	Nat				A	X						SCP
	Hygrotus sp. *undetermined*	Nat				A	X						SCP
	Ischnura cervula	Nat				A	X						SCP
	Ischnura sp. *undetermined*	Nat				A	X						SCP
	Isoperla nr. *quinquepunctata*	Nat				A	X						SCP
	Juga (*Oreobasis*) *laurae*	Nat				A	X						SCP
	Laccobius nr. *agilis*	Nat				A	X						SCP
	Laccobius nr. *nevadensis*	Nat				A	X						SCP
	Laccophilus decipiens	Nat				A	X						SCP
	Lamproscatella (*Haloscatella*) nr. *nivosa*	Nat				A	X						SCP
	Larsia sp.	Nat				A	X						SCP
	Lepidostoma sp. (*turret case*)	Nat				A	X						SCP
	Lepidurus lemmoni	Nat				A	X						SCP
	Lestes congener	Nat				A	X						SCP
	Libellula (nr.*forensis*)	Nat				A	X						SCP
	Limnephilus sp.	Nat				A	X						SCP
	Limnesia sp.	Nat				A	X						SCP
	Limnophora sp.	Nat				A	X						SCP
	Limoniinae sp. (*undetermined*)	Nat				A	X						SCP
	Listronotus sp.	Nat				A	X						SCP
	Lynceus brachyurus	Nat				A	X						SCP
	Malenka sp.	Nat				A	X						SCP
	Megalocypris nr. *alba*	Nat				A	X						SCP
	Meropelopia sp.	Nat				A	X						SCP

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	Metriocnemus hygropetricus group	Nat				A	X						SCP
	Microcylloepus similis	Nat				A	X						SCP
	Microcylloepus thermarum	Nat				A	X						SCP
	Micropsectra sp.	Nat				A	X						SCP
	Microtendipes pedellus group	Nat				A	X						SCP
	Nanocladius nr. *bicolor group*	Nat				A	X						SCP
	Narpus concolor	Nat				A	X						SCP
	Notonecta kirbyi	Nat				A	X						SCP
	Notonecta sp.	Nat				A	X						SCP
	Notonecta undulata	Nat				A	X						SCP
	nr. *Ergasilus* sp.	Nat				A	X						SCP
	nr. *Huitfeldtia rectipes*	Nat				A	X						SCP
	nr. *Hyperodes* sp.	Nat				A	X						SCP
	Ochrotrichia sp.	Nat				A	X						SCP
	Ochthebius nr. *interruptus*	Nat				A	X						SCP
	Ochthebius sp. *undetermined*	Nat				A	X						SCP
	Odondomyia (*Odontomyia*) sp.	Nat				A	X						SCP
	Odontomyia (*Catatasina*) sp.	Nat				A	X						SCP
	Oecetis nr. sp. *A* (*Floyd 1995*)	Nat				A	X						SCP
	Oecetis sp. *undetermined*	Nat				A	X						SCP
	Oigochaeta - unidentified	Nat				A	X						SCP
	Ophiogomphus nr. *morrisoni*	Nat				A	X						SCP
	Optioservus divergens	Nat				A	X						SCP
	Optioservus quadrimaculatus	Nat				A	X						SCP
	Ormosia sp.	Nat				A	X						SCP

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	Orthocladinae spp. (*undetermined*)	Nat				A	X						SCP
	Ostracoda - unidentified	Nat				A	X						SCP
	Oxyethira sp.	Nat				A	X						SCP
	Pagastia sp.	Nat				A	X						SCP
	Paraleptophlebia sp.	Nat				A	X						SCP
	Parapsyche sp.	Nat				A	X						SCP
	Paratanytarsus sp.	Nat				A	X						SCP
	Parochlus sp.	Nat				A	X						SCP
	Parydra (*Chaetoapnaea*) nr. *pedalis*	Nat				A	X						SCP
	*Pelina truncula*ta	Nat				A	X						SCP
	Peltodytes callosus	Nat				A	X						SCP
	Pericoma sp.	Nat				A	X						SCP
	Phaenopsectra sp.	Nat				A	X						SCP
	Physa sp.	Nat				A	X						SCP
	Physella sp.	Nat				A	X						SCP
	Piona sp.	Nat				A	X						SCP
	Pisidium sp.	Nat				A	X						SCP
	Polycentropus sp.	Nat				A	X						SCP
	Potamocypris sp. *A*	Nat				A	X						SCP
	Potamocypris sp. *B* (*thermal*)	Nat				A	X						SCP
	Potamonectes griseostriatus	Nat				A	X						SCP
	Potamonectes striatellus	Nat				A	X						SCP
	Procladius (nr. *Holotanypus*) sp.	Nat				A	X						SCP
	Procladius sp.	Nat				A	X						SCP
	Psectrocladius nr. *flavus*	Nat				A	X						SCP

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	Psectrocladius nr. *psilopterus group*	Nat				A	X						SCP
	Psectrocladius sordidellus group	Nat				A	X						SCP
	Psectrotanypus sp.	Nat				A	X						SCP
	Pseudodiamesa (*Pseudodiamesa*) sp.	Nat				A	X						SCP
	Pyrgulopsis sp.	Nat				A	X						SCP
	Rhantus binotatus	Nat				A	X						SCP
	Rhantus gutticollis	Nat				A	X						SCP
	Rheotanytarsus sp.	Nat				A	X						SCP
	Rhyacophila sibirica group (nr. *visor*)	Nat				A	X						SCP
	Scatella (*Scatella*) *obsoleta group*	Nat				A	X						SCP
	Scirtes sp.	Nat				A	X						SCP
	Setacera aldrichi	Nat				A	X						SCP
	Sialis sp.	Nat				A	X						SCP
	Sigara nr. *nevadensis*	Nat				A	X						SCP
	Sigara omani	Nat				A	X						SCP
	Simulium sp.	Nat				A	X						SCP
	Stagnicola sp.	Nat				A	X						SCP
	Sweltsa sp.	Nat				A	X						SCP
	Synorthocladius sp.	Nat				A	X						SCP
	Tanytarsus sp.	Nat				A	X						SCP
	Thaumalea sp.	Nat				A	X						SCP
	Thermacarus - sp. *nova* (*new species*)	Nat				A	X						SCP
	Thermacarus nevadensis	Nat				A	X						SCP

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	Thienemannia nr. *gracilis*	Nat				A	X						SCP
	Thienemanniella nr. *clavicornis*	Nat				A	X						SCP
	Thienemanniella nr. *similis*	Nat				A	X						SCP
	Thienemannimyia sp.	Nat				A	X						SCP
	Triaenodes nr. *ignitus*	Nat				A	X						SCP
	Tricorythodes nr. *minutus*	Nat				A	X						SCP
	Tropisternus ellipticus	Nat				A	X						SCP
	Tropisternus lateralis	Nat				A	X						SCP
	Tvetenia bavarica group	Nat				A	X						SCP
	Unidentified sp.	Nat				A	X						SCP
	Wormaldia sp.	Nat				A	X						SCP
	Zaitzevia parvula	Nat				A	X						SCP
Invertebrate - Butterfly													
Alexander's sulpher	*Colias alexandra*	Nat											SCP
Alpine green hairstreak	*Callophrys lemberti*	Nat											SCP
Ampelo ringlet	*Coenonympha ampelos*	Nat											SCP
Anicia checkerspot	*Euphydryas anicia*	Nat											SCP
Anise Swallowtail	*Papilio zelicaon*	Nat											SCP
Arrowhead Blue	*Glaucopsyche piasus*	Nat											SCP
Becker's White	*Pontia beckerii*	Nat											SCP
Behr's hairstreak	*Satyrium behrii*	Nat											SCP
Blue cooper	*Lycaena heteronea*	Nat											SCP
Blue spp.	*Euphilotes* spp.	Nat											SCP
Boisduval's blue	*Plebejus icarioides*	Nat											SCP

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Branded skipper	*Hesperia comma*	Nat											SCP
California hairstreak	*Satyrium califonicum*	Nat											SCP
California tortoiseshell	*Nymphalis californica*	Nat											SCP
Callipi fritialley	*Speyeria callippe*	Nat											SCP
Chalcedon checkerspot	*Euphydryas chalcedona*	Nat											SCP
Checkered skipper	*Prygus communis*	Nat											SCP
Checkered White	*Pontia protodice*	Nat											SCP
Clouded Sulphur	*Colias philodice*	Nat											SCP
Colon's checkerspot	*Euphydryas colon*	Nat											SCP
Coronis' fritialley	*Speyeria coronis*	Nat											SCP
Edith's checkerspot	*Euphydryas editha*	Nat											SCP
Edith's cooper	*Lycaena editha*	Nat											SCP
Field cresent	*Phyciodes campestris*	Nat											SCP
Great Basin sooty skipper	*Pholisora libya*	Nat											SCP
Great Basin woodnymph	*Cercyonis sthenele*	Nat											SCP
Great spangled fritillary	*Speyeria cybele*	Nat											SCP
Greenish blue	*Plebejus saepiolus*	Nat											SCP
Hoary comma	*Polygonia gracilis*	Nat											SCP
Juba skipper	*Hesperia juba*	Nat											SCP
Large heath	*Coenonympha tullia*	Nat											SCP
Large marble	*Euchloe ausonides*	Nat											SCP
Large white skipper	*Heliopetes ericetorum*	Nat											SCP
Large woodnymph	*Cercyonis pegala*	Nat											SCP

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Leanira checkerspot	*Chlosyne leanira*	Nat											SCP
Lorguins admiral	*Limenitis lorguini*	Nat											SCP
Lupine blue	*Icaricia icarioides*	Nat											SCP
Lustrous copper	*Lycaeides cuprea*	Nat											SCP
Melissa blue	*Plebejus melissa*	Nat											SCP
Milbert's tortoiseshell	*Nymphalis milberti*	Nat											SCP
Monarch butterfly	*Danaus plexippus*	Nat											SCP
Mormon fritillary	*Speyeria mormonia*	Nat											SCP
Mourning cloak	*Nymphalis antiopa*	Nat											SCP
Mylitta crescent	*Phyciodes mylitta*	Nat											SCP
Nivalis copper	*Lycaeides nivalis*	Nat											SCP
Northern checkerspot	*Chlosyne palla*	Nat											SCP
Northwest ringlet	*Coenonympha ampelos ampelos*	Nat											SCP
Olive hairstreak	*Mitoura grynea*	Nat											SCP
Orange sulphur	*Colias eurytheme*	Nat											SCP
Painted lady	*Vanessa cardui*	Nat											SCP
Pearly marblewing	*Euchloe hyantis*	Nat											SCP
Pine butterfly	*Neophasia menapia*	Nat											SCP
Purplish copper	*Lycaena helloides*	Nat											SCP
Ridings satyr	*Neominois ridingsii*	Nat											SCP
Ruddy cooper	*Lycaena rubidus*	Nat											SCP
Sagebrush checkerspot	*Chlosyne acastus*	Nat											SCP
Sandhill skipper	*Polites sabuleti*	Nat											SCP
Sara's orangetip	*Anthocharis sara*	Nat											SCP

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Satyr comma	*Polygonia satyrus*	Nat											SCP
Shasta blue	*Icaricia shasta*	Nat											SCP
Sheridan's hairstreak	*Callophrys sheridanii*	Nat											SCP
Silvery blue	*Glaucopsyche lygdamus*	Nat											SCP
Small white	*Pieris rapae*	Nat											SCP
Small woodnymph	*Cercyonis oetus*	Nat											SCP
Soatz hairstreak	*Satyrium fuliginosum*	Nat											SCP
Spring white	*Pieris sisymbrii*	Nat											SCP
Tailed copper butterfly	*Tharsalea arota*	Nat											SCP
Two-tailed wwallowtail	*Papilio multicaudatus*	Nat											SCP
Uncas skipper	*Hesperia uncas*	Nat											SCP
West coast lady	*Vanessa annabella*	Nat											SCP
Western pygmy-blue	*Brephidium exile*	Nat											SCP
Western square-dotted blue	*Euphilotes battoides*	Nat											SCP
Western tiger swallowtail	*Papilio rutulus*	Nat											SCP
Western white	*Pieris occidentalis*	Nat											SCP
Woodland skipper	*Ochlodes sylvanoides*	Nat											SCP
Zephyrus angelewing	*Polygonia zephyrus*	Nat											SCP
Zerene's fritialley	*Speyeria zerene*	Nat											SCP
Mammals													
American badger	*Taxidea taxus*	Nat		X									SCP

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American pika	*Ochotona princeps*	Nat									X		SCP
Beaver	*Castor canadensis*	Nat							X				SCP
Belding's ground squirrel	*Spermophilus beldingi*	Nat		X	X	X	X	X					SCP
Black-tailed jack rabbit	*Lepus californicus*	Nat	X	X									SCP
Bobcat	*Felis rufus*	Nat	X	X					X	X	X		SCP
Bushy-tailed woodrat	*Neotoma cinerea*	Nat								X	X		SCP
California bighorn sheep	*Ovis canadensis*	Nat	X	X	X	X	X	X			C, F		SCP
Coyote	*Canis latrans*	Nat	X	X					X				SCP
Dark kangaroo mouse	*Microdipodops megacephalus*	Nat	X	X									SCP
Deer mouse	*Peromyscus maniculatus*	Nat											SCP
Desert wood rat	*Neotoma lepida*	Nat	X	X							X		SCP
Domestic wild burro (Feral)	*Equus asinus*	Int											SCP
Domestic wild horse (Feral)	*Equus caballus*	Int											SCP
Ermine	*Mustela erminea*	Nat							X				SCP
Fringed myotis	*Myotis thysanodes*	Nat							X		X		SCP
Golden-mantled ground squirrel	*Spermophilus lateralis*	Nat								X			SCP
Great Basin pocket mouse	*Perognathus parvus*	Nat	X	X						X			SCP
Hoary bat	*Lasiurus cinereus*	Nat			X	X	X	X	X	X			SCP
Kit fox	*Vulpes macrotis*	Nat	X	X									SCP
Least chipmunk	*Tamias minimus*	Nat							X	X	X		SCP
Little brown myotis	*Myotis lucifugus*	Nat						X	X		X		SCP
Long-legged myotis	*Myotis volans*	Nat			X	X	X	X					SCP

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Long-tailed weasel	*Mustela frenata*	Nat							X				SCP
Merriam's shrew	*Sorex merriami*	Nat			X	X	X	X					SCP
Montane vole	*Microtus montanus*	Nat			X	X	X	X					SCP
Mountain lion	*Felis concolor*	Nat	X	X					X	X	X		SCP
Mule deer	*Odocoileus hemionus*	Nat	X	F, N	X	X	X	X	F	C, F	C		SCP
Muskrat	*Ondatra zibethicus*	Nat				S							SCP
Northern grasshopper mouse	*Onychomys leucogaster*	Nat	X	X									SCP
Nuttall's cottontail	*Sylvilagus nuttallii*	Nat	X	X					X				SCP
Ord's kangaroo rat	*Dipodomys ordii*	Nat		X									SCP
Pacific Townsend's big-eared bat	*Corynorhinus townsendii townsendii*	Nat									X		SCP
Pale Townsend's big-eared bat	*Corynorhinus townsendii pallescens*	Nat									X		SCP
Pallid bat	*Antrozous pallidus*	Nat									X		SCP
Pinyon mouse	*Peromyscus truei*	Nat											SCP
Pocket gopher	*Thomomys talpoides*	Nat											SCP
Porcupine	*Erethizon dorsatum*	Nat			X	X	X	X	X	X	X		SCP
Preble's shrew	*Sorex preblei*	Nat	X	X	X	X	X	X	X				SCP
Pronghorn antelope	*Antilocapra americana*	Nat	N	X	X	X	X	X		C	C		SCP
Pygmy rabbit	*Brachylagus idahoensis*	Nat	A										SCP
River otter	*Lontra canadensis*	Nat				S							SCP
Sagebrush vole	*Lagurus curtatus*	Nat	X	X						X			SCP
Spotted bat	*Euderma maculatum*	Nat			X	X	X	X			X		SCP
Stripped skunk	*Mephitis mephitis*	Nat			X	X	X	X					SCP
Townsend's ground squirrel	*Spermophilus townsendii*	Nat											SCP
Vagrant shrew	*Sorex vagrans*	Nat			X	X	X	X	X				SCP

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Water shrew	*Sorex palustris*	Nat			X	X	X	X	X				SCP
Western small-footed myotis	*Myotis ciliolabrum*	Nat							X				SCP
White-tailed antelope ground squirrel	*Ammospermophilus leucurus*	Nat			X	X	X	X					SCP
White-tailed jackrabbit	*Lepus townsendii*	Nat		X									SCP
Yellow pine chipmunk	*Tamias amoenus*	Nat							X	X			SCP
Yellow-bellied marmot	*Marmota flaviventris*	Nat		X							X		SCP
Yuma myotis	*Myotis yumanensis*	Nat											SCP
Plants													
	Abronia turbinata	Nat											SCP
	Acer negundo californicum	Nat											SCP
	Achillea millefolium var. *occidentalis*	Nat											SCP
	Achnatherum lettermanii	Nat											SCP
	Achnatherum nelsonii ssp. *dorei*	Nat											SCP
	Achnatherum nevadense	Nat											SCP
	Achnatherum webberi	Nat											SCP
	Aesculus californica	Nat											SCP
	Agastache urticifolia	Nat											SCP
	Ageratina occidentalis	Nat											SCP
	Agoseris glauca glauca	Nat											SCP
	Agoseris heterophylla	Nat											SCP
	Agropyron elongatum	Nat											SCP

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	Agropyron smithii smithii	Nat											SCP
	Agrostis exarata exarata	Nat											SCP
	Agrostis idahoensis	Nat											SCP
	Agrostis scabra	Nat											SCP
	Aliciella leptomeria	Nat											SCP
	Aliciella micromeria	Nat											SCP
	Aliciella triodon	Nat											SCP
	Allium acuminatum	Nat											SCP
	Allium anceps	Nat											SCP
	Allium bisceptrum	Nat											SCP
	Allium nevadense	Nat											SCP
	Allium parvum	Nat											SCP
	Allium platycaule	Nat											SCP
	Allium punctum	Nat											SCP
	Allium tolmiei var. *tolmiei*	Nat											SCP
	Alopecurus aequalis	Nat											SCP
	Alopecurus geniculatus	Nat											SCP
	Alopecurus pratensis	Nat											SCP
	Alyssum simplex	Nat											SCP
	Amelanchier utahensis	Nat											SCP
	Amsinckia tessellata	Nat											SCP
	Antennaria dimorpha	Nat											SCP
	Antennaria microphylla	Nat											SCP
	Antennaria rosea	Nat											SCP
	Antennaria stenophylla	Nat											SCP
	Aquilegia formosa var. *formosa*	Nat											SCP

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	Arabis cobrensis	Nat											SCP
	Arabis divaricarpa	Nat											SCP
	Arabis holboellii	Nat											SCP
	Arabis pubernula	Nat											SCP
	Arabis sparsiflora var. *sparsiflora*	Nat											SCP
	Arenaria aculeata	Nat											SCP
	Arenaria congesta var. *simulans*	Nat											SCP
	Arenaria franklinii var. *franklinii*	Nat											SCP
	Argentina anserina	Nat											SCP
	Arnica chamissonis	Nat											SCP
	Arnica chamissonis foliosa	Nat											SCP
	Arnica longifolia	Nat											SCP
	Arnica sororia	Nat											SCP
	Asclepias speciosa	Nat											SCP
	Astragalus agrestis	Nat											SCP
	Astragalus alvordensis	Nat											SCP
	Astragalus curvicarpus var. *curvicarpus*	Nat											SCP
	Astragalus filipes	Nat											SCP
	Astragalus iodanthus var. *diaphanoides*	Nat											SCP
	Astragalus iodanthus var. *iodanthus*	Nat											SCP
	Astragalus lentiginosus var. *chartaceus*	Nat											SCP
	Astragalus malacus	Nat											SCP

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	Astragalus newberryi var. *castoreus*	Nat											SCP
	Astragalus newberryi var. *newberryi*	Nat											SCP
	Astragalus obscurus	Nat											SCP
	Astragalus purshii var. *lectulus*	Nat											SCP
	Astragalus purshii var. *purshii*	Nat											SCP
	Astragalus salmonis	Nat											SCP
	Astragalus tetrapterus	Nat											SCP
	Balsamorhiza hookeri	Nat											SCP
	Balsamorhiza sagittata	Nat											SCP
	Balsamorhiza serrata	Nat											SCP
	Bassia americana	Nat											SCP
	Beckmannia syzigachne	Nat											SCP
	Berula erecta	Nat											SCP
	Blepharidachne kingii	Nat											SCP
	Blepharipappus scaber scaber	Nat											SCP
	Brickellia microphylla	Nat											SCP
	Bromus carinatus	Nat											SCP
	Bromus commutatus	Nat											SCP
	Bromus hordeaceus ssp. *hordeaceus*	Nat											SCP
	Callitriche hermaphroditica	Nat											SCP
	Callitriche verna	Nat											SCP
	Calochortus bruneaunis	Nat											SCP
	Calyptridium roseum	Nat											SCP
	Calyptridium umbellatum	Nat											SCP

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	Camassia quamash ssp. *breviflora*	Nat											SCP
	Camissonia andina	Nat											SCP
	Camissonia boothii alyssoides	Nat											SCP
	Camissonia claviformis ssp. *integrior*	Nat											SCP
	Camissonia pterosperma	Nat											SCP
	Camissonia pusilla	Nat											SCP
	Camissonia subacaulis	Nat											SCP
	Camissonia tanacetifolia ssp. *tanacetifolia*	Nat											SCP
	Canbya aurea	Nat											SCP
	Carex athrostachya	Nat											SCP
	Carex douglasii	Nat											SCP
	Carex microptera	Nat											SCP
	Carex nebrascensis	Nat											SCP
	Carex pellita	Nat											SCP
	Carex petasata	Nat											SCP
	Carex rossii	Nat											SCP
	Carex simulata	Nat											SCP
	Carex vesicaria var. *vesicaria*	Nat											SCP
	Castilleja applegatei	Nat											SCP
	Castilleja chromosa	Nat											SCP
	Castilleja exilis	Nat											SCP
	Castilleja linariifolia	Nat											SCP
	Castilleja pilosa var. *longispica*	Nat											SCP
	Castilleja pilosa var. *pilosa*	Nat											SCP

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	Castilleja tenuis	Nat											SCP
	Caulanthus crassicaulis	Nat											SCP
	Cerastium glomeratum	Nat											SCP
	Ceratophyllum demersum	Nat											SCP
	Cercocarpus ledifolius ledifolius	Nat											SCP
	Cercocarpus ledifolius var. *intercedens*	Nat											SCP
	Chaenactis douglasii var. *douglasii*	Nat											SCP
	Chaenactis macrantha	Nat											SCP
	Chaenactis stevioides	Nat											SCP
	Chaetadelpha wheeleri	Nat											SCP
	Chamaebatiaria millefolium	Nat											SCP
	Chenopodium desiccatum	Nat											SCP
	Chenopodium nevadense	Nat											SCP
	Chenopodium salinum	Nat											SCP
	Chorispora tenella	Nat											SCP
	Chorizanthe watsonii	Nat											SCP
	Claytonia rubra ssp. *depressa*	Nat											SCP
	Cleome platycarpa	Nat											SCP
	Cleomella hillmanii	Nat											SCP
	Cleomella parviflora	Nat											SCP
	Collinsia parviflora	Nat											SCP
	Collomia grandiflora	Nat											SCP
	Collomia linearis	Nat											SCP
	Collomia tinctoria	Nat											SCP

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	Cordylanthus maritimus ssp. *canescens*	Nat											SCP
	Cordylanthus ramosus	Nat											SCP
	Crassula aquatica	Nat											SCP
	Crepis acuminata	Nat											SCP
	Crepis atribarba	Nat											SCP
	Crepis modocensis ssp. *modocensis*	Nat											SCP
	Crepis occidentalis	Nat											SCP
	Crepis runcinata ssp. *imbricata*	Nat											SCP
	Cryptantha ambigua	Nat											SCP
	Cryptantha circumscissa var. *circumscissa*	Nat											SCP
	Cryptantha gracilis	Nat											SCP
	Cryptantha humilis	Nat											SCP
	Cryptantha intermedia	Nat											SCP
	Cryptantha micrantha	Nat											SCP
	Cryptantha pterocarya var. *pterocarya*	Nat											SCP
	Cryptantha watsonii	Nat											SCP
	Cuscuta californica var. *breviflora*	Nat											SCP
	Cymopterus corrugatus	Nat											SCP
	Cymopterus purpurascens	Nat											SCP
	Cystopteris fragilis	Nat											SCP
	Damasonium californicum	Nat											SCP
	Danthonia californica	Nat											SCP
	Danthonia unispicata	Nat											SCP

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	Delphinium andersonii	Nat											SCP
	Delphinium nuttallianum	Nat											SCP
	Deschampsia danthonioides	Nat											SCP
	Deschampsia elongata	Nat											SCP
	Descurainia incana ssp. *procera*	Nat											SCP
	Descurainia paradisa paradisa ssp.	Nat											SCP
	Descurainia pinnata filipes ssp.	Nat											SCP
	Descurainia pinnata nelsonii ssp.	Nat											SCP
	Dimeresia howellii	Nat											SCP
	Dodecatheon conjugens conjugens ssp.	Nat											SCP
	Downingia bacigalupii	Nat											SCP
	Downingia bicornuta	Nat											SCP
	Downingia laeta	Nat											SCP
	Draba verna	Nat											SCP
	Eatonella nivea	Nat											SCP
	Elatine brachysperma	Nat											SCP
	Ephedra nevadensis	Nat											SCP
	Epilobium brachycarpum	Nat											SCP
	Epilobium ciliatum ciliatum ssp.	Nat											SCP
	Epilobium pygmaeum	Nat											SCP
	Epilobium torreyi	Nat											SCP
	Equisetum arvense	Nat											SCP
	Equisetum hyemale var. *affine*	Nat											SCP

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	Equisetum laevigatum	Nat											SCP
	Eragrostis orcuttiana	Nat											SCP
	Eriastrum wilcoxii	Nat											SCP
	Ericameria bloomeri	Nat											SCP
	Erigeron aphanactis	Nat											SCP
	Erigeron austiniae	Nat											SCP
	Erigeron bloomeri var. *bloomeri*	Nat											SCP
	Erigeron compositus	Nat											SCP
	Erigeron divergens	Nat											SCP
	Erigeron filifolius var. *filifolius*	Nat											SCP
	Erigeron linearis	Nat											SCP
	Erigeron lonchophyllus	Nat											SCP
	Eriogonum baileyi var. *baileyi*	Nat											SCP
	Eriogonum brachyanthum	Nat											SCP
	Eriogonum caespitosum	Nat											SCP
	Eriogonum collinum	Nat											SCP
	Eriogonum esmeraldense var. *esmeraldense*	Nat											SCP
	Eriogonum heracleoides var. *heracleoides*	Nat											SCP
	Eriogonum hookeri	Nat											SCP
	Eriogonum maculatum	Nat											SCP
	Eriogonum microthecum var. *ambiguum*	Nat											SCP
	Eriogonum microthecum var. *laxiflorum*	Nat											SCP
	Eriogonum nidularium	Nat											SCP

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	Eriogonum nudum var. *publiflorum*	Nat											SCP
	Eriogonum nutans var. *nutans*	Nat											SCP
	Eriogonum ochrocephalum var. *alexandrae*	Nat											SCP
	Eriogonum ovalifolium var. *ovalifolium*	Nat											SCP
	Eriogonum ovalifolium var. *purpureum*	Nat											SCP
	Eriogonum palmerianum	Nat											SCP
	Eriogonum rubricaule	Nat											SCP
	Eriogonum sphaerocephalum	Nat											SCP
	Eriogonum strictum	Nat											SCP
	Eriogonum umbellatum var. *nevadense*	Nat											SCP
	Eriogonum vimineum	Nat											SCP
	Eriophyllum lanatum var. *integrifolium*	Nat											SCP
	Erysimum asperum	Nat											SCP
	Erysimum capitatum	Nat											SCP
	Euphorbia glyptosperma	Nat											SCP
	Floerkea proserpinacoides	Nat											SCP
	Frasera albicaulis var. *albicaulis*	Nat											SCP
	Fritillaria atropurpurea	Nat											SCP
	Fritillaria pudica	Nat											SCP
	Galium aparine	Nat											SCP
	Galium bifolium	Nat											SCP
	Galium multiflorum	Nat											SCP

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	Gayophytum diffusum	Nat											SCP
	Gayophytum racemosum	Nat											SCP
	Gayophytum ramosissimum	Nat											SCP
	Gentianopsis simplex	Nat											SCP
	Geranium viscosissimum var. *viscosissimum*	Nat											SCP
	Geum macrophyllum	Nat											SCP
	Geum triflorum	Nat											SCP
	Gilia brecciarum ssp. *brecciarum*	Nat											SCP
	Gilia inconspicua	Nat											SCP
	Gilia salticola	Nat											SCP
	Gilia sinuata	Nat											SCP
	Glyptopleura marginata	Nat											SCP
	Gnaphalium palustre	Nat											SCP
	Gymnosteris parvula	Nat											SCP
	Hackelia micrantha	Nat											SCP
	Helianthus annuus	Nat											SCP
	Heliotropium curassavicum var. *oculatum*	Nat											SCP
	Hesperochiron californicus	Nat											SCP
	Heterocodon rariflorum	Nat											SCP
	Heuchera rubescens var. *alpicola*	Nat											SCP
	Hieracium scouleri var. *nudicaule*	Nat											SCP
	Hieracium scouleri var. *scouleri*	Nat											SCP
	Hippuris vulgaris	Nat											SCP

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	Hordeum brachyantherum	Nat											SCP
	Hordeum jubatum	Nat											SCP
	Horkelia fusca ssp. *capitata*	Nat											SCP
	Hutchinsia procumbens	Nat											SCP
	Hydrophyllum capitatum var. *alpinum*	Nat											SCP
	Hymenopappus filifolius var. *filifolis*	Nat											SCP
	Hypericum scouleri ssp. *scouleri*	Nat											SCP
	Ionactis alpina	Nat											SCP
	Ipomopsis congesta ssp. *congesta*	Nat											SCP
	Ivesia baileyi var. *baileyi*	Nat											SCP
	Juncus arcticus ssp. *littoralis*	Nat											SCP
	Juncus longistylis	Nat											SCP
	Juncus nevadensis	Nat											SCP
	Juncus orthophyllus	Nat											SCP
	Juncus saximontanus	Nat											SCP
	Lactuca tatarica var. *pulchella*	Nat											SCP
	Lappula occidentalis var. *occidentalis*	Nat											SCP
	Lathrocasis tenerrima	Nat											SCP
	Layia glandulosa	Nat											SCP
	Lemna minor	Nat											SCP
	Leptochloa fusca ssp. *fascicularis*	Nat											SCP
	Leptosiphon septentrionalis	Nat											SCP
	Lesquerella kingii ssp. *kingii*	Nat											SCP

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	Lesquerella kingii ssp. *kingii* var. *cobrensis*	Nat											SCP
	Leucocrinum montanum	Nat											SCP
	Leucophysalis nana	Nat											SCP
	Lewisia rediviva	Nat											SCP
	Leymus triticoides	Nat											SCP
	Lilaea scilloides	Nat											SCP
	Limosella aquatica	Nat											SCP
	Linanthus pungens	Nat											SCP
	Linum lewisii var. *lewisii*	Nat											SCP
	Lithophragma glabrum	Nat											SCP
	Lithophragma parviflorum	Nat											SCP
	Lithophragma tenellum	Nat											SCP
	Lithospermum ruderale	Nat											SCP
	Lolium perenne	Nat											SCP
	Lomatium austiniae	Nat											SCP
	Lomatium bicolor	Nat											SCP
	Lomatium canbyi	Nat											SCP
	Lomatium cous	Nat											SCP
	Lomatium dissectum	Nat											SCP
	Lomatium donnellii	Nat											SCP
	Lomatium foeniculaceum	Nat											SCP
	Lomatium macrocarpum	Nat											SCP
	Lomatium nevadense	Nat											SCP
	Lomatium nevadense var. *parishii*	Nat											SCP

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	Lomatium triternatum var. *macrocarpum*	Nat											SCP
	Lomatium vaginatum	Nat											SCP
	Lotus unifoliolatus var. *unifoliolatus*	Nat											SCP
	Lupinus argenteus ssp. *argenteus*	Nat											SCP
	Lupinus argenteus ssp. *argenteus* var. *laxiflorus*	Nat											SCP
	Lupinus aridus ssp. *aridus*	Nat											SCP
	Lupinus brevicaulis	Nat											SCP
	Lupinus caudatus	Nat											SCP
	Lupinus nevadensis	Nat											SCP
	Lupinus polyphyllus	Nat											SCP
	Lupinus pusillus ssp. *intermontanus*	Nat											SCP
	Lupinus saxosus	Nat											SCP
	Lupinus uncialis	Nat											SCP
	Lygodesmia spinosa	Nat											SCP
	Machaeranthera canescens	Nat											SCP
	Madia glomerata	Nat											SCP
	Madia gracilis	Nat											SCP
	Maianthemum stellatum	Nat											SCP
	Malacothrix glabrata	Nat											SCP
	Malacothrix sonchoides	Nat											SCP
	Malacothrix torreyi	Nat											SCP
	Marsilea vestita	Nat											SCP
	Melica bulbosa	Nat											SCP

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	Melica fugax	Nat											SCP
	Melica stricta	Nat											SCP
	Mentzelia albicaulis	Nat											SCP
	Mentzelia congesta	Nat											SCP
	Mentzelia laevicaulis	Nat											SCP
	Mentzelia veatchiana	Nat											SCP
	Mertensia ciliata var. *ciliata*	Nat											SCP
	Mertensia longiflora	Nat											SCP
	Mertensia oblongifolia	Nat											SCP
	Microseris nutans	Nat											SCP
	Microseris troximoides	Nat											SCP
	Microsteris gracilis var. *humilior*	Nat											SCP
	Mimulus floribundus	Nat											SCP
	Mimulus guttatus	Nat											SCP
	Mimulus nanus	Nat											SCP
	Mimulus pilosus	Nat											SCP
	Mimulus suksdorfii	Nat											SCP
	Monardella glauca	Nat											SCP
	Monolepis nuttalliana	Nat											SCP
	Monolepis pusilla	Nat											SCP
	Montia chamissoi	Nat											SCP
	Montia fontana	Nat											SCP
	Montia linearis	Nat											SCP
	Muhlenbergia asperifolia	Nat											SCP
	Muhlenbergia richardsonis	Nat											SCP

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	Myosurus apetalus var. *borealis*	Nat											SCP
	Myosurus minimus	Nat											SCP
	Nama aretioides var. *aretioides*	Nat											SCP
	Nama densum	Nat											SCP
	Navarretia breweri	Nat											SCP
	Navarretia capillaris	Nat											SCP
	Navarretia intertexta ssp. *propinqua*	Nat											SCP
	Nemacladus rigidus	Nat											SCP
	Nemophila breviflora	Nat											SCP
	Nemophila pedunculata	Nat											SCP
	Nestotus stenophyllus	Nat											SCP
	Nothocalais troximoides	Nat											SCP
	Oenothera deltoides	Nat											SCP
	Orobanche fasciculata	Nat											SCP
	Orobanche uniflora	Nat											SCP
	Orthocarpus cuspidatus ssp. *copelandii*	Nat											SCP
	Osmorhiza occidentalis	Nat											SCP
	Oxytheca dendroidea	Nat											SCP
	Packera cana	Nat											SCP
	Paeonia brownii	Nat											SCP
	Parietaria pensylvanica	Nat											SCP
	Pectocarya setosa	Nat											SCP
	Pediocactus simpsonii	Nat										Protected	SCP
	Penstemon deustus var. *pedicellatus*	Nat											SCP

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	Penstemon gracilentus	Nat											SCP
	Penstemon humilis	Nat											SCP
	Penstemon laetus	Nat											SCP
	Penstemon rydbergii var. *oreocharis*	Nat											SCP
	Penstemon rydbergii var. *rydbergii*	Nat											SCP
	Penstemon speciosus	Nat											SCP
	Perideridia bolanderi	Nat											SCP
	Perideridia lemmonii	Nat											SCP
	Phacelia adenophora	Nat											SCP
	Phacelia glandulifera	Nat											SCP
	Phacelia gymnoclada	Nat											SCP
	Phacelia hastata var. *hastata*	Nat											SCP
	Phacelia humilis	Nat											SCP
	Phacelia inundata	Nat											SCP
	Phacelia linearis	Nat											SCP
	Phacelia lutea var. *calva*	Nat											SCP
	Phacelia lutea var. *lutea*	Nat											SCP
	Phacelia mutabilis	Nat											SCP
	Phacelia ramosissima	Nat											SCP
	Phacelia rattanii	Nat											SCP
	Phlox austromontana	Nat											SCP
	Phlox diffusa ssp. *longistylis*	Nat											SCP
	Phlox hoodii	Nat											SCP
	Phlox longifolia ssp. *longifolia*	Nat											SCP
	Phoenicaulis cheiranthoides	Nat											SCP

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	Pinus ponderosa	Nat										Protected	SCP
	Plagiobothrys kingii var. *harknessii*	Nat											SCP
	Plagiobothrys leptocladus	Nat											SCP
	Plagiobothrys scouleri var. *hispidulus*	Nat											SCP
	Plectritis macrocera	Nat											SCP
	Poa ampla	Nat											SCP
	Poa cusickii	Nat											SCP
	Poa fendleriana	Nat											SCP
	Poa juncifolia	Nat											SCP
	Poa nevadensis	Nat											SCP
	Poa pratensis	Nat											SCP
	Poa sandbergii	Nat											SCP
	Poa scabrella	Nat											SCP
	Polemonium micranthum	Nat											SCP
	Polyctenium fremontii	Nat											SCP
	Polygala subspinosa	Nat											SCP
	Polygonum amphibium var. *stipulaceum*	Nat											SCP
	Polygonum bistortoides	Nat											SCP
	Polygonum douglasii ssp. *douglasii*	Nat											SCP
	Polygonum heterosepalum	Nat											SCP
	Polygonum lapathifolium	Nat											SCP
	Polygonum polygaloides ssp. *kelloggii*	Nat											SCP
	Polygonum watsonii	Nat											SCP
	Porterella carnosula	Nat											SCP

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	Potamogeton diversifolius	Nat											SCP
	Potamogeton foliosus ssp. *foliosus*	Nat											SCP
	Potamogeton pusillus	Nat											SCP
	Potentilla glandulosa ssp. *nevadensis*	Nat											SCP
	Potentilla glandulosa ssp. *pseudorupestri*	Nat											SCP
	Potentilla gracilis var. *fastigiata*	Nat											SCP
	Potentilla newberryi	Nat											SCP
	Potentilla rivalis	Nat											SCP
	Psilocarphus brevissimus	Nat											SCP
	Psoralea lanceolata	Nat											SCP
	Puccinellia lemmonii	Nat											SCP
	Puccinellia nuttalliana	Nat											SCP
	Puccinellia pauciflora	Nat											SCP
	Pyrrocoma lanceolata	Nat											SCP
	Ranunculus andersonii	Nat											SCP
	Ranunculus aquatilis	Nat											SCP
	Ranunculus cymbalaria	Nat											SCP
	Ranunculus glaberrimus	Nat											SCP
	Ranunculus sceleratus var. *multifidus*	Nat											SCP
	Ranunculus trichophyllus var. *trichophyllus*	Nat											SCP
	Ranunculus uncinatus var. *uncinatus*	Nat											SCP
	Rorippa cruvisilaqua var. *curvisiliqua*	Nat											SCP

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	Rosa woodsii var. *ultramontana*	Nat											SCP
	Rumex maritimus	Nat											SCP
	Rumex salicifolius var. *denticulatus*	Nat											SCP
	Rumex salicifolius var. *mexicanus*	Nat											SCP
	Rumex venosus	Nat											SCP
	Sagittaria cuneata	Nat											SCP
	Salix fragilis	Nat											SCP
	Salix geyeriana	Nat											SCP
	Salix ligulifolia	Nat											SCP
	Salix lucida ssp. *caudata*	Nat											SCP
	Salix melanopsis	Nat											SCP
	Salix scouleriana	Nat											SCP
	Salvia dorrii ssp. *dorrii* var. *incana*	Nat											SCP
	Salvia dorrii ssp. *dorrii* var. *pilosa*	Nat											SCP
	Sambucus nigra ssp. *cerulea*	Nat											SCP
	Saxifraga nidifica var. *nidifica*	Nat											SCP
	Schedonorus phoenix	Nat											SCP
	Schoenoplectus acutus	Nat											SCP
	Schoenoplectus americanus	Nat											SCP
	Schoenoplectus maritimus	Nat											SCP
	Schoenoplectus pungens var. *longispicatus*	Nat											SCP
	Scirpus microcarpus	Nat											SCP
	Scrophularia lanceolata	Nat											SCP

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	Scutellaria nana	Nat											SCP
	Senecio hydrophilus	Nat											SCP
	Senecio integerrimus var. *exaltatus*	Nat											SCP
	Senecio integerrimus var. *major*	Nat											SCP
	Senecio serra	Nat											SCP
	Sidalcea oregana ssp. *oregana*	Nat											SCP
	Silene menziesii ssp. *menziesii* var. *viscosa*	Nat											SCP
	Silene scaposa var. *lobata*	Nat											SCP
	Sisyrinchium idahoense	Nat											SCP
	Solanum triflorum	Nat											SCP
	Solidago spectabilis	Nat											SCP
	Sparganium angustifolium	Nat											SCP
	Spergularia salina	Nat											SCP
	Sphaeralcea grossulariifolia	Nat											SCP
	Spirodela polyrhiza	Nat											SCP
	Sporobolus airoides	Nat											SCP
	Sporobolus cryptandrus	Nat											SCP
	Stanleya pinnata var. *pinnata*	Nat											SCP
	Stellaria longipes	Nat											SCP
	Stenotus acaulis	Nat											SCP
	Stephanomeria exigua ssp. *exigua*	Nat											SCP
	Stephanomeria minor var. *minor*	Nat											SCP
	Streptanthella longirostris	Nat											SCP
	Streptanthus cordatus	Nat											SCP

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	Stuckenia pectinata	Nat											SCP
	Stylocline psilocarphoides	Nat											SCP
	Suaeda calceoliformis	Nat											SCP
	Suaeda moquinii	Nat											SCP
	Symphoricarpos longiflorus	Nat											SCP
	Symphoricarpos oreophilus	Nat											SCP
	Symphoricarpos oreophilus var. *utahensis*	Nat											SCP
	Symphyotrichum eatonii	Nat											SCP
	Symphyotrichum frondosum	Nat											SCP
	Symphyotrichum spathulatum	Nat											SCP
	Tetradymia glabrata	Nat											SCP
	Tetradymia spinosa	Nat											SCP
	Thelypodium flexuosum	Nat											SCP
	Thelypodium integrifolium ssp. *complanatum*	Nat											SCP
	Thelypodium laciniatum	Nat											SCP
	Thelypodium milleflorum	Nat											SCP
	Thelypodium sagittatum ssp. *sagittatum*	Nat											SCP
	Thermopsis montana var. *montana*	Nat											SCP
	Tiquilia nuttallii	Nat											SCP
	Trifolium cyathiferum	Nat											SCP
	Trifolium gymnocarpon ssp. *plummerae*	Nat											SCP
	Trifolium kingii	Nat											SCP
	Trifolium longipes ssp. *Hansenii*	Nat											SCP

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	Trifolium macrocephalum	Nat											SCP
	Trifolium productum	Nat											SCP
	Trifolium variegatum	Nat											SCP
	Trifolium wormskioldii	Nat											SCP
	Triglochin concinna	Nat											SCP
	Triteleia hyacinthina	Nat											SCP
	Typha domingensis	Nat											SCP
	Typha latifolia	Nat											SCP
	Urtica dioica ssp. *holosericea*	Nat											SCP
	Valeriana edulis	Nat											SCP
	Veratrum californicum var. *californicum*	Nat											SCP
	Veronica americana	Nat											SCP
	Veronica peregrina ssp. *xalapensis*	Nat											SCP
	Vicia americana ssp. *americana*	Nat											SCP
	Viola nephrophylla	Nat											SCP
	Viola purpurea	Nat											SCP
	Viola vallicola var. *vallicola*	Nat											SCP
	Vulpia microstachys var. *pauciflora*	Nat											SCP
	Woodsia oregana	Nat											SCP
	Zannichellia palustris	Nat											SCP
	Zigadenus paniculatus	Nat											SCP
	Zigadenus venenosus var. *venenosus*	Nat											SCP
Alkali pepperweed	*Lepidium dictyotum*	Nat				X							SCP

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American yellowrocket	*Barbarea orthoceras*	Nat											SCP
Annual bluegrass	*Poa annua*	Int											SCP
Annual bursage	*Ambrosia acanthicarpa*	Nat											SCP
Antelope bitterbrush	*Purshia tridentata*	Nat											SCP
Austin's knotweed	*Polygonum douglasii* ssp. *austiniae*	Nat											SCP
Barbwire Russian thistle	*Salsola paulsenii*	Int											SCP
Barnyardgrass	*Echinochloa crus-galli*	Int											SCP
Basin big sagebrush	*Artemisia tridentata* ssp. *tridentata*	Nat											SCP
Beatley's clover	*Trifolium andersonii* ssp. *beatleyae*	Nat											SCP
Biennial wormwood	*Artemisia biennis*	Nat /Int											SCP
Black sagebrush	*Artemisia nova*	Nat											SCP
Bluebunch wheatgrass	*Pseudoroegneria spicata*	Nat											SCP
Boraxweed	*Nitrophila occidentalis*	Nat				X							SCP
Buckwheat	*Polygonaceae* spp.	Nat											SCP
Bud sagebrush	*Artemisia spinescens*	Nat											SCP
Bulbous bluegrass	*Poa bulbosa*	Int											SCP
Bull thistle	*Cirsium vulgare*	Int											SCP
Canada thistle	*Cirsium arvense*	Int											SCP
Cereal rye	*Secale cereale*	Int											SCP
Cheatgrass	*Bromus tectorum*	Int											SCP
Chokecherry	*Prunus virginiana* var. *melanocarpa*	Nat											SCP

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Clasping pepperweed	*Lepidium perfoliatum*	Int											SCP
Coast buckthorn	*Amsinckia menziesii*	Nat											SCP
Common cocklebur	*Xanthium strumarium canadense*	Nat											SCP
Common dandelion	*Taraxacum officinale*	Int											SCP
Common mallow	*Malva neglecta*	Int											SCP
Common oats	*Avena sativa*	Int											SCP
Common reed	*Phragmites australis*	Nat											SCP
Common sowthistle	*Sonchus oleraceus*	Int											SCP
Common wheat	*Triticum aestivum*	Int											SCP
Coyote tobacco	*Nicotiana attenuata*	Nat											SCP
Creeping bentgrass	*Agrostis stolonifera*	Int											SCP
Crested wheatgrass	*Agropyron cristatum*	Int											SCP
Curly dock	*Rumex crispus*	Int											SCP
Curveseed butterwort	*Ceratocephala testiculata*	Int											SCP
Desert cantaury	*Centaurium exaltatum*	Nat				X							SCP
Desert dodder	*Cuscuta denticulata*	Nat											SCP
Desert gooseberry	*Ribes velutinum*	Nat											SCP
Diffuse knapweed	*Centaurea diffusa*	Int											SCP
Disc mayweed	*Matricaria matricarioides*	Int											SCP
Douglas' draba	*Cusickiella douglasii*	Nat											SCP
Dwarf phacelia	*Phacelia tetramera*	Nat											SCP
Dwarf rush	*Juncus hemiendytus*	Nat											SCP
Elk thistle	*Cirsium foliosum*	Nat											SCP
Field bindweed	*Convolvulus arvensis*	Int											SCP
Field mint	*Mentha arvensis*	Nat											SCP

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Field pennycress	*Thlaspi arvense*	Nat											SCP
Filaree	*Erodium cicutarium*	Int											SCP
Fivehorn smotherweed	*Bassia hyssopifolia*	Int											SCP
Flat topped broom rape	*Orobanche corymbosa*	Nat											SCP
Flixweed	*Descurainia sophia*	Int											SCP
Fourwing saltbrush	*Atriplex canescens*	Nat											SCP
Golden currant	*Ribes aureum*	Nat											SCP
Gray horsebrush	*Tetradymia canescens*	Nat											SCP
Greasewood	*Sarcobatus vermiculatus*	Nat											SCP
Great Basin wildrye	*Leymus cinereus*	Nat											SCP
Green bristlegrass	*Setaria viridis*	Int											SCP
Grimy ivesia	*Ivesia rhypara* var. *rhypara*	Nat	X									Endangered	SCP
Hairy whitetop	*Cardaria pubescens*	Int											SCP
Hoary cress	*Cardaria draba*	Int											SCP
Horehound	*Marrubium vulgare*	Int											SCP
Horseweed	*Conyza canadensis*	Nat											SCP
Idaho fescue	*Festuca idahoensis*	Nat											SCP
Indian hemp	*Apocynum sibiricum*	Nat											SCP
Indian ricegrass	*Achnatherum hymenoides*	Nat											SCP
Kellogg's rush	*Juncus kelloggii*	Nat											SCP
Kochia	*Bassia scoparia*	Nat											SCP
Lambsquarter	*Chenopodium album*	Int											SCP
Lombardy poplar	*Populus nigra*	Int											SCP
Low sagebrush	*Artemisia arbuscula*	Nat											SCP
Matrimony vine	*Lycium barbarum*	Int											SCP

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Mediterranean barley	*Hordeum geniculatum*	Int											SCP
Mountain big sagebrush	*Artemisia tridentata* ssp. *vaseyana*	Nat											SCP
Needle-and-thread	*Hesperostipa comata* ssp. *comata*	Nat											SCP
New Mexico thistle	*Cirsium utahense*	Nat											SCP
Nodding beggertick	*Bidens cernua*	Nat											SCP
Oceanspray	*Holodiscus discolor*	Nat											SCP
Oregon checkerbloom	*Sigina saginoides*	Nat											SCP
Perennial pepperweed	*Lepidium latifolium*	Int											SCP
Pond lily	*Nuphar* spp.	Nat											SCP
Povertyweed	*Iva axillaris*	Nat						X					SCP
Prairie junegrass	*Koeleria macrantha*	Nat											SCP
Prickly lettuce	*Lactuca serriola*	Int											SCP
Prickly russian thistle	*Salsola tragus*	Int											SCP
Prostrate knotweed	*Polygonum aviculare*	Int											SCP
Prostrate pigweed	*Amaranthus blitoides*	Int											SCP
Quaking aspen	*Populus tremuloides*	Nat											SCP
Rabbitbrush	*Ericameria nauseosa*	Nat											SCP
Rabbitfootgrass	*Polypogon monspeliensis*	Int											SCP
Rattlesnake stickweed	*Hackelia ophiobia*	Nat									X		SCP
Red clover	*Trifolium pratense*	Int											SCP
Reed canarygrass	*Phalaris arundinacea*	Nat											SCP
Rose biscuitroot	*Lomatium roseanum*	Nat	X								X		SCP
Rough bluegrass	*Poa trivialis*	Int											SCP

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Rough pigweed	*Amaranthus retroflexus*	Nat											SCP
Rubber rabbitbrush	*Ericameria nauseosa* ssp. *consimilis* var. *oreophila*	Nat											SCP
Rubber rabbitbrush	*Ericameria nauseosa* ssp. *nauseosa* var. *speciosa*	Nat											SCP
Russian olive	*Elaeagnus angustifolia*	Int											SCP
Sagebrush mariposa lilly	*Calochortus macrocarpus*	Nat											SCP
Saline saltbrush	*Atriplex subspicata*	Nat											SCP
Saltgrass	*Distichlis spicata*	Nat											SCP
Saltlover	*Halogeton glomeratus*	Int											SCP
Sandberg's bluegrass	*Poa secunda*	Nat											SCP
Scotch thistle	*Onopordum acanthium*	Int											SCP
Sea-blight	*Suaeda torreyana*	Nat											SCP
Shadscale saltbrush	*Atriplex confertifolia*	Nat											SCP
Silver sagebrush	*Artemisia cana*	Nat											SCP
Silver saltbrush	*Atriplex argentea* ssp. *argentea*	Nat											SCP
Smooth brome	*Bromus inermis*	Int											SCP
Snowbrush ceanothus	*Ceanothus velutinus*	Nat											SCP
Spear saltbrush	*Atriplex patula*	Nat											SCP
Spikesedge	*Eleocharis acicularis*	Nat						X					SCP
Spikesedge	*Eleocharis palustris*	Nat						X					SCP
Spikesedge	*Eleocharis quinqueflora*	Nat						X					SCP
Spiny hopsage	*Grayia spinosa*	Nat											SCP
Spotted knapweed	*Centaurea maculosa*	Int											SCP

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Spotted ladysthumb	*Polygonum persicaria*	Int											SCP
Spreading wallflower	*Erysimum repandum*	Int											SCP
Squirreltail	*Elymus elymoides* ssp. *elymoides*	Nat											SCP
Squirreltail	*Elymus trachycaulus*	Nat											SCP
Stinkgrass	*Eragrostis ciliamensis*	Int											SCP
Strict forget-me-not	*Myosotis micrantha*	Int											SCP
Tall tumblemustard	*Sisymbrium altissimum*	Int											SCP
Threetip sagebrush	*Artemisia tripartite*	Nat											SCP
Thurber's needlegrass	*Achnatherum thurberianum*	Nat											SCP
Timothy	*Phleum pratense*	Int											SCP
Toad rush	*Juncus bufonius*	Nat											SCP
Tufted evening-primrose	*Oenothera caespitosa* ssp. *marginata*	Nat											SCP
Tumble pigweed	*Amaranthus albus*	Int											SCP
Tumbling saltbrush	*Atriplex rosea*	Nat											SCP
Twoscale saltbrush	*Atriplex heterosperma*	Nat											SCP
Valley sedge	*Carex vallicola*	Nat											SCP
Water hemlock	*Cicuta douglasii*	Nat											SCP
Watercress	*Nasturtium officinale*	Int											SCP
Wax currant	*Ribes cereum*	Nat											SCP
Wedgeleaf dock	*Rumex triangulivalvis*	Nat											SCP
Wedgescale saltbrush	*Atriplex truncata*	Nat											SCP
Weeping alkaligrass	*Puccinellia distans*	Nat /Int											SCP
Western blue flag	*Iris missouriensis*	Nat											SCP

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Western juniper	*Juniperus occidentalis occidentalis*	Nat										Protected	SCP
White poplar	*Populus alba*	Int											SCP
White sagebrush	*Artemisia ludoviciana* ssp. *ludoviciana*	Nat											SCP
Whitestem gooseberry	*Ribes inerme* var. *inerme*	Nat											SCP
Winterfat	*Krascheninnikovia lanata*	Nat											SCP
Witchgrass	*Panicum capillare*	Nat											SCP
Wyoming big sagebrush	*Artemisia tridentata* ssp. *wyomingensis*	Nat											SCP
Yellow rabbitbrush	*Chrysothamnus viscidiflorus*	Nat											SCP
Yellow rabbitbrush	*Chrysothamnus viscidiflorus* ssp. *viscidiflorus*	Nat											SCP
Yellow rabbitbrush	*Chrysothamnus viscidiflorus* ssp. *viscidiflorus* var. *viscidiflorus*	Nat											SCP
Yellow salsify	*Tragopogon dubius*	Int											SCP
Yellow sweetclover	*Melilotus officinalis*	Int											SCP
Reptiles													
Collared lizard	*Crotaphytus collaris*	Nat	X	X							X		SCP
Desert horned lizard	*Phrynosoma platyrhinos*	Nat	X	X									SCP
Gopher snake	*Pituophis melanoleucus*	Nat											SCP
Long-nosed leopard lizard	*Gambelia wislizenii*	Nat	X	A									SCP
Night snake	*Hypsiglena torquata*	Nat									X		SCP
Northern alligator lizard	*Elgaria coerulea*	Nat							X				SCP

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Pygmy short-horned lizard	*Phrynosoma douglasii*	Nat	X	X						X			SCP
Racer	*Coluber constrictor*	Nat								X			SCP
Rubber boa	*Charina bottae*	Nat		X									SCP
Sagebrush lizard	*Sceloporus graciosus*	Nat	X	X									SCP
Short-horned lizard	*Phrynosoma douglassi*	Nat											SCP
Side-blotched lizard	*Uta stansburiana*	Nat									X		SCP
Striped whipsnake	*Masticophis taeniatus*	Nat	X	X									SCP
Western fence lizard	*Sceloporus occidentalis*	Nat									X		SCP
Western rattlesnake	*Crotalus viridis*	Nat		X									SCP
Western terrestrial garter snake	*Thamnophis elegans*	Nat											SCP
Western whiptail	*Cnemidophorus tigris*	Nat	X	X									SCP

[1] Sagebrush-Steppe Habitats: Big Basin, Wyoming, Low sagebrush, salt desert scrub/ greasewood
[2] Montane Sagebrush Steppe: mountain big sage, bitterbrush, semi-desert grassland
[3] Ephemeral Wetlands: playas, salt flats, and mudflats
SCP = Species of Conservation Priority (Nevada Wildlife Action Plan)

Appendix C. Appropriate Use Determinations

Introduction

The Appropriate Refuge Uses Policy (603 FW 1 [2006]) outlines the process that the Service uses to determine when general public uses on refuges may be considered. Priority public uses previously defined as wildlife-dependent uses (hunting, fishing, wildlife observation and photography, and environmental education and interpretation) under the National Wildlife Refuge System Improvement Act of 1997 are generally exempt from appropriate use review. Other exempt uses include situations in which the Service does not have adequate jurisdiction to control the activity, as well as refuge management activities.

In essence, the appropriate use policy provides refuge managers with a consistent procedure to first screen and then document decisions concerning a public use. When a use is determined to be appropriate, refuge managers must then decide if the use is compatible before allowing it on a refuge. The policy also requires review of existing public uses.

During the CCP process, the Refuge Manager evaluated all existing and proposed refuge uses at Sheldon National Wildlife Refuge using the following guidelines and criteria as outlined in the appropriate use policy:

- Do we have jurisdiction over the use?
- Does the use comply with applicable laws and regulations (Federal, State, tribal, and local)?
- Is the use consistent with applicable Executive Orders and Department and Service policies?
- Is the use consistent with public safety?
- Is the use consistent with goals and objectives in an approved management plan or other document?
- Has an earlier documented analysis not denied the use or is this the first the use has been proposed?
- Is the use manageable within available budget and staff?
- Will this be manageable in the future within existing resources?
- Does the use contribute to the public's understanding and appreciation of the refuge's natural or cultural resources, or is the use beneficial to the refuge's natural or cultural resources?
- Can the use be accommodated without impairing existing wildlife-dependent recreational uses or reducing the potential to provide quality (see Section 1.6D of the appropriate use policy for recreational uses description), compatible, wildlife-dependent recreation into the future?

Using this process and these criteria, and as documented on the following pages, the Refuge Manager determined the following use(s) are not appropriate: None.

The Refuge Manager also determined the following refuge use(s) were appropriate and directed that compatibility determinations be completed for each use: Hunting (big-game guiding and outfitting); Rock Collecting; and Research, Scientific Collecting, and Survey Activities.

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Sheldon National Wildlife Refuge CCP

FINDING OF APPROPRIATENESS OF A REFUGE USE

Refuge Name: Sheldon National Wildlife Refuge

Use: Hunting (big-game guiding and outfitting)

This form is not required for wildlife-dependent recreational uses, take regulated by the State, or uses already described in a refuge CCP or step-down management plan approved after October 9, 1997.

Decision Criteria:	YES	NO
(a) Do we have jurisdiction over the use?	✓	
(b) Does the use comply with applicable laws and regulations (Federal, State, tribal, and local)?	✓	
(c) Is the use consistent with applicable Executive orders and Department and Service policies?	✓	
(d) Is the use consistent with public safety?	✓	
(e) Is the use consistent with goals and objectives in an approved management plan or other document?	✓	
(f) Has an earlier documented analysis not denied the use or is this the first time the use has been proposed?	✓	
(g) Is the use manageable within available budget and staff?	✓	
(h) Will this be manageable in the future within existing resources?	✓	
(i) Does the use contribute to the public's understanding and appreciation of the refuge's natural or cultural resources, or is the use beneficial to the refuge's natural or cultural resources?	✓	
(j) Can the use be accommodated without impairing existing wildlife-dependent recreational uses or reducing the potential to provide quality (see section 1.6D, 603 FW 1, for description), compatible, wildlife-dependent recreation into the future?	✓	

Where we do not have jurisdiction over the use ("no" to (a)), there is no need to evaluate it further as we cannot control the use. Uses that are illegal, inconsistent with existing policy, or unsafe ("no" to (b), (c), or (d)) may not be found appropriate. If the answer is "no" to any of the other questions above, we will **generally** not allow the use.

If indicated, the refuge manager has consulted with State fish and wildlife agencies. Yes ✓ No ___

When the refuge manager finds the use appropriate based on sound professional judgment, the refuge manager must justify the use in writing on an attached sheet and obtain the refuge supervisor's concurrence.

Based on an overall assessment of these factors, my summary conclusion is that the proposed use is:

Not Appropriate____ **Appropriate** ✓

Refuge Manager: _____ Date: 9/25/2012

If found to be **Not Appropriate**, the refuge supervisor does not need to sign concurrence if the use is a new use.

If an existing use is found **Not Appropriate** outside the CCP process, the refuge supervisor must sign concurrence.

If found to be **Appropriate**, the refuge supervisor must sign concurrence.

Acting Refuge Supervisor: _____ Date: SEP 27 2012

A compatibility determination is required before the use may be allowed.

FWS Form 3-2319
02/06

Attachment 1

Supporting documentation for appropriateness finding based on sound professional judgment for:

Hunting (big-game guiding and outfitting)

Commercial guide services for sport hunting of big-game animals support an existing priority compatible wildlife-dependent public use of Sheldon Refuge. In particular, the services of a licensed hunting guide are often a critical factor when determining the quality of sport-hunting opportunities for animals such as bighorn sheep that inhabit remote and difficult terrain often unfamiliar to sport hunters.

As an economic refuge use, big-game guiding and outfitting is generally authorized by Special Use Permit. Special Use Permits and associated stipulations provide the refuge with an enforceable mechanism that promotes safety and compliance with laws and regulations, minimizes conflict with other visitors, promotes resource stewardship and conservation, provides reliable opportunities to experience wildlife, and uses client satisfaction to help define and evaluate services provided—all of which increase the quality of sport-hunting experiences for the visiting public.

Commercial guides are generally expected to provide specialized services and equipment of equal or greater quality that are often not available to the general public. These specialized services and equipment offer hunting opportunities to a wider segment of the public than would otherwise be provided by the Service, including wilderness and backcountry opportunities and opportunities for hunters with disabilities.

Based upon the findings listed on the preceding form and this attached justification, it is my professional judgment big-game guiding and outfitting contributes the Mission of the Refuge System, does not conflict with the purposes for Sheldon Refuge, and is an appropriate use of Sheldon Refuge.

Sheldon National Wildlife Refuge CCP

FINDING OF APPROPRIATENESS OF A REFUGE USE

Refuge Name: Sheldon National Wildlife Refuge

Use: Recreational Rock Collecting

This form is not required for wildlife-dependent recreational uses, take regulated by the State, or uses already described in a refuge CCP or step-down management plan approved after October 9, 1997.

Decision Criteria:	YES	NO
(a) Do we have jurisdiction over the use?	✓	
(b) Does the use comply with applicable laws and regulations (Federal, State, tribal, and local)?	✓	
(c) Is the use consistent with applicable Executive orders and Department and Service policies?	✓	
(d) Is the use consistent with public safety?	✓	
(e) Is the use consistent with goals and objectives in an approved management plan or other document?	✓	
(f) Has an earlier documented analysis not denied the use or is this the first time the use has been proposed?	✓	
(g) Is the use manageable within available budget and staff?	✓	
(h) Will this be manageable in the future within existing resources?	✓	
(i) Does the use contribute to the public's understanding and appreciation of the refuge's natural or cultural resources, or is the use beneficial to the refuge's natural or cultural resources?		✓
(j) Can the use be accommodated without impairing existing wildlife-dependent recreational uses or reducing the potential to provide quality (see section 1.6D, 603 FW 1, for description), compatible, wildlife-dependent recreation into the future?	✓	

Where we do not have jurisdiction over the use ("no" to (a)), there is no need to evaluate it further as we cannot control the use. Uses that are illegal, inconsistent with existing policy, or unsafe ("no" to (b), (c), or (d)) may not be found appropriate. If the answer is "no" to any of the other questions above, we will generally not allow the use.

If indicated, the refuge manager has consulted with State fish and wildlife agencies. Yes ✓ No ___

When the refuge manager finds the use appropriate based on sound professional judgment, the refuge manager must justify the use in writing on an attached sheet and obtain the refuge supervisor's concurrence.

Based on an overall assessment of these factors, my summary conclusion is that the proposed use is:

Not Appropriate____ **Appropriate** ✓

Refuge Manager: _____ Date: 9/25/2012

If found to be **Not Appropriate**, the refuge supervisor does not need to sign concurrence if the use is a new use.

If an existing use is found **Not Appropriate** outside the CCP process, the refuge supervisor must sign concurrence.

If found to be **Appropriate**, the refuge supervisor must sign concurrence.

Acting Refuge Supervisor: _____ Date: SEP 2 7 2012

A compatibility determination is required before the use may be allowed.

FWS Form 3-2319
02/06

Attachment 1

Supporting documentation for appropriateness finding based on sound professional judgment for:

Rock Collecting

Recreational surface collection of rocks and minerals from what is now Sheldon Refuge is a long-standing and traditional use that pre-dates establishment of Sheldon Refuge, and that has been repeatedly found compatible with the purposes for Sheldon Refuge.

The management of wildlife- and wildlands-oriented recreation activities on refuges is guided by the Public Use Management Policy of the Refuge Manual (8 RM 9). Section 9.5G of this policy specifically addresses the collection of non-renewable resources including minerals, crystals, and rocks and directs that these resources must be protected, but also states such uses may be allowed for scientific collection or investigation and in unusual cases involving renewable crystals. However, Section 9.2 recognizes that there are some unique refuges where non-wildlife-oriented recreation activities have co-existed in harmony with wildlife needs since the refuges were established. Furthermore, on these refuges where traditional forms of non-wildlife oriented activities have taken place for many years and have proven to be compatible with the primary purposes for which the refuges were established, such recognized uses will be incorporated into the Refuge Plan.

After comparing and contrasting the resource benefits from protecting and preserving rocks and minerals commonly collected from Sheldon Refuge, the public recreation benefits from limited surface collection of these rocks and minerals, and the potential for refuge environmental education and interpretation related to these activities and Sheldon Refuge natural history and geology, it is my sound professional judgment the continued surface collection of mineral specimens and small amounts of common rocks and from Sheldon Refuge is an appropriate non-wildlife-dependent public use that does not conflict with the purposes for Sheldon Refuge or other priority wildlife-dependent public uses.

Consistent with public use management policy for the Refuge System, the Sheldon Refuge Comprehensive Conservation Plan and the Compatibility Determination for Recreational Rock Collecting will contain specific, detailed guidance as to how the use will be managed, including stipulations to ensure rock collecting remains compatible with the purposes for Sheldon Refuge and the System Mission.

FINDING OF APPROPRIATENESS OF A REFUGE USE

Refuge Name: Sheldon National Wildlife Refuge

Use: Research, scientific collecting, and survey activities

This form is not required for wildlife-dependent recreational uses, take regulated by the State, or uses already described in a refuge CCP or step-down management plan approved after October 9, 1997.

Decision Criteria:	YES	NO
(a) Do we have jurisdiction over the use?	✓	
(b) Does the use comply with applicable laws and regulations (Federal, State, tribal, and local)?	✓	
(c) Is the use consistent with applicable Executive orders and Department and Service policies?	✓	
(d) Is the use consistent with public safety?	✓	
(e) Is the use consistent with goals and objectives in an approved management plan or other document?	✓	
(f) Has an earlier documented analysis not denied the use or is this the first time the use has been proposed?	✓	
(g) Is the use manageable within available budget and staff?	✓	
(h) Will this be manageable in the future within existing resources?	✓	
(i) Does the use contribute to the public's understanding and appreciation of the refuge's natural or cultural resources, or is the use beneficial to the refuge's natural or cultural resources?	✓	
(j) Can the use be accommodated without impairing existing wildlife-dependent recreational uses or reducing the potential to provide quality (see section 1.6D, 603 FW 1, for description), compatible, wildlife-dependent recreation into the future?	✓	

Where we do not have jurisdiction over the use ("no" to (a)), there is no need to evaluate it further as we cannot control the use. Uses that are illegal, inconsistent with existing policy, or unsafe ("no" to (b), (c), or (d)) may not be found appropriate. If the answer is "no" to any of the other questions above, we will **generally** not allow the use.

If indicated, the refuge manager has consulted with State fish and wildlife agencies. Yes ✓ No ___

When the refuge manager finds the use appropriate based on sound professional judgment, the refuge manager must justify the use in writing on an attached sheet and obtain the refuge supervisor's concurrence.

Based on an overall assessment of these factors, my summary conclusion is that the proposed use is:

Not Appropriate_____ **Appropriate** ✓

Refuge Manager: _____ Date: 9/25/2012

If found to be **Not Appropriate**, the refuge supervisor does not need to sign concurrence if the use is a new use.

If an existing use is found **Not Appropriate** outside the CCP process, the refuge supervisor must sign concurrence.

If found to be **Appropriate**, the refuge supervisor must sign concurrence.

Acting Refuge Supervisor: _____ Date: SEP 27 2012

A compatibility determination is required before the use may be allowed.

FWS Form 3-2319
02/06

Attachment 1

Supporting documentation for Appropriateness finding based on sound professional judgment for:

Research, scientific collecting, and survey activities

Research, scientific collecting, and survey activities conducted within Sheldon Refuge by independent third parties including non-profit organizations, colleges, universities, and consulting companies may have purposes that support objectives and strategies for the management of Sheldon Refuge. With limited resources and budgets, activities conducted by third parties often meet identified but lower project priorities that Sheldon Refuge would not have the staff or funding to complete.

Proposals for research, scientific collecting, and survey activities are reviewed on a case-by-case basis to determine whether the purpose for the activities would benefit Sheldon Refuge and whether the proposed methods and techniques are sound, defensible, and necessary. When conducted in accordance with a refuge Special Use Permit and applicable permit conditions, these activities generally do not conflict with other management activities or wildlife-dependent public uses.

Based upon the findings listed on the preceding form and this attached justification, it is my professional judgment that research, scientific collecting, and survey activities contribute to the Mission of the Refuge System, do not conflict with the purposes for Sheldon Refuge, and are an appropriate use of Sheldon Refuge.

Appendix D. Compatibility Determinations

D. Introduction

Compatibility is a tool refuge managers use to ensure that recreational and other uses do not interfere with wildlife conservation, the primary focus of refuges. Under the Compatibility Policy (603 FW 2), refuge managers are directed to determine if a proposed or existing refuge use is compatible with refuge purposes and the National Wildlife Refuge System mission. Refuge uses are defined as recreational or economic/commercial or management use of the refuge by the public or a non-Refuge System entity. The Service does not, however, prepare compatibility determinations for uses when the Service does not have jurisdiction. Compatibility determinations are re-evaluated concurrently with the preparation of a comprehensive conservation plan (CCP) and are required to be in writing. The Service is also required to provide the public with an opportunity for review and comment on compatibility determinations. The purpose of this appendix is to meet these requirements.

The Service recognizes that compatibility determinations are complex. For this reason, refuge managers are required to consider principles of sound fish and wildlife management and best available science in making these determinations. If an existing use is not compatible, the refuge manager is directed to modify the use to make it compatible or terminate it, as expeditiously as practicable.

Compatibility Determinations Evaluated at This Time

This set of compatibility determinations evaluates uses projected to occur under the CCP for Sheldon Refuge. The evaluation of funds needed for management and implementation of each use also assumes implementation as described under the plan. Compatibility determinations are based on the professional judgment of refuge personnel, including observations of existing refuge uses.

Refuge Use	Compatible	Page
Wildlife Observation, Wildlife Photography, Environmental Education, and Interpretation	Yes	D-3
Sport Fishing	Yes	D-25
Sport Hunting	Yes	D-43
Guiding	Yes	D-69
Rock Collecting	Yes	D-91
Research	Yes	D-109

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D.1 Compatibility Determination for Wildlife Observation, Wildlife Photography, Environmental Education, and Interpretation on Sheldon National Wildlife Refuge

Use(s): Wildlife observation, wildlife photography, environmental education, and interpretation

Supporting Uses: Temporary viewing blinds, camping, boating, hiking, backpacking, horseback riding, and off-highway vehicle (OHV) use

Refuge Name: Sheldon National Wildlife Refuge

City/County and State: Washoe County, Nevada; Humboldt County, Nevada; Lake County, Oregon

Establishing and Acquisition Authority(ies):

What is today known as the Sheldon National Wildlife Refuge was initially established by Executive Order 5540 dated January 26, 1931, and later enlarged by Executive Order 7364 dated May 6, 1936, and Executive Order 7522 dated December 21, 1936.

The authorities for nearly all Federal lands within Sheldon Refuge are the Migratory Bird Conservation Act of 1929, as amended (16 U.S.C. 715-715r) and the National Wildlife Administration Act of 1966, as amended (16 U.S.C. 668dd-668ee). A small portion of Sheldon Refuge was acquired under the authority of the Endangered Species Act of 1973, as amended (16 U.S.C. 1231-1544).

Refuge Purpose(s):

> "…as a refuge and breeding ground for wild animals and birds…" Executive Order 5540 dated January 26, 1931.
>
> "… set apart for the conservation and development of natural wildlife resources and for the protection and improvement of public grazing lands and natural forage resources…" Executive Order 7522 dated December 21, 1936.
>
> "… to conserve (A) fish or wildlife which are listed as endangered species or threatened species… or (B) plants…" 16 U.S.C. § 1534 (Endangered Species Act of 1973)
>
> "… for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." 16 U.S.C. § 715d (Migratory Bird Conservation Act)

Consistent with Service Policy (601 FW 2), proposed wilderness areas are to be managed as designated wilderness. The Wilderness Act of 1964 creates additional purposes within and supplemental to other refuge purposes. Proposed wilderness areas are to be managed for the purposes of securing an enduring resource of wilderness, protecting and preserving wilderness character, and providing opportunities for public use and enjoyment and for "solitude or a primitive and unconfined type of recreation" in ways that will leave the wilderness unimpaired for future use and enjoyment as wilderness.

National Wildlife Refuge System Mission:

> "The mission of the [National Wildlife Refuge] System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans" (National Wildlife Refuge System Administration Act of 1966, as amended [16 U.S.C. 668dd-668ee]).

Description of Use(s):

Wildlife observation, wildlife photography, environmental education, and interpretation occur throughout Sheldon Refuge but are concentrated along highways, improved roads, and unimproved vehicle routes.

While precise visitation and participation are unknown, certain locations, such as the Virgin Valley Campground, are popular and consistently used throughout the summer months. Wildlife photography and wildlife observation within Sheldon Refuge are most often conducted in conjunction with other activities and by motorists and tourists passing through Sheldon Refuge. The number of people who visit Sheldon Refuge specifically to observe and photograph wildlife is estimated to be smaller than the number of people fishing, hunting, or participating in non-wildlife-dependent uses such as rock collecting.

Wildlife Viewing and Photography

Sheldon Refuge has no facilities managed and maintained specifically for these activities other than a few unimproved areas posted as places to view wildlife. Wildlife viewers and photographers are free to roam Sheldon Refuge and use personally provided temporary blinds. There are no available data to estimate the number of visitors participating in wildlife viewing and photography, but most people likely participate in these activities while visiting Sheldon Refuge. Generally, the majority of visitors in the spring are engaged in wildlife viewing and camping as well as rock collecting. Parts of Sheldon Refuge are very remote, and access is limited by the terrain and adverse seasonal conditions. This wilderness character is an important part of Sheldon Refuge's attractiveness for wildlife viewing and photography.

Of particular interest is the viewing and photographing of Greater sage-grouse when concentrated at lek locations to display their annual mating dances. This activity is becoming increasingly popular, both with amateur and professional photographers. High-quality full-frame photographs, even when using telephoto camera lenses, are only possible from relatively close distances due to early morning low light conditions and vegetation. Professional photographers currently use Sheldon Refuge and are required to obtain a Special Use Permit.

Refuge-specific regulations that apply to the use of temporary hunting blinds specifically apply to sport fishing and sport hunting, but are interpreted as applying to other compatible wildlife-dependent public uses as well. Consistent with 50 Code of Federal Regulations (CFR) 32.47, temporary ground blinds are considered a compatible supporting activity when consistent with the stipulations listed at the end of this compatibility determination. The location and number of blinds are controlled through refuge Special Use Permits issued on a first-come, first-served basis. Other secondary uses of Sheldon Refuge that support wildlife observation and wildlife photography include

hiking, horseback riding, boating, and vehicle use on designated access routes. Overnight camping in support of the use occurs at all 13 designated campgrounds and by permit in backcountry areas.

Environmental Education and Interpretation

The environmental education and interpretation program at Sheldon Refuge is minimal, with most interpretation conducted opportunistically during visitor contact or through printed materials, kiosk information and displays, and signs at various locations associated with refuge entrance points and campgrounds. Sheldon Refuge Complex also maintains a website (http://www.fws.gov/sheldonhartmtn) where current information can be obtained at any time.

The remoteness of Sheldon Refuge does not lend itself to many opportunities for environmental education in a traditional format where school children are presented programs on-site. The majority of hosted environmental education and interpretation activities are conducted primarily by the Refuge Manager and volunteers at the Sheldon Refuge Office (Dufurrena) and the Virgin Valley Campground. Environmental education and interpretation is provided through wildlife viewing tours hosted by refuge staff twice a year, in the spring and fall, and by volunteer groups. Tours are available on request to the staff; however, refuge staffing is extremely limited and there is no visitor contact station or regular staffing at the Sheldon Refuge Office.

As part of the Sheldon Refuge CCP management direction, several visitor facilities will be constructed or enhanced to increase environmental education, interpretation, and participation in wildlife viewing and photography. These facilities include a larger visitor contact facility along Highway 140, an interpretive hiking trail at Kinney Camp (McKinney Ranch), a designated wildlife viewing auto tour route with roadside pullouts and interpretive signs, and a wildlife observation deck. These facilities will be more noticeable and accessible to people traveling Highway 140, and as a result we anticipate visitation to Sheldon Refuge will increase by approximately 500 visitors per year.

Supporting Uses:

Camping

Camping itself is not a priority public use on Service lands, but because of the size, remoteness, and quality of roads within Sheldon Refuge, it is important in supporting priority uses including fishing, hunting, wildlife observation, and wildlife photography. There are four types of camping opportunities currently provided within Sheldon Refuge: developed, semi-primitive, primitive, and backcountry/wilderness.

Camping within Sheldon Refuge is allowed in 13 designated campgrounds and by Refuge Special Use Permit for backcountry camping.

Developed Camping: Virgin Valley Campground located at Dufurrena is considered the only developed campground. Virgin Valley Campground is easily accessible year-round for all types of vehicles, including recreational vehicles (RVs), and it offers shade trees, potable water, two vault toilets, 16 picnic tables, 24 fire rings, a meat-hanging pole, a bath-house, and a hot spring developed for swimming. Campground use is managed on a first-come, first-served basis without fees or designated sites. From 2005 through 2007 an average of 18 campsites were occupied per day during

the days surveyed, for a seasonal average of 6,573 visitor use days (U.S. Fish and Wildlife Service [USFWS] undated report).

From mid-August through mid-November, the Virgin Valley Campground is heavily used by hunters. During peak seasons, overcrowding and user conflicts have been a concern, as has overflow into upland areas adjacent to the campground, which can result in further environmental damage. There is also a private developed campground at the Royal Peacock Mine located in the Virgin Valley Mining District, which has RV hookups.

Semi-primitive Camping: Five campgrounds (Catnip Reservoir, West Rock Spring, Fish Spring, Badger, and Big Spring Reservoir) are considered semi-primitive and include outhouses, fire rings, meat-hanging poles, and in the case of Fish Spring and Badger campgrounds, horse corrals. These semi-primitive campgrounds are accessible from primary roads or improved secondary roads suitable for most types of vehicles and are primarily used by hunters. Sport anglers also use campgrounds at Catnip and Big Spring reservoirs.

Additional facilities such as campsite amenities (i.e., picnic tables and accessible fire rings or barbeque grills), potable water, shade structures, kiosks, and dedicated volunteer sites are planned for Virgin Valley, Catnip Reservoir, and Big Spring Reservoir campgrounds. These facilities will provide developed camping opportunities that are not commonly available within Sheldon Refuge or the region. However, these improved facilities will only be sustainable over the long term through campsite fees to support volunteers, maintenance, and replacement.

The Service will also allow public overnight use of some existing historic structures within Sheldon Refuge. The most likely structures are the Little Sheldon Overnight Cabin and Badger Cabin.

Primitive Camping: Seven campgrounds (Little Catnip Spring, Gooch Spring, North Hell Creek, Wheeler Spring, Bateman Spring, Devaney, and East Rock Spring) are considered primitive campgrounds and have only fire rings or no improvements, are remote, and are accessible to four-wheel drive or high-clearance vehicles when road conditions are passable. These primitive campgrounds receive intermittent and low amounts of use, occurring mostly during the big-game hunting seasons (early August through October). All of these campgrounds are located immediately adjacent to, or include, wet meadows, spring, or springbrook habitats. Three primitive campgrounds (Wheeler Spring, Devaney, and East Rock Spring) also include aspen woodland habitats. Impacts associated with primitive campgrounds were identified as an issue during the Sheldon CCP planning process. The impacts identified and stipulations for reducing or eliminating those impacts are addressed in subsequent sections of this compatibility determination.

Backcountry/Wilderness Camping: Backcountry camping for up to 14 days is allowed by Refuge permit. Permits are not limited, but do stipulate visitors must camp at least 0.5 mile from open roads and at least 100 yards from water sources. The majority of backcountry camping permits are issued to hunters, but the amount of use is low and no adverse impacts have been observed. Backcountry use will continue to be monitored, and future management actions to reduce or eliminate any impacts will be implemented as necessary.

Public Access

Public access to areas within Sheldon Refuge is provided by a network of vehicle roads and informal backcountry routes and trails. Roads include one two-lane paved highway, maintained gravel roads,

and numerous primitive and unmaintained dirt roads. Trails throughout the refuge backcountry and wilderness areas are primarily abandoned vehicle routes historically used for access to livestock developments and private inholdings later purchased by the Service.

The most substantial changes to wildlife viewing and photography are expected to result from the relocation and enlargement of the Refuge visitor contact station, improvement of campground facilities, and improved signing of routes open to vehicle use. Improved gravel roads within Sheldon Refuge will be maintained more frequently, and all routes open to the public use of vehicles will be adequately signed and marked. Visitors will be required to register all OHVs consistent with State of Nevada regulation or with Sheldon Refuge for use on refuge roads and routes designated open to vehicle use. These actions are intended to improve the quality of the transportation system and deter vehicle violations while requiring only minimal law enforcement presence.

Maintained Public Roads: In preparation of the Sheldon Refuge CCP, each route within the refuge was evaluated to assess impacts to fish, wildlife, plants, and their habitats, as well as benefits for public use and recreation opportunity. Following this evaluation, 300 miles of existing roads (including State Highway 140 and all maintained county roads) were designated for public vehicle use. The Service has determined the continued use and maintenance of these designated roads, including actions for re-routing or modification as presented in the Sheldon Refuge CCP, will have minimal or no impacts to wildlife and wildlife habitat and/or are subject to existing right-of-way. The unimproved roads within Sheldon Refuge are not regularly maintained, but are repaired on a site-by-site basis to keep them in usable condition or to prevent undue resource damage (i.e., excessive erosion).

Trails and Backcountry Access: Hiking, horseback riding, use of pack stock, and other non-mechanical modes of access are allowed on trails, routes, and other areas of Sheldon Refuge open to the public. All vehicle use is restricted to designated open roads. Existing trails throughout Sheldon Refuge will remain, but will not be marked or maintained for public use. No adverse impacts have been observed from visitors using these routes for hiking, horseback riding, or use of pack stock.

Horseback Riding and Pack Stock Use: Horseback riding has been allowed as a recreation activity within Sheldon Refuge for many years. However, it is estimated that fewer than 10 horseback visitors use Sheldon Refuge each year, and as a result, horseback riding is considered a low-impact activity. Horseback riding gives the public an opportunity to visit remote and undeveloped portions of Sheldon Refuge, and to enjoy the wildlife viewing, solitude, and expansive views that Sheldon Refuge is known for.

There is a concern that the number of visitors engaging in horseback riding may increase, particularly with hunting guides and their clients, and that use of horses and pack stock within the Refuge could introduce invasive non-native plants. These impacts have not been observed, but monitoring will continue, and the Service will take additional action as needed to maintain wilderness character and prevent the introduction of weeds to Sheldon Refuge.

The corrals at Badger and Fish Spring campgrounds are the only facilities that specifically support horseback riding and the use of pack stock.

Boating: Refuge-specific regulations that apply to the use of non-motorized boats and boats with electric motors specifically apply to sport fishing and sport hunting, but are interpreted as applying to other compatible wildlife-dependent public uses as well. In particular, the use of non-motorized

boats and boats with electric motors in Big Spring Reservoir, Catnip Reservoir, and Dufurrena Ponds consistent with 50 CFR 32.47 is considered a compatible activity that supports wildlife observation and wildlife photography.

Availability of Resources:

Administration and management of wildlife observation and photography include information kiosks at Sheldon Refuge entrances; Sheldon Refuge websites, brochures, and leaflets; and certain Special Use Permits. Maintenance of the campgrounds, access roads, and other supporting facilities and routine law enforcement patrols are also conducted by Sheldon Refuge.

As part of the CCP's implementation, a visitor facility will be constructed, staffed, and maintained. This facility represents the majority of costs associated with the environmental education and interpretation program. The visitor contact facility will be constructed when necessary funding and staffing become available.

Category and Itemization	One-time	Annual
Administration and management (volunteer host site development, volunteer campground hosts, law enforcement patrols, backcountry use permits, fee collection and processing, administration and staffing of the visitor contact facility)	$15,000	$70,000
Maintenance (trails, signs, and visitor contact facility)	$15,000	$10,000-$15,000
Monitoring	$500	$500
Special equipment, facilities, or improvements (visitor contact facility, campgrounds and access roads)	$3,000,000	$500-$1,500
Offsetting revenues[1]	$5,500	$5,500

These facilities are analyzed in the Sheldon Refuge CCP and submitted as funding needs under a variety of appropriate funding sources (e.g., deferred maintenance, construction, refuge roads, visitor facility enhancements).

Increased staffing, funding, volunteer assistance, strengthened existing partnerships, and new partnerships will be sought to support these programs in an effective, safe, and compatible manner. Refuge staff will continue volunteer recruiting efforts as needed to ensure assistance is available to provide basic visitor information and maintenance of public use facilities. Volunteers, interns, and various user groups when provided appropriate training can assist Sheldon Refuge with monitoring,

[1] Anticipated campsite fee revenues as proposed in the CCP are based on $5/site/day for 1,100 site-use days.

education, and interpretation programs, and maintenance projects. With additional assistance as described above, staffing and funding is expected to be sufficient to manage these uses.

Anticipated Impacts of the Use(s):

Effects from Wildlife Observation and Wildlife Photography

Wildlife observation and photography within Sheldon Refuge are supported by 13 primitive, semi-primitive, and developed campgrounds. The 13 campgrounds are located near water and partially within riparian habitats and several prehistoric cultural sites. While the majority of impacts occurred following the initial establishment of these campgrounds, some impacts continue due to ongoing soil disturbance and compaction within existing campsites, occasional use of previously unused areas adjacent to the campgrounds, and vehicle use outside designated areas. It is anticipated actions to relocate campgrounds to alternative sites, protect sensitive habitats at each of these campgrounds, and confine use to designated campsites in heavily used campgrounds will mitigate or avoid additional impacts altogether. Effects from camping are described in subsequent sections of this compatibility determination.

Wildlife observation and photography activities have both direct and indirect impacts on wildlife distribution, behavior, and habitats. The most frequent impacts are disturbances to large birds and mammals from people approaching too close and from vehicle presence. These impacts are most severe during periods of mating, nesting, lambing, and fawning. However, because people participating in wildlife observation and photography generally do not venture far from roads and campgrounds, impacts from these visitors are only a portion of the overall wildlife disturbance.

One exception is the potential for disturbance of Greater sage-grouse from viewing and photography activities during the mating display. Greater sage-grouse return to specific lek locations each spring to perform mating displays, and public use activities at these sites can disrupt mating behavior and possibly cause one or more birds to abandon the lek. To minimize adverse effects and still provide high-quality wildlife viewing and photography opportunities, use near active leks will be controlled through Special Use Permit stipulations (see stipulations section).

Access for wildlife observation and photography is provided by approximately 300 miles of motorized vehicle routes and several established routes and trails in the refuge backcountry. Roads and vehicle use can cause a number of impacts to soils, water, habitat, fish, and wildlife. Vehicle use is allowed on routes within the refuge where these impacts are anticipated to be minimal, or where planned management actions such as re-routing, realignment, and seasonal closures will acceptably minimize impacts. Route segments identified for re-routing, realignment, or other action were identified in the Sheldon Refuge CCP's management direction. Effects from vehicle use are described in subsequent sections of this compatibility determination.

Effects from Environmental Education and Interpretation

Impacts related to environmental education and interpretation will primarily be associated with the planned visitor contact facility along Highway 140. This facility will require that approximately 3 to 5 acres of wildlife habitat be eliminated or permanently impacted through construction and facility maintenance. Large wildlife within the area of the visitor contact facility will likely be displaced by construction and increased use of the area by visitors. Construction of new visitor facilities will result in a small permanent loss of habitat in site-specific areas, which will represent a moderate to

major, long-term, adverse impact to plant communities located within construction areas; however, the impact will be negligible at the refuge scale because the area of lost habitat will represent an extremely small percentage of Sheldon Refuge lands and will not impact sensitive or rare habitats. Site-specific adverse impacts to individual or small populations of wildlife species will be likely to occur during construction activities and continue due to visitor and staff use of the facilities in the long term; these direct impacts will be minor and will not be likely to affect the health or diversity of wildlife species or communities on Sheldon Refuge. New facilities intended for wildlife observation and photography may result in long-term, adverse impacts to some species by affecting wildlife behavior. These impacts will likely be similar to the temporary construction impacts previously described. Beneficial impacts may occur as well because many of the new facilities will include educational or interpretive components that will increase public awareness and educate visitors about Sheldon Refuge resources, including wildlife and their habitats. This could possibly result in minor, long-term, indirect, impacts to vegetation and wildlife as visitor appreciation of the importance of Sheldon Refuge habitats and wildlife increases and behaviors are subsequently adjusted to reflect this knowledge.

Monitoring of public use in identified sensitive wildlife habitats (i.e., Thousand Creek Gorge) will be used to determine if impacts from wildlife observation and photography could impact the health, vigor, or productivity of fish, wildlife, or their habitats in these areas. If such potential for impact is identified, Sheldon Refuge will increase public interpretation and education regarding those impacts and/or close the areas to public use for critical periods or longer if necessary. If impacts from public use in general are documented, access for wildlife observation and photography will receive priority over non-wildlife-dependent public uses.

Effects from Camping and Campgrounds

Use of campgrounds within Sheldon Refuge causes impacts to vegetation, soils, water quality, and cultural resources. During dry conditions, carelessness with campfires can lead to wildfires. Management and development of campgrounds is also expected to affect the type and quality of recreation opportunities available.

Impacts to Vegetation, Soils, and Water Quality: Campgrounds and their use within the refuge range from primitive sites with relatively low and only intermittent use to very developed sites with year-round and relatively high amount of use during summer months. Current impacts and expected future impacts associated with use and development of these campgrounds also vary widely. Because the most primitive campgrounds are currently the least impacted, we can expect that these sites will exhibit the greatest amount of additional or potential impact with only slightly more use. Conversely, most impacts have already occurred at the most heavily used and developed campgrounds, and we can expect very little additional impact to vegetation, soils, or water quality even with relatively large increases in use at these campgrounds.

The greatest difference in durability between vegetation types occurs at moderately low use levels (Cole 1985). Sites that are used frequently are likely to be highly impacted regardless of their fragility. Because vegetation loss usually occurs more rapidly than loss of organic soil horizons, sites with either no vegetation or resistant vegetation (e.g., grasses as opposed to forbs) recover more quickly and are less likely to be impacted by low levels of use, while sites with thick organic soil horizons are less susceptible to erosion and are more likely to withstand high amounts of use.

Experimental studies suggest that there is an important difference between a site's resistance (its ability to tolerate use without being damaged) and its resilience (its ability to recover from damage). Cole (1995) has shown, for groundcover plants, that resistance decreases with erectness and that broad-leaved herbs are typically less resistant than grass-like plants and shrubs. Low shrubs, such as heather, are relatively resistant to trampling stress but their resilience is low. Once damaged, they recover slowly. Grass-like plants are most tolerant of trampling (Cole 1989). The compaction of soils from campsite use reduces water infiltration and water holding capacity, which leads to increased runoff and erosion potential (Cole 2004; Monti and Mackintosh 1979). Impacts associated with use at primitive campgrounds can be readily observed and tend to occur rapidly, but these impacts are relatively inconsequential when considered in the context of the entire refuge. Impacts associated with campgrounds located within riparian areas or near water sources are of greater concern, but current impacts are not severe and vegetation, soils, and water quality at primitive campgrounds are expected to recover noticeably within a few years following campground relocation. This assessment is supported by Cole (1981) who noted that hiking and camping impacts on soil and vegetation, while severe when measured at small scales, are minimal at large spatial scales. This suggests that while recreation impacts can be serious for individual plants and animals and perhaps localized rare populations, they are generally of little significance to landscape integrity or regional biotic diversity. Moreover, unless much of a population is impacted by a single affected site, the intensity, size, and distribution of impacts are not relevant to the significance of impacts assessed at large spatial scales (Cole 1989).

Virgin Valley Campground is located at a site previously developed and used by the Civilian Conservation Corps in the late 1930s. Catnip Reservoir and Big Spring Reservoir campgrounds are located immediately adjacent to artificial reservoirs. These three campgrounds receive the greatest amounts of use and exhibit the greatest amount of impact. The core areas of use at these campgrounds no longer support vegetation or vegetation diversity is substantially reduced, water infiltration is considered low due to soil compaction, and gravel has been placed in some areas to reduce erosion and rutting from vehicles. Non-native plants and animals in and around these three campgrounds were likely introduced by early ranching and development activities rather than campground visitors. Monitoring and control efforts will continue to detect and remove or eradicate small or new populations of invasive species.

The remaining 10 campgrounds are all located immediately adjacent to or include aspen woodland, wet meadows, spring, and/or springbrook habitats. Most of these campgrounds have moderate amounts of vegetation loss and soil compaction, which is limited to parking areas, areas around fire rings, outhouses, and along connecting paths. These impacts are generally not continuous throughout the campground and are expected to remain stable with current amounts of intermittent use, which occurs during late summer and fall after most annual and biannual plants have finished growing for the season and when soils are typically drier and more resistant to impact. Some primitive campgrounds have no visible bare ground, and where located in meadow habitats, vegetation is generally able to recover from the current amount of use. Some primitive campgrounds exhibit small areas of bare ground, generally a lack forbs, which are not resistant to trampling, and in the case of Wheeler Spring, Devaney, and East Rock Springs, exhibit some impacts to aspen trees from trampling, soil compaction, root exposure, and cutting. Because these campgrounds receive little visitation or are located near frequently traveled gravel roads, impacts to wildlife from campground use are estimated to be minor or negligible. Due to the nature of these impacts and relatively low amount of use, we anticipate these campgrounds will exhibit the greatest natural recovery compared to the three more developed and heavily used campgrounds if camping use were eliminated, but they will also exhibit the greatest amount of additional impact if camping use were to substantially

increase. Aspen stands associated with the Devaney, Wheeler Spring, and East Rock Springs campgrounds are also expected to recover, but regeneration of the understory shrubs and younger trees will occur slowly and will likely require some active restoration and/or replanting.

Up to nine semi-primitive and primitive campgrounds will be relocated away from sensitive riparian habitats and areas with cultural resources. It is anticipated actions to relocate campgrounds to alternative sites, protect sensitive habitats at each of these campgrounds, and confine use to designated campsites in heavily used campgrounds will minimize or avoid additional impacts altogether.

We expect some primitive campgrounds to be consolidated with other existing campgrounds, which will need to be enlarged and have additional campsites constructed (the most likely candidates for enlargement include Catnip Reservoir, Big Spring Reservoir, Fish Spring, and West Rock Spring campgrounds). Consolidation will result in additional impacts from increased use of existing facilities and campsites and from designation and construction within existing campgrounds. Where camping already occurs, increased use of existing campsites and facilities is expected to have little or no measurable impact to vegetation or wildlife. Impacts to expanded portions of these campgrounds are expected to occur quickly as vegetation is trampled and soil compacted within the first two or three seasons of use, but then stabilize over the long term. We expect enlargement of existing campgrounds will result in minor, site-specific, long-term, direct adverse impacts to plants and their habitats from removal of vegetation, soil compaction, and loss of organic soil horizon at these sites.

Impacts from Wildfire: Campfires are allowed at designated campgrounds but are occasionally prohibited during periods of high fire danger. Wildfires have been started by refuge visitors in the past and we expect some wildfires will occasionally start as a result of escaped campfires or misuse of stoves. Seasonal campfire restrictions and rapid fire suppression response will continue to minimize impacts.

Impacts to Cultural Resources: Most of the 13 designated campgrounds are located within or adjacent to prehistoric cultural sites. While the majority of impacts occurred following the initial establishment and use of these campgrounds, some impacts continue due to ongoing soil disturbance and compaction within existing campsites, trampling and removal of vegetation, occasional use of previously unused areas adjacent to the campgrounds, and vehicle use outside designated areas. Limited fee use of the Little Sheldon Overnight Cabin or Badger Cabin is expected to increase public appreciation for historic resources and understanding for their protection and preservation. In addition, the use of these sites and the collection of fees will provide justification and funding for restoration work and continued maintenance. As a result, the integrity of sites eligible for the National Register of Historic Places will be protected. Therefore, we anticipate use of these facilities to support wildlife photography and observation will have a major, long-term, beneficial impact on cultural resources.

Impacts to Recreation Opportunity: Campsite registration, overnight fees, and the other improvements planned for the developed campgrounds will increase maintenance, increase visitor compliance with rules and regulations (by defining and designating campsites), and decrease competition for campsites. Campground management strategies are expected to result in moderate, indirect, long-term, beneficial impacts to the camping experience, in support of providing quality opportunities for wildlife-dependent recreation.

Effects from Public Access

Adverse impacts are expected to continue as a result of the network of developed and undeveloped roads throughout Sheldon Refuge and their associated maintenance. Road development and use continues to adversely impact the biological integrity within Sheldon Refuge by contributing to the altered composition of plant communities, soil disturbance (Eckert et al. 1979; Iverson et al. 1981; Switalski et al. 2004), altered hydrology and stream sedimentation (Forman and Alexander 1998), facilitation of the spread of invasive vegetation, changes in the natural fire regimes, and habitat fragmentation.

Many direct effects are obvious during construction, but other effects are permanent and can extend substantially beyond the actual road surface (road-effect zone; Forman 2000; Forman and Alexander 1998). At the landscape scale, major ecological impacts of a road network include fragmentation, the disruption of landscape processes, and loss of biodiversity. Biodiversity declines as the road network impacts interior species (species cut off by roads), species with large home ranges, stream and wetland species, and rare native species (Forman and Alexander 1998). Fragmentation of previously extensive landscapes can influence the distribution and abundance of a host of wildlife species through redistribution of habitat types and through the pattern of habitat fragmentation, including characteristics such as decreased patch area and increased habitat edge (Vander Haegen et al. 2000).

Roads (including OHV trails) are commonly identified as important correlates or indicators of loss of ecological health and affect terrestrial and aquatic ecosystems in several general ways: 1) increased mortality from road construction; 2) increased mortality from collision with vehicles; 3) modification of animal behavior; 4) alteration of physical environment; 5) alteration of chemical environment; 6) spread of exotic species; and 7) increased alteration and use of habitats by humans (Trombulak and Frissell 2000; Wildlife Action Plan Team 2006).

The ecological effect of road avoidance is likely related to traffic density and speed of travel, as well as traffic noise levels (Forman and Alexander 1998). Road-effect zones generally result in lower breeding densities and reduced species richness; species demonstrated to avoid or be negatively impacted by roads include arthropods, reptiles, small mammals, ungulates, and forest and grassland birds (Andrews and Gibbons 2005; Carr and Fahrig 2001; Forman and Alexander 1998; McGrann et al. 2006; Rost and Bailey 1979). For example, proximity to OHV trails (<1,000 meters [3,280 feet]) was found to have a direct correlation with reduced-quality habitat for nesting songbirds in sagebrush-steppe habitats, including nest desertion, nest predation, and abandonment (Barton and Holmes 2007). Behavioral disturbance from recreation, including that associated with trails and roads, may also have both immediate and long-term effects on wildlife (Taylor and Knight 2003). In one study of pronghorn, deer, and bison, individuals exhibited a 70% probability of flushing within 1,000 meters (3,280 feet) on either side of a trail used by hikers and mountain bikers (Taylor and Knight 2003); presumably, responses are similar in the presence of vehicles such as OHVs. Road density can be used as an overall index to average patterns over an area. For example, road densities of approximately 1.0 mile per square mile have been recommended as the maximum for a naturally functioning landscape containing sustained populations of large predators (Forman and Alexander 1998). However, the effects of road density are likely sensitive to road width or type, traffic density, network connectivity, and the frequency of spur roads into remote areas (Forman and Alexander 1998).

Within Sheldon Refuge, more than 50 introduced, non-native, and often noxious plant species have been documented (refer to Sheldon Refuge CCP Appendix B). Invasive plants typically need transportation to spread to new areas (Trombulak and Frissell 2000), and within Sheldon Refuge several methods are possible, including vehicles, people, wild and domestic animals, and firefighting

equipment. Indeed, it has been demonstrated that habitats distant from roads may provide important refuge for native grassland species, and that this effect may be even more pronounced in predominately intact landscapes such as those in parts of the Great Basin (Gelbard and Harrison 2003). Human access and disturbance effects on remote areas tend to increase with higher road densities, as well as human-caused fire ignitions (Forman and Alexander 1998).

Various methods, including systematic inventory and monitoring for invasive plants, mowing, use of herbicides, and elimination of grading road shoulders, will be used to detect new infestations, control and contain existing infestations, and treat up to 1,000 acres per year. Management strategies to combat invasive plants support the Service policy for biological integrity and diversity within Sheldon Refuge. With a more systematic approach for inventory of noxious weeds and other invasive plants, populations are more likely to be detected when they are small and more easily managed and controlled. Increased treatment and reduced soil disturbance along road corridors should reduce the spread of invasive plants already present and reduce the potential for new populations. As a result, we anticipate these actions will result in major, long-term, direct, beneficial impacts to all habitats. Implementing treatment strategies (e.g., mechanical removal of vegetation, application of herbicides) will likely eliminate or prevent the spread of noxious weed populations when detected and provide some conservation of native habitats, resulting in minor, site-specific, short-term, direct, beneficial impacts to habitat on approximately 1,000 acres per year.

In conjunction with preparation of the Sheldon Refuge CCP, Refuge staff conducted an evaluation of existing routes and trails and identified known and potential resource impacts and public benefits and recreation opportunities associated with vehicle access. Route segments that were identified as causing substantial impacts to soils, riparian areas, and/or wildlife, were redundant with other routes, or provided very little or no access for wildlife-dependent uses were not identified for designation as open roads for public use of vehicles. To minimize or avoid lesser impacts from roads and vehicle use, the Service will implement a number of transportation management strategies including designating roads that are not duplicative, re-routing or realigning road segments that pass through sensitive resource areas, installing erosion control structures, increasing monitoring and treatment of weeds along road corridors, and posting signs marking all designated open roads. These actions will result in long-term, minor, direct and indirect, beneficial impacts to soils by decreasing erosion in sensitive areas that are currently affected. Overall we expect impacts from road management to be minor, direct, and adverse to habitats on a localized and long-term basis.

Management of wildlife observation, wildlife photography, environmental education, and interpretation supports Service policy by providing various opportunities for primitive and unconfined types of recreation throughout Sheldon Refuge. Hiking, horseback riding, and vehicle access are secondary uses that support wildlife-dependent recreational activities within Sheldon Refuge. Sheldon Refuge allows access on foot, by horseback, or by vehicle. However, all vehicle routes are open to both motorized and non-motorized vehicles, and there are no areas managed for non-motorized vehicle access (i.e., mountain bikes or game carts) or semi-primitive non-motorized recreation opportunity. In areas open to vehicle use we assume impacts to non-motorized vehicle users are asymmetrical (Webber 1995) and occur from conflict, noise, dust, competition with motorized users for recreation opportunity, and displacement to non-motorized areas outside the refuge (Adelman et al. 1982; Gambill 1996; Manning and Valliere 2002; Moore 1994; Stokowski and LaPointe 2000). The somewhat narrow range of vehicle access for non-motorized users provided within the refuge represents a direct, adverse, moderate, long-term impact to quality recreation opportunities.

Effects from Horseback Riding and Use of Pack Stock

Because the number of visitors who ride horseback or use pack stock within Sheldon Refuge is estimated to be less than 10 per year and because little impact has been observed from such use, we expect future impacts from trampling and introduction of non-native weeds will also be low and less than similar impacts associated with overnight camping and vehicle use. Stock use areas at Badger and Fish Spring campgrounds will continue to be monitored, particularly for new populations of non-native plants, and additional action such as requiring certified weed-free feed and weed removal will be implemented as necessary.

Effects from Boating

The use of non-motorized or electric-powered boats is allowed only in Big Spring Reservoir, Catnip Reservoir, and the Dufurrena Ponds, consistent with 50 CFR 32.47. The majority of boating occurs in conjunction with sport fishing, and while migratory bird hunting is not allowed on these waters, occasional and intermittent boating does occur in conjunction with other hunting, wildlife observation, wildlife photography, environmental education, interpretation, research, scientific collecting, and surveys. The amount of boating that occurs within Sheldon Refuge has not been quantified, but is considered low based upon angler participation and incidental observation by staff and volunteers. Boating generally occurs during summer months following the waterfowl nesting season (when the potential for bird disturbance or displacement impacts will be greatest) and following the beginning of trout fishing season, when there are higher water temperatures at Dufurrena Ponds, which provide better fishing success. Requirements for use of non-motorized boats or boats with electric motors will eliminate the potential for water pollution associated with use of outboard motors and will maintain opportunities for visitor solitude. Overall, the amount of boating associated with wildlife-dependent public uses is considered low, and adverse impacts are estimated to be short-term, intermittent, and negligible.

Economic Effects

Wildlife observation and wildlife photography are the most common wildlife-dependent recreational activities taking place on Sheldon Refuge, resulting in an estimated 17,900 annual visits. As a result, expenditures associated with wildlife observation and photography are the largest contributor to gross state product (GSP) of the wildlife-dependent recreational activities assessed, contributing $2.47 million to GSP (30%). Expenditures associated with camping have not been expressly quantified but are expected to largely overlap with other wildlife observation and photography expenditures (Industrial Economics 2010).

As additional opportunities for wildlife observation, wildlife photography, environmental interpretation, and education are provided through the projects and programs planned for Sheldon Refuge, we expect visitation related to wildlife viewing and overall visitation to Sheldon Refuge will increase over the next 15 years. This increase in visitation is an assumed result primarily because of the construction of the new visitor contact station, but it is also expected to result from numerous other planned improvements to refuge facilities. Specifically, visitation is assumed to increase by 5,000 visitors over the course of the 15-year planning period. With this increase, we expect wildlife observation, photography, environmental education, and interpretation at Sheldon Refuge to contribute $2.93 million annually to GSP by the end of this 15-year time period (Industrial Economics 2010).

Effects to Wilderness Character

Naturalness: Approximately 300 miles of existing vehicle routes will remain visible, and their designation for motorized use is not expected to result in any short-term impacts to naturalness. Over the long term, as public use continues to increase, we expect that there will be a need for additional signs, road maintenance, and other developments to ensure compatibility. Increased visitation to these areas will also increase the potential for introduction and spread of weeds and for the disturbance and displacement of wildlife.

Weed treatments occurring on approximately 1,000 acres per year, primarily along road corridors, are expected to slow or possibly reverse the trend of weed spread and invasion into undeveloped and more natural areas of Sheldon Refuge, but will adversely affect natural character due to the presence of dead vegetation and vehicle tracks.

Untrammeled Conditions: Wildlife observation, wildlife photography, environmental education, and interpretation rely primarily on existing campgrounds, roads, and other facilities, which results in little or no change to untrammeled conditions within Sheldon Refuge.

Solitude: Due to the limited number of campsites available and the implementation of fees for use at the Virgin Valley, Catnip Reservoir, and Big Spring Reservoir campgrounds, we anticipate some increased use of primitive campgrounds and some additional overnight backcountry use by visitors participating in wildlife observation and photography who continue to seek opportunities for solitude. Such opportunities will continue to be available throughout much of Sheldon Refuge during substantial portions of the year.

Primitive and Unconfined Recreation: Designation of 300 miles of existing roads for public use of vehicles will result in only minor impacts. These existing roads will maintain their current condition and level of maintenance, and use of unimproved dirt roads is expected to remain low and intermittent for access to more primitive and remote portions of Sheldon Refuge. Other routes will continue to be used for hiking, backpacking, and horseback riding, and occasionally by vehicle for administrative purposes. Management actions will also result in greater management presence, development, and regulation at the Virgin Valley, Catnip, and Big Spring campgrounds. Impacts to opportunities for primitive and unconfined recreation will be minor, with vehicle use confined to existing campgrounds and roads where public use has been well established for many years.

Cumulative Effects from Wildlife Observation, Wildlife Photography, Environmental Education, and Interpretation

Impacts to wildlife populations and other public uses from wildlife observation, photography, environmental education, and interpretation within the refuge, including both direct and indirect impacts, are considered minor. Actions planned to manage public uses within the refuge, including wildlife observation, photography, environmental education, and interpretation, are expected to have both adverse and beneficial impacts to wildlife and wildlife habitat and to increase opportunities for high-quality wildlife-dependent public uses. When considered with other existing and planned public uses and management actions at Sheldon Refuge, cumulative impacts from wildlife observation, photography, environmental education, or interpretation will be minor, and cumulative impacts from management of supporting uses such as temporary viewing blinds, camping, and vehicle access will be beneficial and minor to moderate. Continued monitoring of public uses and visitation to sensitive habitats will provide necessary information and management to ensure impacts

from wildlife observation, photography, environmental education, or interpretation within the refuge remain minor. It is anticipated the overall amount of refuge visitation associated with wildlife observation, photography, environmental education, or interpretation will increase but will not interfere with or detract from the quality of other refuge public uses.

Public Review and Comment:

This and other compatibility determinations were prepared concurrently with the Final CCP/EIS for the Sheldon National Wildlife Refuge (published August 2012). Open houses were held, multiple planning updates were mailed, and written comments were solicited from the public during development of the Final CCP/EIS for the refuge. Appendix A of the CCP further details public involvement during development of the CCP. A summary of public comments received during review of the Draft CCP/EIS along with the Service's response to those comments are included in Appendix N of the CCP.

Determination: (check one below)

___ Use is Not Compatible

_X_ Use is Compatible with the Following Stipulations

Stipulations Necessary to Ensure Compatibility:

Management direction is provided in the CCP for Sheldon Refuge. This directs monitoring of wildlife observation and photography activities. Findings from these monitoring efforts will be used in determining what additional management actions, if any, are needed to ensure public use activities remain compatible with refuge purposes. Stipulations that apply to wildlife viewing and observation within Sheldon Refuge are listed below.

1. The construction and use of temporary blinds for wildlife observation, wildlife photography, environmental education, or outreach is allowed only by refuge Special Use Permit and is subject to the following conditions:

    i. Blinds may not be constructed earlier than one week prior to use.

    ii. All blinds must be portable, temporary, and constructed of synthetic material.

    iii. Blinds must be removed no later than 14 days after construction.

    iv. Blinds must be tagged with the date of construction, owner's full name, physical address of residence, and contact phone number or contact email address.

    v. Destruction of natural vegetation or belowground excavation is prohibited (see 50 CFR 27.51).

    vi. All blinds within 100 yards of any active Greater sage-grouse lek must be specifically authorized for the viewing and/or observation of Greater sage-grouse and be located at a distance of 50 yards or more from all active Greater sage-grouse lek locations as directed by the Refuge Manager. Permittees will construct blinds the afternoon prior to use, occupy blinds no less than two hours prior to sunrise, and leave blinds only after all birds have departed the lek.

vii. Blinds within 100 yards of active Greater sage-grouse leks not specifically authorized by permit will be removed and the owner contacted by Sheldon Refuge.

2. Any person participating in or attempting to participate in the viewing and/or photography of Greater sage-grouse between March 1 and June 1 must be in possession of a valid refuge Special Use Permit specifically authorizing such activities.

3. Applications to view or photograph Greater sage-grouse must be received no later than 60 days prior to the proposed activity. The availability of permits will be limited to regularly scheduled refuge lek count days and staff availability. Permits will be granted on a first-come, first-served basis, unless otherwise determined.

4. A maximum of one (1) refuge special use permit per person per year may be issued for the viewing and/or photography of Greater sage-grouse.

5. All vehicles defined as off-road vehicles under 42 U.S.C. Section 4321 must be registered with the State of Nevada or Sheldon National Wildlife Refuge for use on lands administered by Sheldon Refuge.

6. Vehicle use within Sheldon Refuge is allowed only on roads and routes that are designated "open" on Figure D.1 and that are signed or otherwise marked for such use. Off-road use is prohibited.

7. Unless otherwise indicated by sign, permit, or regulation, the maximum number of consecutive nights any person or attended vehicle may remain at a designated Refuge campground is 14 nights.

8. Except for camping within campgrounds that are designated for such use on maps included in the Final Record of Decision for the Sheldon National Wildlife Refuge CCP/EIS and that are signed or otherwise marked for such use, no overnight use is allowed on lands administered by Sheldon Refuge unless expressly authorized by a valid Special Use Permit.

9. Non-motorized boats or boats with electric motors are allowed only in Big Spring Reservoir, Catnip Reservoir, and Dufurrena Ponds consistent with 50 CFR 32.47.

10. Open fires are allowed only at designated campgrounds and within constructed fire rings, subject to additional seasonal fire restrictions and/or closures.

11. Pets must be leashed, except dogs used for hunting migratory or upland birds. Hunting dogs must be under strict voice control at all times.

12. Riding or packing with horses and mules is allowed in all areas open to public use. All horses and mules must be haltered, branded, tagged, or otherwise visibly marked as a domestic animal and must be tied, hobbled, high-lined, corralled, or otherwise under direct control at all times.

13. Grazing of domestic animals within Sheldon Refuge is not allowed.

14. We encourage the use of certified weed-free hay, pellets, straw, and other livestock feed within Sheldon Refuge. The use of certified weed-free feed will be required if monitoring of stock use areas indicates the spread or introduction of noxious weeds from uncertified feed.

National Special Use Permit Conditions and Requirements

1. Responsibility of Permittee: The permittee by operating on the premises shall be considered to have accepted these premises with all facilities, fixtures, or improvements in their existing condition as of the date of this permit. At the end of the period specified or upon earlier termination, the permittee shall give up the premises in as good order and condition as when received except for reasonable wear, tear, or damage occurring without fault or negligence. The permittee will fully repay the Service for any and all damage directly or indirectly resulting from negligence or failure on his/her part, or the part of anyone of his/her associates, to use reasonable care.

2. Operating Rules and Laws: The permittee shall keep the premises in a neat and orderly condition at all times, and shall comply with all municipal, county, and State laws applicable to the operations under the permit as well as all Federal laws, rules, and regulations governing national wildlife refuges and the area described in this permit. The permittee shall comply with all instructions applicable to this permit issued by the refuge official in charge. The permittee shall take all reasonable precautions to prevent the escape of fires and to suppress fires and shall render all reasonable assistance in the suppression of refuge fires.

3. Use Limitations: The permittee's use of the described premises is limited to the purposed herein specified and does not, unless provided for in this permit, allow him/her to restrict other authorized entry on to his/her area; and permits the Service to carry on whatever activities are necessary for (1) protection and maintenance of the premises and adjacent lands administered by the Service; and (2) the management of wildlife and fish using the premises and other Service lands.

4. Transfer of Privileges: This permit is not transferable, and no privileges herein mentioned may be sublet or made available to any person or interest not mentioned in this permit. No interest hereunder may accrue through lien or be transferred to a third party without the approval of the Regional Director of the Service and the permit shall not be used for speculative purposes.

5. Compliance: The Service's failure to require strict compliance with any of this permit's terms, conditions, and requirements shall not constitute a waiver or be considered as a giving up of the Service's right to thereafter enforce any of the permit's terms or conditions.

6. Conditions of Permit not Fulfilled: If the permittee fails to fulfill any of the conditions and requirements set forth herein, all money paid under this permit shall be retained by the Government to be used to satisfy as much of the permittee's obligation as possible.

7. Payments: All payment shall be made on or before the due date to the local representative of the Service by a postal money order or check made payable to the U.S. Fish and Wildlife Service.

8. Termination Policy: At the termination of this permit the permittee shall immediately give up possession to the Service representative, reserving, however, the rights specified in paragraph 11. If he/she fails to do so, he/she will pay the Government, as liquidated damages, an amount double the rate specified in this permit for the entire time possession is withheld. Upon yielding possession, the permittee will still be allowed to re-enter as needed to remove his/her property as stated in paragraph 11. The acceptance of any fee for liquidated damages or any other act of administration relating to the continued tenancy is not to be considered as an affirmation of the

permittees' action nor shall it operate as a waiver of the Government's right to terminate or cancel the permit for the breach of any specified condition or requirement.

9. Revocation Policy: This permit may be revoked by the Regional Director of the Service without notice for noncompliance with the terms hereof or for violation of general and/or specific laws or regulations governing national wildlife refuges or for nonuse. It is at all times subject to discretionary revocation by the Director of the Service. Upon such revocation the Service, by and through any authorized representative, may take possession of the said premises for its own and sole use, or may enter and possess the premises as the agent of the permittee and for his/her account.

10. Damages: The United States shall not be responsible for any loss or damage to property including, but not limited to, growing crops, animals, and machinery or injury to the permittee or his/her relatives, or to the officers, agents, employees, or any other who are on the premises from instructions or by the sufferance of wildlife or employees or representatives of the Government carrying out their official responsibilities. The permittee agrees to save the United States or any of its agencies harmless from any and all claims for damages or losses that may arise to be incident to the flooding of the premises resulting from any associated Government river and harbor, flood control, reclamation, or Tennessee Valley Authority activity.

11. Removal of Permittee's Property: Upon the expiration or termination of this permit, if all rental charges and/or damage claims due to the Government have been paid, the permittee may, within a reasonable period as stated in the permit or as determined by the refuge official in charge but not to exceed 60 days, remove all structures, machinery, and/or other equipment, etc., from the premises for which he/she is responsible. Within this period the permittee must also remove any other of his/her property including his/her acknowledged share of products or crops grown, cut, harvested, stored, or stacked on the premises. Upon failure to remove any of the above items within the aforesaid period, they shall become the property of the United States.

Sheldon National Wildlife Refuge Special Use Permit Conditions

1. A copy of this permit must be in the permittee's possession at all times while exercising the privileges of this permit.

2. All waste materials must be removed from the Refuge upon the permittee's and/or clients' departure. The permittee is responsible for removal of clients' garbage.

3. The landing of aircraft and use of helicopters is prohibited.

4. Management direction is provided in the CCP for Sheldon Refuge. This directs monitoring of wildlife-dependent recreation activities and other public uses. Findings from these monitoring efforts will be used in determining what additional management actions, if any, are needed to ensure public use activities remain compatible with refuge purposes.

Justification:

The National Wildlife Refuge System Administration Act of 1966 (as amended) identifies wildlife observation and wildlife photography as two of six priority public uses on national wildlife refuges. The law states that, when managed in accordance with principles of sound fish and wildlife

management and administration, wildlife observation, wildlife photography, and the other priority wildlife-dependent recreational uses "have been and are expected to continue to be generally compatible uses." The Act further states that these priority public uses should receive enhanced consideration over other general public uses in refuge planning and management, and directs the USFWS to provide increased opportunities for the public to safely engage in traditional outdoor activities such as fishing and hunting.

Wildlife photography, observation, interpretation, and environmental education can result in disturbance, displacement, and habituation of wildlife. However, overall visitation to the refuge is approximately 17,000 people per year, and the majority of visitors who engage in these activities remain on improved gravel roads and highways. There is sufficient undisturbed habitat available to refuge wildlife for escape and cover. Regulating the use of wildlife-viewing blinds, sage-grouse viewing, and photography will ensure that the use of established leks continues with only minimal disturbance or disruption. Other requirements regarding the use of non-motorized boats or boats with electric motors and designated campgrounds and requirements for backcountry camping permits will also minimize wildlife disturbance and displacement from important habitats and habitat impacts while maintaining opportunities for solitude within proposed wilderness areas and wilderness study areas. Stipulations identified in this compatibility determination are expected to minimize impacts from wildlife observation, photography, interpretation, and environmental education within Sheldon Refuge to fish, wildlife, plants, and their habitats. Thus, allowing wildlife photography, observation, interpretation, and environmental education to occur with stipulations will not materially detract from or interfere with the purposes for which the refuge was established or the Refuge System mission.

Closure of the Virgin Valley and Little Sheldon areas to all hunting and closure of Big Spring and Catnip reservoirs to migratory bird hunting will continue to provide outstanding opportunities for observation and photography of wildlife, including large animals and birds in their natural habitats and exhibiting behavior not influenced by hunting pressure. Construction of a visitor contact station along Highway 140 will provide better interpretive opportunities for a larger number of people than are currently available. Due to the new visitor contact station and other refuge interpretive materials, displays, and signs, we expect visitors will be better informed and more knowledgeable about Sheldon Refuge public use regulations, refuge resources, and the need for conservation of refuge resources.

Mandatory 10- or 15-Year Re-evaluation Date: (provide year for "allowed" uses only)

___2026___ Mandatory 15-year re-evaluation date (for wildlife-dependent public uses)

_____ Mandatory 10-year re-evaluation date (for all uses other than wildlife-dependent public uses)

NEPA Compliance for Refuge Use Decision: (check one below)

___ Categorical Exclusion without Environmental Action Statement

___ Categorical Exclusion and Environmental Action Statement

___ Environmental Assessment and Finding of No Significant Impact

_X_ Environmental Impact Statement and Record of Decision

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Refuge Determination

Prepared by: _____ 9/25/12
(Signature) (Date)

Refuge Manager/
Project Leader
Approval: _____ 9/25/12
(Signature) (Date)

Concurrence

Acting Refuge Supervisor: _____ SEP 27 2012
(Signature) (Date)

Acting Regional Chief,
National Wildlife
Refuge System: _____ 9/27/12
(Signature) (Date)

D.2 Compatibility Determination for Sport Fishing on Sheldon National Wildlife Refuge

Use(s): Fishing

Supporting Uses: Camping, boating, and vehicle use

Refuge Name: Sheldon National Wildlife Refuge

City/County and State: Washoe County, Nevada; Humboldt County, Nevada; Lake County, Oregon

Establishing and Acquisition Authority(ies):

What is today known as the Sheldon National Wildlife Refuge was initially established by Executive Order 5540 dated January 26, 1931, and later enlarged by Executive Order 7364 dated May 6, 1936, and Executive Order 7522 dated December 21, 1936.

The authorities for nearly all Federal lands within Sheldon Refuge are the Migratory Bird Conservation Act of 1929, as amended (16 U.S.C. 715-715r) and the National Wildlife Administration Act of 1966, as amended (16 U.S.C. 668dd-668ee). A small portion of Sheldon Refuge was acquired under the authority of the Endangered Species Act of 1973, as amended (16 U.S.C. 1231-1544).

Refuge Purpose(s):

> "…as a refuge and breeding ground for wild animals and birds…" Executive Order 5540 dated January 26, 1931.
>
> "… set apart for the conservation and development of natural wildlife resources and for the protection and improvement of public grazing lands and natural forage resources…." Executive Order 7522 dated December 21, 1936.
>
> "… to conserve (A) fish or wildlife which are listed as endangered species or threatened species… or (B) plants…" 16 U.S.C. § 1534 (Endangered Species Act of 1973)
>
> "… for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." 16 U.S.C. § 715d (Migratory Bird Conservation Act)

National Wildlife Refuge System Mission:

> "The mission of the [National Wildlife Refuge] System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans" (National Wildlife Refuge System Administration Act of 1966, as amended [16 U.S.C. 668dd-668ee]).

Description of Use(s):

Fishing on Sheldon Refuge occurs within artificial ponds and reservoirs originally constructed to increase late-summer water availability for livestock and to supply irrigation for pastures and fields. Because commercial livestock grazing, haying, and farming no longer occur on Sheldon Refuge, the purposes for these artificial waters are now primarily to provide habitat for fish and wildlife and secondarily to provide recreational fishing opportunities. Both warm-water fishing (i.e., bass) and cold-water fishing (i.e., trout) opportunities exist on Sheldon Refuge. Currently fishing is allowed at Big Spring Reservoir for rainbow trout, at Catnip Reservoir for Lahontan cutthroat trout, and at Dufurrena Ponds (which includes McGee Pond) for bass, crappie, sunfish, and perch. McGee Pond is managed to provide fishing opportunities only for individuals who are age 12 or under, age 65 or older, or disabled. The waters listed are closed to migratory bird hunting, but the use of non-motorized boats and boats with electric motors is allowed.

In the past Big Spring Reservoir has been a popular and productive fishing destination for anglers, and it has facilities in support of fishing, including a campground and a boat launch. More than 1,900 anglers reported an average of five fish caught per day in 1998 (Nevada Department of Wildlife [NDOW] 2009). For comparison, 2007 angler questionnaire results indicated that 1,116 anglers fished Squaw Creek Reservoir (the next closest highway-accessible reservoir fishery in the state), and 3,111 anglers fished Rye Patch Reservoir, located just north of Interstate 84 near Winnemucca, Nevada (NDOW 2009). More recently, drier weather and the resulting lack of water at Big Spring Reservoir has at least temporarily eliminated fishing opportunities. The fishing season is open from the second Saturday in May through the last day of February. The fishing limit is five trout.

Catnip Reservoir also has a campground to support fishing activities, but at 22 acres and accessible by a maintained gravel road, Catnip Reservoir experiences angler use more typical of reservoirs scattered throughout northwest Nevada. Questionnaire results indicate 312 anglers fished Catnip Reservoir in 2007 (NDOW 2009). We assume at least some anglers who fished at Big Spring Reservoir in the past are now visiting Catnip Reservoir. NDOW has periodically stocked up to 3,000 fish in Catnip Reservoir. The fishing season is open the second Saturday in June through November 15. The fishing limit is one trout. Only artificial lures with single barbless hooks may be used.

The least amount of recreational fishing within Sheldon Refuge occurs at Dufurrena Ponds, with 176 anglers reporting 577 fishing days in 2007 (NDOW 2009). The Virgin Valley Campground is located 1.5 miles from Dufurrena Ponds 19 and 20. Dufurrena Pond 20 and McGee Pond have fishing docks that are accessible to people with physical disabilities. Fishing season is open year-round. The fishing limit is 15 fish. The Dufurrena Ponds are more easily accessible than Catnip and Big Spring reservoirs, which are more remote but accessible by maintained gravel roads.

Because there are few people in Nevada, the limited amount of angler visitation data can be misleading. Fishing opportunities provided within Sheldon Refuge represent important regional destinations for recreation fishing, and anglers consistently travel more than 200 miles to reach these locations throughout the summer months. The popularity of fishing on Sheldon Refuge results in visitation that approaches or exceeds campground capacity at some sites during short periods of the summer and fall.

Secondary uses of Sheldon Refuge that support fishing include overnight camping at three designated campgrounds (Virgin Valley, Catnip Reservoir, and Big Spring Reservoir campgrounds), non-motorized boating, and vehicle use on designated access routes.

Supporting Uses

Camping

Camping itself is not a priority public use on Service lands, but because of the size, remoteness, and quality of roads within Sheldon Refuge, it is important in supporting priority uses including fishing, hunting, wildlife observation, and wildlife photography. There are four types of camping opportunities currently provided within Sheldon Refuge: developed, semi-primitive, primitive, and backcountry/wilderness. Fishing activities occur in more developed areas of the Refuge, and fishing is supported by campgrounds at Big Spring and Catnip reservoirs and Virgin Valley Campground. These facilities are described below under developed and semi-primitive camping.

Developed Camping: Virgin Valley Campground located at Dufurrena is considered the only developed campground. Virgin Valley Campground is easily accessible year-round for all types of vehicles, including RVs, and it offers shade trees, potable water, two vault toilets, 16 picnic tables, 24 fire rings, a meat-hanging pole, a bath-house, and a hot spring developed for swimming. Campground use is managed on a first-come, first-served basis without fees or designated sites. From 2005 through 2007, an average of 18 campsites were occupied per day during the days surveyed, for a seasonal average of 6,573 visitor use days (USFWS undated report).

From mid-August through mid-November, the Virgin Valley Campground is heavily used by hunters. Sport anglers also use the Virgin Valley Campground, which supports fishing at the Dufurrena Ponds and McGee Pond. During peak seasons, overcrowding and user conflicts have been a concern as has overflow into upland areas adjacent to the campground, which can result in further environmental damage.

Semi-primitive Camping: Of five semi-primitive campgrounds, only Catnip Reservoir and Big Spring Reservoir campgrounds support fishing within Sheldon Refuge. Both campgrounds include outhouses and fire rings. Catnip Reservoir is accessible from county road 8A, and Big Spring Reservoir is accessible by improved gravel road approximately 1 mile north of State Highway 140; both roads are suitable for most types of vehicles.

Additional facilities such as campsite amenities (i.e., picnic tables and accessible fire rings or barbeque grills), potable water, shade structures, kiosks, and dedicated volunteer sites are planned for Virgin Valley, Catnip Reservoir, and Big Spring Reservoir campgrounds. These facilities will provide developed camping opportunities that are not commonly available within Sheldon Refuge or the region. However, these improved facilities will only be sustainable over the long term through campsite fees to support volunteers, maintenance, and replacement.

Public Access

Public access to fishing areas within the Refuge is provided by three maintained gravel surface roads. The Virgin Valley Road provides access from State Highway 140 to the Dufurrena Ponds and the Virgin Valley Campground, which is located 2.5 miles from the highway. Big Spring Reservoir and

campground are also accessible by 2.25 miles of maintained gravel road from State Highway 140, and county road 8A provides access from multiple locations to Catnip Reservoir and campground.

Changes to fishing activities may result from the relocation and enlargement of the Refuge visitor contact station, improvement of campground facilities, and improved signing of routes open to vehicle use; however, since fishing activities currently occur in the more developed areas of the Refuge these changes are anticipated to be minor as compared to other uses, which will involve use of undeveloped areas of the Refuge or construction of new facilities. Improved gravel roads within Sheldon Refuge will be maintained more frequently, and all routes open to the public use of vehicles will be adequately signed and marked. Visitors will be required to register all OHVs consistent with State of Nevada regulation or with Sheldon Refuge for use on refuge roads and routes designated open to vehicle use. These actions are intended to improve the quality of the transportation system and deter vehicle violations while requiring only minimal law enforcement presence.

Maintained Public Roads: In preparation of the Sheldon Refuge CCP, each route within the refuge was evaluated to assess impacts to fish, wildlife, plants, and their habitats, as well as benefits for public use and recreation opportunity. Following this evaluation, 300 miles of existing roads (including State Highway 140 and all maintained county roads) were designated for public vehicle use. The Service has determined the continued use and maintenance of designated roads to support fishing, including actions for re-routing or modification as presented in the Sheldon Refuge CCP will have minimal or no impacts to wildlife and wildlife habitat and/or are subject to existing right-of-way.

Boating: Refuge-specific regulations that apply to the use of non-motorized boats and boats with electric motors specifically apply to sport fishing and sport hunting, but are interpreted as applying to other compatible wildlife-dependent public uses as well. Primarily, the use of non-motorized boats and boats with electric motors in Big Spring Reservoir, Catnip Reservoir, and Dufurrena Ponds consistent with 50 Code of Federal Regulations (CFR) 32.47 is considered a compatible activity that supports fishing.

Availability of Resources:

Most administration and management of recreational fishing, including periodic restocking, is conducted by NDOW and does not represent a refuge cost for managing sport fishing opportunities. Maintenance of the reservoirs, ponds, docks, campgrounds, access roads, and other supporting facilities and routine law enforcement patrols are conducted by Sheldon Refuge.

All fishing opportunities within Sheldon Refuge are dependent upon constructed ponds and reservoirs, which require occasional dredging and repair to maintain public safety and water depths sufficient for self-sustaining fish populations and their habitats. Both Catnip and Big Spring reservoirs are constructed impoundments with limited to no spawning and rearing habitat that would facilitate self-sustaining trout populations large enough to support a recreational fishery.

The earth dam at Catnip Reservoir is currently in poor condition due to leaking caused by burrowing animals. Extensive repair or possibly complete replacement will be necessary to maintain the Lahontan cutthroat trout population over the long term. The reservoir has gradually filled with sediment, bringing the current depth to approximately 4 feet. To maintain sufficient water depth for a sustainable trout population, Catnip Reservoir will need to be dredged. Previous estimates for the repair of Catnip Reservoir dam range from $334,000 to $795,000 (Sverdrup Corporation 1991). We

estimate an additional $2 to $2.25 million will be necessary to complete the necessary dredging today. However, over the next 10 to 15 years we anticipate Catnip Reservoir will hold water sufficient to support the Lahontan cutthroat trout fishery without major reconstruction or dredging.

Category and Itemization	One-time	Annual
Administration and management (volunteer host site development, volunteer campground hosts, law enforcement patrols, fee collection and processing)	$15,000	$5,000
Maintenance (includes Catnip Reservoir dredging and dam repairs)	$3,000,000	$500-$1,500
Monitoring	$500	$500
Special equipment, facilities, or improvements (campgrounds, docks, and access roads)	$150,000	$500-$1,500
Offsetting revenues[2]	$5,500	$5,500

Increased staffing, funding, volunteer assistance, strengthened existing partnerships, and new partnerships will be sought to support these programs in an effective, safe, and compatible manner. Refuge staff will continue volunteer recruiting efforts as needed to ensure assistance is available to provide basic visitor information and maintenance of public use facilities. Volunteers, interns, and various user groups when provided appropriate training can assist Sheldon Refuge with monitoring and maintenance projects related to sport fishing within Sheldon Refuge. With additional assistance as described above, staffing and funding are expected to be sufficient to manage these uses.

Anticipated Impacts of the Use(s):

Effects from Fishing

Lahontan cutthroat trout were first stocked in Catnip Reservoir in 1947 (Williams et al. 1980). Subsequently, the Lahontan cutthroat trout was federally listed as threatened, and they are currently managed consistent with a special rule under Section 4(d) of the Endangered Species Act, which authorizes the taking of these trout in accordance with state law. Big Spring Reservoir has been repeatedly stocked with rainbow trout since at least 1973. Because both Catnip and Big Spring are constructed reservoirs with limited to no spawning and rearing habitat, regular restocking will be necessary to maintain these sport fishing opportunities in the future. No short-term or long-term adverse impacts to other Sheldon Refuge resources or uses have been identified as a result of recreational fishing at Catnip or Big Spring reservoirs, and none are anticipated over the next 15 years. However, rainbow trout are not considered native or indigenous to the region, and stocking

[2] Anticipated campsite fee revenues as proposed in the CCP are based on $5/site/day for 1,100 site-use days.

Big Spring Reservoir with Lahontan cutthroat, Alvord cutthroat, or redband trout—which are indigenous to the region—will be more desirable and consistent with Service policy.

Non-native fish populations in the Dufurrena Ponds are typically confined to the ponds themselves, but during high flows these fish have escaped into other portions of the Thousand Creek and Virgin Creek watersheds where they have established viable populations. These fish populations likely cause minor adverse impacts to invertebrates and other aquatic wildlife within the ponds themselves. Of greater concern are the moderate adverse impacts to native fishes and the natural ecology of Virgin Creek from non-native fish that escape from Dufurrena Ponds. Under the CCP, these impacts are expected to continue. Over the long term it will be necessary to dredge the various ponds and reservoirs to maintain open water with depths sufficient to support recreational fisheries. This periodic dredging is expected to have both short-term and long-term adverse impacts to water quality and native downstream riparian habitats.

Recreational fishing within Sheldon Refuge is supported by the Catnip, Big Spring, and Virgin Valley campgrounds. These three campgrounds are located near water and partially within riparian habitats and prehistoric cultural sites. While the majority of impacts occurred following the initial establishment of these campgrounds, some impacts continue due to continued soil disturbance and compaction within existing campsites, occasional use of previously unused areas adjacent to the campgrounds, and vehicle use outside designated areas. It is anticipated that actions to define each of these campgrounds and confine use to designated campsites will mitigate or avoid additional impacts altogether.

The three ponds near Dufurrena that provide recreation fishing opportunities are interconnected within the same watershed. Sediment from upper ponds are trapped by lower ponds, but periodic dredging of these lower ponds is expected to have an adverse cumulative impact on the Thousand Creek Gorge portion of the watershed. These impacts are associated with the primary purpose of maintaining open water habitat for wildlife; benefits to fish from dredging are secondary and will occur regardless of the fishing opportunity provided. Most anglers fish from shore or in non-motorized boats, or in boats with electric motors. Only non-motorized boats or boats with electric motors are allowed at Dufurrena Ponds, Big Spring Reservoir, and Catnip Reservoir. No impacts related to the use of boats have been documented within Sheldon Refuge. Angler activities have both direct and indirect impacts on aquatic habitats and dependent wildlife. Other than fish mortality from angling, the most frequent impact is disturbance of birds and mammals. However, because all fishing areas are located near developed roads and campgrounds, impacts from recreational fishing are only a portion of the overall wildlife disturbance at these locations.

Annual NDOW fishing regulations and publications educate anglers about invasive aquatic species and suggest methods to avoid introducing these pests into new areas. Anglers have not been identified as the cause for any invasive species being introduced to Sheldon Refuge.

No fishing or supporting activities occur within proposed wilderness, and no activities to maintain fishing opportunities are anticipated to affect nearby proposed wilderness areas.

Effects from Camping and Campgrounds

Use of campgrounds within Sheldon Refuge causes impacts to vegetation, soils, water quality, and cultural resources. During dry conditions, carelessness with campfires can lead to wildfires.

Management and development of campgrounds is also expected to affect the type and quality of recreation opportunities available.

Impacts to Vegetation, Soils, and Water Quality: Fishing activities are supported by the campgrounds at Big Spring and Catnip reservoirs and Virgin Valley Campground. These campgrounds are among the more developed campgrounds on the Refuge. Because most impacts have already occurred at the most heavily used and developed campgrounds, we can expect very little additional impact to vegetation, soils, or water quality due to fishing activities as compared to other uses despite anticipated increases in use at these campgrounds.

The greatest difference in durability between vegetation types occurs at moderately low use levels (Cole 1985). Sites that are used frequently are likely to be highly impacted regardless of their fragility. Because vegetation loss usually occurs more rapidly than loss of organic soil horizons, sites with either no vegetation or resistant vegetation (e.g., grasses as opposed to forbs) recover more quickly and are less likely to be impacted by low levels of use, while sites with thick organic soil horizons are less susceptible to erosion and are more likely to withstand high amounts of use.

Experimental studies suggest that there is an important difference between a site's resistance (its ability to tolerate use without being damaged) and its resilience (its ability to recover from damage). Cole (1995) has shown, for groundcover plants, that resistance decreases with erectness and that broad-leaved herbs are typically less resistant than grass-like plants and shrubs. Low shrubs, such as heather, are relatively resistant to trampling stress but their resilience is low. Once damaged, they recover slowly. Grass-like plants are most tolerant of trampling (Cole 1989). The compaction of soils from campsite use reduces water infiltration and water holding capacity, which leads to increased runoff and erosion potential (Cole 2004; Monti and Mackintosh 1979). Impacts associated with use at primitive campgrounds can be readily observed and tend to occur rapidly, but these impacts are relatively inconsequential when considered in the context of the entire refuge. Impacts associated with campgrounds located within riparian areas or near water sources are of greater concern, but current impacts are not severe and vegetation, soils, and water quality at primitive campgrounds are expected to recover noticeably within a few years following campground relocation. This assessment is supported by Cole (1981) who noted that hiking and camping impacts on soil and vegetation, while severe when measured at small scales, are minimal at large spatial scales. This suggests that while recreation impacts can be serious for individual plants and animals and perhaps localized rare populations, they are generally of little significance to landscape integrity or regional biotic diversity. Moreover, unless much of a population is impacted by a single impacted site, the intensity, size, and distribution of impacts are not relevant to the significance of impacts assessed at large spatial scales (Cole 1989).

Virgin Valley Campground is located at a site previously developed and used by the Civilian Conservation Corps in the late 1930s. Catnip Reservoir and Big Spring Reservoir campgrounds are located immediately adjacent to artificial reservoirs. These three campgrounds receive the greatest amounts of use and exhibit the greatest amount of impact. The core areas of use at these campgrounds no longer support vegetation or vegetation diversity is substantially reduced, water infiltration is considered low due to soil compaction, and gravel has been placed in some areas to reduce erosion and rutting from vehicles. Non-native plants and animals in and around these three campgrounds were likely introduced by early ranching and development activities rather than campground visitors. Monitoring and control efforts will continue to detect and remove or eradicate small or new populations of invasive species.

We expect some primitive campgrounds to be consolidated with other existing campgrounds, which will need to be enlarged and have additional campsites constructed (the most likely candidates for enlargement include Catnip Reservoir, Big Spring Reservoir, Fish Spring, and West Rock Spring campgrounds). Consolidation will result in additional impacts from increased use of existing facilities and campsites and from the designation and construction within existing campgrounds. Where camping already occurs, increased use of existing campsites and facilities is expected to have little or no measurable impact to vegetation or wildlife. Impacts to expanded portions of these campgrounds are expected to occur quickly as vegetation is trampled and soil compacted within the first two or three seasons of use, but then stabilize over the long term. We expect enlargement of existing campgrounds will result in minor, site-specific, long-term, direct adverse impacts to plants and their habitat from removal of vegetation, soil compaction, and loss of organic soil horizon at these sites.

Impacts from Wildfire: Campfires are allowed at designated campgrounds but are occasionally prohibited during periods of high fire danger. Wildfires have been started by refuge visitors in the past and we expect some wildfires will occasionally start as a result of escaped campfires or misuse of stoves. Seasonal campfire restrictions and rapid fire suppression response will continue to minimize impacts.

Impacts to Cultural Resources: Most of the designated campgrounds that support fishing activities are located within or adjacent to prehistoric cultural sites. While the majority of impacts occurred following the initial establishment and use of these campgrounds, some impacts continue due to ongoing soil disturbance and compaction within existing campsites, trampling and removal of vegetation, occasional use of previously unused areas adjacent to the campgrounds, and vehicle use outside designated areas. Therefore, we anticipate use of these facilities to support fishing will have only negligible or minor, site-specific, long-term, adverse impact on cultural resources.

Impacts to Recreation Opportunity: Campsite registration, overnight fees, and the other improvements planned for the developed campgrounds will increase maintenance, increase visitor compliance with rules and regulations (by defining and designating campsites), and decrease competition for campsites. Campground management strategies are expected to result in moderate, indirect, long-term, beneficial impacts to the camping experience, in support of providing quality opportunities for wildlife-dependent recreation.

Effects from Public Access

Adverse impacts are expected to continue as a result of the network of developed and undeveloped roads throughout Sheldon Refuge and their associated maintenance. Road development and use continues to adversely impact the biological integrity within Sheldon Refuge by contributing to the altered composition of plant communities, soil disturbance (Eckert et al. 1979; Iverson et al. 1981; Switalski et al. 2004), altered hydrology and stream sedimentation (Forman and Alexander 1998), facilitation of the spread of invasive vegetation, changes in the natural fire regimes, and habitat fragmentation.

Many direct effects are obvious during construction, but other effects are permanent and can extend substantially beyond the actual road surface (road-effect zone; Forman 2000; Forman and Alexander 1998). At the landscape scale, major ecological impacts of a road network include fragmentation, the disruption of landscape processes, and loss of biodiversity. Biodiversity declines as the road network impacts interior species (species cut off by roads), species with large home ranges, stream and

wetland species, and rare native species (Forman and Alexander 1998). Fragmentation of previously extensive landscapes can influence the distribution and abundance of a host of wildlife species through redistribution of habitat types and through the pattern of habitat fragmentation, including characteristics such as decreased patch area and increased habitat edge (Vander Haegen et al. 2000).

Roads (including OHV trails) are commonly identified as important correlates or indicators of loss of ecological health and affect terrestrial and aquatic ecosystems in several general ways: 1) increased mortality from road construction; 2) increased mortality from collision with vehicles; 3) modification of animal behavior; 4) alteration of physical environment; 5) alteration of chemical environment; 6) spread of exotic species; and 7) increased alteration and use of habitats by humans (Trombulak and Frissell 2000; Wildlife Action Plan Team 2006).

The ecological effect of road avoidance is likely related to traffic density and speed of travel, as well as traffic noise levels (Forman and Alexander 1998). Road-effect zones generally result in lower breeding densities and reduced species richness; species demonstrated to avoid or be negatively impacted by roads include arthropods, reptiles, small mammals, ungulates, and forest and grassland birds (Andrews and Gibbons 2005; Carr and Fahrig 2001; Forman and Alexander 1998; McGrann et al. 2006; Rost and Bailey 1979). For example, proximity to OHV trails (<1,000 meters [3,280 feet]) was found to have a direct correlation with reduced-quality habitat for nesting songbirds in sagebrush-steppe habitats, including nest desertion, nest predation, and abandonment (Barton and Holmes 2007). Behavioral disturbance from recreation, including that associated with trails and roads, may also have both immediate and long-term effects on wildlife (Taylor and Knight 2003). In one study of pronghorn, deer, and bison, individuals exhibited a 70% probability of flushing within 1,000 meters (3,280 feet) on either side of a trail used by hikers and mountain bikers (Taylor and Knight 2003); presumably responses are similar in the presence of vehicles such as OHVs. Road density can be used as an overall index to average patterns over an area. For example, road densities of approximately 1.0 mile per square mile have been recommended as the maximum for a naturally functioning landscape containing sustained populations of large predators (Forman and Alexander 1998). However, the effects of road density are likely sensitive to road width or type, traffic density, network connectivity, and the frequency of spur roads into remote areas (Forman and Alexander 1998).

Within Sheldon Refuge, more than 50 introduced, non-native, and often noxious plant species have been documented (refer to Sheldon Refuge CCP Appendix B). Invasive plants typically need transportation to spread to new areas (Trombulak and Frissell 2000), and within Sheldon Refuge several methods are possible, including vehicles, people, wild and domestic animals, and firefighting equipment. Indeed, it has been demonstrated that habitats distant from roads may provide important refuge for native grassland species, and that this effect may be even more pronounced in predominately intact landscapes such as those in parts of the Great Basin (Gelbard and Harrison 2003). Human access and disturbance effects on remote areas tend to increase with higher road densities, as well as human-caused fire ignitions (Forman and Alexander 1998).

Various methods, including systematic inventory and monitoring for invasive plants, mowing, use of herbicides, and elimination of grading road shoulders, will be used to detect new infestations, control and contain existing infestations, and treat up to 1,000 acres per year. Management strategies to combat invasive plants support the Service policy for biological integrity and diversity within Sheldon Refuge. With a more systematic approach for inventory of noxious weeds and other invasive plants, populations are more likely to be detected when they are small and more easily managed and controlled. Increased treatment and reduced soil disturbance along road corridors

should reduce the spread of invasive plants already present and reduce the potential for new populations. As a result, we anticipate these actions will result in major, long-term, direct, beneficial impacts to all habitats. Implementing treatment strategies (e.g., mechanical removal of vegetation, application of herbicides) will likely eliminate or prevent the spread of noxious weed populations when detected and provide some conservation of native habitats, resulting in minor, site-specific, short-term, direct, beneficial impacts to habitat on approximately 1,000 acres per year.

In conjunction with preparation of the Sheldon Refuge CCP, Refuge staff conducted an evaluation of existing routes and trails, and identified known and potential resource impacts and public benefits and recreation opportunities associated with vehicle access. Route segments that were identified as causing substantial impacts to soils, riparian areas, and/or wildlife, were redundant with other routes, or provided very little or no access for wildlife-dependent uses were not identified for designation as open roads for public use of vehicles. To minimize or avoid lesser impacts from roads and vehicle use, the Service will implement a number of transportation management strategies including designating roads that are not duplicative, re-routing or realigning road segments that pass through sensitive resource areas, installing erosion control structures, increasing monitoring and treatment of weeds along road corridors, and posting signs marking all designated open roads. These actions will result in long-term, minor, direct and indirect, beneficial impacts to soils by decreasing erosion in sensitive areas that are currently affected. Overall we expect impacts from road management will be minor, direct, and adverse to habitats on a localized and long-term basis.

Economic Effects

Expenditures associated with 1,122 annual fishing days (excluding fishing at Big Spring Reservoir) have been found to constitute 1% of current contribution to the gross state product ($0.1 million). We anticipate these expenditures will continue to support two full-time jobs and contribute approximately $104,000 to the local economy.

We also anticipate that sufficient water will be available in the future at Big Spring Reservoir to again support fishing. Based upon historical use (6,208 angler days reported in 1998), the economic contribution from future use will support 12 full-time jobs and contribute $550,000 to the local economy. When combined, the value of current and expected future sport fishing within Sheldon Refuge will surpass that from hunting (refer to Sheldon Refuge Final CCP/EIS Table 6.2 and Industrial Economics, Inc. 2010).

Effects from Boating

The use of non-motorized or electric-powered boats is allowed only in Big Spring Reservoir, Catnip Reservoir, and the Dufurrena Ponds consistent with 50 CFR 32.47. The majority of boating occurs in conjunction with sport fishing, and while migratory bird hunting is not allowed on these waters, occasional and intermittent boating does occur in conjunction with other hunting, wildlife observation, wildlife photography, environmental education, interpretation, research, scientific collecting, and surveys. The amount of boating that occurs within Sheldon Refuge has not been quantified, but is considered low based upon angler participation and incidental observation by staff and volunteers. Boating generally occurs during summer months following the waterfowl nesting season (when the potential for bird disturbance or displacement impacts will be greatest) and following the beginning of trout fishing season, when there are higher water temperatures at Dufurrena Ponds, which provide better fishing success. Requirements for use of non-motorized boats or boats with electric motors will eliminate the potential for water pollution associated with use

of outboard motors and will maintain opportunities for visitor solitude. Overall, the amount of boating associated with wildlife-dependent public uses is considered low, and adverse impacts are estimated to be short-term, intermittent, and negligible.

Effects to Wilderness Character

Naturalness: Existing vehicle routes will remain visible, and their designation for motorized use is not expected to result in any short-term impacts to naturalness. Over the long term, as public use continues to increase, we expect that additional signs, road maintenance, and other developments will be needed to ensure compatibility. Increased visitation to these areas will also increase the potential for introduction and spread of weeds and for the disturbance and displacement of wildlife.

Weed treatments occurring on approximately 1,000 acres per year, primarily along road corridors, are expected to slow or possibly reverse the trend of weed spread and invasion into undeveloped and more natural areas of Sheldon Refuge, but will adversely affect natural character from the presence of dead vegetation and vehicle tracks.

Untrammeled Conditions: Fishing will rely primarily on existing campgrounds, roads, and other facilities, which will result in little or no change to untrammeled conditions within Sheldon Refuge.

Solitude: Since fishing is associated mainly with developed areas of the Refuge, we do not anticipate increased use of primitive campgrounds or overnight backcountry use by visitors participating in fishing. Opportunities for solitude will continue to be available throughout much of Sheldon Refuge during substantial portions of the year.

Primitive and Unconfined Recreation: Management direction for designation of existing roads for public use of vehicles to access fishing areas will result in only minor impacts. These existing roads will remain in the current condition and level of maintenance. Management actions will also result in greater management presence and development, and regulation at the Virgin Valley, Catnip, and Big Spring campgrounds. Impacts to opportunities for primitive and unconfined recreation will be minor with vehicle use confined to existing campgrounds and roads where public use has been well established for many years.

Cumulative Effects from Fishing

Impacts to fish populations and other public uses from sport fishing within Sheldon Refuge, including both direct and indirect impacts, are considered minor. Actions to manage public uses within the refuge, including sport fishing, are expected to reduce impacts to fish, wildlife, and habitat and to maintain opportunities for high-quality wildlife-dependent public uses. Sport fishing has a negligible impact on refuge fisheries and habitat conditions when compared with past water development and refuge management actions to maintain wetland conditions. When considered with other existing and planned public uses and management actions at Sheldon Refuge, sport fishing is secondary and cumulative impacts will be negligible. Cumulative impacts from management of supporting uses such as camping will be minor and beneficial. It is anticipated the overall amount of refuge visitation associated with sport fishing will remain relatively stable and will not interfere with or detract from the quality of other refuge public uses.

Public Review and Comment:

This and other compatibility determinations were prepared concurrently with the Final CCP/EIS for the Sheldon National Wildlife Refuge (published August 2012). Open houses were held, multiple planning updates were mailed, and written comments were solicited from the public during development of the Final CCP/EIS for the refuge. Appendix A of the CCP further details public involvement during development of the CCP. A summary of public comments received during review of the Draft CCP/EIS along with the Service's response to those comments are included in Appendix N of the CCP.

Determination: (check one below)

___ Use is Not Compatible

_X_ Use is Compatible with the Following Stipulations

Stipulations Necessary to Ensure Compatibility:

Management direction is provided in the CCP for Sheldon Refuge. This directs monitoring of wildlife-dependent recreational fishing activities. Findings from these monitoring efforts will be used in determining what additional management actions, if any, are needed to ensure all fishing activities remain compatible with refuge purposes. Stipulations identified in this compatibility determination are expected to minimize impacts from fishing within Sheldon Refuge to fish, wildlife, plants, and their habitats.

1. The primary purpose for maintaining Catnip Reservoir and the associated Lahontan cutthroat trout fishery is to support Lahontan cutthroat reintroduction and recovery efforts elsewhere in the region (Sheldon CCP Objective 3d). Sport fishing at Catnip Reservoir will be allowed to continue to the extent the activity does not interfere with the implementation of this primary objective.

2. The primary management objective for McGee Pond will be to provide sustainable fishing opportunities for individuals who are age 12 or under, age 65 or older, or disabled.

3. Special State of Nevada sport fishing regulations apply to recreational fishing on Sheldon Refuge. Sheldon Refuge staff will continue to work cooperatively with the State's regulatory process to maintain harvest regulations necessary and appropriate to minimize adverse impacts to fisheries resources. To minimize impacts on refuge lands and resources, law enforcement patrols will routinely be conducted in an effort to maximize compliance with applicable policies, rules, and/or regulations.

4. Catnip Reservoir will continue to be stocked with Lahontan cutthroat trout, and Big Spring Reservoir will be stocked with Lahontan cutthroat, Alvord cutthroat, redband trout, or other trout indigenous to the region when sufficient water is available. Sport fishing at these reservoirs is considered secondary to other refuge management objectives. Therefore, the funding and staffing necessary for restocking these fisheries to maintain recreation opportunities will remain the responsibility of NDOW and the State of Nevada. To further restore biological integrity, diversity, and environmental health to Sheldon Refuge, all fish stocked or restocked to the Virgin Creek watershed, Catnip Reservoir, or Big Spring Reservoir will be regionally indigenous native

fish species. Consistent with Refuge System policy (7 RM 10, 7 RM 12), restocking of fish to these locations may be allowed when and where determined necessary to maintain healthy populations but will not be conducted primarily to maintain or enhance recreation opportunity.

5. All vehicles defined as off-road vehicles under 42 U.S.C. Section 4321 must be registered with the State of Nevada or Sheldon National Wildlife Refuge for use on lands administered by Sheldon Refuge.

6. Vehicle use within Sheldon Refuge is allowed only on roads and routes that are designated "open" on Figure D.1 and that are signed or otherwise marked for such use. Off-road use is prohibited.

7. Unless otherwise indicated by sign, permit, or regulation, the maximum number of consecutive nights any person or attended vehicle may remain at a designated Refuge campground is 14 nights.

8. Except for camping within campgrounds that are designated for such use on maps included in the Final Record of Decision for the Sheldon National Wildlife Refuge CCP/EIS and that are signed or otherwise marked for such use, no overnight use is allowed on lands administered by Sheldon Refuge unless expressly authorized by a valid Special Use Permit.

9. Non-motorized boats or boats with electric motors are allowed only in Big Spring Reservoir, Catnip Reservoir, and Dufurrena Ponds, consistent with 50 CFR 32.47.

10. Open fires are allowed only at designated campgrounds and within constructed fire rings, subject to additional seasonal fire restrictions and/or closures.

11. Pets must be leashed, except dogs used for hunting migratory or upland birds. Hunting dogs must be under strict voice control at all times.

12. Riding or packing with horses and mules is allowed in all areas open to public use. All horses and mules must be haltered, branded, tagged, or otherwise visibly marked as a domestic animal and must be tied, hobbled, high-lined, corralled, or otherwise under direct control at all times.

13. Grazing of domestic animals within Sheldon Refuge is not allowed. We encourage the use of certified weed-free hay, pellets, straw, and other livestock feed within Sheldon Refuge. The use of certified weed-free feed will become required if monitoring of stock use areas indicates the spread or introduction of noxious weeds from uncertified feed.

Justification:

The National Wildlife Refuge System Administration Act of 1966 (as amended) identifies recreational fishing as one of six priority public uses on national wildlife refuges. The law states that, when managed in accordance with principles of sound fish and wildlife management and administration, fishing and the other priority wildlife-dependent recreational uses "have been and are expected to continue to be generally compatible uses." The Act further states that these priority public uses should receive enhanced consideration over other general public uses in refuge planning and management, and directs the USFWS to provide increased opportunities for the public to safely engage in traditional outdoor activities such as fishing and hunting.

Management of sport fisheries and sport fishing opportunity are considered secondary to other management objectives and purposes for Sheldon Refuge. Management of the Dufurrena Ponds is primarily to benefit migratory birds and other wildlife, and management of Catnip Reservoir is primarily to aid in the recovery of the threatened Lahontan cutthroat trout. Impacts and costs associated with management and maintenance of the Dufurrena Ponds and Catnip Reservoir will occur regardless of any benefits or impacts to sport fishing opportunities. There are no plans to modify Big Spring Reservoir or the impoundment dam, but maintenance will continue to provide seasonal migratory bird habitat.

Because fishing opportunities are made possible by constructed ponds and reservoirs, there is little associated wetland habitat, and aquatic ecosystems are not considered natural or fully intact. As a result, fish populations have little adverse impact. Allowing only non-motorized boats or boats with electric motors on Big Spring Reservoir, Catnip Reservoir, and Dufurrena Ponds will continue to eliminate the risk of pollution associated with use of internal combustion boat motors, and maintain opportunities for solitude.

To reduce impacts to fishery resources and to provide the continued opportunity for recreational uses of these species by the American public, NDOW regularly adopts regulations in response to fish population levels and management needs. These regulations currently provide adequate protection for Sheldon Refuge's fishery resources, continued recreation opportunities, and other refuge purposes. Requirements for future stocking by NDOW will ensure fisheries management remains consistent with Service policy.

Although allowing fishing can result in disturbance to wildlife, disturbance will be intermittent and short-term and limited in time and space. There are more than adequate amounts of undisturbed habitat available to the majority of wildlife for escape and cover.

It is anticipated that wildlife populations will find sufficient food resources and resting places such that their abundance and use of Sheldon Refuge will not be measurably lessened from fishing activities. The relatively limited number of individuals expected to be adversely affected due to fishing will not cause wildlife populations to materially decline, the physiological condition and production of species will not be impaired, their behavior and normal activity patterns will not be altered dramatically, and their overall welfare will not be negatively impacted. Thus, allowing fishing to occur with stipulations will not materially detract from or interfere with the purposes for which the refuge was established or the Refuge System mission.

Mandatory 10- or 15-Year Re-evaluation Date: (provide year for "allowed" uses only)

___2026___ Mandatory 15-year re-evaluation date (for wildlife-dependent public uses)

_____ Mandatory 10-year re-evaluation date (for all uses other than wildlife-dependent public uses)

NEPA Compliance for Refuge Use Decision: (check one below)

____ Categorical Exclusion without Environmental Action Statement

____ Categorical Exclusion and Environmental Action Statement

____ Environmental Assessment and Finding of No Significant Impact

_X_ Environmental Impact Statement and Record of Decision

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Refuge Determination

Prepared by: _____ 9/25/12
(Signature) (Date)

Refuge Manager/
Project Leader
Approval: _____ 9/25/12
(Signature) (Date)

Concurrence

Acting Refuge Supervisor: _____ SEP 27 2012
(Signature) (Date)

Acting Regional Chief,
National Wildlife
Refuge System: _____ 9/24/12
(Signature) (Date)

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D.3 Compatibility Determination for Sport Hunting on Sheldon National Wildlife Refuge

Use(s): Hunting

Supporting Uses: Camping, boating, hiking, backpacking, horseback riding, and vehicle use

Refuge Name: Sheldon National Wildlife Refuge

City/County and State: Washoe County, Nevada; Humboldt County, Nevada; Lake County, Oregon

Establishing and Acquisition Authority(ies):

What is today known as the Sheldon National Wildlife Refuge was initially established by Executive Order 5540 dated January 26, 1931, and later enlarged by Executive Order 7364 dated May 6, 1936, and Executive Order 7522 dated December 21, 1936.

The authorities for nearly all Federal lands within Sheldon Refuge are the Migratory Bird Conservation Act of 1929, as amended (16 U.S.C. 715-715r) and the National Wildlife Administration Act of 1966, as amended (16 U.S.C. 668dd-668ee). A small portion of Sheldon Refuge was acquired under the authority of the Endangered Species Act of 1973, as amended (16 U.S.C. 1231-1544).

Refuge Purpose(s):

> "…as a refuge and breeding ground for wild animals and birds…" Executive Order 5540 dated January 26, 1931.
>
> "… set apart for the conservation and development of natural wildlife resources and for the protection and improvement of public grazing lands and natural forage resources …" Executive Order 7522 dated December 21, 1936.
>
> "… to conserve (A) fish or wildlife which are listed as endangered species or threatened species… or (B) plants…" 16 U.S.C. § 1534 (Endangered Species Act of 1973)
>
> "… for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." 16 U.S.C. § 715d (Migratory Bird Conservation Act)

National Wildlife Refuge System Mission:

> "The mission of the [National Wildlife Refuge] System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans" (National Wildlife Refuge System Administration Act of 1966, as amended [16 U.S.C. 668dd-668ee]).

Description of Use(s):

Hunting considered in this compatibility determination is limited to the following specific animals or groups of animals as defined by state and Federal hunting regulations: pronghorn, mule deer, California bighorn sheep, chukar, California quail, Greater sage-grouse, geese, ducks, and coots. Hunting is allowed throughout much of Sheldon Refuge. However, all hunting is prohibited within the Dufurrena Ponds Closed Area, and within the Little Sheldon Closed Area (Figure D.1), and hunting of migratory birds is prohibited on Catnip and Big Spring reservoirs. Big-game hunting seasons, which vary by wildlife species and weapon type (archery, muzzleloading rifle, modern rifle, and shotgun) begin in early August and end in early November. Hunting seasons for upland game birds begin in mid- to late September and end in early February. It is estimated that slightly more than 4,000 visitors participate in hunting within Sheldon Refuge each year.

Waterfowl/Waterbird Hunting

Waterfowl/waterbird hunting for geese, ducks, and coots is permissible in accordance with NDOW regulations. Hunting seasons generally extend from mid-October through January. Harvest limits are reviewed annually and established through Service regulations, which establish Migratory Bird Hunting Frameworks, and state wildlife commissions. The majority of Sheldon Refuge is open to waterfowl hunting except Virgin Valley, the Little Sheldon area, Big Spring Reservoir, and Catnip Reservoir (Figure D.1). However, as a desert environment, few areas of Sheldon Refuge provide waterfowl hunting opportunities, and migratory bird hunting occurs primarily at the IXL-managed wetlands, which were reconstructed in partnership with Ducks Unlimited specifically to provide waterfowl resting habitat and hunting opportunity. Additional opportunities are available at various small ponds, water developments, and wetland areas scattered throughout other portions of Sheldon Refuge.

Hunting for migratory waterfowl/waterbirds is authorized annually by the Secretary of the Interior through the Migratory Bird Frameworks and Federal regulation. The Migratory Bird Hunting Frameworks provide season dates, bag limits, and other options for states to select from that should result in the level of harvest determined to be appropriate based upon Service-prepared annual biological assessments detailing the status of migratory game bird populations. Wildlife commissions for Oregon, Nevada, and other states within the Pacific Flyway then select season dates, bag limits, shooting hours, and other options from the Pacific Flyway package. Their selections can be more restrictive, but cannot be more liberal than allowed by options in the Pacific Flyway package. Thus, the level of hunting opportunity afforded each state increases or decreases each year in accordance with the annual status of waterfowl populations.

There are no data on the number of hunters who participate in waterfowl/waterbird hunting or the amount of waterfowl/waterbird harvest within Sheldon Refuge. Based upon staff observation and field reports, waterfowl/waterbird hunting within the refuge is intermittent, and we estimate not more than 100 hunter days each year. Considering the size of waterfowl/waterbird populations within the Pacific Flyway and the maximum estimated annual number of 100 hunter days within the refuge, we expect that the level of harvest occurring within the refuge is negligible and has no measurable impact on waterfowl/waterbird population numbers.

Upland Bird Hunting

Most of Sheldon Refuge is open to upland game bird hunting except Virgin Valley and the Little Sheldon area (Figure D.1). Upland game birds open to hunting include Greater sage-grouse, chukar, and California quail. Hunting of upland game birds is largely controlled by state harvest limits. Hunting for upland birds often includes the use of dogs for pointing and retrieval of birds.

Chukar Partridge and California Quail: The hunting seasons for chukar and quail generally open in late September and continue through early February. Hunting effort for these upland game birds is considered low, with 40 California quail and chukar hunters estimated in 2007, the most recent year for which information is available. California quail and chukar are introduced non-native species (Gullion and Christensen 1952). The impacts of these species to the environment are considered low. California quail have been released throughout northern Nevada and eastern Oregon; 130 quail were first noted within Sheldon Refuge in 1941, and hunting for these birds was first allowed within Sheldon Refuge in 1961, although populations are not considered large (Sheldon Refuge files). Chukar were first introduced to Sheldon Refuge in 1941, and harvest has been allowed since 1961 (USFWS 1971).

Twelve water catchments or "guzzlers" were constructed within the eastern portion of Sheldon Refuge and are maintained to provide additional sources of water for small game and to support hunting for chukar and California quail. Guzzlers collect precipitation and divert it into a water storage tank. Water in the tank is fed into a small drinking trough enclosed by a wire fence that small game and other wildlife can access. Guzzlers are the only facilities within Sheldon Refuge that specifically support upland bird hunting.

Greater Sage-grouse: Hunting of Greater sage-grouse within Sheldon Refuge is allowed by permit issued from NDOW. Hunting of Greater sage-grouse provides recreation opportunity for up to 150 hunters drawn by lottery from a pool of roughly 400 applicants each year. Hunting for sage-grouse within Sheldon Refuge is restricted to two separate two-day seasons in September. Seasons and harvest limits are coordinated by NDOW and Sheldon Refuge to maintain healthy populations and adequate data collection. Harvest levels are currently lower than in past years as a result of harvest and possession limits being reduced from three and six birds respectively in 2007. From 2002 through 2010, a minimum of 1,296 Greater sage-grouse were harvested within Sheldon Refuge (based on the number of wings hunters provided). Harvest ranged from 75 birds in 2007 to 230 in 2004, and averaged 144 birds per year (Collins 2010). The sage-grouse hunt is important for determining the success of reproduction for the year. Every hunter is required to deposit one wing from every grouse harvested into a collection barrel before leaving Sheldon Refuge. Wings are then examined each year during the annual NDOW wing bee to estimate population productivity and nesting success. It has been suggested that a minimum of 100 wings from harvested adult and yearling hens are needed to obtain reliable data (Autenrieth et al. 1982), and minimum sample sizes less than 100 wings to estimate productivity would result in confidence intervals that typically have low precision (Autenrieth 1981). However, it needs to be understood that the precision (±20%-33%) of the estimates acquired from a sample size of even 200 wings is considered mediocre (Hagen and Loughlin 2008).

Wing collection barrels are the only facilities that specifically support hunting for Greater sage-grouse in the refuge.

Big-game Hunting

Big-game hunting is a very popular priority public use within Sheldon Refuge. Except for a small part within Oregon, Sheldon Refuge corresponds with Nevada Hunt Unit 033 and is open to big-game hunting, with the exception of Virgin Valley in the eastern portion of Sheldon Refuge and the Little Sheldon area in the western portion (Figure D.1). Big-game species open to hunting are mule deer, pronghorn, and California bighorn sheep in accordance with NDOW regulations. Hunting seasons begin in August and continue through September, October, and early November depending upon the species and the type of weapon used. Sheldon Refuge staff works closely with NDOW to set big-game tag numbers and season dates for the upcoming year. NDOW administers the hunt, including tag issuance, data collection, and the preparation of summary reports, which provide excellent hunt participation information for Sheldon Refuge. Ongoing coordination between NDOW and the Service is required to ensure the number of hunters and hunting regulations are consistent with refuge purposes, Service policies, and refuge goals and objectives.

Hunting seasons and harvest levels are established in cooperation with both NDOW and Oregon Department of Fish and Wildlife (ODFW). In Nevada, the season-setting process begins with the establishment of season dates on a biennial basis. Biologists craft recommendations in accordance with management program strategies. They are also guided by their own assessments of harvest data and population. After all County Advisory Boards have reviewed proposals and made recommendations, the State Board of Wildlife Commissioners convenes to consider public and agency recommendations to adopt hunting seasons and regulations. In the spring of each year, biologists again assess their data to prepare population estimates. These estimates are used to establish hunting objectives for that year only. Harvest data are reported by hunters to NDOW and ODFW, and season and bag limits are adjusted accordingly to ensure that overall populations of game species remain healthy into the future. Impacts will be monitored, and, if necessary, additional measures will be developed in coordination with NDOW and ODFW to protect refuge resources.

Sheldon Refuge is managed to provide a quality big-game hunting experience consistent with the Sheldon Refuge management goal to provide visitors of diverse interests and abilities with opportunities to experience a variety of quality wildlife-dependent recreational and interpretive activities on vast, rugged, and remote high desert landscapes. Sheldon Refuge is renowned for its big-game hunting, and hunters come from throughout Nevada as well as 10 or more additional states each year. Hunt quality is considered high, as measured by the number of animals seen; the quality and health of the animals; the opportunity to use a variety of weapons, hunting techniques, means of access, and modes of transportation; the opportunity for solitude with little crowding or competition with other hunters and a lack of interference from refuge users; scenic quality and natural settings characterized by few structures or evidence of people; and biological integrity of the areas visited while hunting. Sheldon Refuge has a reputation for producing exceptional trophies, and tags are highly sought after.

Big-game hunting areas are established in cooperation with the NDOW and ODFW. Big-game hunting units within the Nevada portion of Sheldon Refuge include all of Hunt Unit 033. The relatively small portion of Sheldon Refuge within Oregon is within Wildlife Management Unit 70 (Beaty's Butte). Big-game hunting activities have remained relatively stable within Sheldon Refuge over the past 15 years due to the limited number of hunting tags issued. A lottery system is used to distribute a limited number of harvest tags for each pronghorn, mule deer, and bighorn hunting season, which occur from August through October. Harvest tags are limited to ensure healthy populations of wildlife are maintained, to maintain low hunting pressure and reduce hunting

competition, to allow for non-overlapping bow, rifle, and muzzleloader seasons, and to reduce crowding at campgrounds. Tags are further distributed between seasons during different times of the year and for different methods of hunting, including seasons for archery, muzzleloading rifle, and modern rifle. The peak for big-game hunting within Sheldon Refuge occurred in 2007 with 337 tags issued (five California sheep, 89 pronghorn, and 243 mule deer tags), resulting in a harvest of 197 animals.

Mule Deer: In 2010 the State of Nevada issued 100 mule deer harvest tags for Hunt Unit 033 (Sheldon Refuge), with a reported harvest of 43 deer. These numbers are reduced from 2006 when 258 tags were issued for a reported harvest of 113 deer, and from 2003 when139 harvest tags were issued with a reported harvest of 72 deer.

Fires within the past 20 years that have burned stands of mountain mahogany and bitterbrush in the Badger Mountain, Catnip Mountain, and Alkali Peak areas, combined with drought conditions during several more recent years and overgrazing by feral horses, have affected areas of important mule deer summer range within Sheldon Refuge. Declines in mule deer numbers and consequently mule deer hunting from 2007 through 2010 are largely attributed to drought conditions (NDOW 2011b), but significant moisture in 2011 combined with continued reduction in the number of feral horses is expected to improve habitat conditions and should allow for herd growth.

Pronghorn: In 2010 the State of Nevada issued 105 pronghorn harvest tags for Hunt Unit 033 (Sheldon Refuge), with a reported harvest of 68 pronghorn. These numbers have steadily increased since 2003when 50 tags were issued for a reported harvest of 39 pronghorn.

Annual numbers of pronghorn within Sheldon Refuge during the hunting season have remained static at about 1,500 pronghorn since 2005 (NDOW 2011b). Buck ratios remain high and the quality of the hunting experience is considered excellent.

California Bighorn Sheep: In 2010 the State of Nevada issued five California bighorn sheep harvest tags for Hunt Unit 033 (Sheldon Refuge), with a reported harvest of six bighorn sheep (one additional sheep was harvested under the special statewide Governor's tag). These numbers have increased since 2003 when three tags were issued, but have remained stable from 2006 with five tags issued and five bighorn sheep harvested each year.

Bighorn sheep numbers continue to slowly increase within Sheldon Refuge, particularly within the western portion of the Refuge. NDOW estimated about 220 sheep within the Refuge in 2011 (NDOW 2011b).

Six water catchments or "guzzlers" within Sheldon Refuge were constructed and will be maintained to provide additional water sources and support hunting for big game, primarily bighorn sheep. Although use of water catchments continues to be a popular management tool in the western United States, the efficacy of such efforts has been questioned and their use is controversial, particularly within wilderness areas.

Supporting Uses

Camping

Camping itself is not a priority public use on Service lands, but because of the size, remoteness, and quality of roads within Sheldon Refuge, it is important in supporting priority uses including fishing, hunting, wildlife observation, and wildlife photography. There are four types of camping opportunities currently provided within Sheldon Refuge: developed, semi-primitive, primitive, and backcountry/wilderness.

Camping within Sheldon Refuge is allowed in 13 designated campgrounds and by Refuge Special Use Permit for backcountry camping.

Developed Camping: Virgin Valley Campground located at Dufurrena is considered the only developed campground. Virgin Valley Campground is easily accessible year-round for all types of vehicles, including RVs, and it offers shade trees, potable water, two vault toilets, 16 picnic tables, 24 fire rings, a meat-hanging pole, a bath-house, and a hot spring developed for swimming. Campground use is managed on a first-come, first-served basis without fees or designated sites. From 2005 through 2007 an average of 18 campsites were occupied per day during the days surveyed, for a seasonal average of 6,573 visitor use days (USFWS undated report).

From mid-August through mid-November, the Virgin Valley Campground is heavily used by hunters. During peak seasons, overcrowding and user conflicts have been a concern as has overflow into upland areas adjacent to the campground, which can result in further environmental damage. There is also a private developed campground at the Royal Peacock Mine located in the Virgin Valley Mining District, which has RV hookups.

Semi-primitive Camping: Five campgrounds (Catnip Reservoir, West Rock Spring, Fish Spring, Badger, and Big Spring Reservoir) are considered semi-primitive and include outhouses, fire rings, meat-hanging poles, and, in the case of Fish Spring and Badger campgrounds, horse corrals. These semi-primitive campgrounds are accessible from primary roads or improved secondary roads suitable for most types of vehicles and are primarily used by hunters. Sport anglers also use campgrounds at Catnip and Big Spring reservoirs.

Additional facilities such as campsite amenities (i.e., picnic tables and accessible fire rings or barbeque grills), potable water, shade structures, kiosks, and dedicated volunteer sites are planned for Virgin Valley, Catnip Reservoir, and Big Spring Reservoir campgrounds. These facilities will provide developed camping opportunities that are not commonly available within Sheldon Refuge or the region. However, these improved facilities will only be sustainable over the long term through campsite fees to support volunteers, maintenance, and replacement.

The Service will also allow public overnight use of some existing historic structures within Sheldon Refuge. The most likely structures are the Little Sheldon Overnight Cabin and Badger Cabin.

Primitive Camping: Seven campgrounds (Little Catnip Spring, Gooch Spring, North Hell Creek, Wheeler Spring, Bateman Spring, Devaney, and East Rock Spring) are considered primitive campgrounds and have only fire rings or no improvements, are remote, and are accessible to four-wheel drive or high-clearance vehicles when road conditions are passable. These primitive campgrounds receive intermittent and low amounts of use, occurring mostly during the big-game

hunting seasons (early August through October). All of these campgrounds are located immediately adjacent to, or include, wet meadows, spring, or springbrook habitats. Three primitive campgrounds (Wheeler Spring, Devaney, and East Rock Spring) also include aspen woodland habitats. Impacts associated with primitive campgrounds were identified as an issue during the Sheldon CCP planning process. The impacts identified and stipulations for reducing or eliminating those impacts are addressed in subsequent sections of this compatibility determination.

Backcountry/Wilderness Camping: Backcountry camping for up to 14 days is allowed by Refuge permit. Permits are not limited, but do stipulate visitors must camp at least 0.5 mile from open roads and at least 100 yards from water sources. The majority of backcountry camping permits are issued to hunters, but the amount of use is low and no adverse impacts have been observed. Backcountry use will continue to be monitored, and future management actions to reduce or eliminate any impacts will be implemented as necessary.

Public Access

Public access to areas within the Refuge is provided by a network of vehicle roads and informal backcountry routes and trails. Roads include one two-lane paved highway, maintained gravel roads, and numerous primitive and unmaintained dirt roads. Trails throughout the refuge backcountry and wilderness areas are primarily abandoned vehicle routes historically used for access to livestock developments and private inholdings later purchased by the Service.

The most substantial changes to sport hunting are expected to result from the relocation and enlargement of the refuge visitor contact station, improvement of campground facilities, and improved signing of routes open to vehicle use. Improved gravel roads within Sheldon Refuge will be maintained more frequently and all routes open to the public use of vehicles will be adequately signed and marked. Visitors will be required to register all OHVs consistent with State of Nevada regulation or with Sheldon Refuge for use on refuge roads and routes designated open to vehicle use. These actions are intended to improve the quality of the transportation system and deter vehicle violations while requiring only minimal law enforcement presence.

Maintained Public Roads: In preparation of the Sheldon Refuge CCP, each route within the refuge was evaluated to assess impacts to fish, wildlife, plants, and their habitats, as well as benefits for public use and recreation opportunity. Following this evaluation, 300 miles of existing roads (including State Highway 140 and all maintained county roads) were designated for public vehicle use. The Service has determined the continued use and maintenance of these designated roads, including actions for re-routing or modification as presented in the Sheldon Refuge CCP, will have minimal or no impacts to wildlife and wildlife habitat and/or are subject to existing right-of-way. The unimproved roads within Sheldon Refuge are not regularly maintained, but are repaired on a site-by-site basis to keep them in usable condition or to prevent undue resource damage (i.e., excessive erosion).

Trails and Backcountry Access: Hiking, horseback riding, use of pack stock, and other non-mechanical modes of access are allowed on trails, routes, and other areas of Sheldon Refuge open to the public. All vehicle use is restricted to designated open roads. Existing trails throughout Sheldon Refuge will remain, but will not be marked or maintained for public use. No adverse impacts have been observed from visitors using these routes for hiking, horseback riding, or use of pack stock.

Horseback Riding and Pack Stock Use: Horseback riding has been allowed as a recreation activity within Sheldon Refuge for many years. However, it is estimated fewer than 10 horseback visitors use Sheldon Refuge each year, and as a result, horseback riding is considered a low-impact activity. Horseback riding gives the public an opportunity to visit remote and undeveloped portions of Sheldon Refuge, and to enjoy the wildlife viewing, solitude, and expansive views that Sheldon Refuge is known for.

There is a concern that the number of visitors engaging in horseback riding may increase, particularly with hunting guides and their clients, and that use of horses and pack stock within the Refuge will introduce invasive non-native plants. These impacts have not been observed, but monitoring will continue and the Service will take additional action as needed to maintain wilderness character and prevent the introduction of weeds to the refuge.

The corrals at Badger and Fish Spring campgrounds are the only facilities that specifically support horseback riding and the use of pack stock.

Boating: Refuge-specific regulations that apply to the use of non-motorized boats and boats with electric motors specifically apply to sport fishing and sport hunting, but are interpreted as applying to other compatible wildlife-dependent public uses as well. However, because migratory bird hunting is not allowed on these waters, the use of non-motorized boats and boats with electric motors in Big Spring Reservoir, Catnip Reservoir, and Dufurrena Ponds consistent with 50 Code of Federal Regulations (CFR) 32.47 is assumed to rarely occur in conjunction with hunting activities, but is considered a compatible activity that supports hunting within Sheldon Refuge.

Commercial Guiding and Outfitting

Commercial guiding and outfitting is permitted specifically to support hunting. This refuge economic use is addressed in detail in the compatibility determination for guiding within Sheldon Refuge.

Availability of Resources:

Most administration and management of hunting, including issuing of licenses, permits, and harvest tags, is conducted by NDOW and ODFW. Maintenance of guzzlers will be conducted primarily by NDOW and volunteers in cooperation with the Service. Maintenance of the IXL wetlands, campgrounds, access roads, and other supporting facilities and routine law enforcement patrols are conducted primarily by the Service. Sheldon Refuge currently has adequate funding and staff to administer this use.

Category and Itemization	One-time	Annual
Administration and management (volunteer host site development, volunteer campground hosts, law enforcement patrols, fee collection and processing)	$15,000	$5,000
Maintenance	$5,000	$500-$1,500
Monitoring	$500	$500
Special equipment, facilities, or improvements (campgrounds, docks, and access roads)	$150,000	$500-$1,500
Offsetting revenues[3]	$5,500	$5,500

Anticipated Impacts of the Use(s):

Effects from Hunting

Both state and Federal wildlife biologists have determined that the current hunting seasons and levels of harvest are sustainable and are not expected to have any significant long-term adverse impacts on wildlife populations. In general we expect management objectives for the hunting program at Sheldon Refuge, which emphasize quality hunting experiences, to be characterized by less crowding, less competition, fewer conflicts between hunters, relatively undisturbed wildlife, greater hunter safety, and less interference from or dependence on mechanized aspects of the sport. The number of compatible facilities that accommodate hunting represent a lower threshold for compatibility and will be more limiting than game populations for hunting. Therefore, both direct and indirect impacts from current and projected amounts of hunting are expected to have only minor adverse impacts to game populations.

Hunting, by its nature, results in the intentional take of individual animals, as well as wounding and disturbance (DeLong 2002). It can also alter behavior (e.g., foraging time), population structure, and distribution patterns of wildlife (Bartelt 1987; Cole and Knight 1990; MacArthur et al. 1979; Wehausen 1980). Immediate responses by wildlife to recreational activity can range from behavioral changes including nest abandonment or change in food habits, physiological changes such as elevated heart rates due to flight, or even death (Knight and Cole 1995). The long-term effects are more difficult to assess but may include altered behavior, vigor, productivity, or death of individuals; altered population abundance, distribution, or demographics; and altered community species composition and interactions.

Impacts to other wildlife populations from sport hunting within Sheldon Refuge, including both direct and indirect impacts, are considered minor. In addition to the minor, adverse impacts to the

[3]Anticipated campsite fee revenues for Catnip Reservoir, Big Spring Reservoir, and Virgin Valley campgrounds, if fee structure adopted as proposed in the CCP, is based on $5/site/day for 1,100 site-use days.

species or population as a result of individual animal mortality (e.g., mule deer, pronghorn, bighorn sheep, and Greater sage-grouse), short-term, direct, adverse impacts (e.g., trampling of vegetation, wildlife displacement, disturbance of animal behavior) are expected from hunters shooting and moving throughout the Refuge while hunting. Impacts are expected to be minor and will likely be limited to specific areas scattered throughout Sheldon Refuge.

Harvest data are reported by hunters to NDOW, and season and bag limits are adjusted accordingly to ensure that overall populations of game species remain healthy into the future. Sheldon Refuge staff will continue to cooperate with the State of Nevada to ensure protection and stability of wildlife populations. Hunting opportunities will be managed to maintain primitive and semi-primitive natural settings characterized by few developments or facilities and wildlife largely unaccustomed to people. In such a setting, hunters will encounter few other people, face little competition from other hunters, and have the opportunity to pursue game largely undisturbed.

In its 2010 finding, the Service evaluated the impact of hunting on sage-grouse throughout their current range and determined that although the allowable harvest of sage-grouse through hunting was very high in past years, substantial reductions in harvest began during the 1990s, and harvest has continued to drop. Since approximately 2000, total mortality due to hunting has been lower than in the last 50 years (USFWS 2010). The present level of hunting mortality shows no sign of being a significant threat to the hunted species. However, in light of present and threatened habitat loss and other considerations (e.g., West Nile virus outbreaks in local populations), states and tribes will need to continue to carefully manage hunting mortality, including adjusting seasons and harvest levels and imposing emergency closures if needed. The Service concluded that the Greater sage-grouse is not threatened by overutilization for commercial, recreational, scientific, or educational purposes now or in the foreseeable future. The Western Association of Fish and Wildlife Agencies (WAFWA) recommends that where populations are hunted, harvest rates should be 10% or less than the estimated fall population to minimize negative effects on the subsequent year's breeding population (Armentrout et al. 2004).

In 2004, NDOW estimated that the sage-grouse population within Sheldon Refuge was 2,896 to 3,475 birds, and the minimum harvest was 230 birds (calculated from wings provided by hunters), or 7.9% to 6.6% of the population. In 2001, Sheldon Refuge fall population estimate was 3,652 birds and harvest was 180 birds, or 5% of the fall population (Collins 2010). Based upon these estimates, total harvest is likely less than 10% of the total sage-grouse population within Sheldon Refuge (which is the WAFWA guideline used by NDOW for Sheldon Refuge), and we anticipate continued hunting, as currently managed, will not pose a threat that would lead to the endangerment of the Refuge's sage-grouse population or the species in the foreseeable future. Sage-grouse populations within Sheldon Refuge and population productivity estimates derived from wing analyses will continue to be evaluated and considered in future sage-grouse population management decisions and recovery efforts as appropriate to ensure overall harvest does not exceed 10% of the population and that wing data are appropriate and necessary for sage-grouse management within the refuge.

A large proportion of visitation to Sheldon Refuge is day-use wildlife observation and photography, which occur in and around more developed areas of Sheldon Refuge such as the maintained gravel roads and Highway 140, and the Virgin Valley Campground and Dufurrena area. Disturbance and displacement of wildlife away from areas where hunting occurs can adversely impact opportunities for wildlife observation and photography. We estimate such impacts are relatively minor because the Virgin Valley area is closed to hunting, and wildlife observation and photography in remote portions

of Sheldon Refuge away from maintained gravel roads and Highway 140 where the majority of hunting activities occur, is low.

Effects from Camping and Campgrounds

Use of campgrounds within Sheldon Refuge causes impacts to vegetation, soils, water quality, and cultural resources. During dry conditions, carelessness with campfires can lead to wildfires. Management and development of campgrounds is also expected to affect the type and quality of recreation opportunities available.

Impacts to Vegetation, Soils, and Water Quality: Campgrounds and their use within Sheldon Refuge range from primitive sites with relatively low and only intermittent use to very developed sites with year-round and relatively high amount of use during summer months. Current impacts and expected future impacts associated with use and development of these campgrounds also vary widely. Because the most primitive campgrounds are currently the least impacted, we can expect these sites to exhibit the greatest amount of additional or potential impact with only slightly more use. Conversely, most impacts have already occurred at the most heavily used and developed campgrounds, and we can expect very little additional impact to vegetation, soils, or water quality even with relatively large increases in use at these campgrounds.

The greatest difference in durability between vegetation types occurs at moderately low use levels (Cole 1985). Sites that are used frequently are likely to be highly impacted regardless of their fragility. Because vegetation loss usually occurs more rapidly than loss of organic soil horizons, sites with either no vegetation or resistant vegetation (e.g., grasses as opposed to forbs) recover more quickly and are less likely to be impacted by low levels of use, while sites with thick organic soil horizons are less susceptible to erosion and are more likely to withstand high amounts of use.

Experimental studies suggest that there is an important difference between a site's resistance (its ability to tolerate use without being damaged) and its resilience (its ability to recover from damage). Cole (1995) has shown, for groundcover plants, that resistance decreases with erectness and that broad-leaved herbs are typically less resistant than grass-like plants and shrubs. Low shrubs, such as heather, are relatively resistant to trampling stress but their resilience is low. Once damaged, they recover slowly. Grass-like plants are most tolerant of trampling (Cole 1989). The compaction of soils from campsite use reduces water infiltration and water holding capacity, which leads to increased runoff and erosion potential (Cole 2004; Monti and Mackintosh 1979). Impacts associated with use at primitive campgrounds can be readily observed and tend to occur rapidly, but these impacts are relatively inconsequential when considered in the context of the entire refuge. Impacts associated with campgrounds located within riparian areas or near water sources are of greater concern, but current impacts are not severe and vegetation, soils, and water quality at primitive campgrounds are expected to recover noticeably within a few years following campground relocation. This assessment is supported by Cole (1981) who noted that hiking and camping impacts on soil and vegetation, while severe when measured at small scales, are minimal at large spatial scales. This suggests that while recreation impacts can be serious for individual plants and animals and perhaps localized rare populations, they are generally of little significance to landscape integrity or regional biotic diversity. Moreover, unless much of a population is impacted by a single affected site, the intensity, size, and distribution of impacts are not relevant to the significance of impacts assessed at large spatial scales (Cole 1989).

Virgin Valley Campground is located at a site previously developed and used by the Civilian Conservation Corps in the late 1930s. Catnip Reservoir and Big Spring Reservoir campgrounds are located immediately adjacent to artificial reservoirs. These three campgrounds receive the greatest amounts of use and exhibit the greatest amount of impact. The core areas of use at these campgrounds no longer support vegetation or vegetation diversity is substantially reduced, water infiltration is considered low due to soil compaction, and gravel has been placed in some areas to reduce erosion and rutting from vehicles. Non-native plants and animals in and around these three campgrounds were likely introduced by early ranching and development activities rather than campground visitors. Monitoring and control efforts will continue to detect and remove or eradicate small or new populations of invasive species.

The remaining 10 campgrounds are all located immediately adjacent to or include aspen woodland, wet meadows, spring, and/or springbrook habitats. Most of these campgrounds have moderate amounts of vegetation loss and soil compaction, which is limited to parking areas, areas around fire rings, outhouses, and along connecting paths. These impacts are generally not continuous throughout the campground and are expected to remain stable with current amounts of intermittent use, which occurs during late summer and fall, after most annual and biannual plants have finished growing for the season and when soils are typically drier and more resistant to impact. Some primitive campgrounds have no visible bare ground, and where located in meadow habitats, vegetation is generally able to recover from the current amount of use. Some primitive campgrounds exhibit small areas of bare ground, generally a lack forbs, which are not resistant to trampling, and in the case of Wheeler Spring, Devaney, and East Rock Springs, exhibit some impacts to aspen trees from trampling, soil compaction, root exposure, and cutting. Because these campgrounds receive little visitation or are located near frequently traveled gravel roads, impacts to wildlife from campground use are estimated to be minor or negligible. Due to the nature of these impacts and relatively low amount of use, we anticipate these campgrounds will exhibit the greatest amount of natural recovery compared to the three more developed and heavily used campgrounds if camping use were eliminated, but they will also exhibit the greatest amount of additional impact if camping use were to substantially increase. Aspen stands associated with the Devaney, Wheeler Spring, and East Rock Springs campgrounds are also expected to recover, but regeneration of the understory shrubs and younger trees will occur slowly and will likely require some active restoration and/or replanting.

Up to nine semi-primitive and primitive campgrounds will be relocated away from sensitive riparian habitats and areas with cultural resources. It is anticipated actions to relocate campgrounds to alternative sites, protect sensitive habitats at each of these campgrounds, and confine use to designated campsites in heavily used campgrounds will minimize or avoid additional impacts altogether.

We expect some primitive campgrounds to be consolidated with other existing campgrounds, which will need to be enlarged and have additional campsites constructed (the most likely candidates for enlargement include Catnip Reservoir, Big Spring Reservoir, Fish Spring, and West Rock Spring campgrounds). Consolidation will result in additional impacts from increased use of existing facilities and campsites and from designation and construction within existing campgrounds. Where camping already occurs, increased use of existing campsites and facilities is expected to have little or no measurable impact to vegetation or wildlife. Impacts to expanded portions of these campgrounds are expected to occur quickly as vegetation is trampled and soil compacted within the first two or three seasons of use, but will then stabilize over the long term. We expect enlargement of existing campgrounds will result in minor, site-specific, long-term, direct adverse impacts to plants and their habitat from removal of vegetation, soil compaction, and loss of organic soil horizon at these sites.

Impacts from Wildfire: Campfires are allowed at designated campgrounds but are occasionally prohibited during periods of high fire danger. Wildfires have been started by refuge visitors in the past, and we expect some wildfires will occasionally start as a result of escaped campfires or misuse of stoves. Seasonal campfire restrictions and rapid fire suppression response will continue to minimize impacts.

Impacts to Cultural Resources: Most of the 13 designated campgrounds are located within or adjacent to prehistoric cultural sites. While the majority of impacts occurred following the initial establishment and use of these campgrounds, some impacts continue due to ongoing soil disturbance and compaction within existing campsites, trampling and removal of vegetation, occasional use of previously unused areas adjacent to the campgrounds, and vehicle use outside designated areas. Limited fee use of the Little Sheldon Overnight Cabin or Badger Cabin is expected to increase public appreciation for historic resources and understanding for their protection and preservation. In addition, the use of these sites and the collection of fees will provide justification and funding for restoration work and continued maintenance. As a result, the integrity of sites eligible for the National Register of Historic Places will be protected. Therefore, we anticipate use of these facilities to support sport hunting will have a major, long-term, beneficial impact on cultural resources.

Impacts to Recreation Opportunity: Campsite registration, overnight fees, and the other improvements planned for the developed campgrounds will increase maintenance, increase visitor compliance with rules and regulations (by defining and designating campsites), and decrease competition for campsites. Campground management strategies are expected to result in moderate, indirect, long-term, beneficial impacts to the camping experience, in support of providing quality opportunities for wildlife-dependent recreation.

Effects from Public Access

Adverse impacts are expected to continue as a result of the network of developed and undeveloped roads throughout Sheldon Refuge and their associated maintenance. Road development and use continues to adversely impact the biological integrity within Sheldon Refuge by contributing to the altered composition of plant communities, soil disturbance (Eckert et al. 1979; Iverson et al. 1981; Switalski et al. 2004), altered hydrology and stream sedimentation (Forman and Alexander 1998), facilitation of the spread of invasive vegetation, changes in the natural fire regimes, and habitat fragmentation.

Many direct effects are obvious during construction, but other effects are permanent and can extend substantially beyond the actual road surface (road-effect zone; Forman 2000; Forman and Alexander 1998). At the landscape scale, major ecological impacts of a road network include fragmentation, the disruption of landscape processes, and loss of biodiversity. Biodiversity declines as the road network impacts interior species (species cut off by roads), species with large home ranges, stream and wetland species, and rare native species (Forman and Alexander 1998). Fragmentation of previously extensive landscapes can influence the distribution and abundance of a host of wildlife species through redistribution of habitat types and through the pattern of habitat fragmentation, including characteristics such as decreased patch area and increased habitat edge (Vander Haegen et al. 2000).

Roads (including OHV trails) are commonly identified as important correlates or indicators of loss of ecological health and affect terrestrial and aquatic ecosystems in several general ways: 1) increased mortality from road construction; 2) increased mortality from collision with vehicles; 3) modification of animal behavior; 4) alteration of physical environment; 5) alteration of chemical environment; 6)

spread of exotic species; and 7) increased alteration and use of habitats by humans (Trombulak and Frissell 2000; Wildlife Action Plan Team 2006).

The ecological effect of road avoidance is likely related to traffic density and speed of travel, as well as traffic noise levels (Forman and Alexander 1998). Road-effect zones generally result in lower breeding densities and reduced species richness; species demonstrated to avoid or be negatively impacted by roads include arthropods, reptiles, small mammals, ungulates, and forest and grassland birds (Andrews and Gibbons 2005; Carr and Fahrig 2001; Forman and Alexander 1998; McGrann et al. 2006; Rost and Bailey 1979). For example, proximity to OHV trails (<1,000 meters [3,280 feet]) was found to have a direct correlation with reduced-quality habitat for nesting songbirds in sagebrush-steppe habitats, including nest desertion, nest predation, and abandonment (Barton and Holmes 2007). Behavioral disturbance from recreation, including that associated with trails and roads, may also have both immediate and long-term effects on wildlife (Taylor and Knight 2003). In one study of pronghorn, deer, and bison, individuals exhibited a 70% probability of flushing within 1,000 meters (3,280 feet) on either side of a trail used by hikers and mountain bikers (Taylor and Knight 2003); presumably, responses are similar in the presence of vehicles such as OHVs. Road density can be used as an overall index to average patterns over an area. For example, road densities of approximately 1.0 mile per square mile have been recommended as the maximum for a naturally functioning landscape containing sustained populations of large predators (Forman and Alexander 1998). However, the effects of road density are likely sensitive to road width or type, traffic density, network connectivity, and the frequency of spur roads into remote areas (Forman and Alexander 1998).

Within Sheldon Refuge, more than 50 introduced, non-native, and often noxious plant species have been documented (refer to Sheldon Refuge CCP Appendix B). Invasive plants typically need transportation to spread to new areas (Trombulak and Frissell 2000), and within Sheldon Refuge several methods are possible, including vehicles, people, wild and domestic animals, and firefighting equipment. Indeed, it has been demonstrated that habitats distant from roads may provide important refuge for native grassland species, and that this effect may be even more pronounced in predominately intact landscapes such as those in parts of the Great Basin (Gelbard and Harrison 2003). Human access and disturbance effects on remote areas tend to increase with higher road densities, as well as human-caused fire ignitions (Forman and Alexander 1998).

Various methods, including systematic inventory and monitoring for invasive plants, mowing, use of herbicides, and elimination of grading road shoulders, will be used to detect new infestations, control and contain existing infestations, and treat up to 1,000 acres per year. Management strategies to combat invasive plants support the Service policy for biological integrity and diversity within Sheldon Refuge. With a more systematic approach for inventory of noxious weeds and other invasive plants, populations are more likely to be detected when they are small and more easily managed and controlled. Increased treatment and reduced soil disturbance along road corridors should reduce the spread of invasive plants already present and reduce the potential for new populations. As a result, we anticipate these actions will result in major, long-term, direct, beneficial impacts to all habitats. Implementing treatment strategies (e.g., mechanical removal of vegetation, application of herbicides) will likely eliminate or prevent the spread of noxious weed populations when detected and provide some conservation of native habitats, resulting in minor, site-specific, short-term, direct, beneficial impacts to habitat on approximately 1,000 acres per year.

In conjunction with preparation of the Sheldon Refuge CCP, Refuge staff conducted an evaluation of existing routes and trails and identified known and potential resource impacts and public benefits and

recreation opportunities associated with vehicle access. Route segments that were identified as causing substantial impacts to soils, riparian areas, and/or wildlife, were redundant with other routes, or provided very little or no access for wildlife-dependent uses were not identified for designation as open roads for public use of vehicles. To minimize or avoid lesser impacts from roads and vehicle use, the Service will implement a number of transportation management strategies including designating roads that are not duplicative, re-routing or realigning road segments that pass through sensitive resource areas, installing erosion control structures, increasing monitoring and treatment of weeds along road corridors, and posting signs marking all designated open roads. These actions will result in long-term, minor, direct and indirect, beneficial impacts to soils by decreasing erosion in sensitive areas that are currently affected. Overall we expect impacts from road management will be minor, direct, and adverse to habitats on a localized and long-term basis.

Management of sport hunting supports Service policy by providing various opportunities for primitive and unconfined types of recreation throughout Sheldon Refuge. Hiking, horseback riding, and vehicle access are secondary uses that support wildlife-dependent recreational activities within Sheldon Refuge. Sheldon Refuge allows access on foot, by horseback, or by vehicle. However, all vehicle routes are open to both motorized and non-motorized vehicles, and there are no areas managed for non-motorized vehicle access (i.e., mountain bikes or game carts) or semi-primitive non-motorized recreation opportunity. In areas open to vehicle use, we assume impacts to non-motorized vehicle users are asymmetrical (Webber 1995) and occur from conflict, noise, dust, competition with motorized users for recreation opportunity, and displacement to non-motorized areas outside the refuge (Adelman et al. 1982; Gambill 1996; Manning and Valliere 2002; Moore 1994; Stokowski and LaPointe 2000). The somewhat narrow range of vehicle access for non-motorized users provided within the refuge represents a direct, adverse, moderate, long-term impact to quality recreation opportunities.

Effects from Water Guzzlers

Although use of water guzzlers continues to be a popular management tool in the western United States, the efficacy of such efforts has been questioned and their use is controversial, particularly within wilderness areas (Cain et al. 2008). Water guzzlers intended to increase populations of small game (i.e., chukar), and big game (i.e., bighorn sheep) impound a relatively small percentage of rainfall within any particular drainage; water guzzlers have been shown to have little long-term effect on the target wildlife population levels or distribution. Therefore, guzzlers will continue to have negligible impact.

Effects from Horseback Riding and Use of Pack Stock

Because the number of visitors who ride horseback or use pack stock within Sheldon Refuge is estimated less than 10 per year and because little impact has been observed from such use, we expect future impacts from trampling and introduction of non-native weeds will also be low and less than similar impacts associated with overnight camping and vehicle use. Stock use areas at Badger and Fish Spring campgrounds will continue to be monitored, particularly for new populations of non-native plants, and additional actions such as requiring certified weed-free feed and weed removal will be implemented as necessary.

Effects from Boating

The use of non-motorized or electric-powered boats is allowed only in Big Spring Reservoir, Catnip Reservoir, and the Dufurrena Ponds consistent with 50 CFR 32.47. The majority of boating occurs in conjunction with sport fishing, and while migratory bird hunting is not allowed on these waters, occasional and intermittent boating does occur in conjunction with other hunting, wildlife observation, wildlife photography, environmental education, interpretation, research, scientific collecting, and surveys. The amount of boating that occurs within Sheldon Refuge has not been quantified, but is considered low based upon angler participation and incidental observation by staff and volunteers. Boating generally occurs during summer months following the waterfowl nesting season (when the potential for bird disturbance or displacement impacts will be greatest) and following the beginning of trout fishing season, when there are higher water temperatures at Dufurrena Ponds, which provide better fishing success. Requirements for use of non-motorized boats or boats with electric motors will eliminate the potential for water pollution associated with use of outboard motors and will maintain opportunities for visitor solitude. Overall, the amount of boating associated with wildlife-dependent public uses is considered low, and adverse impacts are estimated to be short-term, intermittent, and negligible.

Economic Effects

Annual expenditures associated with 1,691 annual sport hunting days (associated with mule deer, pronghorn, and bighorn sheep hunting) have been found to constitute 5% of current contribution to the gross state product ($0.4 million). We anticipate these expenditures will continue to support 10 full-time jobs and contribute approximately $428,000 to the local economy (refer to Sheldon Refuge Final CCP/EIS Table 6.2).

Effects to Wilderness Character

Naturalness: Approximately 300 miles of existing vehicle routes will remain visible, and their designation for motorized use is not expected to result in any short-term impacts to naturalness. Over the long term, as public use continues to increase, we expect that additional signs, road maintenance, and other developments will be needed to ensure compatibility. Increased visitation to these areas will also increase the potential for introduction and spread of weeds and for the disturbance and displacement of wildlife.

Guzzlers will continue to adversely impact undeveloped natural wilderness character. However, because these permanent structures are relatively small and unobtrusive, and because future repairs will make these structures blend more with natural surroundings, impacts are confined to specific locations and are minor.

Weed treatments occurring on approximately 1,000 acres per year, primarily along road corridors, are expected to slow or possibly reverse the trend of weed spread and invasion into undeveloped and more natural areas of Sheldon Refuge, but will adversely affect natural character due to the presence of dead vegetation and vehicle tracks.

Untrammeled Conditions: Management of hunting will rely primarily on existing campgrounds, roads, guzzlers, and other facilities, which will result in little or no change to untrammeled conditions within Sheldon Refuge.

Solitude: Due to the limited number of campsites available and the implementation of fees for use at the Virgin Valley, Catnip Reservoir, and Big Spring Reservoir campgrounds, we anticipate some increased use of primitive campgrounds and some additional overnight backcountry use by hunters and other visitors who continue to seek opportunities for solitude. Such opportunities will continue to be available throughout much of Sheldon Refuge during substantial portions of the year.

Primitive and Unconfined Recreation: Management direction for designation of 300 miles of existing roads for public use of vehicles will result in only minor impacts. These existing roads will remain in the current condition and level of maintenance, and use of unimproved dirt roads is expected to remain low and intermittent, with the majority of use occurring during the hunting seasons for access to more primitive and remote portions of Sheldon Refuge. Other routes will continue to be used for hiking, backpacking, and horseback riding, and occasionally by vehicle for administrative purposes. Management actions will also result in greater management presence, development, and regulation at the Virgin Valley, Catnip, and Big Spring campgrounds. Impacts to opportunities for primitive and unconfined recreation will be minor, with vehicle use confined to existing campgrounds and roads where public use has been well established for many years.

Cumulative Effects from Hunting

Actions to manage public uses within the refuge, including sport hunting, are expected to reduce impacts to wildlife and wildlife habitat and to maintain opportunities for high-quality wildlife-dependent public uses. When considered with other existing and planned public uses and management actions at Sheldon Refuge, cumulative impacts from sport hunting are expected to be minor, and cumulative impacts from management of supporting uses such as camping and vehicle access will likely be beneficial and minor to moderate. Continued monitoring of wildlife populations and coordination with NDOW and the ODFW will provide necessary information and management to ensure impacts to wildlife populations from sport hunting within the refuge remain minor. It is anticipated that the overall amount of refuge visitation associated with sport hunting will remain relatively stable and not interfere with or detract from the primary purposes for Sheldon Refuge or the quality of other refuge public uses. It is also important to note the very large landscape context within which hunting and other public use activities are occurring at Sheldon Refuge. Hunting and other public use activities occur on very small, scattered portions of the refuge. The large areas where hunting and public uses do not occur provide wildlife with ample sanctuary. Although public use activities can result in disturbance to wildlife and associated habitats, disturbance will be largely intermittent and short term when activities are conducted according to the stipulations described. It is anticipated that wildlife populations will find sufficient food resources and resting places such that their abundance and use of the refuge will not be measurably reduced from allowing these activities to occur. The relatively limited number of individual animals and plants expected to be adversely affected will not cause wildlife populations to materially decline, the physiological condition and production of refuge species will not be impaired, their behavior and normal activity patterns will not be altered dramatically, and their overall welfare will not be negatively impacted.

Public Review and Comment:

This and other compatibility determinations were prepared concurrently with the Final CCP/EIS for the Sheldon National Wildlife Refuge (published August 2012). Open houses were held, multiple planning updates were mailed, and written comments were solicited from the public during development of the CCP for the refuge. Appendix A of the CCP further details public involvement during development of the CCP. A summary of public comments received during review of the

Draft CCP/EIS along with the Service's response to those comments are included in Appendix N of the CCP.

Determination: (check one below)

___ Use is Not Compatible

_X_ Use is Compatible with the Following Stipulations

Stipulations Necessary to Ensure Compatibility:

Management direction is provided in the CCP for Sheldon Refuge. It directs monitoring of wildlife-dependent recreational hunting activities. Findings from these monitoring efforts will be used in determining what additional management actions, if any, are needed to ensure all hunting activities remain compatible with refuge purposes. Stipulations that apply to hunting within Sheldon Refuge are as follows:

1. Hunting within Sheldon Refuge, consistent with state and Federal regulations, may be allowed only for the following game animals: goose, duck, coot, quail, chukar, Greater sage-grouse, pronghorn, mule deer, and California bighorn sheep.

2. Hunting will not be allowed in identified areas of Sheldon Refuge to ensure public safety, to provide sanctuary areas for wildlife, and to provide outstanding high-quality opportunities for other wildlife-dependent public uses. Identified areas include Dufurrena, lower Virgin Valley, and the area referred to as Little Sheldon (Figure D.1), which will remain closed to all hunting. Catnip Reservoir and Big Spring Reservoir will remain closed to migratory bird hunting.

3. As a priority species for Sheldon Refuge and as a candidate species under the Endangered Species Act, Greater sage-grouse will be managed within Sheldon Refuge to ensure long-term population health and viability and to maintain or restore declining or extirpated populations (Sheldon Refuge CCP Objective 6d). In coordination with the NDOW, the refuge will continue to adjust hunting seasons adaptively at the population level, using the best available science and guidelines, current sage-grouse population data (e.g., lek counts, productivity estimates from wing data or brood counts, survival estimates from local radio-telemetry studies), and local circumstances that can change annually (e.g., West Nile virus, drought, or habitat loss due to wildfire). The biological implications of changes to harvest seasons, as well as implications for public use will be thoughtfully considered as hunting regulations are developed. In coordination with NDOW, we will critically evaluate harvest survey techniques and adjust accordingly to ensure results are sufficiently accurate and precise. The determination to close or modify sport hunting for Greater sage-grouse will be made in coordination with the NDOW and consideration of WAFWA guidelines currently used for determining the appropriate level of harvest for this species at a local level. If and when this species were to be listed under the Endangered Species Act, hunting will be discontinued unless provided for in the listing decision.

4. Special Federal and State of Nevada hunting regulations apply to recreational hunting within Sheldon Refuge. Sheldon Refuge staff will continue to work cooperatively with the State's regulatory process to maintain harvest regulations necessary and appropriate to minimize adverse impacts to wildlife resources. To minimize impacts on refuge lands and resources, law

enforcement patrols will routinely be conducted in an effort to maximize compliance with applicable policies, rules, and/or regulations.

5. Maintenance of guzzlers within Sheldon Refuge proposed wilderness areas will be conducted in accordance with the minimum requirements decision and analysis included in Appendix G of the Sheldon Refuge CCP.

6. All vehicles defined as off-road vehicles under 42 U.S.C. Section 4321 must be registered with the State of Nevada or Sheldon National Wildlife Refuge for use on lands administered by Sheldon Refuge.

7. Vehicle use within Sheldon Refuge is allowed only on roads and routes that are designated "open" on Figure D.1 and that are signed or otherwise marked for such use. Off-road use is prohibited.

8. Unless otherwise indicated by sign, permit, or regulation, the maximum number of consecutive nights any person or attended vehicle may remain at a designated Refuge campground is 14 nights.

9. Except for camping within campgrounds that are designated for such use on maps included in the Final Record of Decision for the Sheldon National Wildlife Refuge CCP/EIS and that are signed or otherwise marked for such use, no overnight use is allowed on lands administered by Sheldon Refuge unless expressly authorized by a valid Special Use Permit.

10. Non-motorized boats or boats with electric motors are allowed only in Big Spring Reservoir, Catnip Reservoir, and Dufurrena Ponds consistent with 50 CFR 32.47.

11. Open fires are allowed only at designated campgrounds and within constructed fire rings, subject to additional seasonal fire restrictions and/or closures.

12. Pets must be leashed, except dogs used for hunting migratory or upland birds. Hunting dogs must be under strict voice control at all times.

13. Riding or packing with horses and mules is allowed in all areas open to public use. All horses and mules must be haltered, branded, tagged, or otherwise visibly marked as a domestic animal and must be tied, hobbled, high-lined, corralled, or otherwise under direct control at all times.

14. Grazing of domestic animals within Sheldon Refuge is not allowed.

15. We encourage the use of certified weed-free hay, pellets, straw, and other livestock feed within Sheldon Refuge. The use of certified weed-free feed will be required if monitoring of stock use areas indicates the spread or introduction of noxious weeds from uncertified feed.

Justification:

The National Wildlife Refuge System Administration Act of 1966, as amended, identifies recreational hunting as one of six priority public uses on national wildlife refuges. The law states that, when managed in accordance with principles of sound fish and wildlife management and administration, hunting and the other priority wildlife-dependent recreational uses "have been and are expected to continue to be generally compatible uses." The Act further states that these priority

public uses should receive enhanced consideration over other general public uses in refuge planning and management, and directs the USFWS to provide increased opportunities for the public to safely engage in traditional outdoor activities such as fishing and hunting.

Sport hunting does result in harm to individual animals and can result in additional disturbance or displacement of wildlife. Based on the number of hunting tags issued, and the average size of hunting groups during the hunting seasons, we estimate visitation associated with hunting is less than 4,000 people per year, and the majority of visitors who engage in hunting stay in designated campgrounds and travel on roads throughout the refuge primarily by four-wheel drive truck or OHV.

By designating approximately 300 miles of existing vehicles routes that are not duplicative, facilitate public access, and are not causing substantial adverse impacts to wildlife and wildlife habitat, we expect overall adverse impacts to wildlife from motorized vehicles and vehicle use during the hunting seasons will occur at a level that does not result in significant impact to fish, wildlife, or their habitats within Sheldon Refuge. Other requirements for the use of non-motorized boats and designated campgrounds, and requirements for backcountry camping permits will also minimize wildlife disturbance and displacement from important habitats while maintaining opportunities for solitude within proposed wilderness areas and wilderness study areas. Stipulations identified in this compatibility determination are expected to minimize impacts from hunting within Sheldon Refuge to fish, wildlife, plants, and their habitats.

Continued management of Virgin Valley, Little Sheldon, Big Spring Reservoir, and Catnip Reservoir will provide outstanding opportunities for other wildlife-dependent public uses and provide sanctuary for some big-game and game bird animals.

To reduce impacts to wildlife resources and to provide the continued opportunity for recreational uses of these species by the American public, Sheldon Refuge, NDOW, and ODFW cooperatively conduct population surveys and studies and adopt regulations in response to wildlife population survey and study results and management needs. These regulations currently provide adequate protection for Sheldon Refuge's wildlife resources, continued recreation opportunities, and other refuge purposes.

In sum, although sport hunting does result in harm to individual animals and can result in additional disturbance or displacement of wildlife, the relatively limited number of individual animals and plants expected to be adversely affected will not cause wildlife populations to materially decline. The physiological condition and production of refuge species will not be impaired, their behavior and normal activity patterns will not be altered dramatically, and their overall welfare will not be negatively impacted. It is anticipated that wildlife populations will find sufficient food resources and resting places such that their abundance and use of the refuge will not be measurably reduced from allowing these activities to occur. Thus, allowing hunting to occur under the stipulations described above will not materially detract or interfere with the purposes for which the refuge was established or the refuge system's mission.

Mandatory 10- or 15-Year Re-evaluation Date: (provide year for "allowed" uses only)

__2026__ Mandatory 15-year re-evaluation date (for wildlife-dependent public uses)

_____ Mandatory 10-year re-evaluation date (for all uses other than wildlife-dependent public uses)

NEPA Compliance for Refuge Use Decision: (check one below)

___ Categorical Exclusion without Environmental Action Statement

___ Categorical Exclusion and Environmental Action Statement

___ Environmental Assessment and Finding of No Significant Impact

_X_ Environmental Impact Statement and Record of Decision

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Refuge Determination

Prepared by: _____ 9/25/12
(Signature) (Date)

Refuge Manager/
Project Leader
Approval: _____ 9/25/12
(Signature) (Date)

Concurrence

Acting Refuge Supervisor: _____ SEP 27 2012
(Signature) (Date)

Acting Regional Chief,
National Wildlife
Refuge System: _____ 9/24/12
(Signature) (Date)

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D.4 Compatibility Determination for Guiding on Sheldon National Wildlife Refuge

Use(s): Guiding (big-game hunting, upland bird hunting, and migratory bird hunting)

Supporting Uses: Camping, boating, hiking, backpacking, horseback riding, and vehicle use

Refuge Name: Sheldon National Wildlife Refuge

City/County and State: Washoe County, Nevada; Humboldt County, Nevada; Lake County, Oregon

Establishing and Acquisition Authority(ies):

What is today known as the Sheldon National Wildlife Refuge was initially established by Executive Order 5540 dated January 26, 1931, and later enlarged by Executive Order 7364 dated May 6, 1936, and Executive Order 7522 dated December 21, 1936.

The authorities for nearly all Federal lands within Sheldon Refuge are the Migratory Bird Conservation Act of 1929, as amended (16 U.S.C. 715-715r) and the National Wildlife Administration Act of 1966, as amended (16 U.S.C. 668dd-668ee). A small portion of Sheldon Refuge was acquired under the authority of the Endangered Species Act of 1973, as amended (16 U.S.C. 1231-1544).

Refuge Purpose(s):

> "…as a refuge and breeding ground for wild animals and birds…" Executive Order 5540 dated January 26, 1931.
>
> "… set apart for the conservation and development of natural wildlife resources and for the protection and improvement of public grazing lands and natural forage resources…" Executive Order 7522 dated December 21, 1936.
>
> "… to conserve (A) fish or wildlife which are listed as endangered species or threatened species… or (B) plants…" 16 U.S.C. § 1534 (Endangered Species Act of 1973)
>
> "… for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." 16 U.S.C. § 715d (Migratory Bird Conservation Act)

National Wildlife Refuge System Mission:

> "The mission of the [National Wildlife Refuge] System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans" (National Wildlife Refuge System Administration Act of 1966, as amended [16 U.S.C. 668dd-668ee]).

Description of Use(s):

Guiding and outfitting considered in this compatibility determination are limited to commercial and economic activities related to transporting, assisting, and accompanying hunters within Sheldon Refuge. Sheldon Refuge issues approximately 10 Special Use Permits each year for guiding and outfitting hunters within Sheldon Refuge, nearly all of which are for guided big-game hunting. Professional guides are occasionally permitted to provide services in support of other recreational uses such as photography. However, the demand and number of requests for these permits are rare and typically issued on a case-by-case basis.

Commercial outfitting and guiding generally occur throughout much of Sheldon Refuge and at the same times and locations as sport hunting. However, guides and outfitters often conduct trips within Sheldon Refuge prior to the hunting season to scout for and spot game and to transport equipment and supplies for temporary campsites.

Guides and outfitters typically use designated campgrounds for short periods of less than 14 days throughout the hunting seasons or travel into Sheldon Refuge for day-use hunting. Access to hunting areas typically includes both motorized vehicle use along designated roads and routes, as well as hiking. Few guides or outfitters use boats or provide pack or saddle stock for access to wilderness and other backcountry areas of Sheldon Refuge. Guides who provide opportunities for hunting migratory or upland game birds often use trained dogs for finding and retrieving birds as allowed by state hunting regulations.

Refuge policy allows commercial services within proposed wilderness to the extent they are necessary for activities that are proper for realizing the recreation or other wilderness purposes of the wilderness areas. Most big-game hunting opportunities are found within proposed wilderness areas, and it is assumed all commercial outfitters and guides will use portions of one or more proposed wilderness areas during any particular hunt. The types and amounts of commercial guiding and outfitting necessary for recreation opportunities within the eight proposed wilderness areas were evaluated in the Final Sheldon Refuge CCP/EIS and are determined as part this compatibility determination.

The Service will permit up to 10 operators to provide outfitting and guide services within Sheldon Refuge. Permits will be awarded through a competitive prospectus bid system through which guides and outfitters submit a detailed proposal to the Service for review. The Service will then select operators determined to be the most qualified and able to further the management goals and objectives for Sheldon Refuge based upon their proposals, client interviews, and known history (refer to Exhibit D.1 for prospectus details).

Supporting Uses

Camping

Camping itself is not a priority public use on Service lands, but because of the size, remoteness, and quality of roads within Sheldon Refuge, it is important in supporting priority uses including fishing, hunting, wildlife observation, and wildlife photography as well as non-priority public uses such as guiding. There are four types of camping opportunities currently provided within Sheldon Refuge: developed, semi-primitive, primitive, and backcountry/wilderness.

Camping within Sheldon Refuge is allowed in 13 designated campgrounds and by Refuge Special Use Permit for backcountry camping.

Developed Camping: Virgin Valley Campground located at Dufurrena is considered the only developed campground. Virgin Valley Campground is easily accessible year-round for all types of vehicles, including RVs, and it offers shade trees, potable water, two vault toilets, 16 picnic tables, 24 fire rings, a meat-hanging pole, a bath-house, and a hot spring developed for swimming. Campground use is managed on a first-come, first-served basis without fees or designated sites. From 2005 through 2007 an average of 18 campsites were occupied per day during the days surveyed, for a seasonal average of 6,573 visitor use days (USFWS undated report).

From mid-August through mid-November, the Virgin Valley Campground is heavily used by hunters. During peak seasons, overcrowding and user conflicts have been a concern, as has overflow into upland areas adjacent to the campground, which can result in further environmental damage. There is also a private developed campground at the Royal Peacock Mine located in the Virgin Valley Mining District, which has RV hookups.

Semi-primitive Camping: Five campgrounds (Catnip Reservoir, West Rock Spring, Fish Spring, Badger, and Big Spring Reservoir) are considered semi-primitive and include outhouses, fire rings, meat-hanging poles, and in the case of Fish Spring and Badger campgrounds, horse corrals. These semi-primitive campgrounds are accessible from primary roads or improved secondary roads suitable for most types of vehicles and are primarily used by hunters. Sport anglers also use campgrounds at Catnip and Big Spring reservoirs.

Additional facilities such as campsite amenities (i.e., picnic tables and accessible fire rings or barbeque grills), potable water, shade structures, kiosks, and dedicated volunteer sites are planned for Virgin Valley, Catnip Reservoir, and Big Spring Reservoir campgrounds. These facilities will provide developed camping opportunities that are not commonly available within Sheldon Refuge or the region. However, these improved facilities will only be sustainable over the long term through campsite fees to support volunteers, maintenance, and replacement.

The Service will also allow public overnight use of some existing historic structures within Sheldon Refuge. The most likely structures are the Little Sheldon Overnight Cabin and Badger Cabin.

Primitive Camping: Seven campgrounds (Little Catnip Spring, Gooch Spring, North Hell Creek, Wheeler Spring, Bateman Spring, Devaney, and East Rock Spring) are considered primitive campgrounds and have only fire rings or no improvements, are remote, and are accessible to four-wheel drive or high-clearance vehicles when road conditions are passable. These primitive campgrounds receive intermittent and low amounts of use, occurring mostly during the big-game hunting seasons (early August through October). All of these campgrounds are located immediately adjacent to, or include, wet meadows, spring, or springbrook habitats. Three primitive campgrounds (Wheeler Spring, Devaney, and East Rock Spring) also include aspen woodland habitats. Impacts associated with primitive campgrounds were identified as an issue during the Sheldon CCP planning process. The impacts identified and stipulations for reducing or eliminating those impacts are addressed in subsequent sections of this compatibility determination.

Backcountry/Wilderness Camping: Backcountry camping for up to 14 days is allowed by refuge permit. Permits are not limited, but do stipulate visitors must camp at least 0.5 mile from open roads and at least 100 yards from water sources. The majority of backcountry camping permits are issued

to hunters, but the amount of use is low and no adverse impacts have been observed. Backcountry use will continue to be monitored, and future management actions to reduce or eliminate any impacts will be implemented as necessary.

Public Access

Public access to areas within Sheldon Refuge is provided by a network of vehicle roads and informal backcountry routes and trails. Roads include one two-lane paved highway, maintained gravel roads, and numerous primitive and unmaintained dirt roads. Trails throughout the refuge backcountry and wilderness areas are primarily abandoned vehicle routes historically used for access to livestock developments and private inholdings later purchased by the Service.

The most substantial changes to guiding are expected to result from the relocation and enlargement of the Refuge visitor contact station, improvement of campground facilities, and improved signing of routes open to vehicle use. Improved gravel roads within Sheldon Refuge will be maintained more frequently, and all routes open to the public use of vehicles will be adequately signed and marked. Visitors will be required to register all OHVs consistent with State of Nevada regulation or with Sheldon Refuge for use on refuge roads and routes designated open to vehicle use. These actions are intended to improve the quality of the transportation system and deter vehicle violations while requiring only minimal law enforcement presence.

Maintained Public Roads: In preparation of the Sheldon Refuge CCP, each route within the refuge was evaluated to assess impacts to fish, wildlife, plants, and their habitats, as well as benefits for public use and recreation opportunity. Following this evaluation, 300 miles of existing roads (including State Highway 140 and all maintained county roads) were designated for public vehicle use. The Service has determined that the continued use and maintenance of these designated roads, including actions for re-routing or modification as presented in the Sheldon Refuge CCP, will have minimal or no impacts to wildlife and wildlife habitat and/or are subject to existing right-of-way. The unimproved roads within Sheldon Refuge are not regularly maintained, but are repaired on a site-by-site basis to keep them in usable condition or to prevent undue resource damage (i.e., excessive erosion).

Trails and Backcountry Access: Hiking, horseback riding, use of pack stock, and other non-mechanical modes of access are allowed on trails, routes, and other areas of Sheldon Refuge open to the public. All vehicle use is restricted to designated open roads. Existing trails throughout Sheldon Refuge will remain, but will not be marked or maintained for public use. No adverse impacts have been observed from visitors using these routes for hiking, horseback riding, or use of pack stock.

Horseback Riding and Pack Stock Use: Horseback riding has been allowed as a recreation activity within Sheldon Refuge for many years. However, it is estimated fewer than 10 horseback visitors use Sheldon Refuge each year, and as a result, horseback riding is considered a low-impact activity. Horseback riding gives the public an opportunity to visit remote and undeveloped portions of Sheldon Refuge, and to enjoy the wildlife viewing, solitude, and expansive views that Sheldon Refuge is known for.

There is a concern that the number of visitors engaging in horseback riding may increase, particularly with hunting guides and their clients, and that use of horses and pack stock within the Refuge will introduce invasive non-native plants. These impacts have not been observed, but monitoring will

continue and the Service will take additional action as needed to maintain wilderness character and prevent the introduction of weeds to the refuge.

The corrals at Badger and Fish Spring campgrounds are the only facilities that specifically support horseback riding and the use of pack stock.

Boating: Refuge-specific regulations that apply to the use of non-motorized boats and boats with electric motors specifically apply to sport fishing and sport hunting, but are interpreted as applying to other compatible wildlife-dependent public uses as well. While the use of non-motorized boats and boats with electric motors in Big Spring Reservoir, Catnip Reservoir, and Dufurrena Ponds consistent with 50 Code of Federal Regulations (CFR) 32.47 in conjunction with guiding and outfitting is considered rare and incidental, the use is considered a compatible activity that supports outfitting and guiding services within Sheldon Refuge.

Availability of Resources:

The primary cost to Sheldon Refuge of managing commercial guiding and outfitting is for the administration of Special Use Permits. Fees for permits and client use days typically cover the costs associated with issuing and administering the permits. However, if demand exceeds the limit of 10 commercial permits available, the costs associated with reviewing and selecting permittees through a competitive bid process will not be offset or recovered through fees.

Most administration and management of recreational hunting, including issuing of licenses, permits, and harvest tags is conducted by the NDOW and ODFW. Maintenance of the IXL wetlands, campgrounds, access roads, and other supporting facilities and routine law enforcement patrols are conducted by Sheldon Refuge primarily to provide quality wildlife-dependent public uses. The amount of use at these facilities by commercial guides and outfitters is considered negligible and does not represent an added cost for administration of this economic use.

Category and Itemization	One-time	Annual
Administration and management (issuance and administration of Special Use Permits)	$2,500	$2,500
Maintenance		
Monitoring (law enforcement contacts and review of client-use reports)	$1,000	$1,000
Special equipment, facilities, or improvements (campgrounds, docks, and access roads)		
Offsetting revenues[4]	$3,500	$3,500

[4] Anticipated Special Use Permit fees and revenues as proposed in the CCP are based on $250 annual fee and 10 client-use days per permit.

Anticipated Impacts of the Use(s):

Effects from Guiding

It is anticipated that commercial guiding and outfitting and associated public uses will have impacts similar to those described for sport hunting (refer to impacts discussed in the sport hunting compatibility determination in this appendix), but the conditions included in all Special Use Permits for guiding and outfitting within Sheldon Refuge (included later in this compatibility determination) should reduce the effects of these impacts.

Proposed wilderness areas located within Sheldon Refuge provide remote isolated settings characterized by vast expanses of open sagebrush country, rugged terrain, highly variable weather and temperatures, and isolation. Safe travel and exploration of Sheldon Refuge demands visitors be prepared, knowledgeable, and experienced in wilderness and backcountry settings. Allowing a limited number of commercial outfitters and guides who possess adequate equipment, knowledge, and skills to operate within Sheldon Refuge will provide wilderness recreation opportunities for many people who otherwise would be unable or unwilling to visit. Because visitation within much of Sheldon Refuge is characterized as low or very low, the presence of outfitters or guides with small groups of clients is not expected to affect overall opportunities for wilderness solitude or natural character. Because most demand for outfitting and guiding is currently from a small proportion of the limited number of big-game hunting tag holders, there currently is no need to consider limits on the number of clients or client-use days to maintain wilderness character.

Issuing up to 10 permits for commercial outfitting and guiding will be consistent with past use within Sheldon Refuge and is expected to supply an adequate number of choices and variety of services for the visiting public while maintaining a level of competition sufficient to ensure quality services are provided.

Effects from Camping and Campgrounds

Use of campgrounds within Sheldon Refuge causes impacts to vegetation, soils, water quality, and cultural resources. During dry conditions, carelessness with campfires can lead to wildfires. Management and development of campgrounds is also expected to affect the type and quality of recreation opportunities available.

Impacts to Vegetation, Soils, and Water Quality: Campgrounds and their use within the refuge range from primitive sites with relatively low and only intermittent use to very developed sites with year-round and relatively high amount of use during summer months. Current impacts and expected future impacts associated with use and development of these campgrounds also vary widely. Because the most primitive campgrounds are currently the least impacted, we can expect these sites will exhibit the greatest amount of additional or potential impact with only slightly more use. Conversely, most impacts have already occurred at the most heavily used and developed campgrounds and we can expect very little additional impact to vegetation, soils, or water quality even with relatively large increases in use at these campgrounds.

The greatest difference in durability between vegetation types occurs at moderately low use levels (Cole 1985). Sites that are used frequently are likely to be highly impacted regardless of their fragility. Because vegetation loss usually occurs more rapidly than loss of organic soil horizons, sites with either no vegetation or resistant vegetation (e.g., grasses as opposed to forbs) recover more

quickly and are less likely to be impacted by low levels of use, while sites with thick organic soil horizons are less susceptible to erosion and are more likely to withstand high amounts of use.

Experimental studies suggest that there is an important difference between a site's resistance (its ability to tolerate use without being damaged) and its resilience (its ability to recover from damage). Cole (1995) has shown, for groundcover plants, that resistance decreases with erectness and that broad-leaved herbs are typically less resistant than grass-like plants and shrubs. Low shrubs, such as heather, are relatively resistant to trampling stress but their resilience is low. Once damaged, they recover slowly. Grass-like plants are most tolerant of trampling (Cole 1989). The compaction of soils from campsite use reduces water infiltration and water holding capacity, which leads to increased runoff and erosion potential (Cole 2004; Monti and Mackintosh 1979). Impacts associated with use at primitive campgrounds can be readily observed and tend to occur rapidly, but these impacts are relatively inconsequential when considered in the context of the entire refuge. Impacts associated with campgrounds located within riparian areas or near water sources are of greater concern, but current impacts are not severe, and vegetation, soils, and water quality at primitive campgrounds are expected to recover noticeably within a few years following campground relocation. This assessment is supported by Cole (1981) who noted that hiking and camping impacts on soil and vegetation, while severe when measured at small scales, are minimal at large spatial scales. This suggests that while recreation impacts can be serious for individual plants and animals and perhaps localized rare populations, they are generally of little significance to landscape integrity or regional biotic diversity. Moreover, unless much of a population is affected by a single impacted site, the intensity, size, and distribution of impacts are not relevant to the significance of impacts assessed at large spatial scales (Cole 1989).

Virgin Valley Campground is located at a site previously developed and used by the Civilian Conservation Corps in the late 1930s. Catnip Reservoir and Big Spring Reservoir campgrounds are located immediately adjacent to artificial reservoirs. These three campgrounds receive the greatest use and exhibit the greatest amount of impact. The core areas of use at these campgrounds no longer support vegetation or vegetation diversity is substantially reduced, water infiltration is considered low due to soil compaction, and gravel has been placed in some areas to reduce erosion and rutting from vehicles. Non-native plants and animals in and around these three campgrounds were likely introduced by early ranching and development activities rather than campground visitors. Monitoring and control efforts will continue to detect and remove or eradicate small or new populations of invasive species.

The remaining 10 campgrounds are all located immediately adjacent to or include aspen woodland, wet meadows, spring, and/or springbrook habitats. Most of these campgrounds have moderate amounts of vegetation loss and soil compaction, which is limited to parking areas, areas around fire rings, outhouses, and along connecting paths. These impacts are generally not continuous throughout the campground and are expected to remain stable with current amounts of intermittent use, which occurs during late summer and fall after most annual and biannual plants have finished growing for the season and when soils are typically drier and more resistant to impact. Some primitive campgrounds have no visible bare ground, and where located in meadow habitats, vegetation is generally able to recover from the current amount of use. Some primitive campgrounds exhibit small areas of bare ground, generally a lack forbs, which are not resistant to trampling, and in the case of Wheeler Spring, Devaney, and East Rock Springs, also exhibit some impacts to aspen trees from trampling, soil compaction, root exposure, and cutting. Because these campgrounds receive little visitation or are located near frequently traveled gravel roads, impacts to wildlife from campground use are estimated to be minor or negligible. Due to the nature of these impacts and relatively low

amount of use, we anticipate these campgrounds will exhibit the greatest amount of natural recovery compared to the three more developed and heavily used campgrounds if camping use were eliminated, but will also experience the greatest amount of additional impact if camping use were to substantially increase. Aspen stands associated with the Devaney, Wheeler Spring, and East Rock Springs campgrounds are also expected to recover, but regeneration of the understory shrubs and younger trees will occur slowly and likely require some active restoration and/or replanting.

Up to nine semi-primitive and primitive campgrounds will be relocated away from sensitive riparian habitats and areas with cultural resources. It is anticipated that actions to relocate campgrounds to alternative sites, protect sensitive habitats at each of these campgrounds, and confine use to designated campsites in heavily used campgrounds will minimize or avoid additional impacts altogether.

We expect some primitive campgrounds to be consolidated with other existing campgrounds, which will need to be enlarged and have additional campsites constructed (the most likely candidates for enlargement are Catnip Reservoir, Big Spring Reservoir, Fish Spring, and West Rock Spring campgrounds). Consolidation will result in additional impacts from increased use of existing facilities and campsites and from the designation and construction within existing campgrounds. Where camping already occurs, increased use of existing campsites and facilities is expected to have little or no measurable impact to vegetation or wildlife. Impacts to expanded portions of these campgrounds are expected to occur quickly as vegetation is trampled and soil compacted within the first two or three seasons of use, but will then stabilize over the long term. We expect enlargement of existing campgrounds will result in minor, site-specific, long-term, direct adverse impacts to plants and their habitat from removal of vegetation, soil compaction, and loss of organic soil horizon at these sites.

Impacts from Wildfire: Campfires are allowed at designated campgrounds but are occasionally prohibited during periods of high fire danger. Wildfires have been started by refuge visitors in the past, and we expect some wildfires will occasionally start as a result of escaped campfires or misuse of stoves. Seasonal campfire restrictions and rapid fire suppression response will continue to minimize impacts.

Impacts to Cultural Resources: Most of the 13 designated campgrounds are located within or adjacent to prehistoric cultural sites. While the majority of impacts occurred following the initial establishment and use of these campgrounds, some impacts continue due to ongoing soil disturbance and compaction within existing campsites, trampling and removal of vegetation, occasional use of previously unused areas adjacent to the campgrounds, and vehicle use outside designated areas. Limited fee use of the Little Sheldon Overnight Cabin or Badger Cabin is expected to increase public appreciation for historic resources and understanding for their protection and preservation. In addition, the use of these sites and the collection of fees will provide justification and funding for restoration work and continued maintenance. As a result, the integrity of sites eligible for the National Register of Historic Places will be protected. Therefore, we anticipate use of these facilities to support sport hunting and guiding will have a major, long-term, beneficial impact on cultural resources.

Impacts to Recreation Opportunity: Campsite registration, overnight fees, and the other improvements planned for the developed campgrounds will increase maintenance, increase visitor compliance with rules and regulations (by defining and designating campsites), and decrease competition for campsites. Campground management strategies are expected to result in moderate,

indirect, long-term, beneficial impacts to the camping experience, in support of providing quality opportunities for wildlife-dependent recreation.

Effects from Public Access

Adverse impacts are expected to continue as a result of the network of developed and undeveloped roads throughout Sheldon Refuge and their associated maintenance. Road development and use continues to adversely impact the biological integrity within Sheldon Refuge by contributing to the altered composition of plant communities, soil disturbance (Eckert et al. 1979; Iverson et al. 1981; Switalski et al. 2004), altered hydrology and stream sedimentation (Forman and Alexander 1998), facilitation of the spread of invasive vegetation, changes in the natural fire regimes, and habitat fragmentation.

Many direct effects are obvious during construction, but other effects are permanent and can extend substantially beyond the actual road surface (road-effect zone; Forman 2000; Forman and Alexander 1998). At the landscape scale, major ecological impacts of a road network include fragmentation, the disruption of landscape processes, and loss of biodiversity. Biodiversity declines as the road network impacts interior species (species cut off by roads), species with large home ranges, stream and wetland species, and rare native species (Forman and Alexander 1998). Fragmentation of previously extensive landscapes can influence the distribution and abundance of a host of wildlife species through redistribution of habitat types and through the pattern of habitat fragmentation, including characteristics such as decreased patch area and increased habitat edge (Vander Haegen et al. 2000).

Roads (including OHV trails) are commonly identified as important correlates or indicators of loss of ecological health and affect terrestrial and aquatic ecosystems in several general ways: 1) increased mortality from road construction; 2) increased mortality from collision with vehicles; 3) modification of animal behavior; 4) alteration of physical environment; 5) alteration of chemical environment; 6) spread of exotic species; and 7) increased alteration and use of habitats by humans (Trombulak and Frissell 2000; Wildlife Action Plan Team 2006).

The ecological effect of road avoidance is likely related to traffic density and speed of travel, as well as traffic noise levels (Forman and Alexander 1998). Road-effect zones generally result in lower breeding densities and reduced species richness; species demonstrated to avoid or be negatively impacted by roads include arthropods, reptiles, small mammals, ungulates, and forest and grassland birds (Andrews and Gibbons 2005; Carr and Fahrig 2001; Forman and Alexander 1998; McGrann et al. 2006; Rost and Bailey 1979). For example, proximity to OHV trails (<1,000 meters [3,280 feet]) was found to have a direct correlation with reduced-quality habitat for nesting songbirds in sagebrush-steppe habitats, including nest desertion, nest predation, and abandonment (Barton and Holmes 2007). Behavioral disturbance from recreation, including that associated with trails and roads, may also have both immediate and long-term effects on wildlife (Taylor and Knight 2003). In one study of pronghorn, deer, and bison, individuals exhibited a 70% probability of flushing within 1,000 meters (3,280 feet) on either side of a trail used by hikers and mountain bikers (Taylor and Knight 2003); presumably, responses are similar in the presence of vehicles such as OHVs. Road density can be used as an overall index to average patterns over an area. For example, road densities of approximately 1.0 mile per square mile have been recommended as the maximum for a naturally functioning landscape containing sustained populations of large predators (Forman and Alexander 1998). However, the effects of road density are likely sensitive to road width or type, traffic density, network connectivity, and the frequency of spur roads into remote areas (Forman and Alexander 1998).

Within Sheldon Refuge, more than 50 introduced, non-native, and often noxious plant species have been documented (refer to Sheldon Refuge CCP Appendix B). Invasive plants typically need transportation to spread to new areas (Trombulak and Frissell 2000), and within Sheldon Refuge several methods are possible, including vehicles, people, wild and domestic animals, and firefighting equipment. Indeed, it has been demonstrated that habitats distant from roads may provide important refuge for native grassland species, and that this effect may be even more pronounced in predominately intact landscapes such as those in parts of the Great Basin (Gelbard and Harrison 2003). Human access and disturbance effects on remote areas tend to increase with higher road densities, as well as human-caused fire ignitions (Forman and Alexander 1998).

Various methods, including systematic inventory and monitoring for invasive plants, mowing, use of herbicides, and elimination of grading road shoulders, will be used to detect new infestations, control and contain existing infestations, and treat up to 1,000 acres per year. Management strategies to combat invasive plants support the Service policy for biological integrity and diversity within Sheldon Refuge. With a more systematic approach for inventory of noxious weeds and other invasive plants, populations are more likely to be detected when they are small and more easily managed and controlled. Increased treatment and reduced soil disturbance along road corridors should reduce the spread of invasive plants already present and reduce the potential for new populations. As a result, we anticipate these actions will result in major, long-term, direct, beneficial impacts to all habitats. Implementing treatment strategies (e.g., mechanical removal of vegetation, application of herbicides) will likely eliminate or prevent the spread of noxious weed populations when detected and provide some conservation of native habitats, resulting in minor, site-specific, short-term, direct, beneficial impacts to habitat on approximately 1,000 acres per year.

In conjunction with preparation of the Sheldon Refuge CCP, Refuge staff conducted an evaluation of existing routes and trails and identified known and potential resource impacts and public benefits and recreation opportunities associated with vehicle access. Route segments that were identified as causing substantial impacts to soils, riparian areas, and/or wildlife, were redundant with other routes, or provided very little or no access for wildlife-dependent uses were not identified for designation as open roads for public use of vehicles. To minimize or avoid lesser impacts from roads and vehicle use, the Service will implement a number of transportation management strategies including designating roads that are not duplicative, re-routing or realigning road segments that pass through sensitive resource areas, installing erosion control structures, increasing monitoring and treatment of weeds along road corridors, and posting signs marking all designated open roads. These actions will result in long-term, minor, direct and indirect, beneficial impacts to soils by decreasing erosion in sensitive areas that are currently affected. Overall, we expect impacts from road management will be minor, direct, and adverse to habitats on a localized and long-term basis.

Management of guiding activities supports Service policy by providing various opportunities for primitive and unconfined types of recreation throughout Sheldon Refuge. Hiking, horseback riding, and vehicle access are secondary uses that support wildlife-dependent recreational activities within Sheldon Refuge. Sheldon Refuge allows access on foot, by horseback, or by vehicle. However, all vehicle routes are open to both motorized and non-motorized vehicles, and there are no areas managed for non-motorized vehicle access (i.e., mountain bikes or game carts) or semi-primitive non-motorized recreation opportunity. In areas open to vehicle use we assume impacts to non-motorized vehicle users are asymmetrical (Webber 1995) and occur from conflict, noise, dust, competition with motorized users for recreation opportunity, and displacement to non-motorized areas outside the refuge (Adelman et al. 1982; Gambill 1996; Manning and Valliere 2002; Moore 1994; Stokowski and LaPointe 2000). The somewhat narrow range of vehicle access for non-

motorized users provided within the refuge represents a direct, adverse, moderate, long-term impact to quality recreation opportunities.

Effects from Horseback Riding and Use of Pack Stock

Because the number of visitors who ride horseback or use pack stock within Sheldon Refuge is estimated to be less than 10 per year and because little impact has been observed from such use, we expect future impacts from trampling and introduction of non-native weeds will also be low and less than similar impacts associated with overnight camping and vehicle use. Stock use areas at Badger and Fish Spring campgrounds will continue to be monitored, particularly for new populations of non-native plants, and additional action such as requiring certified weed-free feed and weed removal will be implemented as necessary.

Effects from Boating

The use of non-motorized or electric-powered boats is allowed only in Big Spring Reservoir, Catnip Reservoir, and the Dufurrena Ponds consistent with 50 CFR 32.47. The majority of boating occurs in conjunction with sport fishing, and while migratory bird hunting is not allowed on these waters, occasional and intermittent boating does occur in conjunction with other hunting, wildlife observation, wildlife photography, environmental education, interpretation, research, scientific collecting, and surveys. The amount of boating that occurs within Sheldon Refuge has not been quantified, but is considered low based upon angler participation and incidental observation by staff and volunteers. Boating generally occurs during summer months following the waterfowl nesting season (when the potential for bird disturbance or displacement impacts will be greatest) and following the beginning of trout fishing season, when there are higher water temperatures at Dufurrena Ponds, which provide better fishing success. Requirements for use of non-motorized boats or boats with electric motors will eliminate the potential for water pollution associated with use of outboard motors and will maintain opportunities for visitor solitude. Overall, the amount of boating associated with wildlife-dependent public uses is considered low, and adverse impacts are estimated to be short-term, intermittent, and negligible.

Economic Effects

For the purposes of evaluating compatibility, outfitting and guiding are considered economic effects from hunting, and therefore are not considered to separately have an economic effect on the local economy.

Effects to Wilderness Character

Naturalness: Approximately 300 miles of existing vehicle routes will remain visible, and their designation for motorized use is not expected to result in any short-term impacts to naturalness. Over the long term, as public use continues to increase, we expect that additional signs, road maintenance, and other developments will be needed to ensure compatibility. Increased visitation to these areas will also increase the potential for introduction and spread of weeds and for the disturbance and displacement of wildlife.

Weed treatments occurring on approximately 1,000 acres per year, primarily along road corridors, are expected to slow or possibly reverse the trend of weed spread and invasion into undeveloped and

more natural areas of Sheldon Refuge, but will adversely affect natural character from the presence of dead vegetation and vehicle tracks.

Untrammeled Conditions: Guides and outfitters rely primarily on existing campgrounds, roads, and other facilities, which will result in little or no change to untrammeled conditions within Sheldon Refuge.

Solitude: Due to the limited number of campsites available and the implementation of fees for use at the Virgin Valley, Catnip Reservoir, and Big Spring Reservoir campgrounds, we anticipate some increased use of primitive campgrounds and some additional overnight backcountry use by guides and outfitters who continue to seek opportunities for solitude. Such opportunities will continue to be available throughout much of Sheldon Refuge during substantial portions of the year.

Primitive and Unconfined Recreation: Management direction for designation of 300 miles of existing roads for public use of vehicles will result in only minor impacts. These existing roads will remain in their current condition and level of maintenance, and use of unimproved dirt roads is expected to remain low and intermittent for access to more primitive and remote portions of Sheldon Refuge. Other routes will continue to be used for hiking, backpacking, and horseback riding, and occasionally by vehicle for administrative purposes. Management actions will also result in greater management presence, development, and regulation at the Virgin Valley, Catnip, and Big Spring campgrounds. Impacts to opportunities for primitive and unconfined recreation will be minor, with vehicle use confined to existing campgrounds and roads where public use has been well established for many years.

Cumulative Effects from Guiding

Impacts to wildlife populations and other public uses from commercial outfitting and guiding within the refuge, including both direct and indirect impacts, are considered minor. Actions to manage commercial uses within the refuge, including big-game guiding and outfitting, are expected to have both adverse and beneficial impacts to wildlife and wildlife habitat and to increase opportunities for high-quality wildlife-dependent public uses. When considered with other existing and planned public uses and management actions at Sheldon Refuge, cumulative impacts from outfitting and guiding and cumulative impacts from management of supporting uses such as camping and vehicle access will be beneficial and minor to moderate. Continued monitoring of public uses and outfitters and guides operating within the refuge and Special Use Permit conditions will provide necessary information and management to ensure the continued benefit of commercial services to the visiting public. It is anticipated the overall amount of refuge visitation associated with outfitting and guiding will remain relatively low and stable, and will not interfere with or detract from the quality of other refuge public uses.

Public Review and Comment:

This and other compatibility determinations were prepared concurrently with the Final CCP/EIS for the Sheldon National Wildlife Refuge (published August 2012). Open houses were held, multiple planning updates were mailed, and written comments were solicited from the public during development of the Final CCP/EIS for the refuge. Appendix A of the CCP further details public involvement during development of the CCP. A summary of public comments received during review of the Draft CCP/EIS along with the Service's response to those comments are included in Appendix N of the CCP.

Determination: (check one below)

___ Use is Not Compatible

_X_ Use is Compatible with the Following Stipulations

Stipulations Necessary to Ensure Compatibility:

1. Any guide or outfitter using lands managed by the Service within Sheldon Refuge while conducting or in support of his or her business must obtain a Refuge Special Use Permit. In addition to standard conditions and requirements that apply to all National Wildlife Refuge Special Use Permits, additional conditions and requirements apply to Special Use Permits issued by Sheldon Refuge and for all commercial outfitting and guiding activities conducted within Sheldon National Wildlife Refuge. A list of these refuge-specific conditions and requirements is provided below.

2. A maximum of 10 commercial outfitters or guides will be issued Special Use Permits to conduct activities within Sheldon Refuge at any given time. Each Special Use Permit will be issued for a period of 5 years. Such permits will only be issued after applicants are selected by the Complex Project Leader through a competitive prospectus bid process. Exhibit D-1 provides an example prospectus and request for proposal.

3. Special state regulations apply to all licensed hunting guides operating within the States of Oregon and Nevada. Additional Refuge Special Use Permit conditions are intended to increase the quality of recreation opportunities for clients and other members of the visiting public. These permit conditions are included as stipulations of this determination to ensure compatibility. Law enforcement patrols will routinely be conducted in an effort to maximize compliance with applicable policies, rules, and/or regulations.

4. All vehicles defined as off-road vehicles under 42 U.S.C. Section 4321 must be registered with the State of Nevada or Sheldon National Wildlife Refuge for use on lands administered by Sheldon Refuge.

5. Vehicle use within Sheldon Refuge is allowed only on roads and routes that are designated "open" on Figure D.1 and that are signed or otherwise marked for such use. Off-road use is prohibited.

6. Unless otherwise indicated by sign, permit, or regulation, the maximum number of consecutive nights any person or attended vehicle may remain at a designated Refuge campground is 14 nights.

7. Except for camping within campgrounds that are designated for such use on maps included in the Final Record of Decision for the Sheldon National Wildlife Refuge CCP/EIS and that are signed or otherwise marked for such use, no overnight use is allowed on lands administered by Sheldon Refuge unless expressly authorized by a valid Special Use Permit.

8. Non-motorized boats or boats with electric motors are allowed only in Big Spring Reservoir, Catnip Reservoir, and Dufurrena Ponds consistent with 50 CFR 32.47.

9. Open fires are allowed only at designated campgrounds and within constructed fire rings, subject to additional seasonal fire restrictions and/or closures.

10. Pets must be leashed, except dogs used for hunting migratory or upland birds. Hunting dogs must be under strict voice control at all times.

11. Riding or packing with horses and mules is allowed in all areas open to public use. All horses and mules must be haltered, branded, tagged, or otherwise visibly marked as a domestic animal and must be tied, hobbled, high-lined, corralled, or otherwise under direct control at all times.

12. Grazing of domestic animals within Sheldon Refuge is not allowed.

13. We encourage the use of certified weed-free hay, pellets, straw, and other livestock feed within Sheldon Refuge. The use of certified weed-free feed will be required if monitoring of stock use areas indicates the spread or introduction of noxious weeds from uncertified feed.

National Special Use Permit Conditions and Requirements

1. Responsibility of Permittee: The permittee by operating on the premises shall be considered to have accepted these premises with all facilities, fixtures, or improvements in their existing condition as of the date of this permit. At the end of the period specified or upon earlier termination, the permittee shall give up the premises in as good order and condition as when received except for reasonable wear, tear, or damage occurring without fault or negligence. The permittee will fully repay the Service for any and all damage directly or indirectly resulting from negligence or failure on his/her part, or the part of anyone of his/her associates, to use reasonable care.

2. Operating Rules and Laws: The permittee shall keep the premises in a neat and orderly condition at all times, and shall comply with all municipal, county, and State laws applicable to the operations under the permit as well as all Federal laws, rules, and regulations governing national wildlife refuges and the area described in this permit. The permittee shall comply with all instructions applicable to this permit issued by the refuge official in charge. The permittee shall take all reasonable precautions to prevent the escape of fires and to suppress fires and shall render all reasonable assistance in the suppression of refuge fires.

3. Use Limitations: The permittee's use of the described premises is limited to the purposed herein specified and does not, unless provided for in this permit, allow him/her to restrict other authorized entry on to his/her area; and permits the Service to carry on whatever activities are necessary for (1) protection and maintenance of the premises and adjacent lands administered by the Service; and (2) the management of wildlife and fish using the premises and other Service lands.

4. Transfer of Privileges: This permit is not transferable, and no privileges herein mentioned may be sublet or made available to any person or interest not mentioned in this permit. No interest hereunder may accrue through lien or be transferred to a third party without the approval of the Regional Director of the Service and the permit shall not be used for speculative purposes.

5. Compliance: The Service's failure to require strict compliance with any of this permit's terms, conditions, and requirements shall not constitute a waiver or be considered as a giving up of the Service's right to thereafter enforce any of the permit's terms or conditions.

6. Conditions of Permit not Fulfilled: If the permittee fails to fulfill any of the conditions and requirements set forth herein, all money paid under this permit shall be retained by the Government to be used to satisfy as much of the permittee's obligation as possible.

7. Payments: All payment shall be made on or before the due date to the local representative of the Service by a postal money order or check made payable to the U.S. Fish and Wildlife Service.

8. Termination Policy: At the termination of this permit the permittee shall immediately give up possession to the Service representative, reserving, however, the rights specified in paragraph 11. If he/she fails to do so, he/she will pay the Government, as liquidated damages, an amount double the rate specified in this permit for the entire time possession is withheld. Upon yielding possession, the permittee will still be allowed to re-enter as needed to remove his/her property as stated in paragraph 11. The acceptance of any fee for liquidated damages or any other act of administration relating to the continued tenancy is not to be considered as an affirmation of the permittees' action nor shall it operate as a waiver of the Government's right to terminate or cancel the permit for the breach of any specified condition or requirement.

9. Revocation Policy: This permit may be revoked by the Regional Director of the Service without notice for noncompliance with the terms hereof or for violation of general and/or specific laws or regulations governing national wildlife refuges or for nonuse. It is at all times subject to discretionary revocation by the Director of the Service. Upon such revocation the Service, by and through any authorized representative, may take possession of the said premises for its own and sole use, or may enter and possess the premises as the agent of the permittee and for his/her account.

10. Damages: The United States shall not be responsible for any loss or damage to property including, but not limited to, growing crops, animals, and machinery or injury to the permittee or his/her relatives, or to the officers, agents, employees, or any other who are on the premises from instructions or by the sufferance of wildlife or employees or representatives of the Government carrying out their official responsibilities. The permittee agrees to save the United States or any of its agencies harmless from any and all claims for damages or losses that may arise to be incident to the flooding of the premises resulting from any associated Government river and harbor, flood control, reclamation, or Tennessee Valley Authority activity.

11. Removal of Permittee's Property: Upon the expiration or termination of this permit, if all rental charges and/or damage claims due to the Government have been paid, the permittee may, within a reasonable period as stated in the permit or as determined by the refuge official in charge but not to exceed 60 days, remove all structures, machinery, and/or other equipment, etc., from the premises for which he/she is responsible. Within this period the permittee must also remove any other of his/her property including his/her acknowledged share of products or crops grown, cut, harvested, stored, or stacked on the premises. Upon failure to remove any of the above items within the aforesaid period, they shall become the property of the United States.

Sheldon National Wildlife Refuge Special Use Permit Conditions

1. A copy of this permit must be in the permittee's possession at all times while exercising the privileges of this permit.

2. All waste materials must be removed from the Refuge upon the permittee's and/or clients' departure. The permittee is responsible for removal of clients' garbage.

3. The landing of aircraft and use of helicopters is prohibited.

4. All guides operating under a refuge Special Use Permit must accompany each client a minimum of one use day in the field while hunting.

5. Management direction is provided in the CCP for Sheldon Refuge. This directs monitoring of wildlife-dependent recreation activities and other public uses. Findings from these monitoring efforts will be used in determining what additional management actions, if any, are needed to ensure public use activities remain compatible with refuge purposes. In addition to the stipulations listed here, all general public use stipulations included above, and all stipulations listed within compatibility determinations for all other public uses are hereby incorporated as stipulations of this compatibility determination and as special conditions of each commercial outfitter and guide SUPs unless otherwise specifically excluded by the Special Use Permit.

Additional Sheldon Refuge Special Use Permit Conditions for Commercial Guiding and Outfitting

1. Failure to abide by any part of this Special Use Permit; violation of any refuge-related provision in Titles 43 (Part 36) or 50 (sub-chapters B and C) Code of Federal Regulations; or violation of any pertinent state regulation (e.g., fish or game violation) will, with due process, be considered grounds for immediate revocation of this permit and could result in denial of future permit requests for lands administered by the USFWS. This provision applies to all persons working under the authority of this permit (e.g., assistants). Appeals of decisions relative to permits are handled in accordance with Title 50 Code of Federal Regulations Part 36.41.

2. All guides operating under a refuge Special Use Permit must accompany each client a minimum of one use day in the field while hunting.

3. The permittee is responsible for ensuring that all employees, party members, aircraft pilots, and any other persons working for the permittee and conducting activities allowed by this permit are familiar with and adhere to the conditions of this permit.

4. The permittee may not sublet any part of the authorized use area and is prohibited from subcontracting clients with any other guide.

5. The permittee and permittee's clients do not have the exclusive use of the site(s) or lands covered by this permit, except for authorized camp facilities.

6. This permit may be canceled or revised at any time by the refuge manager in case of emergency (e.g., high fire danger, flooding, unusual resource problems, etc.).

7. The permittee shall notify the Refuge Manager during refuge working hours in person or by telephone before beginning and upon completion of annual activities allowed by this permit.

8. Prior to beginning any activities allowed by this permit, the permittee shall provide the Refuge Manager with (1) proof of appropriate comprehensive general liability ($300,000 each occurrence, $500,000 aggregate), marine liability, and/or aviation passenger liability insurance covering all aspects of operations throughout the annual use period; (2) aircraft and other vehicle types to be used, with identification information, if different from the original permit or previous year; (3) changes in names of assistant guides and other employees; and (4) any other changes in information provided in the original permit/proposed operations plan.

9. The permittee is responsible for accurate recordkeeping and will provide the Refuge Manager with a comprehensive summary report of the number of clients, and number of client days per activity type by December 31 for all uses during that calendar year unless stated otherwise in the permit. A legible copy of the State's "Hunt Record" for each client will be required in addition to the summary report.

10. Failure to report the actual number of client use days per type of authorized activity by December 31 of each calendar year and annually pay the Service's established fees (client-use day and reserved land site) within 30 days after receiving a bill for collection will be grounds for revocation of this permit.

11. In accordance with the Archaeological Resources Protection Act (16 U.S.C. 470aa), the removal or disturbance of archaeological or historic artifacts is prohibited. The excavation, disturbance, collection, or purchase of historical or archaeological specimens or artifacts on refuge lands are prohibited.

12. Permittees shall maintain their use areas in a neat and sanitary condition. Latrines, seepage pits, etc., associated with permitted use areas or campsites must be located at least 100 feet, measured horizontally, to the nearest edge of the mean annual high water level of lakes, rivers, streams, springs, sloughs, or other body of surface water. No privies are to be installed in areas subject (no less than 4 feet to maximum water table elevation) to flooding. All property of the permittee must be removed from refuge lands upon completion of permitted activities.

13. The use of off-road vehicles is prohibited unless specifically authorized in writing in this permit.

14. The operation of aircraft at altitudes and in flight paths resulting in the herding, harassment, hazing, or driving of wildlife is prohibited. It is recommended that all aircraft maintain a minimum altitude of 2,000 feet above ground level.

15. All aircraft being used in a commercial guiding operation must have 12-inch identification numbers in contrasting colors which are readily visible.

16. Construction of any permanent structure is prohibited.

17. Any action by a permittee or the permittee's employees that unduly interferes with or harasses other refuge visitors or impedes access to any site is strictly prohibited. Examples of prohibited acts include, but are not limited to, low flights over camps or persons at less than 500 feet.

18. The permittee's operations plan, as amended and accepted by the U.S. Fish and Wildlife Service, is hereby incorporated in its entirety as a special condition. All deviations from the operations plan must receive prior written approval by the Refuge Manager or his/her designee.

Justification:

The National Wildlife Refuge System Administration Act of 1966 (as amended) identifies recreational hunting as one of six priority public uses on national wildlife refuges. The law states that, when managed in accordance with principles of sound fish and wildlife management and administration, hunting and the other priority wildlife-dependent recreational uses "have been and are expected to continue to be generally compatible uses." The Act further states that these priority public uses should receive enhanced consideration over other general public uses in refuge planning and management, and directs the USFWS to provide increased opportunities for the public to safety engage in traditional outdoor activities such as fishing and hunting.

The services provided by outfitters and guides increase hunting quality and in some cases enable hunters to visit and experience Sheldon Refuge who would otherwise be unwilling or unable to do so. The remoteness, rugged terrain, and limited hunting seasons make experience, skill, and first-hand knowledge important for a safe, enjoyable, and productive hunt. In the case of bighorn sheep, hunters who are awarded a hunting tag must wait 10 years to reapply. For these rare and highly sought-after hunting opportunities, the services of an experienced guide often ensure a successful hunting experience.

To reduce impacts to wildlife resources and to provide the continued opportunity for recreational uses of these species by the American public, Sheldon Refuge, NDOW, and ODFW cooperatively conduct population surveys and studies and adopt regulations in response to wildlife population survey and study results and management needs. These regulations currently provide adequate protection for Sheldon Refuge's wildlife resources, continued recreation opportunities, and other refuge purposes.

Allowing outfitting and guiding as a private economic use contributes to the quality of compatible wildlife-dependent uses within Sheldon Refuge. The maximum number of 10 operators that will be permitted is slightly higher than the average number of operators permitted over the past several years. This number was determined by considering public use goals and wilderness management direction for Sheldon Refuge, the number of potential hunters at any given time given the current number of harvest tags issued, the remoteness and size of Sheldon Refuge, and the Service's desire to provide hunters a range of operators to choose from and the opportunity for one-on-one guide services, which facilitate a high-quality hunting experience. The competitive prospectus selection process in conjunction with numerous Special Use Permit stipulations will ensure commercial outfitters and guides conserve fish, wildlife, plants, and their habitats within Sheldon Refuge while providing high-quality service and recreation experiences to the visiting public.

Together, the use, under the stipulations herein, will result in a set of actions that generate minor adverse effects and modest beneficial effects. On net, the use will contribute to achievement of Sheldon Refuge's purposes and the Refuge System mission.

Mandatory 10- or 15-Year Re-evaluation Date: (provide year for "allowed" uses only)

_____ Mandatory 15-year re-evaluation date (for wildlife-dependent public uses)

___2021___ Mandatory 10-year re-evaluation date (for all uses other than wildlife-dependent public uses)

NEPA Compliance for Refuge Use Decision: (check one below)

____ Categorical Exclusion without Environmental Action Statement

____ Categorical Exclusion and Environmental Action Statement

____ Environmental Assessment and Finding of No Significant Impact

__X__ Environmental Impact Statement and Record of Decision

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Refuge Determination

Prepared by: _____ 9/25/12
(Signature) (Date)

Refuge Manager/
Project Leader
Approval: _____ 9/25/12
(Signature) (Date)

Concurrence

Acting Refuge Supervisor: _____ SEP 27 2012
(Signature) (Date)

Acting Regional Chief,
National Wildlife
Refuge System: _____ 9/24/12
(Signature) (Date)

D.5 Compatibility Determination for Rock Collecting on Sheldon National Wildlife Refuge

Use(s): Rock Collecting

Supporting Uses: Camping, hiking, backpacking, horseback riding, and OHV use

Refuge Name: Sheldon National Wildlife Refuge

City/County and State: Washoe County, Nevada; Humboldt County, Nevada; Lake County, Oregon

Establishing and Acquisition Authority(ies):

What is today known as the Sheldon National Wildlife Refuge was initially established by Executive Order 5540 dated January 26, 1931, and later enlarged by Executive Order 7364 dated May 6, 1936, and Executive Order 7522 dated December 21, 1936.

The authorities for nearly all Federal lands within Sheldon Refuge are the Migratory Bird Conservation Act of 1929, as amended (16 U.S.C. 715-715r) and the National Wildlife Administration Act of 1966, as amended (16 U.S.C. 668dd-668ee). A small portion of Sheldon Refuge was acquired under the authority of the Endangered Species Act of 1973, as amended (16 U.S.C. 1231-1544).

Refuge Purpose(s):

> "…as a refuge and breeding ground for wild animals and birds…" Executive Order 5540 dated January 26, 1931.
>
> "… set apart for the conservation and development of natural wildlife resources and for the protection and improvement of public grazing lands and natural forage resources…" Executive Order 7522 dated December 21, 1936.
>
> "… to conserve (A) fish or wildlife which are listed as endangered species or threatened species… or (B) plants…" 16 U.S.C. § 1534 (Endangered Species Act of 1973)
>
> "… for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." 16 U.S.C. § 715d (Migratory Bird Conservation Act)

Consistent with Service Policy (601 FW 2), proposed wilderness areas are to be managed as designated wilderness. The Wilderness Act of 1964 creates additional purposes within and supplemental to other refuge purposes. Proposed wilderness areas are to be managed for the purposes of securing an enduring resource of wilderness, protecting and preserving wilderness character, and providing opportunities for public use and enjoyment and for "solitude or a primitive and unconfined type of recreation" in ways that will leave the wilderness unimpaired for future use and enjoyment as wilderness.

National Wildlife Refuge System Mission:

> "The mission of the [National Wildlife Refuge] System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans" (National Wildlife Refuge System Administration Act of 1966, as amended [16 U.S.C. 668dd-668ee]).

Description of Use(s):

Rock collecting is a non-priority public use that occurs throughout Sheldon Refuge, but it is concentrated within Virgin Valley, at abandoned mining claims and prospect pits, and other areas located primarily in the southern portion of Sheldon Refuge along improved roads, and unimproved vehicle routes. Mining on established claims within the Virgin Valley Mining District is not considered rock collecting. Commercial operators provide fee-based recreation rock collecting and mining opportunities for precious opal on private lands and patented mining claims in the Virgin Valley area within Sheldon Refuge. No digging or excavation is allowed on areas of Sheldon Refuge withdrawn from mineral entry.

Visitors seek primarily precious and semi-precious opals, petrified wood, and other common variety rocks and minerals. Currently each visitor is authorized to surface collect up to seven pounds of rock or mineral per day from public lands.

Rock collecting opportunities within Sheldon Refuge are widely known, and many visitors see the area as a destination for rock collecting both on public lands and on private mining claims within Sheldon Refuge. Visitation to the Virgin Valley portion of Sheldon Refuge occurs between May and August and constitutes the greatest amount of annual public use within Sheldon Refuge. Most visitors to Virgin Valley collect and dig for precious black opal on private mining claims, with an unknown number of visitors collecting from public lands. Other known locations are popular and consistently used throughout the summer months. Secondary uses of Sheldon Refuge that support rock collecting include camping, hiking, backpacking, horseback riding, and OHV use. Overnight camping in support of the use occurs primarily at the Virgin Valley Campground, with much smaller amounts of use occurring at the 11 other designated campgrounds and by permit in backcountry areas.

Supporting Uses

Camping

Camping itself is not a priority public use on Service lands, but because of the size, remoteness, and quality of roads within Sheldon Refuge, it is important in supporting priority uses including fishing, hunting, wildlife observation, and wildlife photography as well as non-priority public uses such as rock collecting. There are four types of camping opportunities currently provided within Sheldon Refuge: developed, semi-primitive, primitive, and backcountry/wilderness.

Camping within Sheldon Refuge is allowed in 13 designated campgrounds and by Refuge Special Use Permit for backcountry camping.

Developed Camping: Virgin Valley Campground located at Dufurrena is considered the only developed campground. Virgin Valley Campground is easily accessible year-round by all types of

vehicles, including RVs, and it offers shade trees, potable water, two vault toilets, 16 picnic tables, 24 fire rings, a meat-hanging pole, a bath-house, and a hot spring developed for swimming. Campground use is managed on a first-come, first-served basis without fees or designated sites. From 2005 through 2007 an average of 18 campsites were occupied per day during the days surveyed, for a seasonal average of 6,573 visitor use days (USFWS undated report).

From mid-August through mid-November, the Virgin Valley Campground is heavily used by hunters. During peak seasons, overcrowding and user conflicts have been a concern as has overflow into upland areas adjacent to the campground, which can result in further environmental damage. There is also a private developed campground at the Royal Peacock Mine located in the Virgin Valley Mining District, which has RV hookups.

Semi-primitive Camping: Five campgrounds (Catnip Reservoir, West Rock Spring, Fish Spring, Badger, and Big Spring Reservoir) are considered semi-primitive and include outhouses, fire rings, meat-hanging poles, and in the case of Fish Spring and Badger campgrounds, horse corrals. These semi-primitive campgrounds are accessible from primary roads or improved secondary roads suitable for most types of vehicles and are primarily used by hunters. Sport anglers also use campgrounds at Catnip and Big Spring reservoirs.

Additional facilities such as campsite amenities (i.e., picnic tables and accessible fire rings or barbeque grills), potable water, shade structures, kiosks, and dedicated volunteer sites are planned for Virgin Valley, Catnip Reservoir, and Big Spring Reservoir campgrounds. These facilities will provide developed camping opportunities that are not commonly available within Sheldon Refuge or the region. However, these improved facilities will only be sustainable over the long term through campsite fees to support volunteers, maintenance, and replacement.

The Service will also allow public overnight use of some existing historic structures within Sheldon Refuge. The most likely structures are the Little Sheldon Overnight Cabin and Badger Cabin.

Primitive Camping: Seven campgrounds (Little Catnip Spring, Gooch Spring, North Hell Creek, Wheeler Spring, Bateman Spring, Devaney, and East Rock Spring) are considered primitive campgrounds and have only fire rings or no improvements, are remote, and are accessible by four-wheel drive or high-clearance vehicles when road conditions are passable. These primitive campgrounds receive intermittent and low amounts of use, occurring mostly during the big-game hunting seasons (early August through October). All of these campgrounds are located immediately adjacent to, or include, wet meadows, spring, or springbrook habitats. Three primitive campgrounds (Wheeler Spring, Devaney, and East Rock Spring) also include aspen woodland habitats. Impacts associated with primitive campgrounds were identified as an issue during the Sheldon CCP planning process. The impacts identified and stipulations for reducing or eliminating those impacts are addressed in subsequent sections of this compatibility determination.

Backcountry/Wilderness Camping: Backcountry camping for up to 14 days is allowed by refuge permit. Permits are not limited, but do stipulate visitors must camp at least 0.5 mile from open roads and at least 100 yards from water sources. The majority of backcountry camping permits are issued to hunters, but the amount of use is low and no adverse impacts have been observed. Backcountry use will continue to be monitored, and future management actions to reduce or eliminate any impacts will be implemented as necessary.

Public Access

Public access to areas within the Refuge is provided by a network of vehicle roads and informal backcountry routes and trails. Roads include one two-lane paved highway, maintained gravel roads, and numerous primitive and unmaintained dirt roads. Trails throughout the Refuge backcountry and wilderness areas are primarily abandoned vehicle routes historically used for access to livestock developments and private inholdings later purchased by the Service.

The most substantial changes to rock collecting are expected to result from the relocation and enlargement of the Refuge visitor contact station, improvement of campground facilities, and improved signing of routes open to vehicle use. Improved gravel roads within Sheldon Refuge will be maintained more frequently, and all routes open to the public use of vehicles will be adequately signed and marked. Visitors will be required to register all OHVs consistent with State of Nevada regulation or with Sheldon Refuge for use on refuge roads and routes designated open to vehicle use. These actions are intended to improve the quality of the transportation system and deter vehicle violations while requiring only minimal law enforcement presence.

Maintained Public Roads: In preparation of the Sheldon Refuge CCP, each route within the refuge was evaluated to assess impacts to fish, wildlife, plants, and their habitats, as well as benefits for public use and recreation opportunity. Following this evaluation, 300 miles of existing roads (including State Highway 140 and all maintained county roads) were designated for public vehicle use. The Service has determined the continued use and maintenance of these designated roads, including actions for re-routing or modification as presented in the Sheldon Refuge CCP, will have minimal or no impacts to wildlife and wildlife habitat and/or are subject to existing right-of-way. The unimproved roads within Sheldon Refuge are not regularly maintained, but are repaired on a site-by-site basis to keep them in usable condition or to prevent undue resource damage (i.e., excessive erosion).

Trails and Backcountry Access: Hiking, horseback riding, use of pack stock, and other non-mechanical modes of access are allowed on trails, routes, and other areas of Sheldon Refuge open to the public. All vehicle use is restricted to designated open roads. Existing trails throughout Sheldon Refuge will remain, but will not be marked or maintained for public use. No adverse impacts have been observed from visitors using these routes for hiking, horseback riding, or use of pack stock.

Horseback Riding and Pack Stock Use: Horseback riding has been allowed as a recreation activity within Sheldon Refuge for many years. However, it is estimated that fewer than 10 horseback visitors use Sheldon Refuge each year, and as a result, horseback riding is considered a low-impact activity. Horseback riding gives the public an opportunity to visit remote and undeveloped portions of Sheldon Refuge, and to enjoy the wildlife viewing, solitude, and expansive views that Sheldon Refuge is known for.

There is a concern that the number of visitors engaging in horseback riding may increase, particularly with hunting guides and their clients, and that use of horses and pack stock within the Refuge will introduce invasive non-native plants. These impacts have not been observed, but monitoring will continue and the Service will take additional action as needed to maintain wilderness character and prevent the introduction of weeds to the Refuge.

The corrals at Badger and Fish Spring campgrounds are the only facilities that specifically support horseback riding and the use of pack stock.

Availability of Resources:

Administration and management of rock collecting is very limited. Information kiosks at Sheldon Refuge entrances, the Sheldon Refuge website, brochures, and leaflets provide general information about Sheldon Refuge. Private companies and individuals with mining claims provide additional signs, websites, brochures, and other information about rock collecting within Sheldon Refuge. Maintenance of the campgrounds, access roads, and other supporting facilities and routine law enforcement patrols are also conducted by Sheldon Refuge.

Category and Itemization	One-time	Annual
Administration and management (volunteer host site development, volunteer campground hosts, law enforcement patrols, backcountry use permits, fee collection and processing)	$15,000	$5,000
Maintenance	$1,500	$500-$1,500
Monitoring	$500	$500
Special equipment, facilities, or improvements (campgrounds and access roads)	$150,000	$500-$1,500
Offsetting revenues[5]	$8,000	$8,000

As part of a 2001 memorandum of agreement with Sheldon Refuge, Humboldt County, Nevada, provides approximately $2,500 per year to support volunteer staffing, maintenance, and administration of the Virgin Valley Campground and associated public facilities. When adjusted for inflation, the 2001 funding amount has the purchasing power of approximately $1,850 dollars today (2010). If inflation continues at this rate, the funding amount will have the purchasing power of about $1,370 in 2021. As a result, the continued maintenance of the Virgin Valley Campground and associated public facilities will require increased funding and support. Volunteer organizations provide additional support for the maintenance and administration of facilities that support rock collecting within Sheldon Refuge. We anticipate current funding and volunteer support when combined with campground use fees will be adequate for management of the Virgin Valley Campground over the next 10 to 15 years.

Anticipated Impacts of the Use(s):

Effects from Rock Collecting

[5] Anticipated campsite fee revenues as proposed in the CCP based on $5/site/day for 1,100 site-use days and $2,500 from Humboldt County, Nevada.

Rock collecting is a non-priority public use that represents the majority of summer public use within Sheldon Refuge, and in particular the Virgin Valley area. Because most rock collecting occurs during late spring and early summer, there is little competition with visitors engaged in wildlife-dependent uses that either occur at other locations or later in the year. Therefore, the use does not currently conflict with priority public uses within Sheldon Refuge and is not anticipated to conflict with these uses within the 10-year timeframe of this compatibility determination. If the Refuge Manager determines such conflicts occur, the Refuge Manager may allocate rock collecting activities in time and/or space to reduce or eliminate conflicts among users of the refuge. If this cannot be done, the Refuge Manager may need to terminate or disallow rock collecting within Sheldon Refuge.

Rock collecting is supported by 13 designated campgrounds. The 13 campgrounds are located near water and partially within riparian habitats and several prehistoric cultural sites. While the majority of impacts occurred following the initial establishment of these campgrounds, some impacts continue due to continued soil disturbance and compaction within existing campsites, occasional use of previously unused areas adjacent to the campgrounds, and vehicle use outside designated areas. It is anticipated that actions to define each of these campgrounds and confine use to designated campsites will mitigate or avoid additional impacts altogether.

Access for rock collecting is provided by approximately 300 miles of motorized vehicle routes and several established routes and trails in the refuge backcountry. Roads and vehicle use can cause a number of impacts to soils, water, habitat, fish, and wildlife. Vehicle use is allowed on routes within the refuge where these impacts are anticipated to be minimal, or where planned management actions such as re-routing, realignment, and seasonal closures will acceptably minimize impacts. Route segments identified for re-routing, realignment, or other action were identified in the Sheldon Refuge CCP's management direction.

Rock collecting activities have both direct and indirect impacts on wildlife distribution, behavior, and habitats. The most frequent impacts are disturbance to large birds and mammals from people approaching too close and from vehicle presence. These impacts are most severe during periods of mating, nesting, lambing, and fawning. However, because the number of people participating in rock collecting is small and visitors generally do not venture far from roads and campgrounds, impacts from rock collectors are only a portion of the overall wildlife disturbance.

Rock collecting can cause impact through removal of interesting or unique specimens that could otherwise be enjoyed by future visitors. We expect these impacts are minor due to the likelihood that most valuable or unique specimens within the Virgin Valley have been or will be collected through mining activities and due to the common nature of most rocks collected outside the Virgin Valley area.

Monitoring of public use and law enforcement at identified sensitive cultural resource sites, known fossil deposits, and areas with large specimens of petrified wood are conducted to determine if either intentional or unintentional illegal collection are impacting these resources. While violations associated with rock collecting are suspected to occur on Sheldon Refuge, it is unknown how many violations occur or if a sufficient number are inadvertent or unintentional that violations could effectively be reduced through additional regulation or permit. An adaptive management strategy will be used to more accurately document where and why violations occur and adjust refuge outreach efforts accordingly. If it is that determined violations are inadvertent or unintentional and that outreach and education methods prove ineffective, compatibility of this use will be re-evaluated.

Effects from Camping and Campgrounds

Use of campgrounds within Sheldon Refuge causes impacts to vegetation, soils, water quality, and cultural resources. During dry conditions, carelessness with campfires can lead to wildfires. Management and development of campground is also expected to affect the type and quality of recreation opportunities available.

Impacts to Vegetation, Soils, and Water Quality: Campgrounds and their use within the Refuge range from primitive sites with relatively low and only intermittent use to very developed sites with year-round and relatively high amount of use during summer months. Current impacts and expected future impacts associated with use and development of these campgrounds also vary widely. Because the most primitive campgrounds are currently the least impacted, we can expect these sites will exhibit the greatest amount of additional or potential impact with only slightly more use. Conversely, most impacts have already occurred at the most heavily used and developed campgrounds, and we can expect very little additional impact to vegetation, soils, or water quality even with relatively large increases in use at these campgrounds.

The greatest difference in durability between vegetation types occurs at moderately low use levels (Cole 1985). Sites that are used frequently are likely to be highly impacted regardless of their fragility. Because vegetation loss usually occurs more rapidly than loss of organic soil horizons, sites with either no vegetation or resistant vegetation (e.g., grasses as opposed to forbs) recover more quickly and are less likely to be impacted by low levels of use, while sites with thick organic soil horizons are less susceptible to erosion and are more likely to withstand high amounts of use.

Experimental studies suggest that there is an important difference between a site's resistance (its ability to tolerate use without being damaged) and its resilience (its ability to recover from damage). Cole (1995) has shown, for groundcover plants, that resistance decreases with erectness and that broad-leaved herbs are typically less resistant than grass-like plants and shrubs. Low shrubs, such as heather, are relatively resistant to trampling stress but their resilience is low. Once damaged, they recover slowly. Grass-like plants are most tolerant of trampling (Cole 1989). The compaction of soils from campsite use reduces water infiltration and water holding capacity, which leads to increased runoff and erosion potential (Cole 2004; Monti and Mackintosh 1979). Impacts associated with use at primitive campgrounds can be readily observed and tend to occur rapidly, but these impacts are relatively inconsequential when considered in the context of the entire Refuge. Impacts associated with campgrounds located within riparian areas or near water sources are of greater concern, but current impacts are not severe, and vegetation, soils, and water quality at primitive campgrounds are expected to recover noticeably within a few years following campground relocation. This assessment is supported by Cole (1981) who noted that hiking and camping impacts on soil and vegetation, while severe when measured at small scales, are minimal at large spatial scales. This suggests that while recreation impacts can be serious for individual plants and animals and perhaps localized rare populations, they are generally of little significance to landscape integrity or regional biotic diversity. Moreover, unless much of a population is impacted by a single impacted site, the intensity, size, and distribution of impacts are not relevant to the significance of impacts assessed at large spatial scales (Cole 1989).

Virgin Valley Campground is located at a site previously developed and used by the Civilian Conservation Corps in the late 1930s. Catnip Reservoir and Big Spring Reservoir campgrounds are located immediately adjacent to artificial reservoirs. These three campgrounds receive the greatest amounts of use and exhibit the greatest amount of impact. The core areas of use at these

campgrounds no longer support vegetation, or vegetation diversity is substantially reduced, water infiltration is considered low due to soil compaction, and gravel has been placed in some areas to reduce erosion and rutting from vehicles. Non-native plants and animals in and around these three campgrounds were likely introduced by early ranching and development activities rather than campground visitors. Monitoring and control efforts will continue to detect and remove or eradicate small or new populations of invasive species.

The remaining 10 campgrounds are all located immediately adjacent to or include aspen woodland, wet meadows, spring, and/or springbrook habitats. Most of these campgrounds have moderate amounts of vegetation loss and soil compaction, which is limited to parking areas, areas around fire rings, outhouses, and along connecting paths. These impacts are generally not continuous throughout the campground and are expected to remain stable with current amounts of intermittent use, which occurs during late summer and fall, after most annual and biannual plants have finished growing for the season and when soils are typically drier and more resistant to impact. Some primitive campgrounds have no visible bare ground, and where located in meadow habitats, vegetation is generally able to recover from the current amount of use. Some primitive campgrounds exhibit small areas of bare ground, generally a lack forbs, which are not resistant to trampling, and in the case of Wheeler Spring, Devaney, and East Rock Springs, exhibit some impacts to aspen trees from trampling, soil compaction, root exposure, and cutting. Because these campgrounds receive little visitation or are located near frequently traveled gravel roads, impacts to wildlife from campground use are estimated to be minor or negligible. Due to the nature of these impacts and relatively low amount of use, we anticipate these campgrounds will exhibit the greatest amount of natural recovery compared to the three more developed and heavily used campgrounds if camping use were eliminated, but they will also exhibit the greatest amount of additional impact if camping use were to substantially increase. Aspen stands associated with the Devaney, Wheeler Spring, and East Rock Springs campgrounds are also expected to recover, but regeneration of the understory shrubs and younger trees will occur slowly and will likely require some active restoration and/or replanting.

Up to nine semi-primitive and primitive campgrounds will be relocated away from sensitive riparian habitats and areas with cultural resources. It is anticipated actions to relocate campgrounds to alternative sites, protect sensitive habitats at each of these campgrounds, and confine use to designated campsites in heavily used campgrounds will minimize or avoid additional impacts altogether.

We expect some primitive campgrounds to be consolidated with other existing campgrounds, which will need to be enlarged and have additional campsites constructed (the most likely candidates for enlargement include Catnip Reservoir, Big Spring Reservoir, Fish Spring, and West Rock Spring campgrounds). Consolidation will result in additional impacts from increased use of existing facilities and campsites and from the designation and construction within existing campgrounds. Where camping already occurs, increased use of existing campsites and facilities is expected to have little or no measurable impact to vegetation or wildlife. Impacts to expanded portions of these campgrounds are expected to occur quickly as vegetation is trampled and soil compacted within the first two or three seasons of use, but will then stabilize over the long term. We expect enlargement of existing campgrounds will result in minor, site-specific, long-term, direct adverse impacts to plants and their habitat from removal of vegetation, soil compaction, and loss of organic soil horizon at these sites.

Impacts from Wildfire: Campfires are allowed at designated campgrounds but are occasionally prohibited during periods of high fire danger. Wildfires have been started by refuge visitors in the

past, and we expect some wildfires will occasionally start as a result of escaped campfires or misuse of stoves. Seasonal campfire restrictions and rapid fire suppression response will continue to minimize impacts.

Impacts to Cultural Resources: Most of the 13 designated campgrounds are located within or adjacent to prehistoric cultural sites. While the majority of impacts occurred following the initial establishment and use of these campgrounds, some impacts continue due to ongoing soil disturbance and compaction within existing campsites, trampling and removal of vegetation, occasional use of previously unused areas adjacent to the campgrounds, and vehicle use outside designated areas. Limited fee use of the Little Sheldon Overnight Cabin or Badger Cabin is expected to increase public appreciation for historic resources and understanding for their protection and preservation. In addition, the use of these sites and the collection of fees will provide justification and funding for restoration work and continued maintenance. As a result, the integrity of sites eligible for the National Register of Historic Places will be protected. Therefore, we anticipate use of these facilities to support sport hunting will have a major, long-term, beneficial impact on cultural resources.

Impacts to Recreation Opportunity: Campsite registration, overnight fees, and the other improvements planned for the developed campgrounds will increase maintenance, increase visitor compliance with rules and regulations (by defining and designating campsites), and decrease competition for campsites. Campground management strategies are expected to result in moderate, indirect, long-term, beneficial impacts to the camping experience, in support of providing quality opportunities for wildlife-dependent recreation.

Effects from Public Access

Adverse impacts are expected to continue as a result of the network of developed and undeveloped roads throughout Sheldon Refuge and associated maintenance. Road development and use continues to adversely impact the biological integrity within Sheldon Refuge by contributing to the altered composition of plant communities, soil disturbance (Eckert et al. 1979; Iverson et al. 1981; Switalski et al. 2004), altered hydrology and stream sedimentation (Forman and Alexander 1998), facilitation of the spread of invasive vegetation, changes in the natural fire regimes, and habitat fragmentation.

Many direct effects are obvious during construction, but other effects are permanent and can extend substantially beyond the actual road surface (road-effect zone; Forman 2000; Forman and Alexander 1998). At the landscape scale, major ecological impacts of a road network include fragmentation, the disruption of landscape processes, and loss of biodiversity. Biodiversity declines as the road network impacts interior species (species cut off by roads), species with large home ranges, stream and wetland species, and rare native species (Forman and Alexander 1998). Fragmentation of previously extensive landscapes can influence the distribution and abundance of a host of wildlife species through redistribution of habitat types and through the pattern of habitat fragmentation, including characteristics such as decreased patch area and increased habitat edge (Vander Haegen et al. 2000).

Roads (including OHV trails) are commonly identified as important correlates or indicators of loss of ecological health and affect terrestrial and aquatic ecosystems in several general ways: 1) increased mortality from road construction; 2) increased mortality from collision with vehicles; 3) modification of animal behavior; 4) alteration of physical environment; 5) alteration of chemical environment; 6) spread of exotic species; and 7) increased alteration and use of habitats by humans (Trombulak and Frissell 2000; Wildlife Action Plan Team 2006).

The ecological effect of road avoidance is likely related to traffic density and speed of travel, as well as traffic noise levels (Forman and Alexander 1998). Road-effect zones generally result in lower breeding densities and reduced species richness; species demonstrated to avoid or be negatively impacted by roads include arthropods, reptiles, small mammals, ungulates, and forest and grassland birds (Andrews and Gibbons 2005; Carr and Fahrig 2001; Forman and Alexander 1998; McGrann et al. 2006; Rost and Bailey 1979). For example, proximity to OHV trails (<1,000 meters [3,280 feet]) was found to have a direct correlation with reduced-quality habitat for nesting songbirds in sagebrush-steppe habitats, including nest desertion, nest predation, and abandonment (Barton and Holmes 2007). Behavioral disturbance from recreation, including that associated with trails and roads, may also have both immediate and long-term effects on wildlife (Taylor and Knight 2003). In one study of pronghorn, deer, and bison, individuals exhibited a 70% probability of flushing within 1,000 meters (3,280 feet) on either side of a trail used by hikers and mountain bikers (Taylor and Knight 2003); presumably, responses are similar in the presence of vehicles such as OHVs. Road density can be used as an overall index to average patterns over an area. For example, road densities of approximately 1.0 mile per square mile have been recommended as the maximum for a naturally functioning landscape containing sustained populations of large predators (Forman and Alexander 1998). However, the effects of road density are likely sensitive to road width or type, traffic density, network connectivity, and the frequency of spur roads into remote areas (Forman and Alexander 1998).

Within Sheldon Refuge, more than 50 introduced, non-native, and often noxious plant species have been documented (refer to Sheldon Refuge CCP Appendix B). Invasive plants typically need transportation to spread to new areas (Trombulak and Frissell 2000); within Sheldon Refuge several methods are possible, including vehicles, people, wild and domestic animals, and firefighting equipment. Indeed, it has been demonstrated that habitats distant from roads may provide important refuge for native grassland species, and that this effect may be even more pronounced in predominately intact landscapes such as those in parts of the Great Basin (Gelbard and Harrison 2003). Human access and disturbance effects on remote areas tend to increase with higher road densities, as well as human-caused fire ignitions (Forman and Alexander 1998).

Various methods, including systematic inventory and monitoring for invasive plants, mowing, use of herbicides, and elimination of grading road shoulders, will be used to detect new infestations, control and contain existing infestations, and treat up to 1,000 acres per year. Management strategies to combat invasive plants support the Service policy for biological integrity and diversity within Sheldon Refuge. With a more systematic approach for inventory of noxious weeds and other invasive plants, populations are more likely to be detected when they are small and more easily managed and controlled. Increased treatment and reduced soil disturbance along road corridors should reduce the spread of invasive plants already present and reduce the potential for new populations. As a result, we anticipate these actions will result in major, long-term, direct, beneficial impacts to all habitats. Implementing treatment strategies (e.g., mechanical removal of vegetation, application of herbicides) will likely eliminate or prevent the spread of noxious weed populations when detected and provide some conservation of native habitats, resulting in minor, site-specific, short-term, direct, beneficial impacts to habitat on approximately 1,000 acres per year.

In conjunction with preparation of the Sheldon Refuge CCP, Refuge staff conducted an evaluation of existing routes and trails and identified known and potential resource impacts and public benefits and recreation opportunities associated with vehicle access. Route segments that were identified as causing substantial impacts to soils, riparian areas, and/or wildlife, were redundant with other routes, or provided very little or no access for wildlife-dependent uses were not identified for designation as

open roads for public use of vehicles. To minimize or avoid lesser impacts from roads and vehicle use, the Service will implement a number of transportation management strategies including designating roads that are not duplicative, re-routing or realigning road segments that pass through sensitive resource areas, installing erosion control structures, increasing monitoring and treatment of weeds along road corridors, and posting signs marking all designated open roads. These actions will result in long-term, minor, direct and indirect, beneficial impacts to soils by decreasing erosion in sensitive areas that are currently affected. Overall we expect impacts from road management will be minor, direct, and adverse to habitats on a localized and long-term basis.

Management of rock collecting supports Service policy by providing various opportunities for primitive and unconfined types of recreation throughout Sheldon Refuge. Hiking, horseback riding, and vehicle access are secondary uses that support wildlife-dependent recreational activities within Sheldon Refuge. Sheldon Refuge allows access on foot, by horseback, or by vehicle. However, all vehicle routes are open to both motorized and non-motorized vehicles and there are no areas managed for non-motorized vehicle access (i.e., mountain bikes or game carts) or semi-primitive non-motorized recreation opportunity. In areas open to vehicle use we assume impacts to non-motorized vehicle users are asymmetrical (Webber 1995) and occur from conflict, noise, dust, competition with motorized users for recreation opportunity, and displacement to non-motorized areas outside the refuge (Adelman et al. 1982; Gambill 1996; Manning and Valliere 2002; Moore 1994; Stokowski and LaPointe 2000). The somewhat narrow range of vehicle access for non-motorized users provided within the refuge represents a direct, adverse, moderate, long-term impact to quality recreation opportunities.

Effects from Horseback Riding and Use of Pack Stock

Because the number of visitors who ride horseback or use pack stock within Sheldon Refuge is estimated to be less than 10 per year and because little impact has been observed from such use, we expect future impacts from trampling and introduction of non-native weeds will also be low and less than similar impacts associated with overnight camping and vehicle use. Stock use areas at Badger and Fish Spring campgrounds will continue to be monitored, particularly for new populations of non-native plants, and additional actions such as requiring certified weed-free feed and weed removal will be implemented as necessary.

Economic Effects

The majority of visitors who pursue opportunities for rock collection with Sheldon Refuge use mining claims and private lands in Virgin Valley. These activities are considered mining, are subject to different rules and regulations, and are not included in the evaluation of rock collecting as a refuge activity. Rock collecting occurs on other lands within Virgin Valley and opportunistically throughout Sheldon Refuge, and we expect some valuable specimens of opal are occasionally collected outside of mining claims and private lands. However, the overall participation and economic value of these activities and the specimens collected are estimated to be negligible in comparison to the value of wildlife-dependent uses occurring within Sheldon Refuge.

Effects to Wilderness Character

Naturalness: Approximately 300 miles of existing vehicle routes will remain visible, and their designation for motorized use is not expected to result in any short-term impacts to naturalness. Over the long term, as public use continues to increase, we expect that there will be a need for additional

signs, road maintenance, and other developments to ensure compatibility. Increased visitation to these areas will also increase the potential for introduction and spread of weeds and for the disturbance and displacement of wildlife.

Weed treatments occurring on approximately 1,000 acres per year, primarily along road corridors, are expected to slow or possibly reverse the trend of weed spread and invasion into undeveloped and more natural areas of Sheldon Refuge, but will adversely affect natural character due to the presence of dead vegetation and vehicle tracks.

Untrammeled Conditions: Rock collecting will rely primarily on existing campgrounds, roads, and other facilities, which will result in little or no change to untrammeled conditions within Sheldon Refuge.

Solitude: Due to the limited number of campsites available and the implementation of fees for use at the Virgin Valley, Catnip Reservoir, and Big Spring Reservoir campgrounds, we anticipate some increased use of primitive campgrounds and some additional overnight backcountry use by visitors participating in rock collecting who continue to seek opportunities for solitude. Such opportunities will continue to be available throughout much of Sheldon Refuge during substantial portions of the year.

Primitive and Unconfined Recreation: Management direction for designation of 300 miles of existing roads for public use of vehicles will result in only minor impacts. These existing roads will remain in their current condition and level of maintenance, and use of unimproved dirt roads is expected to remain low and intermittent for access to more primitive and remote portions of Sheldon Refuge. Other routes will continue to be used for hiking, backpacking, and horseback riding and occasionally by vehicle for administrative purposes. Management actions will also result in greater management presence, development, and regulation at the Virgin Valley, Catnip, and Big Spring campgrounds. Impacts to opportunities for primitive and unconfined recreation will be minor, with vehicle use confined to existing campgrounds and roads where public use has been well established for many years.

Cumulative Effects from Rock Collecting

Impacts to refuge resources and other public uses from rock collecting are suspected, but not well understood or documented. Actions to manage rock collecting within the refuge, including development of targeted outreach and education programs, and additional rules and regulations for use of the Virgin Valley Campground are expected to minimize or reduce impacts. The majority of rock collecting occurs within the Virgin Valley. When considered with other existing and planned public uses and management actions, including management of mining claims within Virgin Valley, cumulative impacts from the surface collection of common variety rocks and minerals, when conducted according to applicable refuge rules and regulations, are negligible.

Public Review and Comment:

This and other compatibility determinations were prepared concurrently with the Final CCP/EIS for the Sheldon National Wildlife Refuge (published August 2012). Open houses were held, multiple planning updates were mailed, and written comments were solicited from the public during development of the Final CCP/EIS for the refuge. Appendix A of the CCP further details public involvement during development of the CCP. A summary of public comments received during

review of the Draft CCP/EIS along with the Service's response to those comments are included in Appendix N of the CCP.

Determination: (check one below)

___ Use is Not Compatible

_X_ Use is Compatible with the Following Stipulations

Stipulations Necessary to Ensure Compatibility:

The following stipulations are included in the management direction provided in the Sheldon Refuge CCP and are required to ensure rock collecting remains compatible with priority wildlife-dependent public uses and purposes for Sheldon Refuge.

1. Surface disturbance or the use of any tool, equipment, or other device will not be allowed for the location or collection of rocks or minerals.

2. Each visitor will be authorized to collect no more than seven pounds of rock or minerals per day.

3. Sheldon Refuge will document all violations committed on refuge lands related to the collection of cultural resources (e.g., prehistoric stone tools and projectiles), vertebrate fossils, surface disturbance, or collection of more than seven pounds per person per day.

4. The number of violations in item three above committed by persons engaged in collection activities shall not exceed five violations per year in two years of any five-year period. If this compatibility threshold is exceeded, refuge compatibility for rock collecting will be re-evaluated.

5. Sheldon Refuge will regulate occupancy and length-of-stay at the Virgin Valley Campground, and other designated campgrounds as necessary, to ensure adequate camping opportunities are available to support priority wildlife-dependent public uses and avoid conflict with such uses.

6. Fees will be collected for overnight use of Virgin Valley Campground to provide necessary funding for maintenance, rock collecting outreach and education programs, resident volunteers, and campground administration.

7. All vehicles defined as off-road vehicles under 42 U.S.C. Section 4321 must be registered with the State of Nevada or Sheldon National Wildlife Refuge for use on lands administered by Sheldon Refuge.

8. Vehicle use within Sheldon Refuge is allowed only on roads and routes that are designated "open" on Figure D.1 and that are signed or otherwise marked for such use. Off-road use is prohibited.

9. Unless otherwise indicated by sign, permit, or regulation, the maximum number of consecutive nights any person or attended vehicle may remain at a designated Refuge campground is 14 nights.

10. Except for camping within campgrounds that are designated for such use on maps included in the Final Record of Decision for the Sheldon National Wildlife Refuge CCP/EIS and that are signed

or otherwise marked for such use, no overnight use is allowed on lands administered by Sheldon Refuge unless expressly authorized by a valid Special Use Permit.

11. Non-motorized boats or boats with electric motors are allowed only in Big Spring Reservoir, Catnip Reservoir, and Dufurrena Ponds, consistent with 50 CFR 32.47.

12. Open fires are allowed only at designated campgrounds and within constructed fire rings, subject to additional seasonal fire restrictions and/or closures.

13. Pets must be leashed, except dogs used for hunting migratory or upland birds. Hunting dogs must be under strict voice control at all times.

14. Riding or packing with horses and mules is allowed in all areas open to public use. All horses and mules must be haltered, branded, tagged, or otherwise visibly marked as a domestic animal and must be tied, hobbled, high-lined, corralled, or otherwise under direct control at all times.

15. Grazing of domestic animals within Sheldon Refuge is not allowed.

16. We encourage the use of certified weed-free hay, pellets, straw, and other livestock feed within Sheldon Refuge. The use of certified weed-free feed will be required if monitoring of stock use areas indicates the spread or introduction of noxious weeds from uncertified feed.

Justification:

Rock collecting is a long-standing and well-established public use within Sheldon Refuge. Rock collecting occurred within the area prior to establishment of the Refuge and has consistently been found compatible with the purposes for Sheldon Refuge and other priority wildlife-dependent public uses.

In finding rock collecting to be an appropriate use within Sheldon Refuge, the Refuge Manager determined the use does not conflict with priority wildlife-dependent public uses, that funding and staffing are available to currently manage the use, and that the use increases public understanding and appreciation of the Refuge's natural resources.

Thresholds for campground use and the number of violations related to collection of cultural artifacts and vertebrate fossils, which are included as stipulations within this compatibility determination, will address the primary management concern related to the use and will ensure rock collection does not result in additional conflict with Sheldon Refuge purposes, management responsibilities, management goals and objectives, or with priority wildlife-dependent public uses. Targeted outreach and education will increase public understanding and appreciation of both natural and cultural resources within Sheldon Refuge. If it is determined that violations are inadvertent or unintentional and that outreach and education methods prove ineffective, compatibility of this use will be re-evaluated prior to the mandatory 10-year re-evaluation date.

In sum, although rock collecting may result in disturbance or displacement of wildlife, the relatively limited number of individual animals and plants expected to be adversely affected will not cause wildlife populations to materially decline. The physiological condition and production of refuge species will not be impaired, their behavior and normal activity patterns will not be altered dramatically, and their overall welfare will not be negatively impacted. It is anticipated that wildlife populations will find sufficient food resources and resting places such that their abundance and use of

the refuge will not be measurably reduced from allowing these activities to occur. Thus, allowing rock collecting to occur under the stipulations described above will not materially detract or interfere with the purposes for which Sheldon Refuge was established or the Refuge System's mission.

Mandatory 10- or 15-Year Re-evaluation Date: (provide year for "allowed" uses only)

_____ Mandatory 15-year re-evaluation date (for wildlife-dependent public uses)

___2021___ Mandatory 10-year re-evaluation date (for all uses other than wildlife-dependent public uses)

NEPA Compliance for Refuge Use Decision: (check one below)

____ Categorical Exclusion without Environmental Action Statement

____ Categorical Exclusion and Environmental Action Statement

____ Environmental Assessment and Finding of No Significant Impact

__X__ Environmental Impact Statement and Record of Decision

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Refuge Determination

Prepared by: _____ 9/25/12
(Signature) (Date)

Refuge Manager/
Project Leader
Approval: _____ 9/25/12
(Signature) (Date)

Concurrence

Acting Refuge Supervisor: _____ SEP 27 2012
(Signature) (Date)

Acting Regional Chief,
National Wildlife
Refuge System: _____ 9/27/12
(Signature) (Date)

D.6 Compatibility Determination for Research on Sheldon National Wildlife Refuge

Use: Research, scientific collecting, and surveys

Supporting Uses: Camping, boating, hiking, backpacking, horseback riding, OHV use, and landing of aircraft

Refuge Name(s): Sheldon National Wildlife Refuge

County and State: Washoe County, Nevada; Humboldt County, Nevada; Lake County, Oregon

Establishing and Acquisition Authority(ies):

What is today known as the Sheldon National Wildlife Refuge was initially established by Executive Order 5540 dated January 26, 1931, and later enlarged by Executive Order 7364 dated May 6, 1936, and Executive Order 7522 dated December 21, 1936.

The authorities for nearly all Federal lands within Sheldon Refuge are the Migratory Bird Conservation Act of 1929, as amended (16 U.S.C. 715-715r) and the National Wildlife Administration Act of 1966, as amended (16 U.S.C. 668dd-668ee). A small portion of Sheldon Refuge was acquired under the authority of the Endangered Species Act of 1973, as amended (16 U.S.C. 1231-1544).

Refuge Purpose(s):

> "…as a refuge and breeding ground for wild animals and birds…" Executive Order 5540 dated January 26, 1931.
>
> "… set apart for the conservation and development of natural wildlife resources and for the protection and improvement of public grazing lands and natural forage resources…" Executive Order 7522 dated December 21, 1936.
>
> "… to conserve (A) fish or wildlife which are listed as endangered species or threatened species… or (B) plants…" 16 U.S.C. § 1534 (Endangered Species Act of 1973)
>
> "… for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." 16 U.S.C. § 715d (Migratory Bird Conservation Act)

National Wildlife Refuge System Mission:

> "The mission of the [National Wildlife Refuge] System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans." (National Wildlife Refuge System Administration Act of 1966, as amended [16 U.S.C. 668dd-668ee].

Description of Use(s):

Sheldon Refuge staff receives periodic requests (fewer than six per year) from non-Service entities (e.g., universities, state agencies, other Federal agencies, and non-governmental organizations) to conduct planned, organized, and systematic investigations of a scientific nature (i.e., research); to gather refuge natural resources or cultural artifacts for scientific purposes (i.e., scientific collecting); and to conduct scientific inventory or monitoring (i.e., surveys) on refuge lands. These activities have previously been found appropriate and compatible with the purposes for Sheldon Refuge and are not considered to be wildlife-dependent public uses or economic refuge uses.

The activities can address a wide range of natural and cultural resources as well as public-use management issues including habitat use and life history requirements for specific species/species groups, practical methods for habitat restoration, extent and severity of environmental contaminants, techniques to control or eradicate pest species, effects of climate change on environmental conditions and associated habitat/wildlife response, identification and analyses of paleontological specimens, wilderness character, quality of wildlife-dependent recreation, modeling of wildlife populations, and assessing response of habitat/wildlife to disturbance from public uses. Projects may be species-specific, use-specific, or refuge-specific, or may evaluate the relative contribution of Sheldon Refuge to larger landscape (e.g., ecoregion, region, flyway, national, international) issues and trends.

Research, scientific collection, and surveys typically employ a wide variety of methodologies, techniques, and tools as dictated by specific information needs, research questions, and hypotheses. It is anticipated that research, scientific collecting, and surveys within Sheldon Refuge will continue to use direct observation of fish, wildlife, and their habitats; the temporary installation of facilities and specialized monitoring and measuring instruments; both non-lethal and lethal collection of fish, wildlife, and plant specimens; excavation of small areas, disturbance and/or removal of cultural artifacts and paleontological specimens; and interaction with refuge visitors.

Activities are expected to occur during all seasons and in all habitat types but will continue to occur primarily in sagebrush habitat types during the spring, summer, and fall seasons. Sheldon Refuge anticipates multiple requests to conduct research, scientific collection, or surveys will be authorized each year. Most activities will occur within Sheldon Refuge for short periods of time, but some temporary facilities or instruments may remain for several months and in rare instances, longer than one year.

Potential means of access and transportation include hiking, horseback, motorized vehicles, fixed-wing aircraft, helicopters, and non-motorized boats or boats with electric motors. Activities may also require short-term use of Sheldon Refuge campgrounds, use of temporary campsites in backcountry areas, or landing of helicopters.

Authorizations for all activities and forms of access included in this compatibility determination within proposed wilderness areas are subject to a minimum requirements analysis (MRA).

The Service's Research and Management Studies (4 RM 6) and Appropriate Refuge Uses policies (603 FW1.10D(4)) indicate priority for scientific investigatory studies that contribute to the enhancement, protection, use, preservation, and management of native wildlife populations and their habitat as well as their natural diversity. Projects that contribute to refuge-specific and/or wilderness management, where applicable, will be given a higher priority over other requests.

Supporting Uses

Camping

Camping itself is not a priority public use on Service lands, but because of the size, remoteness, and quality of roads within Sheldon Refuge, it is important in supporting priority uses including fishing, hunting, wildlife observation, and wildlife photography as well as non-priority public uses such as research. There are four types of camping opportunities currently provided within Sheldon Refuge: developed, semi-primitive, primitive, and backcountry/wilderness.

Camping within Sheldon Refuge is allowed in 13 designated campgrounds by Refuge Special Use Permit for backcountry camping.

Developed Camping: Virgin Valley Campground located at Dufurrena is considered the only developed campground. Virgin Valley Campground is easily accessible year-round for all types of vehicles, including RVs, and it offers shade trees, potable water, two vault toilets, 16 picnic tables, 24 fire rings, a meat-hanging pole, a bath-house, and a hot spring developed for swimming. Campground use is managed on a first-come, first-served basis without fees or designated sites. From 2005 through 2007 an average of 18 campsites were occupied per day during the days surveyed, for a seasonal average of 6,573 visitor-use days (USFWS undated report).

From mid-August through mid-November, the Virgin Valley Campground is heavily used by hunters. During peak seasons, overcrowding and user conflicts have been a concern, as has overflow into upland areas adjacent to the campground, which can result in further environmental damage. There is also a private developed campground at the Royal Peacock Mine, located in the Virgin Valley Mining District, which has RV hookups.

Semi-primitive Camping: Five campgrounds (Catnip Reservoir, West Rock Spring, Fish Spring, Badger, and Big Spring Reservoir) are considered semi-primitive and include outhouses, fire rings, meat-hanging poles, and in the case of Fish Spring and Badger campgrounds, horse corrals. These semi-primitive campgrounds are accessible from primary roads or improved secondary roads suitable for most types of vehicles and are primarily used by hunters. Sport anglers also use campgrounds at Catnip and Big Spring reservoirs.

Additional facilities such as campsite amenities (i.e., picnic tables and accessible fire rings or barbeque grills), potable water, shade structures, kiosks, and dedicated volunteer sites are planned for Virgin Valley, Catnip Reservoir, and Big Spring Reservoir campgrounds. These facilities will provide developed camping opportunities that are not commonly available within Sheldon Refuge or the region. However, these improved facilities will only be sustainable over the long term through campsite fees to support volunteers, maintenance, and replacement.

The Service will also allow public overnight use of some existing historic structures within Sheldon Refuge. The most likely structures are the Little Sheldon Overnight Cabin and Badger Cabin.

Primitive Camping: Seven campgrounds (Little Catnip Spring, Gooch Spring, North Hell Creek, Wheeler Spring, Bateman Spring, Devaney, and East Rock Spring) are considered primitive campgrounds and have only fire rings or no improvements, are remote, and are accessible to four-wheel drive or high-clearance vehicles when road conditions are passable. These primitive campgrounds receive intermittent and low amounts of use, occurring mostly during the big-game

hunting seasons (early August through October). All of these campgrounds are located immediately adjacent to, or include wet meadows, spring, or springbrook habitats. Three primitive campgrounds (Wheeler Spring, Devaney, and East Rock Spring) also include aspen woodland habitats. Impacts associated with primitive campgrounds were identified as an issue during the Sheldon CCP planning process. The impacts identified and stipulations for reducing or eliminating those impacts are addressed in subsequent sections of this compatibility determination.

Backcountry/Wilderness Camping: Backcountry camping for up to 14 days is allowed by Refuge permit. Permits are not limited, but do stipulate visitors must camp at least 0.5 mile from open roads and at least 100 yards from water sources. The majority of backcountry camping permits are issued to hunters, but the amount of use is low and no adverse impacts have been observed. Backcountry use will continue to be monitored, and future management actions to reduce or eliminate any impacts will be implemented as necessary.

Public Access

Public access to areas within the refuge is provided by a network of vehicle roads and informal backcountry routes and trails. Roads include one two-lane paved highway, maintained gravel roads, and numerous primitive and unmaintained dirt roads. Trails throughout the refuge backcountry and wilderness areas are primarily abandoned vehicle routes historically used for access to livestock developments and private inholdings later purchased by the Service.

The most substantial changes to research are expected to result from the relocation and enlargement of the Refuge visitor contact station, improvement of campground facilities, and improved signing of routes open to vehicle use. Improved gravel roads within Sheldon Refuge will be maintained more frequently, and all routes open to the public use of vehicles will be adequately signed and marked. Visitors will be required to register all OHVs consistent with State of Nevada regulation or with Sheldon Refuge for use on refuge roads and routes designated open to vehicle use. These actions are intended to improve the quality of the transportation system and deter vehicle violations while requiring only minimal law enforcement presence.

Maintained Public Roads: In preparation of the Sheldon Refuge CCP, each route within the refuge was evaluated to assess impacts to fish, wildlife, plants and their habitats, as well as benefits for public use and recreation opportunity. Following this evaluation, 300 miles of existing roads (including State Highway 140 and all maintained county roads) were designated for public vehicle use. The Service has determined the continued use and maintenance of these designated roads, including actions for re-routing or modification as presented in the Sheldon Refuge CCP, will have minimal or no impacts to wildlife and wildlife habitat and/or are subject to existing right-of-way. The unimproved roads within Sheldon Refuge are not regularly maintained, but are repaired on a site-by-site basis to keep them in usable condition or to prevent undue resource damage (i.e., excessive erosion).

Trails and Backcountry Access: Hiking, horseback riding, use of pack stock, and other non-mechanical modes of access are allowed on trails, routes, and other areas of Sheldon Refuge open to the public. All vehicle use is restricted to designated open roads. Existing trails throughout Sheldon Refuge will remain, but will not be marked or maintained for public use. No adverse impacts have been observed from visitors using these routes for hiking, horseback riding, or use of pack stock.

Horseback Riding and Pack Stock Use: Horseback riding has been allowed as a recreation activity within Sheldon for many years. However, it is estimated fewer than 10 horseback visitors use Sheldon Refuge each year, and as a result, horseback riding is considered a low-impact activity. Horseback riding gives the public an opportunity to visit remote and undeveloped portions of Sheldon Refuge, and to enjoy the wildlife viewing, solitude, and expansive views that Sheldon Refuge is known for.

There is a concern that the number of visitors engaging in horseback riding may increase, particularly with hunting guides and their clients, and that use of horses and pack stock within the Refuge will introduce invasive non-native plants. These impacts have not been observed, but monitoring will continue and the Service will take additional action as needed to maintain wilderness character and prevent the introduction of weeds to the Refuge.

The corrals at Badger and Fish Spring campgrounds are the only facilities that specifically support horseback riding and the use of pack stock.

Boating: Refuge-specific regulations that apply to the use of non-motorized boats and boats with electric motors specifically apply to sport fishing and sport hunting, but are interpreted as applying to other uses such as research, scientific collecting, and surveys as well. In particular, the use of non-motorized boats and boats with electric motors in Big Spring Reservoir, Catnip Reservoir, and Dufurrena Ponds consistent with 50 Code of Federal Regulations (CFR) 32.47 is considered a compatible activity that supports research, scientific collecting, and surveys.

Availability of Resources:

Refuge staff responsibilities for projects by non-Service entities will be primarily be limited to the following: review and approval of proposals, preparation of Special Use Permits and other requirements (e.g., Section 7, Section 106 of the National Historic Preservation Act), and monitoring of project implementation to ensure that impacts and conflicts remain within acceptable levels (compatibility) over time. Additional administrative, logistical, and operational support may also be provided depending on each specific request. Estimated costs for one-time (e.g., preparation of Special Use Permits) and annually re-occurring tasks by Refuge staff and other Service employees will be determined for each project. Sufficient funding in the general operating budget of Sheldon Refuge must be available to cover expenses for these projects. The terms and conditions for funding necessary to administer each project on Sheldon Refuge will be clearly stated in the Special Use Permit.

The Service has the following staffing and funding to administratively support and monitor research that is currently taking place on Refuge lands. Any substantial increase in the number of projects will create a need for additional resources to oversee the administration and monitoring of the investigators and their projects. Any substantial additional costs above those itemized below will result in finding a project not compatible unless expenses are offset by the investigator(s) or a sponsoring agency or organization.

Category and Itemization	One-time	Annual
Administration and management		$5,000
Maintenance		$500
Monitoring		$2,000
Special equipment, facilities, or improvement		$100
Offsetting revenues[6]		N/A

Itemized costs in the previous table are current estimates, calculated using estimated costs associated with processing and administering past research, scientific collecting, and survey activities within Sheldon Refuge.

Anticipated Impacts of the Use:

Effects from Research

A number of factors such as target species or resources, timing and duration of activities, number of researchers and modes, and frequency of access will determine the extent of impacts within Sheldon Refuge. Impacts on fish and wildlife resources, other refuge resources (e.g., water quality, soil, vegetation), and other refuge users are expected to be project- and site-specific, but are not anticipated to be significant or unacceptable because of the limited scope, Special Use Permit and compatibility stipulations, and administrative oversight of activities proposed.

Data collection techniques will generally result in negligible animal mortality or disturbance, negligible habitat destruction, no introduction of contaminants, and no introduction of non-indigenous species. In contrast, projects involving the collection of biotic samples (plants or animals) or requiring intensive ground-based data or sample collection will have short-term impacts. Impacts will be reduced by authorizing collection of the minimum number of samples (e.g., water, soils, vegetative litter, plants, macroinvertebrates, vertebrates) necessary for identification and/or experimentation and statistical analysis as identified in project proposals submitted.

Impacts from the spread or introduction of invasive species will be minimized or mitigated through monitoring for early detection and rapid response and conditions described in the stipulations section of this compatibility determination.

[6] Anticipated Special Use Permit fees and revenues as proposed in the CCP are based on a $250 annual fee, which typically is waived for research, scientific collection, and surveys that further the purposes for the refuge and/or provide a benefit to the refuge.

There could also be localized and temporary effects from vegetation trampling, collecting of soil and plant samples, or trapping and handling of wildlife. Some level of disturbance is expected with these projects, especially if investigator(s) enter areas closed to the public and collect samples or handle wildlife. However, wildlife disturbance (including altered behavior) will be localized and temporary in nature.

Effects from Camping and Campgrounds

Use of campgrounds within Sheldon Refuge causes impacts to vegetation, soils, water quality, and cultural resources. During dry conditions, carelessness with campfires can lead to wildfires. Management and development of campgrounds is also expected to affect the type and quality of recreation opportunities available.

Impacts to Vegetation, Soils, and Water Quality: Campgrounds and their use within the refuge range from primitive sites with relatively low and only intermittent use to very developed sites with year-round and relatively high amount of use during summer months. Current impacts and expected future impacts associated with use and development of these campgrounds also vary widely. Because the most primitive campgrounds are currently the least impacted, we can expect that these sites will exhibit the greatest amount of additional or potential impact with only slightly more use. Conversely, most impacts have already occurred at the most heavily used and developed campgrounds, and we can expect very little additional impact to vegetation, soils, or water quality even with relatively large increases in use at these campgrounds.

The greatest difference in durability between vegetation types occurs at moderately low use levels (Cole 1985). Sites that are used frequently are likely to be highly impacted regardless of their fragility. Because vegetation loss usually occurs more rapidly than loss of organic soil horizons, sites with either no vegetation or resistant vegetation (e.g., grasses as opposed to forbs) recover more quickly and are less likely to be impacted by low levels of use, while sites with thick organic soil horizons are less susceptible to erosion and are more likely to withstand high amounts of use.

Experimental studies suggest that there is an important difference between a site's resistance (its ability to tolerate use without being damaged) and its resilience (its ability to recover from damage). Cole (1995) has shown, for groundcover plants, that resistance decreases with erectness and that broad-leaved herbs are typically less resistant than grass-like plants and shrubs. Low shrubs, such as heather, are relatively resistant to trampling stress but their resilience is low. Once damaged, they recover slowly. Grass-like plants are most tolerant of trampling (Cole 1989). The compaction of soils from campsite use reduces water infiltration and water holding capacity, which leads to increased runoff and erosion potential (Cole 2004; Monti and Mackintosh 1979). Impacts associated with use at primitive campgrounds can be readily observed and tend to occur rapidly, but these impacts are relatively inconsequential when considered in the context of the entire refuge. Impacts associated with campgrounds located within riparian areas or near water sources are of greater concern, but current impacts are not severe and vegetation, soils, and water quality at primitive campgrounds are expected to recover noticeably within a few years following campground relocation. This assessment is supported by Cole (1981) who noted that hiking and camping impacts on soil and vegetation, while severe when measured at small scales, are minimal at large spatial scales. This suggests that while recreation impacts can be serious for individual plants and animals and perhaps localized rare populations, they are generally of little significance to landscape integrity or regional biotic diversity. Moreover, unless much of a population is affected by a single impacted

site, the intensity, size, and distribution of impacts are not relevant to the significance of impacts assessed at large spatial scales (Cole 1989).

Virgin Valley Campground is located at a site previously developed and used by the Civilian Conservation Corps in the late 1930s. Catnip Reservoir and Big Spring Reservoir campgrounds are located immediately adjacent to artificial reservoirs. These three campgrounds receive the greatest amounts of use and exhibit the greatest amount of impact. The core areas of use at these campgrounds no longer support vegetation or vegetation diversity is substantially reduced, water infiltration is considered low due to soil compaction, and gravel has been placed in some areas to reduce erosion and rutting from vehicles. Non-native plants and animals in and around these three campgrounds were likely introduced by early ranching and development activities rather than campground visitors. Monitoring and control efforts will continue to detect and remove or eradicate small or new populations of invasive species.

The remaining 10 campgrounds are all located immediately adjacent to or include aspen woodland, wet meadows, spring, and/or springbrook habitats. Most of these campgrounds have moderate amounts of vegetation loss and soil compaction, which is limited to parking areas, areas around fire rings, outhouses, and along connecting paths. These impacts are generally not continuous throughout the campground and are expected to remain stable with current amounts of intermittent use, which occurs during late summer and fall after most annual and biannual plants have finished growing for the season and when soils are typically drier and more resistant to impact. Some primitive campgrounds have no visible bare ground, and where located in meadow habitats, vegetation is generally able to recover from the current amount of use. Some primitive campgrounds exhibit small areas of bare ground, generally a lack forbs, which are not resistant to trampling, and in the case of Wheeler Spring, Devaney, and East Rock Springs, also exhibit some impacts to aspen trees from trampling, soil compaction, root exposure, and cutting. Because these campgrounds receive little visitation or are located near frequently traveled gravel roads, impacts to wildlife from campground use are estimated to be minor or negligible. Due to the nature of these impacts and relatively low amount of use, we anticipate these campgrounds will exhibit the greatest amount of natural recovery compared to the three more developed and heavily used campgrounds if camping use were eliminated, but they will also exhibit the greatest amount of additional impact if camping use were to substantially increase. Aspen stands associated with the Devaney, Wheeler Spring, and East Rock Springs campgrounds are also expected to recover, but regeneration of the understory shrubs and younger trees will occur slowly and will likely require some active restoration and/or replanting.

Up to nine semi-primitive and primitive campgrounds will be relocated away from sensitive riparian habitats and areas with cultural resources. It is anticipated actions to relocate campgrounds to alternative sites, protect sensitive habitats at each of these campgrounds, and confine use to designated campsites in heavily used campgrounds will minimize or avoid additional impacts altogether.

We expect some primitive campgrounds to be consolidated with other existing campgrounds that will need to be enlarged and have additional campsites constructed (the most likely candidates for enlargement are Catnip Reservoir, Big Spring Reservoir, Fish Spring, and West Rock Spring campgrounds). Consolidation will result in additional impacts from increased use of existing facilities and campsites and from the designation and construction within existing campgrounds. Where camping already occurs, increased use of existing campsites and facilities is expected to have little or no measurable impact to vegetation or wildlife. Impacts to expanded portions of these campgrounds are expected to occur quickly as vegetation is trampled and soil compacted within the

first two or three seasons of use, but will then stabilize over the long term. We expect enlargement of existing campgrounds will result in minor, site-specific, long-term, direct adverse impacts to plants and their habitat from removal of vegetation, soil compaction, and loss of organic soil horizon at these sites.

Impacts from Wildfire: Campfires are allowed at designated campgrounds but are occasionally prohibited during periods of high fire danger. Wildfires have been started by refuge visitors in the past, and we expect some wildfires will occasionally start as a result of escaped campfires or misuse of stoves. Seasonal campfire restrictions and rapid fire suppression response will continue to minimize impacts.

Impacts to Cultural Resources: Most of the 13 designated campgrounds are located within or adjacent to prehistoric cultural sites. While the majority of impacts occurred following the initial establishment and use of these campgrounds, some impacts continue due to ongoing soil disturbance and compaction within existing campsites, trampling and removal of vegetation, occasional use of previously unused areas adjacent to the campgrounds, and vehicle use outside designated areas. Limited fee use of the Little Sheldon Overnight Cabin or Badger Cabin is expected to increase public appreciation for historic resources and understanding for their protection and preservation. In addition, the use of these sites and the collection of fees will provide justification and funding for restoration work and continued maintenance. As a result, the integrity of sites eligible for the National Register of Historic Places will be protected. Therefore, we anticipate use of these facilities to support research will have a major, long-term, beneficial impact on cultural resources.

Impacts to Recreation Opportunity: Campsite registration, overnight fees, and the other improvements planned for the developed campgrounds will increase maintenance, increase visitor compliance with rules and regulations (by defining and designating campsites), and decrease competition for campsites. Campground management strategies are expected to result in moderate, indirect, long-term, beneficial impacts to the camping experience, in support of providing quality opportunities for wildlife-dependent recreation.

Effects from Public Access

Adverse impacts are expected to continue as a result of the network of developed and undeveloped roads throughout Sheldon Refuge and their associated maintenance. Road development and use continues to adversely impact the biological integrity within Sheldon Refuge by contributing to the altered composition of plant communities, soil disturbance (Eckert et al. 1979; Iverson et al. 1981; Switalski et al. 2004), altered hydrology and stream sedimentation (Forman and Alexander 1998), facilitation of the spread of invasive vegetation, changes in the natural fire regimes, and habitat fragmentation.

Many direct effects are obvious during construction, but other effects are permanent and can extend substantially beyond the actual road surface (road-effect zone; Forman 2000; Forman and Alexander 1998). At the landscape scale, major ecological impacts of a road network include fragmentation, the disruption of landscape processes, and loss of biodiversity. Biodiversity declines as the road network impacts interior species (species cut off by roads), species with large home ranges, stream and wetland species, and rare native species (Forman and Alexander 1998). Fragmentation of previously extensive landscapes can influence the distribution and abundance of a host of wildlife species through redistribution of habitat types and through the pattern of habitat fragmentation, including characteristics such as decreased patch area and increased habitat edge (Vander Haegen et al. 2000).

Roads (including OHV trails) are commonly identified as important correlates or indicators of loss of ecological health and affect terrestrial and aquatic ecosystems in several general ways: 1) increased mortality from road construction; 2) increased mortality from collision with vehicles; 3) modification of animal behavior; 4) alteration of physical environment; 5) alteration of chemical environment; 6) spread of exotic species; and 7) increased alteration and use of habitats by humans (Trombulak and Frissell 2000; Wildlife Action Plan Team 2006).

The ecological effect of road avoidance is likely related to traffic density and speed of travel, as well as traffic noise levels (Forman and Alexander 1998). Road-effect zones generally result in lower breeding densities and reduced species richness; species demonstrated to avoid or be negatively impacted by roads include arthropods, reptiles, small mammals, ungulates, and forest and grassland birds (Andrews and Gibbons 2005; Carr and Fahrig 2001; Forman and Alexander 1998; McGrann et al. 2006; Rost and Bailey 1979). For example, proximity to OHV trails (<1,000 meters [3,280 feet]) was found to have a direct correlation with reduced-quality habitat for nesting songbirds in sagebrush-steppe habitats, including nest desertion, nest predation, and abandonment (Barton and Holmes 2007). Behavioral disturbance from recreation, including that associated with trails and roads, may also have both immediate and long-term effects on wildlife (Taylor and Knight 2003). In one study of pronghorn, deer, and bison, individuals exhibited a 70% probability of flushing within 1,000 meters (3,280 feet) on either side of a trail used by hikers and mountain bikers (Taylor and Knight 2003); presumably, responses are similar in the presence of vehicles such as OHVs. Road density can be used as an overall index to average patterns over an area. For example, road densities of approximately 1.0 mile per square mile have been recommended as the maximum for a naturally functioning landscape containing sustained populations of large predators (Forman and Alexander 1998). However, the effects of road density are likely sensitive to road width or type, traffic density, network connectivity, and the frequency of spur roads into remote areas (Forman and Alexander 1998).

Within Sheldon Refuge, more than 50 introduced, non-native, and often noxious plant species have been documented (refer to Sheldon Refuge CCP Appendix B). Invasive plants typically need transportation to spread to new areas (Trombulak and Frissell 2000), and within Sheldon Refuge several methods are possible, including vehicles, people, wild and domestic animals, and firefighting equipment. Indeed, it has been demonstrated that habitats distant from roads may provide important refuge for native grassland species, and that this effect may be even more pronounced in predominately intact landscapes such as those in parts of the Great Basin (Gelbard and Harrison 2003). Human access and disturbance effects on remote areas tend to increase with higher road densities, as well as human-caused fire ignitions (Forman and Alexander 1998).

Various methods, including systematic inventory and monitoring for invasive plants, mowing, use of herbicides, and elimination of grading road shoulders, will be used to detect new infestations, control and contain existing infestations, and treat up to 1,000 acres per year. Management strategies to combat invasive plants support the Service policy for biological integrity and diversity within Sheldon Refuge. With a more systematic approach for inventory of noxious weeds and other invasive plants, populations are more likely to be detected when they are small and more easily managed and controlled. Increased treatment and reduced soil disturbance along road corridors should reduce the spread of invasive plants already present and reduce the potential for new populations. As a result, we anticipate these actions will result in major, long-term, direct, beneficial impacts to all habitats. Implementing treatment strategies (e.g., mechanical removal of vegetation, application of herbicides) will likely eliminate or prevent the spread of noxious weed populations

when detected and provide some conservation of native habitats, resulting in minor, site-specific, short-term, direct, beneficial impacts to habitat on approximately 1,000 acres per year.

In conjunction with preparation of the Sheldon Refuge CCP, Refuge staff conducted an evaluation of existing routes and trails and identified known and potential resource impacts and public benefits and recreation opportunities associated with vehicle access. Route segments that were identified as causing substantial impacts to soils, riparian areas, and/or wildlife, were redundant with other routes, or provided very little or no access for wildlife-dependent uses were not identified for designation as open roads for public use of vehicles. To minimize or avoid lesser impacts from roads and vehicle use, the Service will implement a number of transportation management strategies including designating roads that are not duplicative, re-routing or realigning road segments that pass through sensitive resource areas, installing erosion control structures, increased monitoring and treatment of weeds along road corridors, and posting signs marking all designated open roads. These actions will result in long-term, minor, direct and indirect, beneficial impacts to soils by decreasing erosion in sensitive areas that are currently affected. Overall we expect impacts from road management will be minor, direct, and adverse to habitats on a localized and long-term basis.

Research activities are appropriate and compatible with the purposes for Sheldon Refuge although they are not considered to be a wildlife-dependent public use or economic refuge use. Hiking, horseback riding, and vehicle access are secondary uses that support research activities within Sheldon Refuge. Sheldon Refuge allows access on foot, by horseback, or by vehicle. However, all vehicle routes are open to both motorized and non-motorized vehicles, and there are no areas managed for non-motorized vehicle access (i.e., mountain bikes or game carts) or semi-primitive non-motorized recreation opportunity. In areas open to vehicle use we assume impacts to non-motorized vehicle users are asymmetrical (Webber 1995) and occur from conflict, noise, dust, competition with motorized users for recreation opportunity, and displacement to non-motorized areas outside the refuge (Adelman et al. 1982; Gambill 1996; Manning and Valliere 2002; Moore 1994; Stokowski and LaPointe 2000). The somewhat narrow range of vehicle access for non-motorized users provided within the refuge represents a direct, adverse, moderate, long-term impact to quality recreation opportunities.

Effects from Horseback Riding and Use of Pack Stock

Because the number of visitors who ride horseback or use pack stock within Sheldon Refuge is estimated at less than 10 per year and because little impact has been observed from such use, we expect future impacts from trampling and introduction of non-native weeds will also be low and less than similar impacts associated with overnight camping and vehicle use. Stock use areas at Badger and Fish Spring campgrounds will continue to be monitored, particularly for new populations of non-native plants, and additional actions such as requiring certified weed-free feed and weed removal will be implemented as necessary.

Effects from Boating

The use of non-motorized or electric-powered boats is allowed only in Big Spring Reservoir, Catnip Reservoir, and the Dufurrena Ponds consistent with 50 CFR 32.47. The majority of boating occurs in conjunction with sport fishing, and while migratory bird hunting is not allowed on these waters, occasional and intermittent boating does occur in conjunction with other hunting, wildlife observation, wildlife photography, environmental education, interpretation, research, scientific collecting, and surveys. The amount of boating that occurs within Sheldon Refuge has not been

quantified, but is considered low based upon angler participation and incidental observation by staff and volunteers. Boating generally occurs during summer months following the waterfowl nesting season (when the potential for bird disturbance or displacement impacts will be greatest) and following the beginning of trout fishing season, or when there are higher water temperatures at Dufurrena Ponds, which provide better fishing success. Requirements for use of non-motorized boats or boats with electric motors will eliminate the potential for water pollution associated with use of outboard motors and will maintain opportunities for visitor solitude. Overall, the amount of boating associated with wildlife-dependent public uses is considered low, and adverse impacts are estimated to be short-term, intermittent, and negligible.

Economic Effects

Research, scientific collection, and surveys allowed by Special Use Permit within Sheldon Refuge occur periodically. Such activities typically involve few individuals for short periods of time. The value of these activities to the local economy is therefore estimated to be negligible when compared to wildlife-dependent uses within Sheldon Refuge.

Effects to Wilderness Character

Naturalness: Approximately 300 miles of existing vehicle routes will remain visible, and their designation for motorized use is not expected to result in any short-term impacts to naturalness. Over the long term, as public use continues to increase, we expect that additional signs, road maintenance, and other developments will be needed to ensure compatibility. Increased visitation to these areas will also increase the potential for introduction and spread of weeds and for the disturbance and displacement of wildlife.

Weed treatments occurring on approximately 1,000 acres per year, primarily along road corridors, are expected to slow or possibly reverse the trend of weed spread and invasion into undeveloped and more natural areas of Sheldon Refuge, but will adversely affect natural character due to the presence of dead vegetation and vehicle tracks.

Untrammeled Conditions: Research activities will rely primarily on existing campgrounds, roads, and other facilities, which will result in little or no change to untrammeled conditions within Sheldon Refuge.

Solitude: Due to the limited number of campsites available, we anticipate some increased use of primitive campgrounds, and some additional overnight backcountry use by visitors participating in research activities. Opportunities for those who seek opportunities for solitude will continue to be available throughout much of Sheldon Refuge during substantial portions of the year.

Primitive and Unconfined Recreation: Management direction for designation of 300 miles of existing roads for public use of vehicles will result in only minor impacts. These existing roads will remain in their current condition and level of maintenance, and use of unimproved dirt roads is expected to remain low and intermittent for access to more primitive and remote portions of Sheldon Refuge. Other routes will continue to be used for hiking, backpacking, and horseback riding, and occasionally by vehicle for administrative purposes. Management actions will also result in greater management presence, development, and regulation at the Virgin Valley, Catnip, and Big Spring campgrounds. Impacts to opportunities for primitive and unconfined recreation will be minor with vehicle use

confined to existing campgrounds and roads where public use has been well established for many years.

Cumulative Effects from Research

When considered with other existing and planned public uses and management actions, cumulative impacts from research when conducted according to applicable refuge rules and regulations are negligible. Research projects expected to result in unavoidable long-term or substantial cumulative adverse effects will not be authorized.

Public Review and Comment:

This and other compatibility determinations were prepared concurrently with the Final CCP/EIS for the Sheldon National Wildlife Refuge (published August 2012). Open houses were held, multiple planning updates were mailed, and written comments were solicited from the public during development of the Final CCP/EIS for the refuge. Appendix A of the CCP further details public involvement during development of the CCP. A summary of public comments received during review of the Draft CCP/EIS along with the Service's response to those comments are included in Appendix N of the CCP.

Determination: (check one below)

___ Use is Not Compatible

_X_ Use is Compatible with the Following Stipulations

Stipulations Necessary to Ensure Compatibility:

1. Only requests that demonstrate scientific validity and/or benefit to Sheldon Refuge may be approved.

2. In order for Refuge staff and others, as needed, to identify unacceptable impacts to Refuge resources, all proposals and requests to conduct research, scientific collecting, or surveys must be submitted in writing to the Refuge Manager at least 90 days prior to project initiation. Continuation of existing projects will require approval by the Complex Project Leader and inclusion of the permit stipulations discussed in this section.

3. Projects will adhere to scientifically defensible protocols for data collection, where available and applicable. A Special Use Permit or Cooperative Agreement will not be issued for any final project proposal or request that the Refuge Manager determines is likely to cause unacceptable impacts to Refuge resources.

4. Unless specifically waived by the Project Leader, any project proposal that includes the capture and handling of wildlife within Sheldon Refuge must be accompanied by written review from an accredited Institutional Animal Care and Use Committee as defined by Section 13(b) of the Animal Welfare Act (7 U.S.C. 2143).

5. Unless otherwise stated in a valid Special Use Permit, all items collected on Refuge lands are the property of the USFWS even while in the possession of the investigator(s). Any future work with previously collected samples not clearly identified in the project proposal will require

submission of a subsequent proposal for review and approval. In addition, a new Special Use Permit will be required for additional project work. For samples or specimens to be stored at other facilities (e.g., museums), a signed copy of the memorandum of understanding must be provided before the Special Use Permit will be issued.

6. For all projects proposed within a designated or proposed wilderness area, an MRA will be submitted by the permittee for Refuge Manager approval and will be included as part of the decision process. An MRA is a two-step process to decide if a proposed activity is necessary in wilderness, and if so, to determine the minimum tool needed to accomplish the project. Although required for all administrative activities, including issuing Special Use Permits, an MRA cannot be used to authorize prohibited activities in designated wilderness by the public.

7. Each project will require a Special Use Permit or Cooperative Agreement, which will typically be issued for a period of one year or less. Some permits may be renewed annually or issued for longer periods if needed to allow completion of a project. However, no Special Use Permit or Cooperative Agreement will be issued or renewed for a period longer than five years.

8. Refuge staff will monitor all research, scientific collection, and surveys being conducted on Sheldon Refuge. Findings from these monitoring efforts will be used to determine what additional management actions, if any, are needed to ensure that research activities remain compatible with refuge purposes.

9. Monitoring of all authorized research, scientific collection, and survey activities will be continued to ensure compliance with specific terms and conditions tailored for each research project's permit as well stipulations incorporated into all research permits to minimize impacts on refuge lands and resources.

10. Management direction is provided in the CCP for Sheldon Refuge. This directs monitoring of public uses and refuge special uses including research, scientific collecting, and surveys. Findings from these monitoring efforts will be used in determining what additional management actions, if any, are needed to ensure activities remain compatible with refuge purposes. Any or all of the following stipulations will be included as conditions and requirements of Refuge Special Use Permits for research, scientific collecting, and surveys as appropriate. Additional conditions may be included as necessary or appropriate for the specific operations or activities that are proposed.

11. All vehicles defined as off-road vehicles under 42 U.S.C. Section 4321 must be registered with the State of Nevada or Sheldon National Wildlife Refuge for use on lands administered by Sheldon Refuge.

12. Vehicle use within Sheldon Refuge is allowed only on roads and routes that are designated "open" on Figure D.1 and that are signed or otherwise marked for such use. Off-road use is prohibited.

13. Unless otherwise indicated by sign, permit, or regulation, the maximum number of consecutive nights any person or attended vehicle may remain at a designated refuge campground is 14 nights.

14. Except for camping within campgrounds that are designated for such use on maps included in the Final Record of Decision for the Sheldon National Wildlife Refuge CCP/EIS and that are signed or otherwise marked for such use, no overnight use is allowed on lands administered by Sheldon Refuge unless expressly authorized by a valid Special Use Permit.

15. Non-motorized boats or boats with electric motors are allowed only in Big Spring Reservoir, Catnip Reservoir, and Dufurrena Ponds, consistent with 50 CFR 32.47.

16. Open fires are allowed only at designated campgrounds and within constructed fire rings, subject to additional seasonal fire restrictions and/or closures.

17. Pets must be leashed, except dogs used for hunting migratory or upland birds. Hunting dogs must be under strict voice control at all times.

18. Riding or packing with horses and mules is allowed in all areas open to public use. All horses and mules must be haltered, branded, tagged, or otherwise visibly marked as a domestic animal and must be tied, hobbled, high-lined, corralled, or otherwise under direct control at all times.

19. Grazing of domestic animals within Sheldon Refuge is not allowed.

20. The use of certified weed-free hay, pellets, straw, and other livestock feed within Sheldon Refuge is encouraged. The use of certified weed-free feed will be required if monitoring of stock use areas indicates the spread or introduction of noxious weeds from uncertified feed.

The following conditions and requirements will be included as part of all Refuge Special Use Permits for research, scientific collecting, and surveys.

National Special Use Permit Conditions and Requirements

1. Responsibility of Permittee: The permittee by operating on the premises shall be considered to have accepted these premises with all facilities, fixtures, or improvements in their existing condition as of the date of this permit. At the end of the period specified or upon earlier termination, the permittee shall give up the premises in as good order and condition as when received except for reasonable wear, tear, or damage occurring without fault or negligence. The permittee will fully repay the Service for any and all damage directly or indirectly resulting from negligence or failure on his/her part, or the part of anyone of his/her associates, to use reasonable care.

2. Operating Rules and Laws: The permittee shall keep the premises in a neat and orderly condition at all times, and shall comply with all municipal, county, and State laws applicable to the operations under the permit as well as all Federal laws, rules, and regulations governing national wildlife refuges and the area described in this permit. The permittee shall comply with all instructions applicable to this permit issued by the refuge official in charge. The permittee shall take all reasonable precautions to prevent the escape of fires and to suppress fires and shall render all reasonable assistance in the suppression of refuge fires.

3. Use Limitations: The permittee's use of the described premises is limited to the purposed herein specified and does not, unless provided for in this permit, allow him/her to restrict other authorized entry on to his/her area; and permits the Service to carry on whatever activities are necessary for (1) protection and maintenance of the premises and adjacent lands administered by

the Service; and (2) the management of wildlife and fish using the premises and other Service lands.

4. Transfer of Privileges: This permit is not transferable, and no privileges herein mentioned may be sublet or made available to any person or interest not mentioned in this permit. No interest hereunder may accrue through lien or be transferred to a third party without the approval of the Regional Director of the Service and the permit shall not be used for speculative purposes.

5. Compliance: The Service's failure to require strict compliance with any of this permit's terms, conditions, and requirements shall not constitute a waiver or be considered as a giving up of the Service's right to thereafter enforce any of the permit's terms or conditions.

6. Conditions of Permit not Fulfilled: If the permittee fails to fulfill any of the conditions and requirements set forth herein, all money paid under this permit shall be retained by the Government to be used to satisfy as much of the permittee's obligation as possible.

7. Payments: All payment shall be made on or before the due date to the local representative of the Service by a postal money order or check made payable to the U.S. Fish and Wildlife Service.

8. Termination Policy: At the termination of this permit the permittee shall immediately give up possession to the Service representative, reserving, however, the rights specified in paragraph 11. If he/she fails to do so, he/she will pay the Government, as liquidated damages, an amount double the rate specified in this permit for the entire time possession is withheld. Upon yielding possession, the permittee will still be allowed to re-enter as needed to remove his/her property as stated in paragraph 11. The acceptance of any fee for liquidated damages or any other act of administration relating to the continued tenancy is not to be considered as an affirmation of the permittees' action nor shall it operate as a waiver of the Government's right to terminate or cancel the permit for the breach of any specified condition or requirement.

9. Revocation Policy: This permit may be revoked by the Regional Director of the Service without notice for noncompliance with the terms hereof or for violation of general and/or specific laws or regulations governing national wildlife refuges or for nonuse. It is at all times subject to discretionary revocation by the Director of the Service. Upon such revocation the Service, by and through any authorized representative, may take possession of the said premises for its own and sole use, or may enter and possess the premises as the agent of the permittee and for his/her account.

10. Damages: The United States shall not be responsible for any loss or damage to property including, but not limited to, growing crops, animals, and machinery or injury to the permittee or his/her relatives, or to the officers, agents, employees, or any other who are on the premises from instructions or by the sufferance of wildlife or employees or representatives of the Government carrying out their official responsibilities. The permittee agrees to save the United States or any of its agencies harmless from any and all claims for damages or losses that may arise to be incident to the flooding of the premises resulting from any associated Government river and harbor, flood control, reclamation, or Tennessee Valley Authority activity.

11. Removal of Permittee's Property: Upon the expiration or termination of this permit, if all rental charges and/or damage claims due to the Government have been paid, the permittee may, within a reasonable period as stated in the permit or as determined by the refuge official in charge but

not to exceed 60 days, remove all structures, machinery, and/or other equipment, etc., from the premises for which he/she is responsible. Within this period the permittee must also remove any other of his/her property including his/her acknowledged share of products or crops grown, cut, harvested, stored, or stacked on the premises. Upon failure to remove any of the above items within the aforesaid period, they shall become the property of the United States.

12. Collected Specimens: You may use specimens collected under this permit, any components of any specimens (including natural organisms, enzymes, genetic materials or seeds), and research results derived from collected specimens for scientific or educational purposes only, and not for commercial purposes unless you have entered into a Cooperative Research and Development Agreement (CRADA) with us. We prohibit the sale of collected research specimens or other transfers to third parties. Breach of any of the terms of this permit will be grounds for revocation of this permit and denial of future permits. Furthermore, if you sell or otherwise transfer collected specimens of any components without a CRADA, you will pay us a royalty rate of 20 percent of the gross revenue from such sales. In addition to such royalty, we may seek other damages and injunctive relief against you.

Sheldon National Wildlife Refuge Special Use Permit Conditions

1. A copy of this permit must be in the permittee's or field party chief's possession at all times while exercising the privileges of this permit. A copy of the permit must be shown to any USFWS employee or Federal law enforcement officer upon request.

2. All waste materials must be removed from the Refuge upon the permittee's and/or clients' departure. The permittee is responsible for removal of clients' garbage.

3. The landing of aircraft and use of helicopters is prohibited.

4. Collected Specimens: Researchers may use specimens collected under permits, any components of any specimens (including natural organisms, enzymes, genetic materials, or seeds), and research results derived from collected specimens for scientific or educational purposes only, and not for commercial purposes unless they have entered into a Cooperative Research and Development Agreement (CRADA) with Sheldon Refuge. The Refuge prohibits the sale of collected research specimens or other transfers to third parties. Furthermore, if researchers sell or otherwise transfer collected specimens or any components without a CRADA, they will pay the Refuge a royalty rate of 20 percent of gross revenue from such sales. In addition to such royalty, the Refuge may seek other damages and injunctive relief against the researchers.

5. Failure to abide by any part of this Special Use Permit; violation of any refuge-related provision in Titles 43 (Part 36) or 50 (sub-chapters B and C), Code of Federal Regulations; or violation of any pertinent state regulation (e.g., fish or game violation) will, with due process, be considered grounds for revocation of this permit and could result in denial of future permit requests for lands administered by the USFWS. This provision applies to all persons working under the authority of this permit. Appeals of decisions relative to permits are handled in accordance with Title 50 Code of Federal Regulations Part 36.41.

6. The permittee and all others conducting activities under this permit are required to follow all refuge-specific regulations unless specific exemptions are included in the Special Use Permit.

7. The permittee is responsible for obtaining, possessing, and complying with all other appropriate state and Federal permits required for their projects, including appropriate collection permits from the State of Nevada and/or ODFW, for research involving fish and wildlife.

8. For each instance, the permittee or party chief shall notify the Refuge Manager during refuge working hours before beginning and upon completion of activities allowed by this permit.

9. Prior to beginning any activities allowed by this permit, the permittee shall provide the Refuge Manager with the following: (1) name and method of contact for the field party chief or supervisor; aircraft and other vehicle types to be used, identification information for these vehicles; and names of assistants (2) any changes in information provided in the original permit application.

10. The Project Leader or appointed representative, upon request, shall be afforded the opportunity and logistical support to accompany the permittee for the purpose of inspection and monitoring permittee activities. A final inspection trip provided by the permittee of the areas of use may be required by the project leader to determine compliance with the terms of this permit.

11. Unless otherwise stated in this Special Use Permit, all items collected on refuge lands remain the property of the USFWS.

12. The permittee shall provide the Refuge Manager with a report of activities under this permit within 30 days of permit expiration, unless otherwise negotiated with the Project Leader.

13. The Project Leader will be provided copies of all raw data in electronic database format (unless otherwise stipulated in this permit) and a final report within one year of completion of the project.

14. The Project Leader will be given adequate opportunity to review draft manuscript(s) from the project before being submitted to a scientific journal(s) for consideration of publication.

15. The Project Leader will be provided with at least three copies (reprints) of all publications resulting from activities authorized by this permit.

16. Sheldon Refuge staff and other Service personnel will be appropriately cited and acknowledged in all written and oral presentations resulting from projects on refuge lands.

Justification:

Research, scientific collecting, and surveys on refuge lands are inherently valuable to the Service because they expand scientific information available for resource management decisions. In addition, only projects that directly or indirectly contribute to the enhancement, protection, use, preservation, and management of refuge wildlife populations and their habitats generally will be authorized on refuge lands. Research, scientific collection, and surveys conducted by other agencies, universities, non-profit organizations, and individuals can provide information and data related to Sheldon Refuge that would otherwise not be available. In many cases, the information and data provided address important management issues and improve the ability of the Service to fulfill the purposes for Sheldon Refuge and the mission of the Refuge System. Furthermore, the uses contribute to the scientific and educational values of the eight proposed wilderness areas encompassing more than half of Sheldon Refuge. By allowing the use to occur under the stipulations

included as part of this compatibility determination, it is anticipated the use will not result in any unacceptable or irreversible adverse impacts to fish, wildlife, plants, and their habitats, or to wildlife-dependent public uses. As a result, these projects will not materially interfere with or detract from fulfilling refuge purpose(s); contributing to the mission of the National Wildlife Refuge System; and maintaining the biological integrity, diversity, and environmental health of Sheldon Refuge.

Mandatory 10- or 15-Year Re-evaluation Date: (provide year for "allowed" uses only)

_____ Mandatory 15-year re-evaluation date (wildlife-dependent public uses)

___2021___ Mandatory 10-year re-evaluation date (uses other than wildlife-dependent public uses)

NEPA Compliance for Refuge Use Decision: (check one below)

____ Categorical Exclusion without Environmental Action Statement

____ Categorical Exclusion and Environmental Action Statement

____ Environmental Assessment and Finding of No Significant Impact

_X_ Environmental Impact Statement and Record of Decision

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Refuge Determination

Prepared by: _____ 9/25/12

(Signature) (Date)

Refuge Manager/
Project Leader
Approval: _____ 9/25/12

(Signature) (Date)

Concurrence

Acting Refuge Supervisor: _____ SEP 2 7 2012

(Signature) (Date)

Regional Chief,
National Wildlife
Refuge System: _____ 9/27/12

Acting (Signature) (Date)

Sheldon National Wildlife Refuge
Humboldt and Washoe Counties, Nevada and Lake County, Oregon

CCP

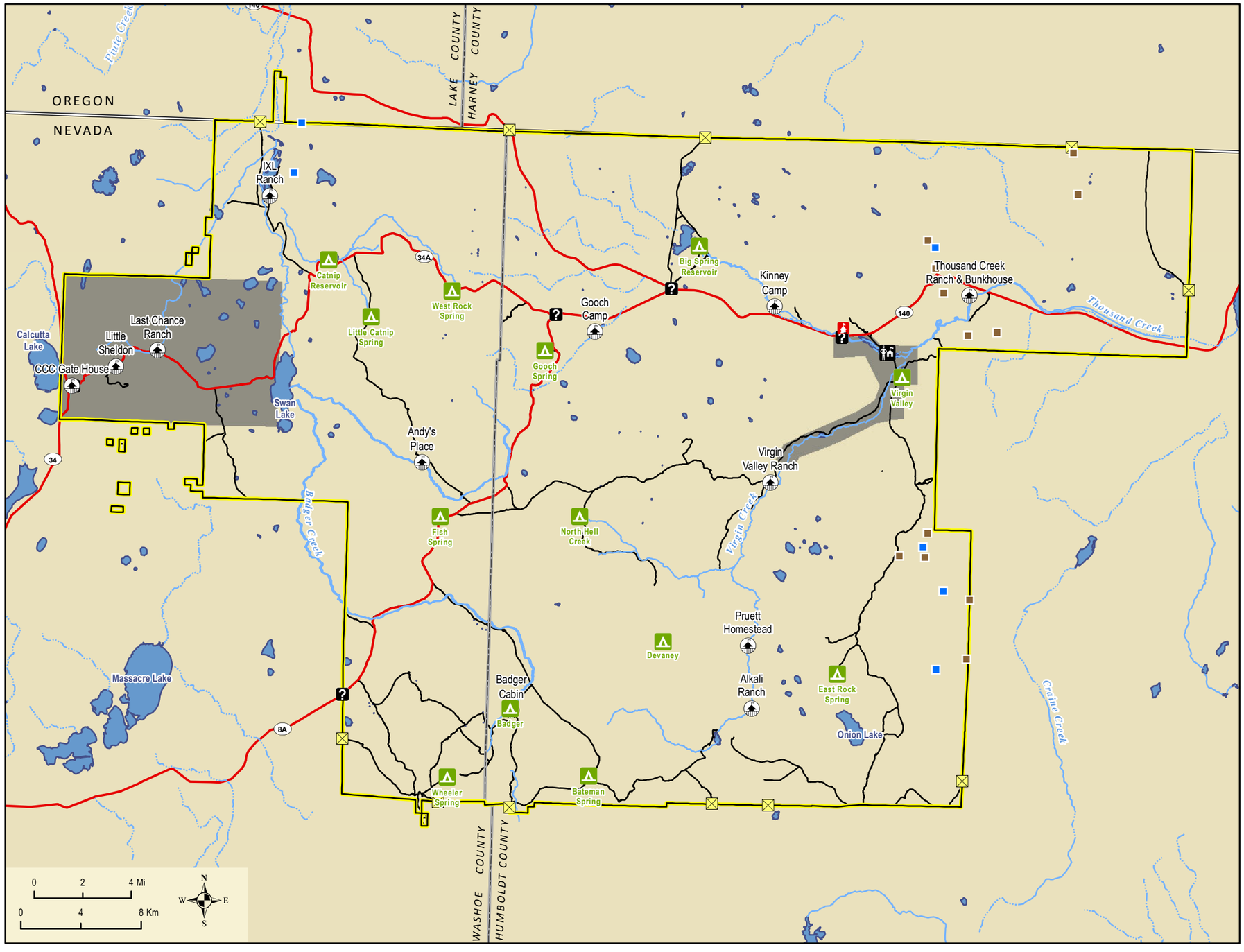
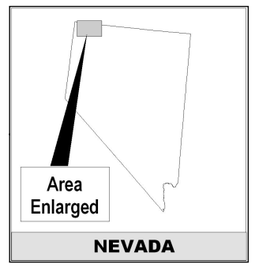


Figure D.1
Compatibility Determination

LEGEND

- Approved Refuge Boundary
- Refuge Headquarters
- Planned Visitor Contact Station
- Campgrounds
- Historic Structures
- Wildlife Guzzler (big game)
- Wildlife Guzzler (small game)
- Kiosk
- Sign
- Hunting Not Allowed
- Lakes
- County Boundary
- State Line
- Public Vehicle Routes (clipped to refuge)
- Highway
- Intermittent Stream
- Perennial Stream



Produced by USFWS Region 1
Refuge Information Branch
Portland, Oregon
Map Date: 11/5/2012
File: 10-068-1.mxd

The back sides of map pages are blank to facilitate map readability.

Exhibit D-1 Prospectus and Request for Proposals to Conduct Commercial Big Game Guide Services (Sample Document)

U.S. Department of the Interior
Fish and Wildlife Service
Sheldon-Hart Mountain National Wildlife Refuge Complex

Prospectus and Request for Proposal

INVITATION FOR PROPOSALS TO CONDUCT COMMERCIAL BIG GAME GUIDE SERVICES WITHIN AREAS OF SHELDON NATIONAL WILDLIFE REFUGE AND HART MOUNTAIN NATIONAL ANTELOPE REFUGE

Issued by:	Project Leader Sheldon-Hart Mountain NWR Complex
Date:	Month number, day, four digit year
Location:	Lakeview, OR
Submittal:	Sealed proposals must be postmarked or hand delivered to the address indicated below by, time, Month number, day, four digit year.

U.S. Fish and Wildlife Service,
Attention: Complex Project Leader
Sheldon-Hart Mountain NWR Complex
PO Box 111
Lakeview, OR 97630.

For Information Contact:

Sheldon-Hart Mountain NWR Complex, P.O. Box 111, Lakeview, OR 97630 (541) 947-3315,

Table of Contents

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II.	Area Description	4
III.	Definitions	6
IV.	Offerings	7
V.	Special Requirements and Considerations	8
VI.	Selection of Successful Applicants	12
VII.	Instructions - How to Submit Proposals	13
VIII.	Information Required	15

Application Cover Sheet
Form A - Proposed Operations Plan
Form B - History of Violations
Form C - Safety Record, Training, Equipment and Plan
Form D - Demonstrated Experience and Knowledge of the Guide Area, and the Terrain, Climate, and Species to be Hunted
Form E - Ability to Provide a High Quality Hunt and Guiding Service to the Public
Form F - Evaluation of Client References

Appendix A - Form Continuation Sheet
Appendix B - Sample Special Use Permit
Appendix C - Map of Sheldon NWR Hunt Area
Appendix D - Map of Hart Mountain NAR Hunt Area[g]

[g] Appendices B, C, and D are not included as part of this CCP appendix, but will be included with the actual prospectus and request for proposals. Figure 5.1 of the Sheldon CCP depicts areas of Sheldon Refuge open to all hunting, and would be the approximate area included in the Prospectus Appendix C.

PROSPECTUS FOR COMMERCIAL BIG GAME GUIDE SERVICES

SHELDON NATIONAL WILDLIFE REFUGE, NEVADA
AND
HART MOUNTAIN NATIONAL ANTELOPE REFUGE, OREGON

I. INTRODUCTION

The Sheldon-Hart Mountain NWR Complex (Sheldon NWR and Hart Mountain NAR) is offering opportunities for up to five (5) big game guides on each refuge, to provide commercial services on Refuge lands. The Refuge will award special use permits for big game guiding services on both refuges through a competitive selection process. Prospective applicants are advised to read this prospectus and the sample permit (see attachment).

The objective of allowing commercial big game guiding is to make a variety of quality services available in support of recreational hunting on the refuges, when such activities are compatible with the refuge's purposes, resources and management objectives. Both refuges encourage family-oriented sport hunting consistent with promoting positive hunting values, hunter ethics such as fair chase, and provide participants with reasonable harvest opportunities, less crowding, less competition, fewer conflicts between hunters, relatively undisturbed wildlife, greater hunter safety, less than average crippling loss, and less interference from or dependence on mechanized aspects of the sport. Commercial guiding activities authorized on refuge lands should contribute to these policies.

Permit holders cannot sublet any part of their permit and are prohibited from subcontracting clients with any other guide.

All applicants are responsible for making their own investigations as to the economic feasibility of any proposal, facts about the area, and estimates of potential business opportunity.

It will be the responsibility of all permit holders selected under this prospectus to adhere to all permit conditions and work diligently to minimize conflicts with other users.

For additional information contact Sheldon-Hart Mountain NWR Complex, P.O. Box 111, Lakeview, OR 97630 (541) 947-3315, Hart Mountain NAR (541) 947-2731, or Sheldon NWR (775) 941-0199, weekdays between 8:00 AM and 5:00 PM.

II. AREA DESCRIPTION

Hart Mountain NAR

Hart Mountain NAR was established in 1936, with the help and support of local residents, as *"a range and breeding ground for pronghorn and other wildlife."* Hart Mountain NAR is located in east-central Lake County, Oregon, and is situated within the northwestern Great Basin. The total area encompassed within the executive borders of the refuge equals 275,173 acres. Including refuge lands outside these borders brings the total to 277,893 acres. Within the executive borders of the refuge, 11,998 acres remain as state inholdings, 14,600 acres remain as private and county inholdings, and the remaining 251,295 acres are refuge lands.

Sheldon NWR

Sheldon was set aside in the 1930s for the conservation and development of natural wildlife resources, primarily pronghorn, and for the protection and improvement of public grazing lands and natural forage resources. The refuge encompasses approximately 575,000 acres of sagebrush-steppe in the northwestern corner of Nevada. Topography of the area is characterized by large tablelands and several mountain ranges separated by stream valleys and, in some cases, steep gorges. Elevations range from over 7,000 feet on the tables and mountain tops to 4,000 feet in the lowlands in the northeast portion of the refuge. Surface water supplies are limited with annual precipitation averaging 7 inches at the lower elevations on the eastern end to 13 inches at the higher elevations on the western end.

Vegetation comprises shrub-steppe communities dominated by big sagebrush, low sagebrush, and bitterbrush. Stands of mountain mahogany are found on the higher elevations throughout the Refuge, western juniper is prevalent at higher elevations on the western end of the refuge, and greasewood and four-wing saltbush are common at lower elevations on the east end. Aspen and willow stands are limited to snow pockets and stringer meadows.

III. DEFINITIONS

Fish and Wildlife Service (Service). U.S. Department of Interior, Fish and Wildlife Service, Sheldon-Hart Mountain National Wildlife Refuge Complex.

Guide. For purposes of this prospectus, "Guide" means to provide, for compensation or with the intent or with an agreement to receive compensation, services, equipment, or facilities to a big game hunter in the field by a person who accompanies or is present with the big game hunter in the field either personally or through an assistant; in this paragraph, "services" includes:

(A) contracting to guide or outfit big game guide hunts;

(B) stalking, pursuing, tracking, killing, or attempting to kill big game;

(C) packing, preparing, salvaging, or caring for meat, except that which is required to properly and safely load the meat on the mode of transportation being used by a transporter;

(D) field preparation of trophies, including skinning and caping;

(E) selling, leasing, or renting goods when the transaction occurs in the field;

(F) using guiding or outfitting equipment, including spotting scopes and firearms, for the benefit of a hunter; and

(G) providing camping or hunting equipment or supplies, which are already located in the field.

Operations Plan. A narrative description of the proposed commercial hunting operation, which contains all information required in Form A of this prospectus.

Party Size. The number of people (including guides, clients, pilots, and any other employees of the holder) who are authorized to be in a use area, by the terms of a special use permit.

Permit Holder or Permittee. An individual who is selected through this prospectus and who is issued a special use permit.

Special Use Permit (Permit). A U.S. Fish and Wildlife Service authorization required for all commercial uses of refuge lands and waters.

Use Area. An area designated by the Service and offered to a commercial operator to provide guided big game hunting services for the public.

Use Day. One calendar day (24 hours), or portion thereof, for each person using the refuge. Used as a measure of human use. Also called a visitor day. Includes use of the refuge by guides, clients, and any other individuals associated with the permit holder for any part of one day (24-hour period from midnight to midnight).

Example: One guide, one assistant guide, and four clients fly in to the refuge at 8:00 A.M, on September 1, spend three nights and leave at 2:00 P.M. on September 4. That equals 24 use days (6 people x 4 days = 24 use days); and 16 client use days (4 clients x 4 days = 16 client use days).

Base Camp. Seasonal camps used as the primary base of guide operations in the field for the entire, or most of the hunting season, and usually used by most or all of the clients during some portion of their hunt.

Spike Camp. Smaller camps usually used only for short duration (e.g., portion of a client trip) while hunting outside the range of the base camp, and then disassembled and moved or removed when no longer in use for a particular hunt or season.

IV. OFFERINGS

Sheldon-Hart Mountain NWR Complex is offering a maximum of five (5) and (10) Big Game Hunting Guide SUP's on Hart Mountain NAR and Sheldon NWR, respectively, as described below. Each individual can submit only one application per guide use area offered.

Offering:

Use area number (and location): Sheldon NWR and/or Hart Mountain

Term of permit(s): August 1, 2009–July 31, 2014

Offering Type: Single use – one permittee

Species available: Pronghorn antelope, mule deer, and/or bighorn sheep

V. SPECIAL REQUIREMENTS AND CONSIDERATIONS

Minimum Requirements (**Applicant must submit copies of all documents with application in order to be evaluated, unless otherwise indicated**)

* Applicant must possess a current State:
  - guide license
  - certification with appropriate State agency

* Applicant shall provide proof of liability insurance (minimum $300,000 each occurrence, $500,000 aggregate), with the Fish and Wildlife Service named as coinsured prior to issuance of the refuge special use permit. Insurance does not have to be purchased prior to applying. The Service may, during the life of this permit, conduct a review of insurance requirements to assess adequacy of our current minimum requirements. Applicants should be aware that if a determination is made to increase minimum insurance requirements, permittees holding the current minimum coverage will be required to increase their insurance coverage to comply with the new requirements.

* Applicant and his/her assistant guides must possess current first aid and CPR cards prior to issuance of the permit and maintain currency through the authorized use period.

* Applicant shall submit an affidavit signed by the applicant that affirms the applicant's financial ability to perform according to the operations plan.

Use Records

The permit holder will be required to furnish the refuge manager a guide use report each year showing the numbers of clients and client use days for each species hunted, numbers of each species harvested, applicable dates, and other data required by special conditions of the special use permit, and provide a copy of the State's hunt report for each client. This report must be provided by December 31 for all uses during that calendar year unless the permit requires otherwise. This report shall be certified by the permit holder as being complete and accurate.

Performance Evaluations

Permit holders will be checked periodically to determine compliance with the permit conditions and operations plan. Evaluations will be based upon compliance inspections, discussions with clients, etc. The permit holder will be advised of deficiencies and any legal actions.

Fees

Fees are required for commercial use of refuge lands. Holders of special use permits awarded under this prospectus will be required to pay a $250 administrative fee for each permit, annual fees for use and occupancy of refuge lands (i.e., cabins, tent platforms, campsite structures, caches, etc.), and client use day fees in accordance with Service Regional Policy.

Total Allowable Use

The Service anticipates the use allowed under the refuge permit will remain the same throughout the time period covered by the permit. However, it is not guaranteed. Use may be adjusted annually by the Service, if necessary due to regulation changes, environmental or resource concerns, or other management needs that may warrant adjustment.

General Terms

1. The government reserves the right to not award portions or all of some use areas being offered; extend the date for receiving the proposals; and reject any or all proposals.

2. Applications containing false or incomplete information may be rejected by the Service. If a permit has been issued based on false or incomplete information, it may be terminated at any time.

3. The Service will use the information submitted with the original applications to rank applicants and award permits. However, the Service also reserves the right to contact all applicants for any offering for additional information, or to evaluate other sources of information prior to award.

4. Economic uses on national wildlife refuges must be approved by an authorized officer (50 CFR 29.1). Successful applicants will be issued special use permits authorizing and governing use and occupancy of refuge lands under the National Refuge System Administration Act (16 U.S.C. 668dd-668ee) and the Refuge Recreation Act (16 U.S.C. 460k-3). Such uses are subject to fees established by the Service. Permits issued in response to this prospectus will only authorize commercial big game guiding activities allowed under a big game guide license by the States of Oregon or Nevada, and specified in the permit holder's approved plan of operations. Other commercial activities (e.g., incidental sport fish guiding or guiding for small game/migratory birds) will be prohibited without the prior written approval of the refuge manager.

5. The permit does not authorize use of other private or state lands.

6. Any oral statement by any representative of the government, modifying or changing any conditions of this prospectus is an expression of opinion only and confers no right upon any applicant.

7. In the event that a contradiction exists between conditions in the prospectus or sample permit and the conditions in the permit holder's special use permit, the conditions in the special use permit will govern.

8. The permit holder's operation plan, as amended and accepted by the Service, will be incorporated as a special condition of the holder's permit. By accepting the permit, the holder must conduct his/her commercial guiding operations in adherence with the plan of operations, as well as other permit conditions. Any deviation from the permit conditions or approved operations plan requires prior written approval from the Refuge Manager. In the event that a contradiction exists between the permit holder's proposal and the conditions in the holder's special use permit, the conditions in the special use permit will govern.

9. All costs incurred by the applicants for items submitted for this prospectus shall be the sole responsibility of the applicant.

Freedom of Information Act

All proposals submitted in response to this prospectus will be disclosed by the Department of the Interior to any person upon request pursuant to the Freedom of Information Act, 5 U.S.C. § 552. The Service believes that it is not necessary for applicants to provide trade secrets or confidential commercial or financial information when completing their proposals. Therefore, inclusion of such information is highly discouraged. However, if the applicant chooses to include commercial or financial information in the application which the applicant believes to be exempt from disclosure under the Freedom of Information Act (5 U.S.C. 552), the cover page of each copy of the proposal shall include an attachment with the following statement:

> "The information specifically identified on pages __, __, __, etc., of this proposal constitutes confidential commercial and financial information which the applicant believes to be exempt from disclosure under the Freedom of Information Act. The applicant requests that this information not be disclosed to the public, except as may be required by law."

The applicant shall also specifically identify confidential commercial and financial information on the page of the proposal which it appears and shall mark each page with the following legend:

> "This page contains confidential commercial and financial information which the applicant believes to be exempt from disclosure under the Freedom of Information Act and which is subject to the legend contained on the cover page of this proposal."

In the event of a request for documents under the Freedom of Information Act, the burden will be on the applicant to establish that the information he/she requests to be withheld as privileged commercial or financial information, qualifies for nondisclosure under the Freedom of Information Act. Information included in the proposals relating to personal privacy such as social security numbers, home telephone numbers, certain items in law enforcement reports, etc. is protected from disclosure under the Freedom of Information Act and the Privacy Act [5 U.S.C. § 552(a)] and will be withheld.

VI. SELECTION OF SUCCESSFUL APPLICANTS

A panel made up of Service employees will evaluate all properly completed applications or proposals for a refuge guide use area, using scoring factors and guidance developed by the Service for each of the criteria listed below. The average score assigned by panel members will determine the applicant's final score for each of the criteria. The sum of scores for all criteria will determine the applicant's total score. After scoring and ranking all applications for a guide use area, the ranking panel will recommend a list of the "best qualified applicants" to be considered for final selection for that area. The refuge managers for Sheldon NWR and Hart Mountain NAR will make the final selections for the guide use areas within the refuge that he/she manages. The refuge manager may either limit his/her selection to the list of best qualified applicants recommended by the ranking panel, or consider all applicants for the area that meet the minimum scores and qualifications. The refuge manager will base his/her final selection on the results of the ranking panel evaluations, the manager's own examination of the applications, interviews of the applicants, client references, and other records or sources of information (e.g., permit files) that can document the applicant's performance and qualifications.

Applicants must attain the minimum scores indicated below in all of the criteria to be considered for selection by the refuge manager. In the last criterion, any applicant whose point deductions for history of violations/convictions reach or exceed 90 points, will be ineligible for a permit.

1) Ability to provide a high quality hunt and guiding service to the public:
(Maximum 75 points; minimum 25 points).

2) Safety record, training, equipment and plan:
(Maximum 60 points; minimum 25 points).

3) Demonstrated experience and knowledge of the guide area, and the terrain, climate, and species to be hunted: (Maximum 110 points; minimum 20 points).

4) Impacts of the proposed operation on wildlife and other refuge resources such as water quality, vegetation disturbance, and soil disturbance:
(Maximum 110 points; minimum 55 points, 60 points for wilderness areas, proposed wilderness areas, or wilderness study areas).

5) Impacts of the proposed operation on other refuge users: (Maximum 45 points; minimum 20 points, 24 points for wilderness areas, proposed wilderness areas, or wilderness study areas).

6) History of compliance with state and federal laws, regulations, and permitting requirements associated with commercial guiding:
(points deducted for each offense; point deductions may not exceed 90 points).

VII. INSTRUCTIONS: HOW TO SUBMIT PROPOSALS

All proposals must be submitted in writing to:

U.S. Fish and Wildlife Service
Attention: Complex Project Leader
Sheldon-Hart Mountain NWR Complex
PO Box 111
Lakeview, OR 97630.

All proposals must either be postmarked at the address indicated above, by [time, month number, day, four digit year]. **An original and two copies of the complete application package(s) must be submitted for each refuge.** Proposals must be submitted in sealed envelopes and must be signed by the individual submitting the proposal. Each sealed envelope shall be clearly marked **"**Sheldon NWR or Hart Mountain NAR Refuge Guiding Proposal**."** Each package should be marked with the name, address, and telephone number of the applicant. Applications that are mailed must be sent by certified or registered mail, return receipt requested.

Incomplete proposals will not be returned to the applicant for more information. Material submitted with the proposals will not be returned to the applicant. All proposals must be legible, either neatly printed in dark ink or typed. **Proposals received after the above deadline will be considered late and will be returned to the sender without evaluation.**

You may apply as a partnership; however, each partner must be individually qualified to receive the permit, and partnership applications will be ranked by the lowest scoring partner. Each partner must sign the permit and be responsible for complying with permit conditions.

The following instructions are provided to guide the applicant in completing the enclosed forms in Section VIII. **The Service will not accept any form of proposal except as specified in the format under Section VIII.** Elements of the proposal may be incorporated as conditions of the special use permit.

An applicant who knowingly provides false or incomplete information will be disqualified.

Proposals must include:

Cover Sheet. By signing this form the applicant attests that all information provided with the application is true and complete and authorizes the Service to verify any information provided.

Form A - Proposed Operations Plan. Information on this form should describe the full services you will offer to the public. The information you provide in your proposed operations plan will be used in evaluating impacts to fish and wildlife resources, other refuge resources, and other refuge users. It will also be considered in evaluating your ability to provide a quality hunt and guiding service to the public, and your knowledge of the area applied for. Instructions on the form indicate the information required.

Form B - History of Violations. You must report felony or misdemeanor convictions (including forfeiture of collateral and no contest pleas) for violations committed during the last 10 years by you, or any of your business partners, or employees, and any pending charges pursuant to the instructions on the form. You must also report convictions and pending charges for any violations committed by individuals who were being guided or accompanied by you or persons associated with your guiding

business at the time of the violation. If a pending charge results in a conviction, the conviction could be cause to revoke a permit, depending on the nature and severity of such conviction. You must also provide copies of official law enforcement records or background reports of criminal history for you and your business partners, as explained on the form.

Form C - Safety Record, Training, Equipment and Plan. Information on this form will be used to evaluate your past safety record and ability to provide clients with a safe hunt.

Form D - Demonstrated Experience and Knowledge of the Guide Area, and the Terrain, Climate, and Species to be Hunted. Use this form to describe your experience and knowledge of the refuge being applied for, including the terrain, climate, and species to be hunted.

Form E - List and Description of Property, Equipment and Accessories. Applicants must describe how they will be able to meet all applicable federal, state, and local requirements pertinent to their full operation. Applicants must also be able to demonstrate that all the equipment and accessories proposed for use in their operations are safe and adequate for general public service.

Form F - Ability to Provide a High Quality Hunt and Guiding Service to the Public. Use this form to describe your ability to provide a high quality hunt and big game guiding service.

Form G - Evaluation of Client References. Applicants must supply a complete list of clients for the past three years. The clients may be contacted by the Service for references to evaluate the quality of your past services.

VIII. INFORMATION REQUIRED

Please read the following forms carefully. Additional information relative to the questions found in these forms can be found in Section V. Be sure to provide in written form the information requested under each element in the format specified. **Additional pages should be used if extra space is needed (use copies of or the same format as the continuation sheet form provided in Appendix A).** Information beyond the minimum requested will be evaluated. All information is subject to verification by the Service and additional supporting data may be required. **Be sure to retain a copy of the application for your records.** The Service is under no obligation to return applications.

SHELDON-HART MOUNTAIN NWR COMPLEX REFUGE GUIDING PROSPECTUS
APPLICATION COVER SHEET

GUIDE USE AREA (SHELDON NWR / HART MOUNTAIN NAR)
circle one

I certify that the information furnished herewith is true and complete to the best of my knowledge and belief. I authorize the Fish and Wildlife Service to verify the information furnished herewith.

BY _____
(Sign in ink as typed or printed below)

_____
(Type or print full name) (Social Security Number)

_____
(Doing business as)

PERMANENT MAILING ADDRESS

_____

_____

_____

ADDRESS DURING APPLICATION REVIEW PERIOD (IF DIFFERENT)

_____

_____

_____

TELEPHONE NUMBER: Daytime _____

Other _____

DATE _____

The following information on Forms A through G must be submitted for your proposal to be evaluated.

FORM A

Proposed Operations Plan

Provide in narrative form a description of the services you propose to offer. Be sure to explain the services for each offering for which you are applying. This narrative should address at a minimum, the type and extent of services, including the following:

1. Dates of operations
2. Species to be hunted and type of hunt(s) provided for each (i.e., archery, muzzleloader)
3. Maximum number of clients for each species, and each type of hunt
4. Methods or strategies to reduce impacts on Refuge resources and other Refuge users
5. Camp site traditionally used and methods to alleviate effects on other campers
6. Methods to minimize interactions with other refuge hunters

FORM B

History of Violations

1. Within the past 10 years, have **you or any of your former, current or proposed business partners**, been convicted, forfeited collateral, pled nolo contendere, had a guiding license or privilege suspended, or been administratively penalized for violation of any federal, state, or local laws, regulations, or permit conditions, related to hunting, fishing (including commercial fishing), guiding, or for any DUI offense? Are you or any of your former, current, or proposed business partners under pending charges for any violation as indicated above? If the answer to either of these questions is yes, list each incident and give the name of the person, place of occurrence and name/address of the law enforcement agency and/or court involved (and provide explanation, if you desire).

1. Within the past 10 years, have any of your **employees** while in your employment, been convicted, forfeited collateral, pled nolo contendere, had a guiding license or privilege suspended, or been administratively penalized for violation of any federal, state, or local laws, regulations, or permit conditions, related to hunting, fishing and guiding? Are any current or proposed employees presently under pending charges for any violation as indicated above? If the answer to either of these questions is yes, list each incident and give the name of the person, place of occurrence and name/address of the law enforcement agency and/or court involved (and provide explanation, if you desire).

3. Within the past 10 years, has any **client** or other individual been convicted, forfeited collateral, pled nolo contendere, or is now under pending charges for any violation that occurred while being guided or accompanied by you or individuals associated with your guiding business? If yes, list each incident and give the name of the person, place of occurrence and name/address of the law enforcement agency and/or court involved (and provide explanation, if you desire).

Applicant's Name _____ Form B - Page 1

FORM C

Safety Record, Training, Equipment and Plan

1. List all accidents, incidents, and safety related violations or enforcement actions involving you or your guiding operations that have occurred within the past 10 years.

2. List all safety related training that you, your partners, and your employees have taken (e.g., advanced first aid, ETT, EMT, arctic survival, wilderness first aid/medicine, cold water survival, etc.) Also describe any relevant experience/training in actual rescue or survival operations or programs, hunter safety programs, etc. Give dates of training or participation and indicate if certification is current (if applicable). Note: the successful applicant and assistant guides are required to submit current first aid and CPR certification prior to permit issuance.

3. Describe your emergency preparedness or safety plan. List emergency communications equipment and address your plans, if any, in the event of mechanical failures, or other types of accidents/incidents.

4. List all safety related equipment and supplies, in addition to the communications equipment listed above.

Applicant's Name _____ Form C - Page 1

FORM D

Demonstrated Experience and Knowledge of the Guide Area, and the Terrain, Climate, and Species to be Hunted

1. Describe and document the number of years of your guiding experience (noting the number of days spent in the field each year) On Sheldon NWR and/or Hart Mountain NAR, during the past 20 years.

2. Describe your guiding/outfitting experience during each of the last 10 years. For each year, list the number of clients, noting the number of days you spent in the field, identify the species hunted, number of each species taken, specific locations and type of terrain and climate where you guided or outfitted. Indicate the specific periods, if any, for which you were not serving as a registered big game guide. You should also indicate if you were the contracting guide. If you guided for activities other than big game guiding, describe the type of activities you guided, and the specific services you provided.

4. You may document experience other than guiding for the same period that you believe is relevant (e.g., personal sport hunting, or fishing, resource management activities, etc.) Describe the experience or activity, the specific location involved, noting the amount of time in the field and, if applicable, the number of clients served each year and the number of each species of animals harvested.

5. Describe any education and/or training you believe is relevant.

Applicant's Name _____ Form D - Page 1

Form E

List and Description of Property, Equipment and Accessories

1. Describe how the property, equipment and accessories proposed for use in your operation are safe and adequate for general public service.

2. Describe how you will be able to meet all applicable federal, state, and local requirements pertinent to your proposed operation.

Applicant's Name _____ Form E - Page 1

FORM F

Ability to Provide a High Quality Guiding Service to the Public

1. Describe your business practices including proposed client rates; payment options; promotional strategies or efforts; reservation, cancellation and refund policies; and acknowledgement of risk forms. Submit your current advertisement leaflets, client price lists, hunter contract forms, or other literature that reflects your business practices.

2. Describe provisions for clients with disabilities.

3. Describe educational and/or interpretive services or programs provided to clients.

4. Describe drinking water supplies and method of treatment if appropriate.

5. Describe your knowledge, abilities, and experience in caring for meat, capes, and hides from big game. List the number of years and estimated number of animals of each species that you and/or your employees have taken care of (e.g., field dressed, skinned, caped, boned, butchered, etc.) Also, document any training that you or your employees have received in care of meat or trophies (e.g., taxidermy, meat cutting, etc.)

6. Describe your plan, methods, provisions, and facilities to salvage, care, and provide opportunity for utilization of meat from harvested animals.

Applicant's Name _____ Form F - Page 1

FORM G

Evaluation of Client References

Provide a complete list of all big game hunting clients that you have contracted and/or personally guided since July 1, 2005. If you need to go back prior to this date in order to have a minimum of 10 clients, you may do so. Include full names; addresses; home telephone and other telephone numbers, if known; species hunted; year of hunt; whether you were the contracting guide; whether it was a guided or drop-off client; and whether the client was guided by you personally or by an assistant.

If you are a recently registered guide and are unable to provide the requested list for a minimum of 10 clients, simply indicate that on this form.

Applicant's Name _____ Form G - Page 1

Applicant's Name_____ Form _____ Page _____

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Appendix E. Projects, Staff, and Facilities Needed to Implement the CCP

E.1 Overview

Implementation of the CCP will require changes in funding, which will be sought from a variety of sources. This plan will depend on additional congressional allocations, partnerships and grants, and adoption demand for horses and burros. There are no guarantees that additional Federal funds will be made available to implement any of these projects. Other sources of funds will need to be obtained (both public and private). Activities and projects identified will be implemented as funds become available.

The CCP included direction for several projects to be implemented over the next 15 years. All of these projects are included in the Refuge Management Information System (Refuge Operational Needs System [RONS] or Maintenance Management System [MMS]), which are used to request funding from Congress. The RONS documents proposed new projects to implement the CCP to meet refuge goals and objectives and legal mandates.

Annual revenue sharing payments to Humboldt, Washoe, and Lake counties will continue. If the refuge expands through the purchase of inholdings (privately owned lands within the current approved boundary) or through an expanded refuge boundary, additional revenue sharing payments in lieu of tax payments will be made to the respective county. See Chapter 5 for a summary of the economic effects of the CCP's implementation.

Monitoring activities will be conducted on a percentage of all new and existing projects and activities to document wildlife populations and changes across time, habitat conditions, and responses to management practices.

E.2 Costs to Implement CCP

The following sections detail both one-time and recurring costs for staffing and projects to implement the CCP that are high priority or that are anticipated to have substantial costs associated with them. Some biological staff positions at Sheldon Refuge have been vacant for several years. To fully implement the CCP management direction, funding for these positions will continue to be necessary and has been included. Therefore, costs to implement the CCP will be greater than refuge management costs in past years. Costs for staffing and projects that are either assumed to be constant or that are not anticipated to be substantial are included under basic categories such as staffing, maintenance, and operations. One-time costs reflect the initial costs associated with a project, such as the purchase of equipment, contracting services, construction, etc. Future operational and maintenance costs associated with the project are identified under recurring costs.

E.2.1 One-Time Costs

One-time costs are project costs that have a start-up cost associated with them, such constructing a new building or relocating a campground. Some are full project costs for projects that can be completed in three years or less. One-time costs can include the cost of temporary or term salary associated with a short-term project. Salary for new positions and operational costs are reflected in operational or recurring costs.

Funds for one-time costs will be sought through increases in refuge base funding, special project funds, grants, etc. Some projects also might require land acquisition funds, other special appropriations, or grants.

Projects listed in Table E.1 show high-priority and major one-time costs for replacement of Catnip Reservoir Dam and replacement of the Sheldon Refuge Headquarters office and visitor information building. The primary differences in one-time costs between previous management and the CCP management direction are for relocation of the existing campgrounds to reduce resource impacts and for upgrades to the three most heavily used and more developed campgrounds.

Table E.1 High-priority and Major One-time Costs

	Current Management	CCP Management Direction	Priority[1]
Reconstruction of the Catnip Reservoir Dam	$3,000,000	$3,000,000	H
Construction of Park Ranger and Law Enforcement Officer Quarters at Sheldon Refuge Headquarters	$200,000	$200,000	M
Replacement of Visitor Center and Headquarters	$0	$2,700,000	H
Relocation of Campgrounds	$0	$450,000	L
Upgrades to Virgin Valley, Big Spring, and Catnip Reservoir Campgrounds	$0	$110,000	M
Total Fixed Costs	$3,200,000	$6,460,000	

[1] H=High; M= Medium; L= Low

E.2.2. Operational (Recurring) Costs

Operational costs reflect refuge spending of base funds allocated each year. These are also known as recurring costs and are usually associated with day-to-day operations and projects that last longer than three years.

Table E.2 displays projected operating costs under the CCP. The CCP reflects increased funding needs for feral horse and burro management; increases in public uses, facilities, and staffing; increased removal of encroaching western juniper and sagebrush, and new monitoring needs. This table includes salaries and operational expenditures such as travel, training, supplies, utilities, and annual maintenance costs.

For comparison purposes, the costs for feral horse and burro management have been calculated as an annual average over the 15-year life of the CCP even though the entire amount will be needed within five years. Increased recurring costs for maintenance supplies and equipment are primarily for maintenance of the Sheldon Refuge Headquarters office and visitor center, additional staff housing, and additional campground facilities, as well as for the removal of water developments and restoration work. Increased funds for fire fuels reduction supplies and equipment will be needed to fully complete fire breaks and for mechanical removal of encroaching western juniper and sagebrush.

Reductions to biological staff salaries under the CCP reflect shorter-term needs for a feral horse and burro specialist. Changes to fire and habitat management staff salaries reflect less need for prescribed fire staff. Additional maintenance, law enforcement, and public use staff will be needed to adequately administer refuge lands as visitation increases and to maintain and operate additional public use facilities.

Table E.2 includes costs for permanent and seasonal staff needed year after year. It does not include staff costs associated with special projects; these are summarized in Table E.1.

Table E.2 Operational (Recurring) Costs

	Current Management	CCP Management Direction	Priority[1]
Feral Horse and Burro Management	$675,000	$333,000	H
Maintenance Supplies and Equipment	$100,000	$170,000	H
Fire Fuels Reduction and Habitat Management Supplies and Equipment	$47,000	$87,000	H
Administrative and Refuge Management Staff Salaries	$278,000	$278,000	H
Biological Staff Salaries	$206,000	$191,000	H
Fire and Habitat Management Staff Salaries	$266,000	$257,000	H
Maintenance Staff Salaries	$148,000	$164,000	H
Public Use and Law Enforcement Staff Salaries	$83,000	$174,000	M
Total Operational (Recurring) Costs	$1,803,000	$1,654,000	

[1]H=High; M= Medium; L= Low

E.2.3. Additional Planning to Implement the CCP

The following step-down management plans will be completed to support implementation of the CCP. Timeframes for completion following the Record of Decision for the CCP/EIS are estimated for each plan, but will depend upon the progress and scheduling of other Sheldon-Hart Mountain Refuge Complex planning efforts, available staffing, and funding.

- Minerals and Mining Management Plan (5-7 years)
- Wilderness Stewardship Plan (3-5 years)
- Transportation Management Plan (8-10 years)
- Visitor Services Plan (3-4 years)
- Law Enforcement Plan (2-5 years)
- Cultural Resources Management Plan (8 years)
- Cold-water Fisheries Management Plan (2-3 years)
- Habitat Management Plan (4-6 years)
- Integrated Pest Management Plan (5-7 years)

E.2.4. Additional Staffing to Implement the CCP

The estimated costs for implementing the CCP management direction, as indicated in Table E.2, reflect the addition of permanent staff necessary to implement the CCP within 15 years. These staffing needs are in addition to 25 permanent and temporary positions currently filled and 15 positions that are currently vacant.

- Law Enforcement Officer (1 Full-time Equivalent [FTE] position, GS-7): Conduct permit compliance checks and enforcement, increase enforcement of vehicle and travel management regulations, and provide additional visitor contact and enforcement associated with public use and use of historic structures.

- Park Ranger (1 FTE, GS-7): Provide direct supervision for volunteers, volunteer projects; administer visitor center; conduct public use, campsite, wilderness, and route inventory and monitoring; maintain and monitor historic public use structures; assist with additional wilderness project workload using primitive/minimum tools; and administer permit systems for off-highway vehicles and campgrounds.
- Refuge Operations Specialist (1 FTE, GS-9): Assist with development of step-down plans, project oversight, habitat evaluation, and invasive species and juniper treatment and control.
- Maintenance Staff (0.5 FTE, WG-4): Assist with upgrading campgrounds, constructing and maintaining additional facilities (visitor center, Kinney Camp, campgrounds), relocating campgrounds, rehabilitating abandoned roads and campgrounds, and maintaining additional signs.
- Maintenance Staff (0.5 FTE, WG-4): Assist with boundary fence monitoring, maintenance, and repair.
- Fuels Crew Leader (0.6 FTE, GS-6): Juniper removal and other mechanical habitat treatments.
- Fuels Crew (0.25 FTE each, GS-4): Three seasonal crew members to conduct juniper removal and other mechanical habitat treatments.

Appendix F. Sheldon National Wildlife Refuge Wilderness Inventory and Review Summary

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F.1 Introduction

Sheldon National Wildlife Refuge was initially established by Executive Order in 1931 as a refuge and breeding ground for wild animals and birds. Additional lands were acquired later, and the refuge's purpose was broadened to include the conservation and development of natural wildlife resources and the protection and improvement of public grazing lands and natural forage resources.

After a comprehensive inventory and evaluation of the wilderness character and value of the entire Sheldon Refuge with public input and involvement, the Service prepared an environmental impact statement and recommended portions of Sheldon Refuge for designation as wilderness under the Wilderness Act of 1964. This recommendation was later expanded, and a proposal was submitted to Congress by the President in 1974. At that time, the President requested Congress not act on his proposal until a mineral survey for Sheldon Refuge could be completed. The mineral survey was completed by the U.S. Geological Survey in 1975, but since that time Congress has taken no action to designate any portion of Sheldon Refuge as wilderness.

F.1.1 Wilderness Review Process

The purpose of a wilderness review is to identify and recommend for congressional designation National Wildlife Refuge System (System) lands and waters that merit inclusion in the National Wilderness Preservation System. Wilderness reviews are a required element of CCPs and are conducted in accordance with the Service's wilderness review and evaluation policy outlined in 610 FW 4 and in accordance with the refuge planning process outlined in 602 FW 1 and 3, including public involvement and National Environmental Policy Act (NEPA) compliance.

There are three phases to a wilderness review: 1) inventory, 2) study, and 3) recommendation.

1) Wilderness Inventory. The wilderness inventory identifies those lands within the refuge that might have wilderness character and satisfy the definition of wilderness as stated in the Wilderness Act and in Service Policy. The inventory preliminarily classifies each unit of land that meets these requirements as a wilderness study area (WSA).

2) Wilderness Study. The wilderness study further evaluates each WSA for values, resources, and uses to determine if each one merits recommendation from the Service to the Secretary of the Interior as wilderness.

3) Wilderness Recommendation. The recommendation phase consists of forwarding or reporting recommendations for wilderness designation from the Director of the U.S. Fish and Wildlife Service, through the Secretary of the Interior, and the President to Congress in a wilderness study report.

This appendix summarizes the wilderness inventory, study, and recommendations for the management direction included in the Sheldon Refuge CCP. The complete 2010 Sheldon Refuge Wilderness Review is available and can be found on the Sheldon Refuge planning website.

F.1.1.1 Inventory Criteria

The wilderness inventory is a broad look at the planning area to identify WSAs. These are roadless areas that meet the minimum criteria for wilderness identified in Section 2(c) of the Wilderness Act:

> A wilderness, in contrast with those areas where man and his works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. An area of wilderness is further defined to mean in this Act an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions, and which: (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological or other features of scientific, educational, scenic, or historical value.

A WSA must appear natural, provide outstanding opportunities for solitude or primitive recreation, meet the size criteria, and may provide other supplemental values. The process for identification of roadless areas in the Sheldon NWR and application of the wilderness criteria are described in the following sections.

Identification of Roadless Areas

Identification of roadless areas required gathering and evaluating land status maps, land uses, road inventory data, and aerial photographs for Sheldon Refuge. By definition, a "roadless area" is a reasonably compact area of undeveloped Federal land that has the general characteristics of a wilderness and within which there is no improved road suitable for public travel by means of four-wheeled, motorized vehicles intended primarily for highway use. A route maintained solely by the passage of vehicles does not constitute a road (610 FW 1.5 Z).

Using the Service's definition of a road, there are six roaded areas within Sheldon Refuge. These areas include Highway 140, County Roads 34 and 34A, County Road 8A, Summit Lake Road, Bog Hot Road, and the Dufurrena/Virgin Valley Road. All other routes within Sheldon Refuge are maintained solely by the passage of vehicles and do not constitute roads for the purposes of the Sheldon Refuge Wilderness Inventory completed in 2010.

Evaluation of the Naturalness Criteria

In addition to being roadless, a WSA must meet the naturalness criteria. Section 2(c) defines wilderness as an area that "generally appears to have been affected primarily by the forces of nature with the imprint of man's work substantially unnoticeable." An area is apparently natural if it looks natural to the average visitor who is not familiar with historic conditions or human influences in a given area. Areas that have been or are in the process of being restored to a substantially natural appearance following previous significant disturbances such as grazing or agriculture may still be found suitable.

An area may also meet the naturalness criteria if human impacts are relatively minor and substantially unnoticeable in the unit as a whole. Minor impacts may include trails, fire towers, fire breaks, pit toilets, fire rings, hitching posts, snow gauges, research monitoring devices, wildlife enhancement facilities (e.g., guzzlers or exclosures), fencing, spring developments, and small reservoirs.

Established or proposed refuge management activities or refuge uses that require the use of temporary roads, motor vehicles, motorized equipment, mechanical transport, landing of aircraft, structures, and installations generally prohibited within designated wilderness or "sights and sounds" of human impacts and activities outside the boundary of the unit do not disqualify an area from meeting the wilderness naturalness criteria. The physical impacts of these practices within the unit should be the focus of the naturalness evaluation. We evaluate existing and proposed refuge management activities and refuge uses in the study phase of the wilderness review.

Evaluation of Outstanding Opportunities for Solitude or Primitive and Unconfined Recreation

In addition to meeting the size and naturalness criteria, a WSA must provide outstanding opportunities for solitude or primitive recreation. An area does not have to possess outstanding opportunities for both solitude and primitive and unconfined recreation and does not need to have outstanding opportunities on every acre. Further, an area does not have to be open to public use and access to qualify under this criteria; Congress has designated a number of wilderness areas in the Refuge System that are closed to public access to protect resource values.

Opportunities for solitude refer to the ability of a visitor to be alone and secluded from other visitors in the area. Primitive and unconfined recreation means non-motorized, dispersed outdoor recreation activities that are compatible and do not require developed facilities or mechanical transport. These primitive recreation activities may provide opportunities to experience challenge, risk, self-reliance, and adventure.

An outstanding opportunity for solitude may be present in an area offering only limited primitive recreation potential. Conversely, an area may be so attractive for primitive and unconfined recreational use that it would be difficult to maintain opportunities for solitude (e.g., around water).

Opportunities are evaluated for each area on its own merits independent from other areas. When an area is contiguous to proposed wilderness, recommended wilderness, a WSA, or other Federal lands that a land management agency has already determined to have wilderness character (i.e., Service, Bureau of Land Management [BLM], National Park Service, or U.S. Forest Service lands), an additional evaluation of outstanding opportunities is not required.

Evaluation of the Size Criteria

Roadless areas or roadless islands meet the size criteria if any one of the following standards apply:

- An area with over 5,000 contiguous acres. State and private lands are not included in making this acreage determination.
- A roadless island of any size. A roadless island is defined as an area surrounded by permanent waters or that is markedly distinguished from the surrounding lands by topographical or ecological features.
- An area of less than 5,000 contiguous Federal acres that is of sufficient size as to make practicable its preservation and use in an unimpaired condition and of a size suitable for wilderness management.
- An area of less than 5,000 contiguous federal acres that is contiguous with a designated wilderness, recommended wilderness, or area under wilderness review by another Federal managing agency such as the U.S. Forest Service, National Park Service, or BLM.

Evaluation of Supplemental Values

Supplemental values are defined by the Wilderness Act as "ecological, geological, or other features of scientific, educational, scenic, or historic value." These values are not required for wilderness, but their presence should be documented.

F.1.1.2 Inventory Process

Refuge staff assessed several factors during the inventory process: the location of the existing 1974 proposed wilderness area boundaries[1], improved roads, well-used and long-standing unimproved roads determined necessary for vehicle access, natural features such as cliffs, canyons, and mountain ranges, and the location of disconnected Refuge lands. From this assessment, refuge staff identified 34 discrete wilderness inventory units (see Figure F.1 for an overview of all Sheldon Refuge Wilderness Inventory Units).

F.1.1.3 Wilderness Inventory Summary

Thirty-four Wilderness Inventory Units were identified during the inventory process. Thirteen Wilderness Inventory Units represent the eight areas proposed for wilderness designation in 1974. Five of the eight proposed wilderness areas (Rye Creek, Round Mountain, Catnip Mountain, Big Mountain, and Sage Hen Hills WSAs) are determined to still meet the criteria for wilderness study throughout their boundaries. As a result the boundaries for these WSAs remain unchanged from the 1974 Wilderness Proposal. For the remaining three proposed wilderness areas (Big Spring, Gooch Table, and Alkali Peak), natural conditions, opportunities for solitude or a primitive and unconfined type of recreation, or size/contiguous status (through acquisition) have changed to the extent that portions either no longer meet the criteria and have been removed from wilderness study or now do meet criteria and have been added for wilderness study. As a result, the recommended boundaries for these three areas have been adjusted (see Figure F.1 for general location). An explanation for these adjustments is included in Table F.1.

Of the 21 Wilderness Inventory Units that have not been previously proposed for designation, 10 are determined to meet the criteria for further wilderness study and have been identified as WSAs. Of the 11 remaining units not identified as WSAs, all but one (Badger Mountain) were determined to not meet the criteria for wilderness study in both the 1973 and 2009 wilderness inventories and for largely the same reasons.

Table F.1 summarizes results of the wilderness inventory for Sheldon Refuge. A detailed description of the wilderness character for each of the 34 wilderness inventory units based upon the wilderness inventory criteria discussed previously is included in the Sheldon Refuge Wilderness Review (USFWS 2010).

[1] The Proposed Wilderness Area boundaries have been corrected and adjusted slightly from earlier refuge planning documents based upon a detailed review of the final 1974 Sheldon Refuge Wilderness Proposal submitted to Congress and updated digital land status and refuge boundary data.

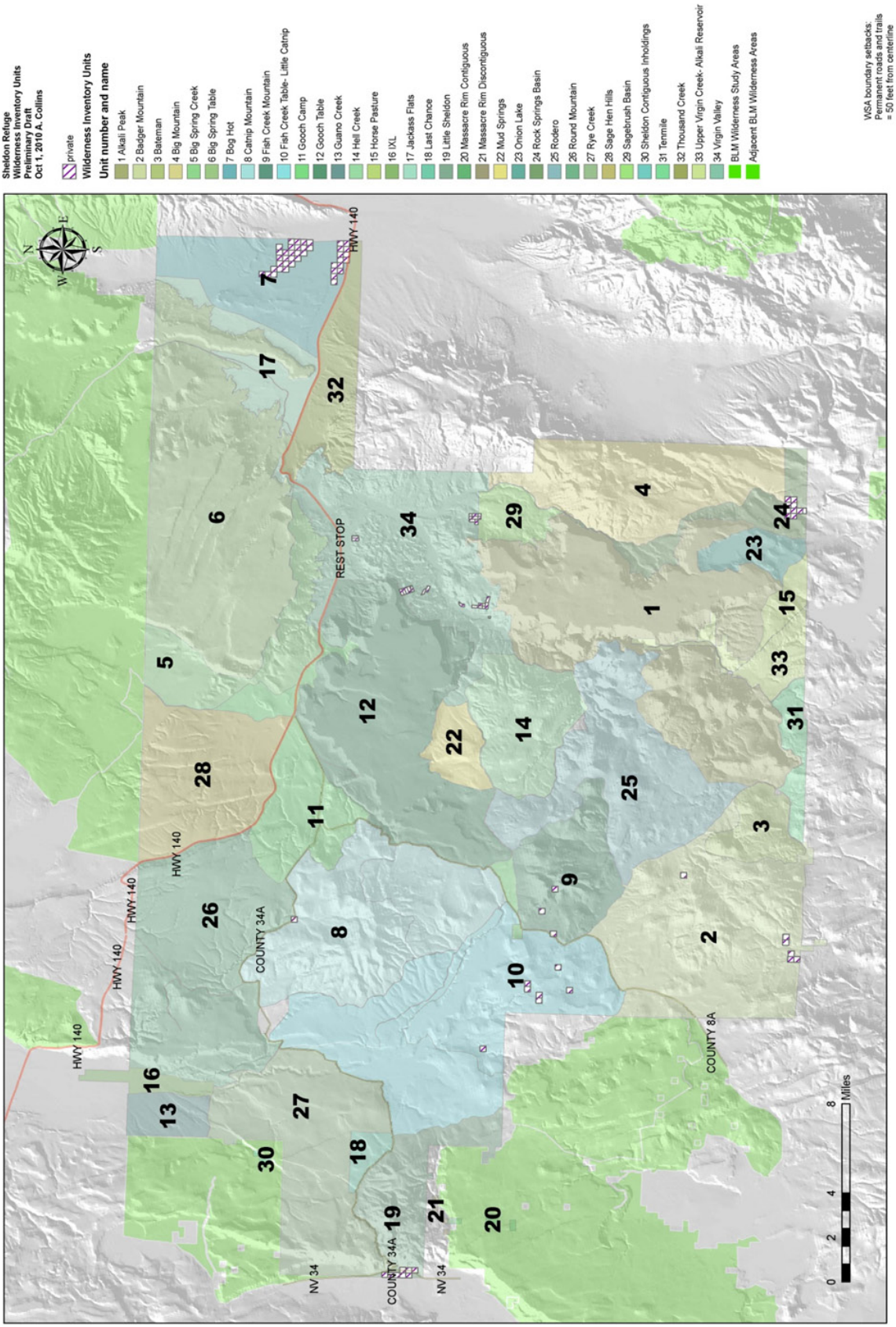

Figure F.1 Sheldon Refuge Wilderness Inventory Units.

Table F.1 Summary of Wilderness Inventory on Sheldon NWR by Unit

Refuge Unit	Proposed Wilderness Area (1974)	Acres	Criteria 1: Naturalness	Criteria 2: Outstanding Opportunities for Solitude or Primitive and Unconfined Recreation (at least one of three required)			Criteria 3: Size	Criteria 4: Supplemental Values	Unit qualifies as WSA[1]
				2a (2a) has outstanding opportunities for solitude	2b (2b) has outstanding opportunities for a primitive and unconfined type of recreation	2c (2c) is contiguous to proposed wilderness, recommended wilderness, or WSA			
Alkali Peak Unit 1	PWA	51,248	Yes			Yes	Yes	Yes: Scenic canyons and prehistoric cultural sites	Yes
Badger Mountain Unit 2		37,252	No: The number and density of primitive vehicle routes and impacts from past wildfire suppression activities detract from the overall natural appearance of the unit	No: Ongoing refuge management activities and relatively high amounts of visitation during summer and fall hunting seasons reduce opportunities for solitude	No: Recreation activities within this unit are supported by motorized vehicles and a network of primitive motorized routes		Yes	Yes: Mountain mahogany habitat	No
Bateman Unit 3		5,772	Yes		Yes		Yes	Yes: Mountain mahogany habitat	Yes
Big Mountain Unit 4	PWA	23,361	Yes			Yes	Yes	Yes: Scenic views	Yes

Refuge Unit	Proposed Wilderness Area (1974)	Acres	Criteria 1: Naturalness	Criteria 2: Outstanding Opportunities for Solitude or Primitive and Unconfined Recreation (at least one of three required)			Criteria 3: Size	Criteria 4: Supplemental Values	Unit qualifies as WSA[1]
				2a	2b	2c			
Big Spring Creek 5 Unit	PWA	13,191	No: A large number of mining disturbances, including disturbance unnoticed during 1974 inventory or which have occurred after the 1974 wilderness proposal are readily apparent from areas within the unit and detract from the natural appearance of the unit as a whole			Yes	Yes		No
Big Spring Table Unit 6	PWA	52,200	Yes			Yes	Yes	Yes: Antelope research, rare habitats, geologic feature	Yes
Bog Hot Unit 7		16,662	No: The unit does not appear natural as a whole due to the presence of permanent roads and additional developments on private lands	No: Activities and uses associated with private inholdings reduce opportunities for solitude or a primitive type of recreation			Yes		No
Catnip Mountain Unit 8	PWA	33,227	Yes			Yes	Yes		Yes
Fish Creek Mountain Unit 9	PWA	13,786	Yes			Yes	Yes		Yes

Refuge Unit	Proposed Wilderness Area (1974)	Acres	Criteria 1: Naturalness	Criteria 2: Outstanding Opportunities for Solitude or Primitive and Unconfined Recreation (at least one of three required)			Criteria 3: Size	Criteria 4: Supplemental Values	Unit qualifies as WSA[1]
				2a	2b	2c			
Fish Creek Table—Little Catnip Unit 10		43,609	Yes: One of the most pristine and undeveloped portions of Sheldon Refuge; Swan Lake Reservoir is noticeable, but does not detract from the natural appearance of the unit as a whole	Yes: Few visitors, very rugged remote terrain, which provides outstanding opportunities for solitude and primitive recreation in an unconfined setting	Yes		Yes		Yes
Gooch Camp Unit 11		16,957	No: Density of roads and other developments give the appearance of unnatural conditions throughout the unit as a whole	No: The presence of major access roads, highways, developed campgrounds, and management facilities provide little or no opportunities for solitude or primitive recreation			Yes		No
Gooch Table Unit 12	PWA	40,038	Yes			Yes	Yes		Yes
Guano Creek Unit 13		4,133	Yes			Yes	Yes		Yes
Hell Creek Unit 14		13,969	Yes			Yes	Yes		Yes
Horse Pasture Unit 15		2,651	Yes	No	No	No	No		No
IXL Unit 16		2,506	No: Developments, structures, and manipulations from water control and farming are readily apparent throughout the majority of the unit			Yes	Yes	Yes: Historic structures	No
Jackass Flats Unit 17		7,815	Yes			Yes	Yes		Yes

Refuge Unit	Proposed Wilderness Area (1974)	Acres	Criteria 1: Naturalness	Criteria 2: Outstanding Opportunities for Solitude or Primitive and Unconfined Recreation (at least one of three required)			Criteria 3: Size	Criteria 4: Supplemental Values	Unit qualifies as WSA[1]
				2a	2b	2c			
Last Chance Unit 18		1,886	No: Density and size of roads and historic livestock developments give the appearance of unnatural conditions throughout the unit as a whole			Yes	Yes	Yes: Historic structures	No
Little Sheldon Unit 19		11,722	No: Density of roads and other developments give the appearance of unnatural conditions throughout the unit as a whole			Yes	Yes	Yes: Scenery and wildlife viewing opportunities	No
Massacre Rim Contiguous Unit 20		334	Yes: Some historic livestock developments and nearby roads and/or motorized trails, but parcels appear natural, especially when considered in context of the contiguous BLM WSA			Yes	Yes		Yes
Massacre Rim Discontiguous Unit 21		142	No: Surrounded by lands found not suitable for wilderness study by BLM and that contain various historic developments for livestock management	No: Opportunities for solitude or primitive recreation greatly affected by proximity (less than 0.25 mile) to motorized vehicle routes and other mechanized and motorized uses			No	No	No

Refuge Unit	Proposed Wilderness Area (1974)	Acres	Criteria 1: Naturalness	Criteria 2: Outstanding Opportunities for Solitude or Primitive and Unconfined Recreation (at least one of three required)			Criteria 3: Size	Criteria 4: Supplemental Values	Unit qualifies as WSA[1]
				2a	2b	2c			
Mud Springs Unit 22	PWA	4,641	No: A number of developments in this portion of the unit have been enlarged, improved, or added since the 1974 proposal; the size and density of these developments now detract from the substantially natural appearance of the unit as a whole			Yes	Yes		No
Onion Lake Unit 23	PWA	4,252	No: Density of historic livestock developments, existing trails, and Onion Reservoir are readily apparent and detract from the overall natural appearance of the unit as a whole			Yes	Yes		No
Rock Springs Basin Unit 24		7,220	No			Yes	Yes		No
Rodero Unit 25	PWA	28,321	No: Density of historic livestock developments, camping, and existing trails are readily apparent and detract from the overall natural appearance of the unit as a whole			Yes	Yes		No
Round Mountain Unit 26	PWA	36,284	Yes			Yes	Yes		Yes
Rye Creek Unit 27	PWA	28,151	Yes			Yes	Yes	Yes: Scenic views, prehistoric rock art/ petroglyphs, wildlife viewing opportunities	Yes

Refuge Unit	Proposed Wilderness Area (1974)	Acres	Criteria 1: Naturalness	Criteria 2: Outstanding Opportunities for Solitude or Primitive and Unconfined Recreation (at least one of three required)			Criteria 3: Size	Criteria 4: Supplemental Values	Unit qualifies as WSA[1]
				2a	2b	2c			
Sage Hen Hills Unit 28	PWA	21,068	Yes			Yes	Yes		Yes
Sagebrush Basin Unit 29		4,241	Yes: Some disturbance from past mineral prospecting and mining, which are gradually returning to a more natural appearance and do not detract from the natural appearance of the unit as a whole			Yes	Yes		Yes
Sheldon Contiguous WSA Inholding Unit 30		119	Yes: Parcels are remote, undeveloped areas within an existing recommended BLM WSA			Yes	Yes		Yes
Tenmile Unit 31		3,702	Yes		Yes	Yes	Yes	Yes: Mountain mahogany habitat	Yes
Thousand Creek Unit 32		10,766	No: The unit does not appear natural as a whole due to the presence of permanent roads and additional developments on private lands	No: Activities and uses associated existing roads and private lands reduce opportunities for solitude or a primitive type of recreation			Yes		No
Upper Virgin Creek/Alkali Reservoir Unit 33		5,715	Yes			Yes	Yes		Yes

Refuge Unit	Proposed Wilderness Area (1974)	Acres	Criteria 1: Naturalness	Criteria 2: Outstanding Opportunities for Solitude or Primitive and Unconfined Recreation (at least one of three required)			Criteria 3: Size	Criteria 4: Supplemental Values	Unit qualifies as WSA[1]
				2a	2b	2c			
Virgin Valley Unit 34		31,220	No: The number, size, and, density of developments and disturbances resulting from mining, ranching, and refuge management activities make this the least naturally appearing unit within Sheldon Refuge; it is unlikely this unit would appear natural even with extensive restoration and rehabilitation or a substantial amount of time to naturally recover	No: Constant commercial mining activities, pubic use, motorized vehicle use, and other activities eliminate nearly all opportunities for solitude or a primitive type of recreation	No: Recreation activities and uses within the unit are highly mechanized, supported by modern development, and controlled through rules and regulation		Yes	Yes: Geology and opals	No

[1] Unit qualifies as WSA if it meets criteria 1, 2a or 2b or 2c, and 3.

F.2 Wilderness Study Areas

Based upon the wilderness review for Sheldon Refuge, 15 of the 34 wilderness inventory units totaling 189,389 acres were determined not suitable for wilderness study because they do not meet the minimum criteria for wilderness character. The remaining 19 of the 34 distinct and separate units totaling 388,772 acres were identified as meeting the definition of wilderness and meeting the criteria for wilderness study. This total area constitutes 67% of the entire 578,161 acres evaluated for wilderness study. These 19 units make up the following 17 wilderness study areas (WSAs):

- Big Mountain WSA
- Sage Hen Hills WSA
- Gooch Table WSA
- Fish Creek Mountain WSA
- Rye Creek WSA
- Round Mountain WSA
- Catnip Mountain WSA
- Big Spring Table WSA (includes portions of the Big Spring Table and Jackass Flats units)
- Railroad Point WSA (includes portions of the Big Spring Table and Jackass Flats units)
- Alkali Peak WSA (includes Alkali Peak and Upper Virgin Creek/ Alkali Reservoir units)
- Hell Creek WSA
- Guano Creek WSA
- Massacre Rim Contiguous WSA
- Sheldon Contiguous Inholdings WSA
- Fish Creek Table-Little Catnip WSA
- Bateman WSA
- Tenmile WSA

F.3 Refuge Recommendations for WSAs

In total, Sheldon Refuge recommends 341,495 acres or 88% of the 388,772 acres found suitable for wilderness study be designated by Congress as wilderness as defined by the Wilderness Act of 1964.

Nearly all of Sheldon Refuge possesses wilderness character but also has been influenced by human activities. Several WSAs determined to meet the definition of wilderness for the purposes of this review include lands previously proposed for wilderness designation. These WSAs continue to contain valuable wilderness resources and, with the exception of vehicle trespass, have been effectively managed to meet the mission of the Service, the purposes for Sheldon Refuge, and the purposes of the Wilderness Act for the past 36 years. Upon further review, Sheldon Refuge has determined the existing situation is not substantially different so as to preclude the effective and continued management of these lands as wilderness. Sheldon Refuge has also determined that lands within certain WSAs acquired subsequent to the initial 1974 wilderness recommendation are substantially similar to surrounding proposed wilderness areas both in terms of resource values and management requirements. Therefore, Sheldon Refuge makes the following recommendations for these WSAs.

F.3.1 Big Mountain WSA

The entire 23,361-acre Big Mountain WSA is recommended for wilderness designation. This recommendation is consistent with the original 1974 recommendation and proposal. Today there are six additional permanent structures (i.e., guzzlers) within the WSA. No routes provide access to any of the six guzzlers and use of a helicopter would likely be necessary to conduct major maintenance or replacement, similar to initial construction. However, these guzzlers and the use of aircraft for their maintenance would not preclude the designation or management of this area as wilderness. Other developments and disturbances noted during the 1974 wilderness inventory are less visible today and no other management manipulation or intrusion has been identified as necessary for the management of the Big Mountain WSA, which would be inconsistent with wilderness purposes.

F.3.2 Sage Hen Hills WSA

The entire 21,068-acre Sage Hen Hills WSA is recommended for designation as wilderness. This is not consistent with the original 1974 recommendation. No specific reason was given as to why this unit was not recommended for wilderness designation in 1974, but Map 6 of the Wilderness Study Report (USFWS 1974) indicated "range rehabilitation" was planned for nearly the entire unit. Presumably, activities would have included additional fencing and intensive artificial water development listed as recommended management activities in Step 1 of the Management Framework Plan for the Catnip Mountain grazing allotment (BLM 1972). These planned activities did not occur, and today the Sage Hen Hills WSA remains some of the most undeveloped, pristine, and productive habitat for pronghorn and Greater sage grouse within Sheldon Refuge. Other than maintenance of fences along the Sheldon Refuge boundary, no specific actions have been determined necessary for the continued management of lands within this WSA which would be inconsistent with wilderness purposes.

F.3.3 Gooch Table WSA

The entire 40,038-acre Gooch Table WSA is recommended for wilderness designation. This is consistent with the original 1974 wilderness recommendation and proposal. The Gooch Table WSA retains the same wilderness character as in 1974.

The majority of the WSA was previously proposed for wilderness designation, but also includes 3,000 acres near Highway 140, which has not been proposed. Most of the 3,000-acre area near Highway 140 is open to the location of mining claims, but little prospecting has occurred, no claims have been established, and there is little or no need for management activities within the unit which conflict with wilderness designation. Therefore, the recommendation would protect and preserve wilderness character of the WSA but would not interfere or hinder any ongoing or planned mining activities.

With the exception of a few historic vehicle routes and disturbances that are gradually recovering to a more natural appearance, the WSA remains unchanged from its natural condition and there is no need for active management to remove developments or conduct habitat restoration work. The isolation of the table topography and abundance of low sagebrush habitat create conditions such that the likelihood and need for aggressive wildfire suppression is low, but the importance and value to pronghorn and other sagebrush-dependent wildlife is high.

F.3.4 Fish Creek Mountain WSA

The entire 13,786-acre Fish Creek Mountain WSA is recommended for wilderness designation. This is consistent with the original 1974 recommendation and proposal. There are two parcels of private land within the WSA, but motorized access has not been documented and is not likely necessary for their use or development. Currently the Service is in negotiations to acquire one of these parcels from a willing seller. It is expected that some management intrusion and use of motorized equipment would be necessary to remove abandoned water troughs and restore three developed springs within the unit. Otherwise, no specific management actions have been determined necessary for the continued management of the WSA that would be inconsistent with wilderness purposes.

F.3.5 Rye Creek WSA

An area 17,453 acres in size within the eastern portion of the Rye Creek WSA is recommended for wilderness designation. The remaining 10,698 acres are not recommended primarily to allow the use of mechanical thinning of encroaching western juniper and prescribed burning to restore natural habitat and fire regime conditions to this portion of Sheldon Refuge. It is anticipated these activities would require repeated use of motorized and mechanized equipment and vehicles along previous established routes which would substantially affect opportunities for solitude and would reduce the natural appearance of the area. The cutting, thinning, and burning of native vegetation on the lands that are not recommended is also not consistent with the principles of wilderness management and would reduce the untrammeled natural character within this portion of the unit.

F.3.6 Round Mountain WSA

Sheldon Refuge recommends this WSA be divided into two separate proposed wilderness areas allowing a former primitive route corridor to be reopened to public vehicle access. The eastern portion of the Round Mountain WSA (15,512 acres) would be separated from the western portion of the Round Mountain WSA (20,600 acres) by a designated route corridor 100 feet wide consisting of approximately 172 acres extending from the northern Sheldon Refuge boundary to County Road 34A and including a 3-mile dead-end route extending to the west. This would be consistent with the original 1974 wilderness review and study, which recommended allowing this north-south route to remain in place. These routes are necessary for the removal, rehabilitation, and monitoring of several abandoned livestock developments located in the western portion of the Round Mountain WSA.

Despite the fact both routes have officially been closed since the 1974 wilderness proposal, recreation users continually use OHVs and other vehicles on these popular routes, making rehabilitation ineffective. Sheldon Refuge anticipates regular vehicle use of these routes to support future management activities and continued use by the public. Once re-established, these routes would provide legal access to an existing BLM vehicle route connecting to Highway 140 in Oregon.

F.3.7 Catnip Mountain WSA

An area 11,737 acres in size, which includes the southern portion of the Catnip Mountain WSA, is recommended for wilderness designation. The remaining 21,490 acres, which include the northern portion of the WSA, are not recommended. Disturbances from past vehicle use in the northern portion of the WSA have altered the natural appearance and are not recovering naturally. Sheldon Refuge is seeking to increase the range of wildlife-dependent recreation opportunities available, and recommending the entire WSA would conflict with this management direction. Currently there are

few remote areas within Sheldon Refuge that provide vehicle access and opportunities for high-quality wildlife viewing and hunting. Recommending the southern portion of the WSA would preserve wilderness character in the most undisturbed and naturally appearing portion of the WSA and enhance other remote recreation opportunities by allowing vehicle use along exiting routes in the remaining portion of the WSA.

F.3.8 Big Spring Table WSA

Sheldon Refuge recommends those portions of the Big Spring Table Unit and the Jackass Flats Unit, which are west of the identified primitive route, be combined to form the approximately 48,915-acre Big Spring Table WSA and that this WSA be designated as wilderness. Despite the fact most lands within the Jackass Flats Unit have been open to location of mining claims, little prospecting has occurred, no claims have been established, and there is little or no need for management activities within the unit that conflict with wilderness designation. The only portion of the Big Spring Table and Jackass Flats units not recommended for designation is a 100-foot-wide corridor extending 8.3 miles from Highway 140 to the northern boundary of Sheldon Refuge consisting of approximately 100 acres. This corridor would continue to provide administrative vehicle access through the Jackass Flats portion of the WSA and would re-establish administrative vehicle access through the current proposed wilderness area to Oregon for maintenance of fence lines and wildlife water guzzlers within Sheldon Refuge. This recommendation would effectively split the proposed wilderness area leaving the portion containing Railroad Point as a separate area approximately 11,000 acres in size.

Recommending the Big Spring Table WSA for wilderness designation would protect and preserve one of the most pristine and ecologically intact portions of Sheldon Refuge. When considered in combination with the adjacent Hawk Mountain and Sage Hen Hills WSAs managed by BLM, this recommendation would protect and preserve wilderness character of a continuous area approximately 102,600 acres in size.

F.3.9 Railroad Point WSA

Sheldon Refuge recommends those portions of the Big Spring Table Unit and Jackass Flats Unit east of the identified route (refer to unit maps) be combined to form the approximately 11,000-acre Railroad Point WSA and designated as wilderness.

Despite the fact most lands within the Jackass Flats Unit have been open to location of mining claims, little prospecting has occurred, no claims have been established, and there is little or no need for management activities within the unit that conflict with wilderness designation. The only portion of the Big Spring Table and Jackass Flats units not recommended for designation is a 100-foot-wide corridor extending 8.3 miles from Highway 140 to the northern boundary of Sheldon Refuge consisting of approximately 100 acres. This corridor would continue to provide administrative vehicle access through the Jackass Flats portion of the WSA and would re-establish administrative vehicle access through the current proposed wilderness area to Oregon for maintenance of fence lines and wildlife water guzzlers within Sheldon Refuge. This recommendation would effectively split the proposed wilderness area leaving the portion containing Railroad Point as a separate area approximately 11,000 acres in size.

F.3.10 Alkali Peak WSA

Sheldon Refuge recommends nearly the entire 61,204-acre Alkali Peak WSA for designation as wilderness. The WSA includes the Alkali Peak Unit (51,248 acres) which was previously proposed for wilderness designation, the Upper Virgin Creek/Alkali Reservoir Unit (5,715 acres) which was acquired by the Service through purchase, and the Sagebrush Basin Unit (4,241 acres). The only portion of the WSA not recommended for designation is a corridor that is 100 feet wide and 4.25 miles in length consisting of approximately 51.5 acres. This corridor extends downstream along Virgin Creek from Alkali Reservoir and contains an administrative vehicle access route and several historic ranching structures. Management efforts for preservation of these permanent structures and regular vehicle use for administrative purposes are not be consistent with wilderness values.

The Sagebrush Basin Unit was not recommended for wilderness designation in 1974 primarily due to anticipated mining and planned restoration activities that were inconsistent with wilderness management and necessary to meet the purposes for Sheldon Refuge. The area was subsequently withdrawn from mineral entry, which precluded additional mining activities, and the remaining management restoration activities (primarily the construction of erosion control structures and removal of sagebrush) have either been completed or are no longer considered necessary.

The reaches of Virgin Creek within the WSA are relatively undisturbed and intact. Preservation and protection of wilderness characteristics would benefit the various nesting raptors and other wildlife sensitive to human activities and disturbances. Protecting and preserving the undeveloped low sagebrush habitats of Rock Spring Table in their natural conditions are important for the conservation of pronghorn, Greater sage grouse, and other sagebrush-dependent wildlife.

Overall the Alkali Peak WSA contains truly remarkable scenery characterized by the broad high expanses of Rock Spring Table and the high vertical cliffs that form the canyon along Virgin Creek. The canyon affords isolation and remoteness to create outstanding opportunities for wilderness solitude.

F.3.11 Hell Creek WSA

Sheldon Refuge recommends the entire 13,969-acre Hell Creek WSA for designation as wilderness. The WSA includes a small portion of land previously proposed for wilderness designation, but primarily consists of that portion of Sheldon Refuge used to support the reintroduction of California bighorn sheep. This area was previously not recommended for wilderness designation due to the need for a large fence exclosure, water developments, and associated vehicle use and access routes. The reintroduction was successful, and the developments and access routes are no longer necessary for management purposes.

The Hell Creek WSA possesses a diversity of habitats, remarkable scenery, and nationally important prehistoric resources in a remote and undeveloped setting. These characteristics provide outstanding opportunities for wilderness solitude and primitive and unconfined types of recreation.

F.3.12 Guano Creek WSA

Sheldon Refuge recommends the entire 4,133-acre Guano Creek WSA for designation as wilderness. This area was not found suitable during the 1973 wilderness review due to historic cultivation for agriculture. Subsequent management by Sheldon Refuge has substantially restored the natural

appearance and ecological function of these lands, which has made them suitable for wilderness designation. When combined with the recommended Rye Creek WSA and Sheldon Contiguous WSA managed by BLM, this recommendation would protect and preserve wilderness character on a continuous area approximately 45,183 acres in size.

F.3.13 Massacre Rim Contiguous WSA

Sheldon Refuge does not recommend the 334-acre Massacre Rim Contiguous WSA for designation as wilderness. This recommendation is consistent with the current BLM recommendation for adjacent lands in the Massacre Rim WSA.

F.3.14 Sheldon Contiguous Inholdings WSA

Sheldon Refuge recommends the entire 119-acre Sheldon Contiguous Inholdings WSA for designation as wilderness. This recommendation is consistent with the current BLM recommendation for adjacent lands in the Sheldon Contiguous WSA.

F.3.15 Fish Creek Table-Little Catnip WSA

Sheldon Refuge recommends two separate portions of WSA be designated as wilderness. The recommendation would include an area approximately 8,755 acres in size west of Little Catnip Spring Road and another area approximately 20,371 acres in size north of County Road 8A. These lands represent some of the most intact natural habitats on Sheldon Refuge. The vast expanses of intact undeveloped sagebrush habitat, which are only occasionally visited by people, provide a sense of complete isolation and outstanding opportunity for wilderness solitude. Natural conditions are untrammeled, and ecological function is largely intact requiring few management activities.

The remaining 14,483 acres of the Fish Creek Table-Little Catnip WSA is not recommended for wilderness designation to allow continued and planned activities to restore and manage wildlife habitats. These management activities include prescribed burning along Andy's Place Road, maintenance of Swan Lake Reservoir and the earthen dam, and mechanical thinning of shrubs and trees on and around Bitner Butte. All of these activities are anticipated to require repeated long-term use of large vehicles and associated access routes, motorized and mechanized equipment, and other tools to manipulate the structure and function of habitats within portions of Sheldon Refuge. These tools and activities are considered necessary to fulfill the purposes for Sheldon Refuge but are generally not consistent with the principles of wilderness management.

F.3.16 Bateman WSA

Sheldon Refuge recommends the entire 5,772-acre Bateman WSA for designation as wilderness. This recommendation would protect and preserve relatively pristine and intact mountain mahogany habitats in their natural condition. These habitats are considered essential for fulfilling the purposes of Sheldon Refuge and for maintaining biological health, integrity, and natural diversity.

F.3.17 Tenmile WSA

Sheldon Refuge recommends the entire 3,702-acre Tenmile WSA for designation as wilderness. This recommendation would be consistent with the 2009 BLM findings and conclusion for the Ten Mile Spring WSA and would protect and preserve relatively pristine and intact mountain mahogany

habitats in their natural condition. These habitats are considered essential for fulfilling the purposes of Sheldon Refuge and for maintaining biological health, integrity, and natural diversity.

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Appendix G. Minimum Requirements Decisions and Analyses

G.1 Final Minimum Requirements Decision and Analysis for Removal of Feral Horses and Burros

Step 1: Determine if any administrative action is necessary. (Refer to the Sheldon Refuge CCP/EIS and preferred alternative).

Management direction for feral horse and burro populations was evaluated through a range of alternatives included in the Sheldon Refuge CCP/EIS. The CCP/EIS preferred alternative for removal of feral horse and burros has been determined necessary for management of Sheldon Refuge and the proposed wilderness areas.

Step 2: Determine the minimum activity/minimum tool.

Description of Alternatives

Activities considered as part of this minimum requirements and decision analysis do not include the use of vehicles for law enforcement purposes. Such uses have not been necessary in the past, but could occur during horse and burros gathers to ensure the health and safety of contractors, employees, and the general public. Uses of motorized vehicles and equipment, mechanical transport, or aircraft within the proposed wilderness may be authorized in emergency situations and are not subject to a minimum requirements and decision analysis (610 FW 1).

Alternative A

Description

Gathers of feral horses and burros would be conducted on horseback, using temporary corrals or bait-traps, and other non-mechanized and non-motorized tools and techniques within proposed wilderness not otherwise prohibited by the Wilderness Act and Service wilderness policy. Gathers would be conducted much as they were prior to the availability of high clearance four-wheel drive vehicles, stock trailers, and portable metal fencing panels commonly used today. Trap sites would consist of exiting canyons or stone corrals and could include sections of lightweight fence, which could be transported on foot or by horseback and erected for temporary use. If trap sites within the proposed wilderness areas are used, a number of herders would then be needed drive animals to additional holding pens located along nearby roads where they could then be loaded and transported by truck and trailer.

Effects

Wilderness Character

"Untrammeled"
The use of horseback riders and temporary corrals would not alter natural processes. Because horses presently occur throughout Sheldon Refuge, the presence of horseback riders would have a temporarily but negligible effect on the behavior and movements of wildlife, particularly large mammals such as bighorn sheep, mule deer, and antelope. Feral horses and burros are by definition the descendants of escaped domesticated livestock and are not part of the native ecology or natural

processes within Sheldon Refuge. The removal of these animals would result in less trammeling of wilderness character over the long term.

"Undeveloped"
This alternative would not require further development of any temporary roads or permanent facilities within the proposed wilderness areas and would have little or no effect on the undeveloped character of the proposed wilderness areas.

"Natural"
The use of horseback riders to conduct gathers would protect and preserve natural conditions within the proposed wilderness areas.

"Outstanding Opportunities for Solitude or a Primitive and Unconfined Type of Recreation"
In areas where gathers take place, the presence of several horseback riders would reduce opportunities for solitude for up to two weeks during the summer months. These activities would not impact opportunities for primitive or unconfined types of recreation.

Other Unique Components that Reflect the Character of this Wilderness

Heritage and Cultural Resources
N/A

Maintaining Traditional Skills
The primitive and traditional skills required for horseback gathers and roundups are used less often and may become lost altogether as both government agencies and rancher increasingly rely on motorized equipment such as helicopters and OHVs. This alternative would result in the continued practice and teaching of these primitive skills, but only for a relatively short period of time until removal is complete.

Special Provisions
N/A

Economic and Time Constraints
It is doubtful any amount of time or money would result in the removal of all horses and burros from Sheldon Refuge with gathers conducted only by horseback. Even if this method could be effective, it is likely dozens of skilled riders would be required to conduct gather operations for several weeks to months each year. The costs for such gathers would likely be greater than those required to implement Alternative B or C and would likely be prohibitive.

Additional Wilderness-specific Comparison Criteria
N/A

Safety of Visitors, Personnel, and Contractors

The terrain of Sheldon Refuge is very rugged, rocky, and difficult to traverse by foot or on horseback. Feral horses living within Sheldon Refuge develop strong hooves and the stamina needed to run long distances over rugged, broken, and uneven rocky terrain. Riding a domestic horse, even shod with steel horseshoes, at similar speed over this terrain to conduct gathers would almost certainly result in injury to some horses and probably riders as well. Proper training, riding skill, and conditioning could reduce the potential for such injuries, but safety risks would remain high.

Alternative B

Description

Gathers of feral horses and burros would be conducted using helicopters to herd animals into temporary corrals located adjacent to, or within, proposed wilderness and along existing trails and routes. Transportation of temporary corrals and captured animals would be accomplished using trucks and trailers travelling on existing routes. Gathers would typically take place once or twice per year over a period of four to six days per gather.

Prior to the location of corral sites within wilderness, the existing access route and corral site would be photographed and monitored and the condition documented in conjunction with a cultural resource inventory. No maintenance or surface disturbance would be allowed to improve the access route or the corral site. The corral site would be located the minimum distance from the proposed wilderness boundary necessary and would be the minimum size necessary to safely and humanely hold the animals for transport.

Prior to motorized vehicle access, truck and trailer drivers would be provided maps indicating the exact route and corral location. Vehicle use would be authorized only for the minimum number of trips necessary to transport corral materials and animals. All other access would be on foot or by horseback.

Upon completion of the gather operations, all materials and structures would be removed. Once the management objective has been achieved, the corral site and route would be restored to their condition prior to use using standard wilderness route rehabilitation and restoration methods and primitive tools. Access routes and corral sites would be photographed and monitored following the first full growing season to document impacts from use and the effectiveness of restoration efforts, as well as to detect any newly introduced noxious weeds or other non-native species. Subsequent monitoring would be conducted as needed to document vehicle trespass and route recovery.

Effects

Wilderness Character

"Untrammeled"
Impacts from gather operations would be greater than those described for Alternative A or C. Impacts would likely affect a larger number of wildlife over the majority of Sheldon Refuge due to the noise and movement of helicopters conducting operations over large areas each day during gather operations.

"Undeveloped"
The use of temporary routes and erection of temporary corrals within proposed wilderness areas under this alternative would result in a more developed appearance during gathers when compared with Alternative A or C. All structures would be removed following each gather and impacts to the undeveloped character of the proposed wilderness areas would be short-term.

"Natural"
The crushing and disturbance of vegetation and soils from the use of motorized vehicles and temporary corral sites would adversely impact the natural appearance within portions of the proposed

wilderness areas. The removal of temporary structures after each gather and rehabilitation of routes and corral sites following completion of horse and burro removal efforts would mostly restore natural conditions and leave little long-term evidence of past use and development. It is anticipated for some routes, restoration efforts would not be effective and evidence of vehicle use would remain visible for several years. Because some routes would remain visible, it is also anticipated public vehicle trespass within the proposed wilderness areas would occur along these routes, causing further adverse impact to wilderness character.

"Outstanding Opportunities for Solitude or a Primitive and Unconfined Type of Recreation"
Where gathers are conducted, very few opportunities for solitude would be available for the anticipated four to six days per gather. Opportunities within a larger area would be impacted than under Alternative A or due to the distances over which helicopters would be seen and heard, and these impacts would occur more frequently than under Alternative C. Impacts to opportunities for solitude would not last as long as those described for Alternative A due to the shorter amount of time necessary to conduct gathers using helicopters. However, few people visit the proposed wilderness areas during summer, and gather operations under all alternatives would impact a relatively small number of recreation users.

Other Unique Components that Reflect the Character of this Wilderness

Heritage and Cultural Resources
N/A

Maintaining Traditional Skills
This alternative would not maintain traditional skills.

Special Provisions
N/A

Economic and Time Constraints
Despite the high costs associated with helicopters, the cost of this alternative would be considerably less than cost associated with potentially dozens of horses and riders needed to conduct gathers under Alternative A. In addition, the use of helicopters results in far less time than that required to conduct horseback gathers in a similarly sized area.

Additional Wilderness-specific Comparison Criteria
N/A

Safety of Visitors, Personnel, and Contractors

The use of helicopters at low elevation to gather horses and burros does increase the level of risk when compared with standard point-to-point helicopter use. Gathers are planned based on the identification and avoidance of hazards such as terrain, fence lines, and power lines to minimize risk to the extent possible. Risks associated with horseback gathers under Alternative A do not necessarily differ from those under this alternative, but the greater number of people and animals involved with horseback gathers does increase the probability for injury or accident when compared with the use of a single helicopter and pilot under this alternative.

Alternative C

Description

Gathers of feral horses and burros would be conducted using a combination of tools and techniques included in Alternatives A and B.

Under this alternative the majority of burros would be gathered by horseback or using bait-traps located outside proposed wilderness, and the majority of horses would typically be gathered using helicopters or other aircraft to herd animals to temporary corrals located adjacent to roads outside proposed wilderness areas. Landing of helicopters would be conducted within wilderness only when determined necessary for pilot, crew, or animal safety.

The placement of temporary corrals for the gathering of horses and burros is critical for safe and effective removal. Recent gather operations have successfully used roads and temporary corral sites outside proposed wilderness, but it is anticipated at least some sites within one or more proposed wilderness areas would be necessary to fully implement the minimum administrative action necessary. Corral site selection criteria include visibility (of the corral site by horses and burros; for horseback riders on the ground; and for safe low-level aircraft operations), terrain and obstacles (as related to effective sight distance, confinement, or interference with the movement of horse and burros being gathered; for horseback riders; and as hazards to low-flying aircraft), other hazards (such as overhead power lines or cliffs), and animal transport time (as a function of weather, safe vehicle speed, and overall distance from the corral site to the holding facility) are all determining factors in corral site selection to ensure a safe and effective gather operation.

The minimum number of temporary corral sites in support of gather operations would be located within proposed wilderness only upon the written determination by the Sheldon Refuge Project Leader that no safe and effective corral site could be located outside proposed wilderness which meets the above stated criteria. In the future, it is most likely two or three temporary corral sites would be located within the Alkali Peak and Big Spring Table proposed wilderness areas due to the number of horses present, the ruggedness of the terrain limiting the distance horses can be moved to trap locations, the relatively larger size of these two areas, and the distance from portions of these areas to adjacent roads. Sites would likely be used once or twice per year for up to five years in order to implement the Sheldon Refuge CCP/EIS preferred alternative.

Effects

Wilderness Character

<u>"Untrammeled"</u>
Impacts to untrammeled wilderness character would likely be between those described for Alternatives A and B.

<u>"Undeveloped"</u>
The types of impacts to untrammeled wilderness character would be similar to those described for Alternative B, but the lower number of temporary corrals proposed under this alternative would impact fewer proposed wilderness areas less often than anticipated under Alternative B.

"Natural"
The types of impacts to natural wilderness character would be similar to those described for Alternative B, but would occur less often and would impact fewer proposed wilderness areas due to the smaller number of temporary corrals located within proposed wilderness under this alternative.

"Outstanding Opportunities for Solitude or a Primitive and Unconfined Type of Recreation"
Horses are found throughout Sheldon Refuge, and impacts to opportunities for solitude from gathers using helicopters would occur in all proposed wilderness areas as described under Alternative B.

Feral burros are commonly observed in and around the southern portion of the Big Spring Table proposed wilderness area and in the northern portion of the Gooch Table Proposed Wilderness Area. Impacts to opportunities for solitude in these areas would be as described under both Alternative A and B.

Other Unique Components that Reflect the Character of this Wilderness

Heritage and Cultural Resources
N/A

Maintaining Traditional Skills
This alternative would maintain traditional skills as described under Alternative A.

Special Provisions
N/A

Economic and Time Constraints
Gathers of both horses and burros are conducted by qualified private contractors. By allowing the use of either horseback riders or helicopters to conduct gathers, Sheldon Refuge would be able to accept the least expensive and most efficient method proposed for each particular gather. In certain areas and under certain conditions it is expected horseback gathers would be both less expensive and less time-consuming than helicopter gathers and vice versa.

Additional Wilderness-specific Comparison Criteria
N/A

Safety of Visitors, Personnel, and Contractors

Typically horseback gathers are most practicable for feral burros in the lower elevation greasewood and salt scrub flats of the Virgin Valley and Thousand Creek drainages. Terrain in these locations is much gentler and domestic horses can more easily and safely be ridden than in other portions of Sheldon Refuge. The use of helicopters in other portions of Sheldon Refuge is generally accepted to be the safest method for the animals and people involved.

Comparison of Alternatives

It may be useful to compare each alternative's relative positive and negative effects to each of the criteria in tabular form, keeping in mind the law's mandate to "preserve wilderness character."

	Alternative A	Alternative B	Alternative C
Untrammeled	+	-	+/-
Undeveloped	+	-	-
Natural	+	-	-
Solitude or Primitive Recreation	+	-	+/-
Unique Components			
Wilderness Character	+	-	-

	Alternative A	Alternative B	Alternative C
Heritage and Cultural Resources			
Maintaining Traditional Skills	+	-	+
Special Provisions			
Economics & Time	-	+	+
Additional Wilderness Criteria			
Other Criteria Summary	+/-	+/-	+

	Alternative A	Alternative B	Alternative C
Safety	-	+	+

Safety Criteria

The selection criteria for each horse and burro corral site are primary to ensure safety for both people and animals. Sites would be located within proposed wilderness **only** after it has been determined that a safe and effective corral site cannot be found outside proposed wilderness that meets the stated selection criteria. This determination will be documented in writing on a site-by-site basis during the gather planning phase.

Step 2 Decision: What is the <u>Minimum</u> Activity/Minimum Tool?

Selected Alternative

Alternative C

<u>Rationale</u> for Selecting this Alternative (Including Documentation of Safety Criterion, If Appropriate)

Gathering of horses and burros by horseback as described under Alternative A would be the least intrusive method within the proposed wilderness areas, but is unlikely to meet the management objective of the Sheldon Refuge CCP preferred alternative. Temporary corrals baited with feed or feed-traps are effective for gathering small numbers of feral burros and the use of horseback riders to herd feral burros has been successful for some gathers on Sheldon Refuge. Gathers conducted from horseback would likely be successful in areas of Sheldon Refuge with high concentrations of feral horses and ideal sites for temporary corrals. However, in areas with lower population density and as the population in other areas are reduced, horseback gathers would become increasingly difficult, time-consuming, and costly. Even with large numbers of riders and sufficient funding, gathers

conducted only from horseback are unlikely to be successful in gathering all feral horses and burros from Sheldon Refuge, which is required to fully implement the minimum administrative action necessary. As a result, horses and burros would continue to cause adverse impacts to Sheldon Refuge and wilderness character discussed under the No Action alternative of the Sheldon Refuge CCP/EIS.

In contrast, Alternative B would likely accomplish the minimum administrative action necessary as discussed under the preferred alternative of the Sheldon Refuge CCP/EIS, but would also result in the greater impact to wilderness character than the other options considered and would result in considerable cost.

Alternative C would minimize impacts to wilderness character to the extent practicable while providing a high probability for full implementation of the minimum administrative action necessary. Alternative C is also determined to be the safest and most cost effective alternative evaluated.

Monitoring and Reporting Requirements

No use of motorized vehicles would occur without a prior written determination by the Sheldon-Hart Mountain Refuge Complex Project Leader based upon a written evaluation using the corral trap site selection criteria listed in Alternative C. All areas where use of mechanized or motorized equipment occurs and where temporary structures are erected would be monitored and degradation of natural conditions reported.

Check Any Wilderness Act Section 4(c) Uses Approved in this Alternative

- ☒ mechanical transport
- ☐ motorized equipment
- ☐ motor vehicles
- ☐ motorboats
- ☐ landing of aircraft
- ☐ temporary road
- ☐ structure or installation

Record and report any authorizations of Wilderness Act Section 4(c) uses according to agency procedures.

Approvals	Signature	Name	Position	Date
Prepared by:		Aaron P. Collins	Park Ranger	9/25/12
Recommended:		John W. Kasbohm	Project Leader	9/25/12
Approved:		Charles J. Houghten	Regional Wilderness Coord.	9/27/12

G.2 Final Minimum Requirements Decision and Analysis for Reduction and Thinning of Western Juniper within Sheldon Refuge Proposed Wilderness Areas

Step 1: Determine if any administrative action is necessary. (Refer to the Sheldon Refuge CCP/EIS and preferred alternative).

Management direction for management of encroaching western juniper was evaluated through a range of alternatives included in the Sheldon Refuge CCP/EIS. The CCP/EIS preferred alternative for the reduction and thinning of western juniper has been determined necessary for management of Sheldon Refuge and the proposed wilderness areas.

Step 2: Determine the minimum activity/minimum tool.

Description of Alternatives
Western juniper is a native species, but its expansion into sagebrush-steppe habitats as a result of continued long-term fire suppression and overgrazing for more than 100 years has severely degraded these habitats and as a result has adversely impacted priority wildlife species and the purposes for Sheldon Refuge. Areas of juniper expansion have been identified at various locations, primarily in the westernmost portion of Sheldon Refuge. While juniper expansion has been identified with proposed wilderness areas, we anticipate project areas would be located almost entirely within the Rye Creek Proposed Wilderness Area in the western portion of Sheldon Refuge, where approximately 5,000 acres have been identified for treatment. Terrain within the Rye Creek Proposed Wilderness Area is rugged and particularly steep along the westernmost edge. The entire unit is within 2 miles of established roads, and two access routes are located in the western half of the Rye Creek Area, where the majority of the 5,000 acres identified are located.

Average tree density and size within the Rye Creek Proposed Wilderness Area are highly variable. Densities range from only a few trees per acre to more than 150 trees per acre. Tree sizes range from less than two inches to more than 12 inches diameter breast height (dbh). These larger trees often have lower branches 4 inches or more in diameter, and near ground level below these lowest branches, trunk diameters can be more than 20 inches. While size and age structures have not been determined for juniper stands within Sheldon Refuge, sampling of western juniper stands in Eastern Oregon reveal juniper less than 5 inches dbh are typically less than70 years old, and represent about 7% of the total juniper trees within the stand. This same study reported 75% of juniper five inches dbh and larger were 70 to 130 years in age, and most were between 90 and 109 years in age (Gedney et al. 1999). These percentages are consistent with estimated areas of juniper expansion within the Rye Creek Proposed Wilderness Area. Using these estimates, approximately 350 acres of juniper within the Rye Creek Proposed Wilderness Area would be categorized as less than 5 inches dbh. Throughout the remaining 4,650 acres, we assume average density is 50 trees per acre.

Removal of western juniper has been focused on accessible non-wilderness areas throughout the region where the use of motorized tools and mechanized equipment are standard practice. Primitive tools and non-motorized methods have rarely been used for large-scale juniper reduction and thinning projects. The alternatives presented in this minimum requirements decision and analysis are considered a reasonable basis for initiating juniper treatments based upon knowledge of these tools and techniques when used for other tree species and in dissimilar environments.

Western juniper grows with branches close to the ground and has a dense, hard wood. Juniper is killed by cutting only when the cut is made below the lowest live branch. These characteristics make effective control of expanding juniper with hand tools more difficult and labor intensive than for other western tree species. Herbicides have been shown to effectively kill only smaller juniper less than 6 feet in height (Lile et al. 2004). For the purposes of this minimum requirements decision and analysis we assume one person using hand tools (e.g., pruning saw, pruning shears, axe, single-person crosscut saw, brush axe) would be able to cut 40 trees with an average dbh of 5 inches or less during a 10-hour workday, or less than 10 trees 5 to 12 inches dbh in the same amount of time. We also assume a one person using power tools (e.g., chainsaw, power pruning saw, power brush cutter) would be able to cut twice the number of trees in the same amount of time when compared to a person using primitive tools. While tree diameter is not the best indicator of tree age, we expect trees larger than 12 inches dbh would usually be considered mature old-growth trees (i.e., >120 years old) and would not be cut as part of juniper reduction and thinning. We anticipate these assumptions and consequently the minimum management action and tools necessary would be adjusted as additional inventory data and experience are obtained.

Alternative A

Description

Control of expanding western juniper on an average of 1,500 acres per year would be completed using a combination of chemical herbicides and cutting with primitive hand tools. Access and transport of tools and equipment would be by foot, horseback, pack stock, or other non-mechanized and non-motorized means.

Chemical control would be single tree application of approved herbicides as liquid concentrate through an applicator gun, dry pellets placed under the drip line, or as a spray applied to the foliage with a backpack sprayer. We anticipate these methods would be used most often where juniper are sufficiently small and occur at low density (less than 10 trees per acre) where carrying hand tools would be more cumbersome and cutting through small fine branches and more flexible stems would be more difficult and time consuming.

Cutting, felling, limbing, piling, and burning of western juniper would be conducted using non-motorized tools and equipment. Work crews using crosscut saws, axes, pruning saws, limbing shears, drip torches, and other primitive hand tools would remove or thin juniper. Burning of felled trees and limb piles would take place during typically cooler and wetter winter months.

Based upon the assumptions for this minimum requirements decision and analysis, accomplishment of the management objectives under the CCP preferred alternative of 1,500 acres per year would require two 20-person crews working for the entire year. In areas furthest from road access and with the highest density of juniper, it is expected seasonal tent camps would be used with regular resupply of food, water, tools, and equipment.

Temporary work crew campsites and latrine sites would be selected in advance. Sites would be capable of supporting one or more potential juniper thinning efforts. Access routes for seasonal camps or campsites anticipated to be used for multiple seasons would also be identified in advance. Both access routes and campsites would be photographed and inventoried prior to use in conjunction with a cultural resource inventory to document wildlife present, measure vegetative cover, and to identify noxious weeds and other invasive non-native plants. No maintenance or surface disturbance

would be allowed to improve access routes. Rocks and other obstacles could be temporarily moved to provide suitable tent sites. Temporary latrines for burial of waste would be excavated to the minimum depth and size necessary.

Upon completion of juniper reduction and thinning operations, all materials and structures would be removed. Once the management objective has been achieved, campsites would be restored to their prior appearance using standard wilderness rehabilitation and restoration methods and primitive tools. Access routes and campsites would be photographed and monitored following the first full growing season to document impacts from use and the effectiveness of restoration efforts, as well as to detect any newly introduced noxious weeds or other non-native species. Subsequent monitoring would be conducted as needed to document wildlife use and campsite recovery.

Effects

Wilderness Character

"Untrammeled"
The presence of 20-person work crews for the entire year within the same general location is expected to alter wildlife behavior and habitat use. These impacts would be expected to last for several years after treatment of the entire 5,000 acres is completed. Over the long term as native perennial grasses, forbs, and shrubs become re-established, we would expect several wildlife species absent from these areas over the past several decades to return. Long-term trammeling of wilderness character from cutting and burning of juniper was evaluated in the Sheldon Refuge CCP/EIS.

"Undeveloped"
Year-long work camps consisting of small and large tents would affect the undeveloped character of small portions of the Rye Creek Proposed Wilderness Area. Following campsite removal and restoration, little or no noticeable evidence of temporary developments would remain. Use along identified access routes would be noticeable but would appear as undeveloped and unmaintained trails.

"Natural"
Where juniper is treated using herbicide, the few trees killed would be left standing and would appear to have died naturally. Higher amounts of herbicide needed to kill larger trees can also kill nearby shrubs, which would create a somewhat less natural appearance.

Natural conditions would be affected for many years by the presence of cut stumps throughout the Rye Creek Proposed Wilderness Area, reminding visitors of past use and human activities. Use of access routes and campsites would result in damage to vegetation, including shrubs and other perennials, and these impacts would be noticeable for several years. Following campsite removal and restoration, impacts would remain readily visible for several years due to the contrast between work camp locations lacking shrubs and other longer-lived plants and the surrounding undisturbed areas where these plants would remain. It is anticipated these impacts would occur at as many as six campsites, each less than 1 acre in size located primarily along the northern portion of the Rye Creek Proposed Wilderness Area. Long-term impacts to the natural conditions from the thinning and reduction of juniper were evaluated in the Sheldon Refuge CCP/EIS.

"Outstanding Opportunities for Solitude or a Primitive and Unconfined Type of Recreation"
Opportunities for solitude would be difficult to find due to the presence of two 20-person work crews within the area for the entire year. Generally, effects would occur within the project area and near campsite locations. The use of hand tools would have little or no impact on opportunities for primitive recreation. However, the appearance of thousands of cut stumps across 5,000 acres would serve as a reminder of human activity and intrusion and would adversely impact opportunities for solitude over the long term. Most of the project area is within a portion of Sheldon Refuge closed to hunting, and recreation use is estimated to be very low. As a result, impacts to solitude would affect few people.

Other Unique Components that Reflect the Character of this Wilderness

Heritage and Cultural Resources
N/A

Maintaining Traditional Skills
Under this alternative dozens of people with little or no prior experience would learn to use, and teach others to use, specialized primitive tools and skills (i.e., crosscut saws and saw maintenance) necessary for future wilderness preservation and management.

Special Provisions
N/A

Time Constraints
To achieve the objectives of the administrative action would require two 20-person crews working throughout the entire year over the next three to four years. Working throughout the year is not practical given the availability of large work crews, the required logistical support to sustain such large crews in a wilderness work environment, and inclement winter weather, which would periodically stop work. The training, tools, equipment, support, and other costs associated with such large numbers of people would require substantially more time to meet management objectives than that required for other alternatives.

Additional Wilderness-specific Comparison Criteria
N/A

Safety of Visitors, Personnel, and Contractors

The use of hand tools required to implement this alternative results in fewer accidents and less severe injuries than motorized tools designed to accomplish the same tasks. The use of herbicides as proposed under this alternative presents little risk to health or safety when handled and applied properly and according to product labels. Other risks and potential safety issues encountered within proposed wilderness are generally no greater than those encountered in other remote areas of Sheldon Refuge.

Alternative B

Description

Cutting, felling, limbing, piling, and burning of western juniper within proposed wilderness would be conducted using both motorized and non-motorized tools and equipment. Transport of tools and

equipment would be by motorized vehicle along two existing routes located in the western portion of the Rye Creek Proposed Wilderness Area. Access for work crews to project areas would be by foot or horseback.

Work crews using chainsaws, motorized pruning saws, limbing shears, drip torches, and other hand tools would remove or thin juniper as described in Alternative A.

Under the assumptions described for this analysis, we expect motorized tools would be twice as effective as hand tools for cutting juniper. As a result, only half as many people (one 20-person crew) or half as much time (two 20-person crews for six months) would be required to accomplish the management objective of treating 1,500 acres as proposed under the CCP preferred alternative when compared with Alternative A. In areas farthest from road access and with the highest density of juniper, it is expected short-term tent camps would be used for periods up to four days. All supplies for temporary camps would be transported with tools and other equipment required for juniper thinning and removal.

Access routes would be photographed and inventoried prior to use to measure vegetative cover, and to identify noxious weeds and other invasive non-native plants. No maintenance or surface disturbance would be allowed to improve access routes. Transport of tools, equipment, and materials would be accomplished using one vehicle making a single trip to the project and/or campsite within the proposed wilderness area, and a single trip out each week.

Upon completion of juniper reduction and thinning operations, all waste, materials, and structures would be removed. Once the management objective has been achieved, campsites would be restored to their prior condition using standard wilderness rehabilitation and restoration methods. Access routes and campsites would be photographed and monitored following the first full growing season to document impacts from use and the effectiveness of restoration efforts, as well as to detect any newly introduced noxious weeds or other non-native species. Subsequent monitoring would be conducted as needed to document route and campsite recovery and document future vehicle trespass into proposed wilderness areas.

Effects

Wilderness Character

"Untrammeled"
The presence of work crews for multiple four-day periods within the same general location is expected to alter wildlife behavior and habitat use until thinning and burning efforts are completed. Because activities would occur less often and for a shorter amount of time than under Alternative A, we anticipate these impacts would not persist for several years after juniper reduction is completed. Long-term trammeling of wilderness character from cutting and burning of juniper was evaluated in the Sheldon Refuge CCP/EIS.

"Undeveloped"
Short-term work camps consisting of small tents would have less temporary impact on the undeveloped character of proposed wilderness than Alternative A. Following campsite removal and restoration, little or no noticeable evidence of temporary developments would remain. Access by motor vehicle would occur less frequently than foot or horseback access described under Alternative A. However, previously established routes would continue to be easily identified as primitive two-

track vehicle routes in contrast to the more naturally appearing undeveloped trails anticipated under Alternative A.

"Natural"
The use of chainsaws and other motorized tools to conduct juniper thinning would result in a less natural appearance of stumps and unburned logs when compared with Alternative A. Use of access routes and campsites would also result in damage to vegetation, including shrubs and other perennials. The use of smaller short-term camps would also avoid impacts from Alternative A of digging latrines to bury waste. When compared with Alternative A these impacts would be less severe, would affect smaller areas, and would be noticeable for a shorter amount of time due to smaller work crews, smaller campsites, and less use of routes with no camp resupplies needed. It is anticipated these impacts would be only somewhat noticeable for many years at as many as three campsites, each less than 0.3 acre in size, located primarily in the most remote northwest portion of the Rye Creek Proposed Wilderness Area where juniper density is highest. Long-term impacts to natural conditions from thinning and removal of juniper were evaluated in the Sheldon Refuge CCP/EIS.

"Outstanding Opportunities for Solitude or a Primitive and Unconfined Type of Recreation"
Opportunities for solitude would be directly affected by the presence of work crews as large as eight people and the sounds of chainsaws and other motorized equipment. Noise from a single vehicle trip for transport of tools, equipment, and supplies would have only a slight short-term impact on wilderness solitude. Overall, noise impacts to wilderness solitude under this alternative would be more intense and would affect a larger area than larger work crews using hand tools as proposed in Alternative A, but these impacts would last for a shorter length of time.

The use of motorized tools and equipment would detract from opportunities for primitive recreation. Impacts to solitude from the long-term presence of cut stumps would be the same as described for Alternative A. Most of the Rye Creek Proposed Wilderness Area is closed to hunting, and recreation use is estimated to be very low. As a result, impacts to solitude and primitive recreation would affect few people.

Other Unique Components that Reflect the Character of this Wilderness

Heritage and Cultural Resources
N/A

Maintaining Traditional Skills
This alternative would not maintain traditional skills.

Special Provisions
N/A

Time Constraints
The need for fewer work crews or less amount of time and only small short-term tent camps under this alternative would require considerably less logistical support than crews and camps proposed under Alternative A. In areas with higher tree density or larger diameter trees, we assume crews working with chainsaws and other motorized equipment would be able to remove and thin juniper twice as fast as similar sized crews working with crosscut saws, axes, and other primitive tools. However, where juniper density is low and most time and effort is spent walking and carrying tools

and equipment from one tree to the next, case studies have demonstrated crews using motorized equipment do not save time or accomplish the same amount of cutting faster than crews using primitive tools (Arthur Carhart Wilderness Training Center 2006). It is anticipated this alternative would save time compared with Alternative A only in those areas furthest from roads and with the highest juniper density.

Additional Wilderness-specific Comparison Criteria
N/A

Safety of Visitors, Personnel, and Contractors

The use of motorized tools required to implement this alternative has been shown to result in a higher accident rate and result in more severe injuries than those from primitive tools designed to accomplish the same tasks (Arthur Carhart Wilderness Training Center 2006). However, the vehicle used to transport tools, equipment, and supplies under this alternative would remain in the project area to provide emergency evacuation to roads or suitable helispots. Improved emergency response time with the use of a motorized vehicle would mitigate some of the injury severity risks associated with the use of motorized equipment under this alternative. Other risks and potential safety issues encountered within proposed wilderness are generally no greater than those encountered in other remote areas of Sheldon Refuge.

Alternative C

Description

This alternative would combine the tools and methods described in Alternatives A and B. In areas with very low density of small trees (less than 10 trees per acre and less than 67 feet in height), herbicide would likely be used. In low juniper density areas (average less than 30 trees per acre) and in areas of small juniper size (average less than 5 inches dbh), thinning and removal would be conducted as described under Alternative A. For areas with juniper density greater than 30 trees per acre and in treatment areas where average juniper dbh is greater than 5 inches, thinning and removal would be conducted as described under Alternative B.

Effects

Wilderness Character

"Untrammeled"
Impacts to untrammeled wilderness character would likely be between those described for Alternatives A and B.

"Undeveloped"
Impacts to undeveloped wilderness character would be as described for Alternative B with the use temporary structures (i.e., tents) at some sites for periods of approximately four days at a time.

"Natural"
The types of impacts to natural wilderness character would include those described for Alternatives A and B. Areas with low juniper density would have a more natural appearance than those with higher juniper density where motorized equipment would be used. However, the use of motorized

equipment in higher density areas would not result in the impacts to natural condition from larger work crews and seasonal work camps described under Alternative A.

"Outstanding Opportunities for Solitude or a Primitive and Unconfined Type of Recreation"
Impacts to untrammeled wilderness character would likely be between those described for Alternatives A and B. In low juniper density areas or areas with smaller juniper where herbicides or primitive tools would be used, opportunities for solitude and primitive recreation would be least impacted from the presence of work crews. In high juniper density areas or areas with larger juniper, opportunities for solitude and primitive recreation would be more intensely impacted, but these impacts would last for less than a week at a time and would end upon completion of cutting, felling, and limbing work. Impacts from piling and burning work would be as described under Alternative B.

Other Unique Components that Reflect the Character of this Wilderness

Heritage and Cultural Resources
N/A

Maintaining Traditional Skills
This alternative would maintain traditional skills as described under Alternative A.

Special Provisions
N/A

Time Constraints
It is more likely Sheldon Refuge would utilize assistance from volunteers and/or other organizations to assist thinning efforts using primitive hand tools in areas of lower juniper density and areas with smaller trees. Work projects in these lower density areas and areas with smaller juniper would also require smaller work crews and less training than would longer-term work projects using motorized equipment. Overall we anticipate the amount of time or number of people required to accomplish the management objective under this alternative would be slightly more than under Alternative B, but much less than required under Alternative A.

Additional Wilderness-specific Comparison Criteria
Safety of Visitors, Personnel, and Contractors

The level of safety involved with this alternative would fall between that described for Alternatives A and B.

Comparison of Alternatives

It may be useful to compare each alternative's positive and negative effects to each of the criteria in tabular form, keeping in mind the law's mandate to "preserve wilderness character."

	Alternative A	Alternative B	Alternative C
Untrammeled	--	-	+/-
Undeveloped	--	-	-
Natural	--	-	-
Solitude or Primitive Recreation	-	--	-
Unique Components			

Wilderness Character	**--**	**--**	**-**

	Alternative A	Alternative B	Alternative C
Heritage and Cultural Resources	N/A	N/A	N/A
Maintaining Traditional Skills	+	-	+
Special Provisions	N/A	N/A	N/A
Time	-	+	+
Additional Wilderness Criteria	N/A	N/A	N/A
Other Criteria Summary	+/-	+/-	+

	Alternative A	Alternative B	Alternative C
Safety	**+**	**-**	**+/-**

Safety Criteria

The use of chainsaws, motorized brush cutters, and other power equipment for the cutting juniper is inherently more dangerous than the use of crosscut saws, pruning shears, and other hand tools. The use of motorized equipment is not being proposed as the necessary minimum tool for safety reasons.

Documentation

Arthur Carhart Wilderness Training Center. 2006. Traditional tools and skills. PowerPoint presentation. Available at: http://www.wilderness.net/index.cfm?fuse=toolboxes&sec=awareness. Accessed September 7, 2010.

Gedney, D.R., D.L. Azuma, C.L. Bolsinger, and N. McKay. 1999. Western juniper in eastern Oregon. Gen. Technical Report PNW-GTR-464. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Portland, OR. 53 pp.

Lile D.F., D.L. Lancaster, and R.G. Wilson. 2004. Control of cut juniper stumps and small trees in northeastern California. University of California Cooperative Extension, Lassen and Modoc Counties. In: 2004 Proceedings of the California Weed Science Society. Vol. 56. Pp. 88-93.

Step 2 Decision: What is the <u>Minimum</u> Activity/Minimum Tool?

Selected Alternative

Alternative C

<u>Rationale</u> for Selecting this Alternative (Including Documentation of Safety Criterion, If Appropriate)

Alternative C would use the tools and techniques least intrusive to opportunities for solitude and primitive recreation where they would be most efficient and would result in the least impact to natural conditions. Tools and techniques more intrusive to opportunities for solitude and primitive recreation would be used where they would be most efficient and would require the least impact to natural conditions from work crew campsites and resupply. Alternative C is also determined to have an acceptable level of safety and would be cost effective when compared with the other alternatives.

Monitoring and Reporting Requirements

Except as specifically described in the alternative selected, no use of motorized vehicles or equipment may occur without prior written determination by the Sheldon-Hart Mountain Refuge Complex Project Leader. All areas where the use of motorized vehicles and temporary structures is to occur would be specifically identified, monitored, and degradation of natural conditions reported.

Check Any Wilderness Act Section 4(c) Uses Approved in this Alternative

- ☐ mechanical transport
- ☒ motorized equipment
- ☒ motor vehicles
- ☐ motorboats
- ☐ landing of aircraft
- ☒ temporary road
- ☐ structure or installation

Record and report any authorizations of Wilderness Act Section 4(c) uses according to agency procedures.

Approvals	Signature	Name	Position	Date
Prepared by:		Aaron P. Collins	Park Ranger	9/25/12
Recommended:		John W. Kasbohm	Project Leader	9/25/12
Approved:		CHARLES J. HOUGHTEN	REGIONAL WILDERNESS COORD.	9/27/12

G.3. Final Minimum Requirements Decision and Analysis for Treatment, Removal, and Eradication of Invasive Non-native Plants

Step 1: Determine if any administrative action is necessary. (Refer to the Sheldon Refuge CCP/EIS and preferred alternative).

Management direction for invasive non-native plans was evaluated through a range of alternatives included in the Sheldon Refuge CCP/EIS. The CCP/EIS preferred alternative for the treatment, removal, and eradication of invasive non-native plants has been determined necessary for management of Sheldon Refuge and the proposed wilderness areas.

Step 2: Determine the minimum activity/minimum tool.

Description of Alternatives

As described in the Sheldon Refuge CCP/EIS, several invasive non-native plants (weeds) are currently found within Sheldon Refuge, or occur immediately adjacent to Sheldon Refuge and are expected to spread to areas within Sheldon Refuge in the near future. These non-native invasive plants include several noxious weeds and have a persistent and growing adverse impact on the natural character of the eight proposed wilderness areas within Sheldon Refuge, and/or threaten the natural character of adjacent contiguous Wilderness Study Areas managed by the Bureau of Land Management.

Based upon analysis of the impacts from the Service's preferred alternative in the Sheldon Refuge CCP/EIS, it has been determined treatment of up to 1,000 acres per year using a variety of weed control techniques through an integrated pest management approach, including herbicides where appropriate and effective, would be the minimum administrative action necessary to fulfill the purposes for Sheldon Refuge and the mission of the Refuge System, and to protect and preserve wilderness character. The alternatives presented here evaluate the least intrusive methods and tools necessary to apply various integrated pest management techniques as necessary to accomplish the objective and strategies of the preferred alternative.

Management strategies of the preferred alternative that would affect the proposed wilderness areas include treatment of invasive non-native plants on as many as 1,000 acres per year primarily along road corridors throughout Sheldon Refuge, and control of non-native species as part of emergency stabilization and rehabilitation efforts following catastrophic fires. Proposed wilderness boundaries within Sheldon Refuge are set back 50 feet or more from the centerline of all roads, and these corridor areas are the locations where weeds most likely occur due to disturbances caused by vehicle use and maintenance activities. Based upon the size of the current road system within Sheldon Refuge, there would be approximately 5,800 non-wilderness acres targeted for repeated weed treatments. We anticipate very few acres associated with weed treatments along road corridors would occur within the proposed wilderness areas. Therefore, the actions evaluated in the alternatives presented would be primarily for weed treatments following catastrophic fires.

Invasion of grasslands and shrub-steppe habitats below 6,800 feet by cheatgrass (*Bromus tectorum*) following fire is the most likely large-scale threat to the natural character of the proposed wilderness areas. Portions of each proposed wilderness area are below 6,800 feet in elevation, and we anticipate treatment of cheatgrass across several hundred, and possibly several thousand acres, within one or more proposed wilderness areas would be necessary in the future. However, such large-scale

treatment efforts are complex and could require a variety of treatment tools and methods. Such large-scale treatments within wilderness would be evaluated on a case-by-case basis through a separate minimum requirements and decision analysis, including a minimum tool analysis.

Other weeds that threaten the ecological integrity of Sheldon Refuge and the natural character of the proposed wilderness areas occupy much smaller areas, ranging from widely scattered individual plants to areas a few acres in size. We anticipate treatment of these weeds would occur repeatedly within each proposed wilderness area, and in many instances at the same or very close to the same locations over the next 10 to 15 years. Due to the fact these types of situations are expected to be the most common, this minimum tool analysis will focus on determining the minimum tools necessary to implement weed treatment of individual plants or patches of weeds within portions of the proposed wilderness areas 10 acres in size or smaller.

Alternative A

Description

Under Alternative A, all weed treatments would be completed using non-mechanized and non-motorized means and other methods not otherwise prohibited by the Wilderness Act. In addition, weed treatment under this alternative would not allow the use of herbicides for treatment of areas 10 acres in size or smaller. Treatments would be completed using hand tools to cut or dig weeds from the ground.

We anticipate removing scattered individual plants and small patches of plants from an area 10 acres in size would require one to four people working for one to four days. Plant parts would either be left on the ground or removed from Sheldon Refuge for disposal, depending upon the type of weed and growth stage.

For treatment of larger areas infested with several acres of weeds, the number of people and/or the amount of time needed would be considerably longer. In areas where native shrubs and other woody plants are common, hand-pulling and grubbing would be the only practicable option. However, we anticipate many weeds would be overlooked under such conditions and treatment would not be very effective.

Because weed control would be limited to hand tools, retreatment of most areas is likely under this alternative.

Effects

Wilderness Character

"Untrammeled"
The presence of work crews for up to four days within the same general area is expected to alter wildlife behavior and habitat use until efforts are completed. Long-term trammeling of wilderness character from the control of non-native plants was evaluated in the Sheldon Refuge CCP/EIS.

"Undeveloped"
Short-term temporary camps consisting of small tents would have a slight effect on the undeveloped character within small portions of the proposed wilderness areas. Following campsite removal and restoration, little or no noticeable evidence of temporary developments would remain.

"Natural"
We do not anticipate hand-pulling, cutting, or digging of scattered weeds or of individual weeds within areas a few acres in size would noticeably affect the natural appearance or condition of the proposed wilderness areas. Digging and grubbing to control numerous large patches of deep-rooted perennial weeds would likely cause substantial soil disturbance and could increase soil erosion from the site. Control of certain deep tap-rooted weeds and large woody plants using only hand-cutting, pulling, or grubbing is simply not effective and will only slow or delay plant growth.

Disturbance from hand tools to control large patches of weeds would make sites more susceptible to future invasion from weeds. Sites would be re-seeded to mitigate these impacts, but a number of efforts to reseed areas within Sheldon Refuge have had mixed results depending on weather, soil type, and other subsequent disturbances such as windstorms and wildlife use. The combination of digging and reseeding would slightly alter the natural appearance of the treated areas, but if successful these effects would not be noticeable after one or two growing seasons.

In areas of dense native vegetation and shrubs, the effectiveness of hand treatment would be limited, and many weeds would likely be overlooked, requiring several subsequent retreatments.

More general long-term impacts to natural conditions from control and removal of non-native invasive plants were evaluated in the Sheldon Refuge CCP/EIS.

"Outstanding Opportunities for Solitude or a Primitive and Unconfined Type of Recreation"
Opportunities for solitude and unconfined types of recreation would be directly affected by the presence of work crews for up to four days. The use of hand tools would have little or no impact on opportunities for primitive recreation. Most weed control activities would occur during the spring before seeds develop and would not coincide with the fall hunting seasons when most visitation to the wilderness areas occurs. As a result impacts to opportunities solitude and primitive and unconfined recreation would affect few people.

Other Unique Components that Reflect the Character of this Wilderness

Heritage and Cultural Resources
The use of hand tools under this alternative could include grubbing and digging of individual plants and could result in damage or destruction of artifacts and minor disturbance of cultural and historic sites.

Maintaining Traditional Skills
The use of simple primitive tools such as hoes and grubbing adzes under this alternative would have little effect on maintaining traditional skills.

Special Provisions
N/A

Time Constraints
Removal of weeds with the use of hand tools would be the most time consuming when compared with Alternative B or C.

Additional Wilderness-specific Comparison Criteria
N/A

Safety of Visitors, Personnel, and Contractors

Hand tools required to implement this alternative are commonly used. Safety issues and concerns can be mitigated through proper job training and protective equipment.

Alternative B

Description

Under this alternative the control and removal of scattered individual plants and treatment of areas 10 acres in size or less would be completed using tools under Alternative A and hand-operated 5-gallon backpack herbicide and/or slightly larger capacity pack stock sprayers over a period of one to four days per treatment. To protect public health and safety, areas treated with herbicides would be closed to public access for a period of time determined from product label recommendations and restrictions.

For herbicide treatment of very large patches or multiple large patches of weeds, we anticipate 10 or more trips per person would be required to refill portable backpack sprayers.

Effects

Wilderness Character

"Untrammeled"
The presence of work crews for periods up to four days per treatment is expected to alter wildlife behavior during treatment and to alter habitat use for several years until natural plant communities are restored. Long-term trammeling of wilderness character from control of invasive non-native plants was evaluated in the Sheldon Refuge CCP/EIS.

"Undeveloped"
Short-term work camps consisting of small tents would have a lesser temporary impact on the undeveloped character of proposed wilderness than Alternative A. Following campsite removal and restoration, little or no noticeable evidence of temporary developments would remain.

"Natural"
Hand tools would be used under this alternative primarily to remove scattered individual weeds, or small patches of weeds. Herbicides would more commonly be used to treat large patches and areas with numerous patches of weeds. While some herbicides that would be used for treatment are plant specific and kill only the target weed (grasses, broadleaf plants, woody plants), some of the most effective herbicides are not specific to only the target weed and would kill native plants as well.

Where herbicides are applied over areas of a few acres or more, vegetation composition would not appear natural, at least until the following growing season. Depending upon the type of herbicide(s) used, either the grass component of the habitat type or the forb component of the habitat type could be largely absent. A discussion of additional impacts to refuge and habitat biological health, diversity, and integrity from the use of herbicides is included in (Appendix O). However, when compared to the often less-effective methods under Alternative A, this alternative would require fewer retreatments and would avoid ground disturbance to remove large patches of deep-rooted perennial weeds.

Long-term impacts to natural conditions from control and treatment of non-native plants were evaluated in the Sheldon Refuge CCP/EIS.

"Outstanding Opportunities for Solitude or a Primitive and Unconfined Type of Recreation"
Opportunities for solitude and unconfined types of recreation would be directly affected by the presence of work crews for up to four days and temporary closures in areas up to 10 acres in size where herbicides are used. The use of hand tools would have little or no impact on opportunities for primitive recreation. Most weed control activities would occur during the spring before seeds develop and would not coincide with the fall hunting seasons when most visitation to the wilderness areas occurs. As a result, impacts to opportunities solitude and primitive and unconfined recreation would affect few people.

Opportunities for solitude would be directly affected by the presence of small crews for several days. Opportunities for unconfined types of recreation would be directly impacted by temporary closures in areas up to 10 acres in size where herbicides are used. Because only herbicides would be used, we anticipate these impacts would last a few days longer than the herbicide application period. Overall, impacts to unconfined recreation would impact larger areas than under Alternative A due to public access closures. Noise impacts to wilderness solitude under this alternative would be more intense and affect a larger area than under Alternative A, but would be less intense than under Alternative C, which proposes the use of motorized vehicles.

Other Unique Components that Reflect the Character of this Wilderness

Heritage and Cultural Resources
Impacts from the use of hand tools would be as described under Alternative A. However, in areas where herbicides are used, the potential for these impacts would be eliminated and as a result impacts to cultural resources are lower under this alternative when compared to Alternative A or C.

Maintaining Traditional Skills
This alternative would maintain only basic skills for using hand tools.

Special Provisions
N/A

Time Constraints
This alternative would require fewer people and less time over the long term when compared with multiple retreatments anticipated under Alternative A. For areas of moderate to gentle terrain, this alternative would require more time than under Alternative C, which would utilize larger-capacity motorized spray equipment and vehicles. In areas of steep, rough, and rocky terrain inaccessible to vehicles, this alternative would require about the same amount of time as Alternative C.

Additional Wilderness-specific Comparison Criteria
N/A

Safety of Visitors, Personnel, and Contractors

The hand tools, hand-powered spray equipment, and livestock required to implement this alternative are commonly used. Backpack sprayers are notorious for developing small leaks and would likely

need to be regularly fixed or replaced to avoid contamination. Safety issues and concerns can be mitigated through proper job training and project planning.

Alternative C

Description

As with Alternative A and B, the control and removal of scattered individual plants and treatment of areas a few acres in size would be completed with the use of hand tools and hand-powered backpack and/or pack stock sprayers by one to four people working over a period of one to four days per treatment.

In addition, motorized vehicles equipped with low-pressure tires and flail mowers or large-volume herbicide sprayers with electric pumps, handheld spray wands, and/or spray booms capable of spraying an area at least 40 feet in width would be used for the treatment of very large weed patches or multiple large patches over areas up to 10 acres in size. Using such equipment we anticipate one person could treat 10 acres within one day under ideal conditions and terrain, but treatments could require as many as two days depending on terrain, weed density, and the number of herbicide refilling trips needed. However, due to the steep rugged terrain within many portions of the proposed wilderness areas, motorized vehicles may not be capable of mowing or spraying all weeds within the treatment areas. The use of hand tools, backpack, or stock pack spray equipment would likely be necessary for treatment of these remaining areas. To protect public health and safety, areas treated with herbicides would be closed to public access for a period of time determined from product label recommendations and restrictions.

Vehicle use would occur off-road within the treatment areas. Vehicle access would occur along previously existing routes and would require a single trip to the treatment area. All fuel, herbicide, tools, equipment, and work crews necessary to complete the treatment would be transported with the vehicle to the treatment area, on foot, or by pack stock.

Effects

Wilderness Character

"Untrammeled"
The presence of work crews and motorized vehicles for periods up to two days per treatment is expected to alter wildlife behavior during treatment and to alter habitat use for several years until natural plant communities are restored. Long-term trammeling of wilderness character from control of invasive non-native plants was evaluated in the Sheldon Refuge CCP/EIS.

"Undeveloped"
Impacts from work crews treating scattered individual plants or areas only a few acres in size would be as described for those activities under Alternatives A and B. Access by motor vehicle would occur less frequently than foot or horseback access described under Alternative A or B. However, previously established routes would continue to be easily identified as primitive two-track vehicle routes in contrast to the more naturally appearing undeveloped trails anticipated under Alternative A. In addition, the use of vehicles off-road to conduct mowing or spraying would create new vehicle tracks, which would likely encourage trespass into these areas and the pioneering of new routes.

"Natural"
Effects from herbicide use would be as described under Alternative B, and we anticipate natural conditions would be affected for many years after treatment.

In areas where flail mowers would be used to cut weeds prior to seed production, vegetation would not appear natural within areas several acres or more in size and effects would be readily apparent to even a casual observer. In grassland habitats, these effects would be noticeable until the following spring or perhaps the end of the next growing season. In shrub-steppe habitats these effects would be noticeable for decades. However, unlike hand-pulling or herbicide use, mowers or flailers can effectively treat large patches of annual or biannual weeds by eliminating most seed production but still allow native plant communities to remain. The combination of followed by herbicide treatment or hand removal of remaining weeds can be effective. These remaining native plants are then able to continue growing and produce seed in following years to revegetate the treated areas and maintain natural conditions over the long term.

The presence of vehicle tracks throughout the treatment areas would appear unnatural and the use of access routes would result in damage to vegetation, including shrubs and other perennials. When compared with short-term campsite use, stock use, and backpacking under Alternatives A and B, these impacts would be more severe, would affect larger areas, and would be noticeable for a longer amount of time due to more intensive trampling from vehicle tires, and access travel concentrated along existing vehicles routes.

Long-term impacts to natural conditions from control and treatment of non-native plants were evaluated in the Sheldon Refuge CCP/EIS.

"Outstanding Opportunities for Solitude or a Primitive and Unconfined Type of Recreation"
Opportunities for solitude would be directly affected by the presence of small hand crews and the sights and sounds of concentrated use of motorized vehicles conducting treatments for one or two days. Opportunities for unconfined types of recreation would be directly impacted by temporary closures in areas ranging from two acres up to 10 acres in size where herbicides are used. Because only herbicides would be used, we anticipate these impacts would last a few days longer than the herbicide application period. Overall, impacts to unconfined recreation would impact larger areas than under Alternative A due to public access closures. Noise impacts to wilderness solitude under this alternative would be more intense and would affect a large area, but would last for a shorter period of time than under Alternative A or B.

The use of motorized vehicles would detract from opportunities for primitive recreation. Most treatments would occur during the spring when recreation use is estimated to be very low. As a result, impacts to solitude and primitive recreation would affect few people.

Other Unique Components that Reflect the Character of this Wilderness

Heritage and Cultural Resources
Impacts from the use of hand tools would be as described under Alternative A. The use of vehicles off-road under this alternative has the potential to disturb unidentified artifacts or other historic and cultural resources. The use of low-pressure tire vehicles would reduce the potential for breaking or otherwise destroying these artifacts.

Maintaining Traditional Skills
This alternative would maintain only basic skills for using hand tools.

Special Provisions
N/A

Time Constraints
The need for fewer people and ability to treat areas within one or two days using vehicles would ensure treatment is conducted within the time period most likely to be effective, and herbicide application would require less time with fewer refilling trips required when compared with small-capacity backpack sprayers. However, when compared with Alternative B, this alternative's use of motorized vehicles would not be effective in treating 100% of project areas, which include steep rocky terrain. As a result, effective treatment under this alternative of all potential sites would require the methods and tools considered under Alternative B.

Additional Wilderness-specific Comparison Criteria
N/A

Safety of Visitors, Personnel, and Contractors

The use of motorized vehicles to haul and apply herbicides off-road in uneven terrain is less safe than application on foot using a portable backpack sprayer. Using motorized vehicles presents a rollover hazard and in the event of an accident, the amount of herbicide that could be spilled is also greater than with a 5-gallon backpack sprayer.

Comparison of Alternatives

	Alternative A	Alternative B	Alternative C
Untrammeled	-	-	-
Undeveloped	-	+	+
Natural	-	+	+/-
Solitude or Primitive Recreation	+/-	+/-	-
Unique Components			
Wilderness Character	-	+	-

	Alternative A	Alternative B	Alternative C
Heritage and Cultural Resources	-	+/-	-
Maintaining Traditional Skills	+	-	-
Special Provisions	NA	NA	NA
Time	-	+/-	+
Additional Wilderness Criteria	NA	NA	NA
Other Criteria Summary	-	-	-

	Alternative A	Alternative B	Alternative C
Safety	+	+	-

Safety Criteria

Safety risks from hand tools for cutting and digging, from herbicide use, and off-road use of motorized vehicles can be mitigated by proper protective equipment and training. However,

Alternative C is the least safe of the three alternatives due to the combined safety risk from the use of all three tools.

Documentation

See Appendix O.

Step 2 Decision: What is the Minimum Activity/Minimum Tool?

Selected Alternative

Alternative B

Rationale for Selecting this Alternative (Including Documentation of Safety Criterion, If Appropriate)

The combination of hand-pulling, hand-cutting, and herbicide use proposed under Alternative B was identified as the minimum set of tools and techniques necessary to effectively maintain and/or restore natural habitat conditions within areas of Sheldon Refuge and the proposed wilderness areas identified. This alternative does not require activities otherwise prohibited by the Wilderness Act and would protect and preserve wilderness character.

Each of these techniques has been shown through experience to be well-suited to the control of certain weeds, while at the same time minimizing soil disturbance, seed germination, and the need for follow-up treatments when compared to more restrictive approaches, which utilize only one method of treatment, or more intensive methods, which utilize motorized equipment and vehicles. Mowing large areas to control weeds is typically combined with other treatment methods over areas larger than 10 acres in size. At this time no specific weeds or areas have been identified where the use of flail mowers would be necessary or effective.

The combination of tools and techniques under Alternative B would avoid activities and uses otherwise prohibited within proposed wilderness areas, and are expected to be effective. Grubbing, digging, and cutting with hand tools under Alternative A could actually aggravate the problem of invasive plants through ground disturbance. The use of herbicides under Alternative B would be effective for some weeds, but would also kill native plants when used for large patches. For such large patches, hand-cutting would eliminate seed production from biannual or annual plants, while only moderately impacting native perennial plants and natural appearance.

Alternative C would allow use of the widest range of tools and techniques, but not all tools and techniques are necessary to efficiently accomplish habitat management objective within relatively small areas of Sheldon Refuge. When combined with added impacts to natural condition from off-road vehicle use, Alternative C would cause the greatest damage to habitats and natural conditions when compared with Alternatives A and B. Treatment of larger areas within wilderness areas will be considered on a case-by-case basis, and each evaluation would consider the use of effective large-scale non-motorized and non-mechanized tools and techniques such as biological control, grazing, or aerial herbicide application.

Monitoring and Reporting Requirements

Except as specifically described in alternative selected, no use of motorized vehicles or equipment may occur without prior written determination by the Sheldon-Hart Mountain Refuge Complex Project Leader.

Check Any Wilderness Act Section 4(c) Uses Approved in this Alternative

- ☐ mechanical transport
- ☐ motorized equipment
- ☐ motor vehicles
- ☐ motorboats
- ☐ landing of aircraft
- ☐ temporary road
- ☐ structure or installation

Record and report any authorizations of Wilderness Act Section 4(c) uses according to agency procedures.

Approvals	Signature	Name	Position	Date
Prepared by:		Aaron P. Collins	Park Ranger	9/25/12
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G.4 Final Minimum Requirements Decision and Analysis for Removal and Restoration for Abandoned Livestock Developments

Step 1: Determine if any administrative action is necessary. (Refer to the Sheldon Refuge CCP/EIS and preferred alternative).

Management direction for abandoned livestock developments was evaluated through a range of alternatives included in the Sheldon Refuge CCP/EIS. The CCP/EIS preferred alternative for removal and restoration of abandoned livestock developments has been determined necessary for management of Sheldon Refuge and the proposed wilderness areas.

Step 2: Determine the minimum activity/minimum tool.

Description of Alternatives

In order to achieve the minimum administrative action determined necessary as described in the Sheldon Refuge CCP/EIS preferred alternative, the minimum tools, equipment, and techniques for use within wilderness must be capable of removing and restoring structures and disturbances associated with at least 20 springs and 20% or more of playas located in the Sheldon Refuge proposed wilderness areas within the next 15 years.

Early pioneers in the Sheldon area quickly recognized that successful agriculture required irrigation during the summer months. These settlers built most of the region's large reservoirs to help ensure water was available through July, August, and September. Early management activities on Sheldon Refuge focused on additional development of water resources to increase year-round water for livestock and, to a lesser degree, wildlife. Ponds were dug in seeps, spring flow diverted to watering troughs, and stock ponds built. Fences were constructed to keep livestock out of riparian areas and directed to troughs. Although these activities have been common since the 1930s there is debate about how effective these activities are for wildlife (Broyles 1995).

In 1994, grazing privileges within Sheldon Refuge were transferred back to Sheldon Refuge by the permittee(s) and permanently retired by the Service. This eliminated all commercial livestock grazing within the Refuge and the need for all associated livestock water developments. These abandoned developments remain throughout Sheldon Refuge including all eight proposed wilderness areas.

There are currently 183 water improvements identified on Sheldon Refuge. Of primary concern for this wilderness minimum requirements decision and analysis are the 77 developed springs and 22 developed playas within Sheldon Refuge, which include the following developments and disturbances:

a) Spring box or head box: A spring box or head box is a structure installed at or near the spring source to collect water for diversion to a water trough, tank, or dug-out using a pipe. Spring boxes or head boxes are typically constructed of concrete or steel to isolate water from contamination and are surrounded with gravel to filter coarse materials. Excavation to install these structures varied from spring to spring, up to about 20 feet in depth.

Figure 1. Typical spring box within Sheldon Refuge (photo Gail H. Collins).

b) Pipeline: Pipelines associated with developed springs connect a spring box to a water trough or tank, connect the spring source and a spring box, or connect directly from a spring source to a water trough or tank. Pipelines usually are constructed of steel or plastic pipe generally 2 inches or less in diameter. Pipelines are commonly buried below the frost line (usually 24-36 inches below ground) or placed on the surface and protected from trampling by a covering of rocks.

c) Troughs and Tanks: Water troughs that remain within Sheldon Refuge vary from 6-foot-long light-gauge galvanized steel "sheep" troughs to converted heavy-gauge steel military surplus aircraft engine containers weighing 300 pounds or more. In some cases a number of troughs are used together at the same spring to store additional water.

Figure 2. Abandoned converted aircraft engine container water troughs in Sheldon Refuge; these two troughs weigh several hundred pounds combined.

d) Stock Ponds and Dug-outs: Stock ponds are created by constructing earthen dams built across ephemeral drainages or depressions and are intended to capture snowmelt runoff and create a watering place that will persist into the summer months. Stock ponds differ from larger reservoirs in that there is no outlet structure such as a canal or headgate to release water. Dug-outs are artificially constructed depressions that collect and store water. Dug-outs differ from reservoirs and stock ponds in that a dam is not relied upon to impound water. Dug-outs within Sheldon Refuge are generally located below water troughs and are 30 feet in diameter or less, but occasionally larger. Seventy water improvements within Sheldon Refuge have been identified as spring dug-outs or stock ponds and 22 water developments have been identified as playa dug-outs. These dug-outs are not associated with springs or water troughs, are typically larger than spring dug-outs, and were constructed using backhoes, bulldozers, and sometimes explosives.

Figure 3. Typical stock pond; note the small earth dam at the right to impound water.

Figure 4. Moderately sized dug-out within the Round Mountain proposed wilderness area.

e) Fence Exclosures: Fences were constructed at some, but not all, springs to protect the spring source, spring box, water pipeline, and riparian vegetation. Exclosures were traditionally constructed using barbed wire and wood or metal posts to protect areas smaller than 1 acre and nearly all have been removed or are in various stages of disrepair.

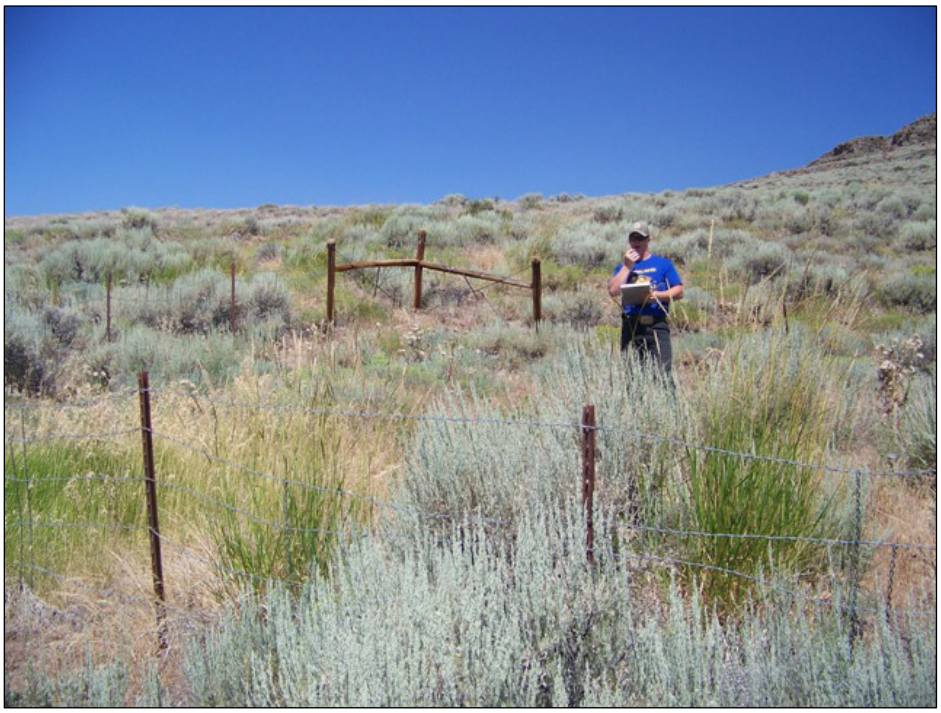

Figure 5. Typical wire fence spring exclosure within Sheldon Refuge.

The primary concerns related to abandoned spring and playa water developments with Sheldon Refuge and the proposed wilderness areas are the long-term impacts to wetland and riparian ecological health from permanent changes to the distribution and timing of water and the visual impacts to the undeveloped and natural character of the proposed wilderness areas from the continued presence of permanent structures.

A secondary concern is the protection of springs and riparian habitats in either their current or restored condition from the impacts of feral horses and burros.

Alternative A

Description

Under Alternative A, primitive techniques, tools, and skills including non-mechanized and non-motorized tools and equipment would be used to remove abandoned debris and restore the natural character and function of developed springs throughout the proposed wilderness areas.

The majority of work under this alternative would be completed using small hand tools such as hand wire rollers, pliers, jacks, picks, shovels, snatch blocks, hand-powered winches, cables, ropes, etc. Transport of all tools, materials, supplies, debris, and people would be by foot or pack stock. Larger debris such as troughs and metal tanks would be dragged or skidded out along existing routes using stock teams, or cut into smaller pieces with gas cutting torches, which could then be packed out.

To protect springs from further damage by feral animals and to ensure successful restoration, spring fence exclosures would either be fully repaired or completely replaced with new fence. Where feasible, replacement fences would be constructed using wood rail or metal pipe, which blend with the surroundings, do not present a tangle hazard to animals, require less maintenance, do not require ground disturbance, and are easily dismantled and removed. However, due to the remote location of many springs within the proposed wilderness areas, and the size, weight, and amount of fence material needed, construction using wood rail or metal pipe fence would be prohibitive (particularly at locations furthest from roads). Instead, we anticipate most exclosures would continue to be constructed using traditional wire and metal t-posts, which can more easily be hauled using pack stock and can be constructed over most terrain.

For deeply buried spring boxes and water pipelines where removal would create substantial surface disturbance, sites would be assessed to determine whether the development should be left intact to allow the continued flow of water or whether the pipe and/or spring box should be severed, plugged, and/or filled in. Most smaller stock ponds and dug-outs would not be refilled or recontoured with soil due to the impacts this would cause to invertebrates, existing riparian vegetation, and increased erosion rates and water turbidity. Instead these sites would be allowed to refill naturally over time or would be filled with coarse rocks and small boulders to create a more natural appearance and restore a more natural timing and amount of water flow by reducing water storage capacity of the structures. For restoration of larger dug-outs and catchments associated with playas and some springs, work crews with highline buckets and shovels and/or horse-drawn dredges and draglines would be used to refill excavated areas.

We anticipate the amount of time and effort required to removal and restore springs and playas under this alternative would vary considerably depending upon location and degree of development. For springs with minimal development (e.g., a few feet of plastic pipe and a single rusted-out light-gauge metal trough) and near roads for motorized access, we estimate complete removal and restoration could be completed by four people in a single day. In the case of springs with extensive developments and ground disturbance (i.e., a steel culvert spring box, 100 feet or more of 2-inch steel pipe, one or two converted aircraft engine container troughs, and a dug-out catchment 4 feet deep and 40 feet in diameter) or playas with large excavations (i.e., 8-12 feet deep and over 100 feet in length), removal and restoration could require seasonal work camps and pack stock resupply to support crews of eight or more people working with stock teams for several weeks.

Temporary work crew campsites and latrine sites would be selected in advance. Sites would be capable of supporting one or more restoration efforts. Access routes for seasonal camps or campsites anticipated to be used for multiple seasons would also be identified in advance. Both access routes and campsites would be photographed and inventoried prior to use in conjunction with a cultural resource inventory to document wildlife present, measure vegetative cover, and identify noxious weeds and other invasive non-native plants. No maintenance or surface disturbance would be allowed to improve access routes. Rocks and other obstacles could be temporarily moved to provide suitable campsites. Temporary latrines for burial of waste would be excavated to the minimum depth and size necessary.

Upon completion of restoration work, all materials and structures would be removed. Once the management objective has been achieved, campsites would be restored to their prior appearance using standard wilderness rehabilitation and restoration methods and primitive tools. Access routes and campsites would be photographed and monitored following the first full growing season to document impacts from use and the effectiveness of restoration efforts, as well as to detect any newly

introduced noxious weeds or other non-native plants. Subsequent monitoring would be conducted as needed to document wildlife use and campsite recovery.

Effects

Wilderness Character

"Untrammeled"
The presence of work crews for periods of a month or possibly longer within the same general location is expected to alter wildlife behavior and habitat use until restoration efforts are completed. Long-term trammeling of wilderness character from management efforts to rehabilitate and restore natural condition to these sites within proposed wilderness was evaluated in the Sheldon Refuge CCP/EIS.

"Undeveloped"
The removal of permanent structures and debris from the proposed wilderness areas would improve the undeveloped character of specific sites and areas within all eight proposed wilderness areas. For specific areas (such as the Alkali Peak Proposed Wilderness Area) where a number of abandoned developments are concentrated, the removal and restoration of these multiple sites would improve the overall undeveloped character of the proposed wilderness as a whole. Temporary short-term seasonal work camps consisting of small and large tents would affect the undeveloped character of small portions of the proposed wilderness areas. Following campsite removal and restoration, little or no noticeable evidence of temporary developments would remain. Use along identified access routes would be noticeable, but would appear as undeveloped and unmaintained single-track trails

"Natural"
Water pipelines, troughs, and playa dug-outs have altered the natural flow and location of water, which in turn have altered the natural ecology of associated riparian and wetland habitats. Actions under this alternative would restore natural ecological function to a number of springs within all eight proposed wilderness areas. However, the ecology of playa habitats is poorly understood and we can only speculate what impacts restoration efforts would have on playa function and ecology.

Water development has altered the natural appearance of the proposed wilderness areas through the placement of water troughs and the construction of dug-outs. Natural erosion and regrowth of vegetation have made a number of dug-outs substantially unnoticeable to the casual observer, particularly at sites with Wyoming big sagebrush and Great Basin wild rye. At other sites, particularly dug-outs in alkaline playa basins, excavation work completed more than 60 years ago remains readily visible and noticeable to most people. Even if work at these sites is unable to restore natural ecological function, efforts would be successful at restoring the natural appearance of these sites. Restoration work itself would result in some short-term soil disturbance and vegetation removal, but we anticipate these impacts would not be readily apparent within one or two growing seasons. Restoration sites would be monitored to determine if reseeding with native plants is needed to stabilize soils or prevent the establishment of invasive non-native plants.

"Outstanding Opportunities for Solitude or a Primitive and Unconfined Type of Recreation"
Opportunities for solitude would be directly affected by the presence of work crews as large as eight people, and effects would primarily occur within the project area and near campsite locations. The use of hand tools would have little or no impact on opportunities for primitive recreation. Recreation use is estimated to be very low during the summer months, but use increases during the fall hunting

seasons within most proposed wilderness areas. As a result, impacts to solitude would affect few people if restoration efforts were conducted during the spring and summer months and would affect sport hunters if conducted during the fall.

Once evidence of past developments has been removed, opportunities for primitive types of recreation would be improved over the long term within all eight proposed wilderness areas.

Other Unique Components that Reflect the Character of this Wilderness

Heritage and Cultural Resources
Each site proposed for restoration has been previously disturbed by construction activities, and any cultural and historic resources were likely disturbed or destroyed at that time. Areas surrounding these sites would be inventoried for sensitive cultural and historic resources that could be damaged by restoration work; activities would be conducted to avoid these areas. However, the risk of disturbing or destroying artifacts and resources not identified during these inventories is greatest under this alternative, which proposes to use large teams of horses or mules, draglines, and dredges to refill large spring and playa dug-outs. Risk to cultural and historic resources from other restoration efforts would be negligible under this alternative.

Maintaining Traditional Skills
The primitive and traditional skills required for handling pack stock and stock teams to pull loads or specialized equipment such as dredges and draglines are used rarely and may become lost altogether as both government agencies and ranchers increasingly rely on motorized equipment such as backhoes and excavators. This alternative would result in the continued practice and teaching of these primitive skills, but only for a relatively short period of time until large-scale restoration efforts are completed.

Special Provisions
N/A

Time Constraints
It is estimated there are a dozen or more extensively developed playas and springs within the proposed wilderness areas. Even if the substantial amount of funding necessary were available, a number of highly skilled team drivers, specially trained horse and mule teams, and specialized equipment would be needed to complete restoration of these sites. It is uncertain if employees and/or contractors meeting these requirements could be hired to complete the work within the 10- to 15-year timeframe of the Sheldon Refuge CCP/EIS preferred alternative.

Additional Wilderness-specific Comparison Criteria
The continued use of traditional four-strand wildlife-friendly fence when reconstructing or replacing protective spring exclosures under this alternative would have a number of drawbacks. While effective, wire fence poses a tangle hazard to wildlife if not properly maintained, requires posts be placed into the ground, is not easily removed, and is more difficult to reuse at other locations when compared to wood rail or metal pipe fence exclosures as proposed under Alternatives B and C.

Safety of Visitors, Personnel, and Contractors

The use of hand tools and equipment required under this alternative would be relatively safe, but even with trained and experienced teamsters the use of horse or mule teams and dredges or draglines to refill large excavations would increase the level of risk and safety hazards. Consequently, this

alternative would be less safe than the use of specialized excavators and other modern motorized equipment specifically designed to operate safely in such situations.

Alternative B

Description

Under this alternative the majority of spring and playa rehabilitation and restoration work would be completed using a combination of hand tools as discussed under Alternative A, non-motorized vehicles, and motorized vehicles and equipment. All vehicle use would be at restoration sites and along existing routes within the proposed wilderness areas.

Hand tools and non-motorized vehicles such as wheeled carts, wheelbarrows, or horse-drawn wagons would be used to transport tools, equipment, and debris, and to refill dug-out water catchments at the majority of sites within the proposed wilderness areas. At the most extensively developed springs and playas (refer to Alternative A Description section), removal and restoration work would be completed using a backhoe or small excavator. At a few locations where complete restoration would require removing large amounts of debris, refilling a dug-out, and constructing a protective fence exclosure around the spring itself, a truck and trailer would be used to transport both the backhoe or excavator and all fence materials to the site and haul out all debris and equipment in a single round trip. Any additional trips to transport supplies, materials, or people would be on foot or by horseback.

Figure 6. Free-standing metal pipe fence exclosure effectively protecting riparian habitat from feral horse and burro impacts (photo Gail H. Collins).

With the use of either mechanized or motorized vehicles under this alternative, we anticipate most protective fence exclosures would be constructed using the less intrusive but heavier wood rail or

metal pipe fence. Exclosures would be constructed using traditional wire and metal t-posts only where terrain would make the use of freestanding rail or pipe fence impractical and ineffective.

Access routes would be photographed and inventoried prior to use to measure vegetative cover and to identify noxious weeds and other invasive non-native plants. Only the minimum maintenance or surface disturbance necessary would be conducted along routes at specific sites for the safe transport of vehicles and heavy equipment.

We anticipate the amount of time and effort to remove materials and complete restoration work under this alternative would not vary greatly due to location or degree of development. For springs with minimal development and near access roads, work could likely be completed by four people in a single day, similar to Alternative A. For springs and playas with extensive development and disturbance, we anticipate the use of mechanized vehicles and/or motorized equipment would enable crews of four to eight people to complete the necessary work within five days. Work crews would access sites each day on foot or by horseback, or would use short-term temporary campsites near the restoration sites.

Effects

Wilderness Character

"Untrammeled"
The presence of work crews for periods up to five days within the same general location is expected to alter wildlife behavior and habitat use until restoration efforts are completed. We anticipate these effects would be somewhat less than under Alternative A or C. Long-term trammeling of wilderness character from management efforts to rehabilitate and restore natural condition to these sites within proposed wilderness was evaluated in the Sheldon Refuge CCP/EIS.

"Undeveloped"
As described under Alternative A, the removal of permanent structures and debris would improve the undeveloped character of all eight proposed wilderness areas. Impacts from short-term temporary crew campsites would be less than those described for longer-term campsites proposed under Alternatives A and C.

"Natural"
Similar to effects identified under Alternative A, restoration work under Alternative B would restore both natural ecological conditions and natural appearance to springs and playas within each of the eight proposed wilderness areas. For sites with extensive development and past disturbance, the use of a backhoe or small excavator would likely cause less disturbance to vegetation and soils than would teams of horses or mules as described under Alternative A. The bucket of a backhoe can be used effectively to a distance of 24 feet without moving the backhoe itself and could completely refill a 40-foot-diameter dug-out by repositioning only a few times. To refill a dug-out this size using teams of horses with a dredge or dragline would take many dozens of passes, and the amount of area required to turn the teams would disturb a much larger area than a backhoe. Similarly, when refilling long deep trenches in playa dug-outs, a backhoe with a front-end loader or small excavator with a blade would be able to move much more soil each pass than a team of horses or mules pulling a dredge or dragline. As with spring dug-outs, stock teams would disturb surrounding portions of the playa when turning around while motorized equipment is capable of backing over the freshly disturbed soil to make subsequent passes.

Vehicle access to restoration sites would occur along existing routes. For access routes to the most disturbed sites, one trip with a single truck and trailer or piece of equipment is expected to cause less damage to vegetation and soils than would the multiple trips on foot or by pack stock required to support long-term temporary camps under Alternative A. However, if the same access route would be used to access other developed springs and playas, impacts would likely be similar to those described under Alternative A.

"Outstanding Opportunities for Solitude or a Primitive and Unconfined Type of Recreation"
Opportunities for solitude would be directly affected by the presence of work crews as large as eight people and the sounds of motorized vehicles. Noise from a single vehicle trip for transport of tools, equipment, and supplies would be expected to have a slight short-term impact on wilderness solitude. Overall, noise impacts to wilderness solitude under this alternative would be more intense and would affect a larger area, but would last for a shorter length of time than would those from larger work crews using hand tools as proposed in Alternative A. In contrast, impacts to wilderness solitude would be less intense, would affect a smaller area, and would last longer than those from the use of helicopters as proposed in Alternative C.

The use of both motorized and non-motorized vehicles would detract from opportunities for primitive recreation. As discussed under Alternative A, impacts would be greatest if restoration efforts are conducted during the fall hunting seasons when recreation use is greatest within the proposed wilderness areas.

Other Unique Components that Reflect the Character of this Wilderness

Heritage and Cultural Resources
Inventories would be conducted as described under Alternative A. Because backhoes or small excavators would be used to refill spring or playa dug-outs with materials previously excavated to construct those structures and would need to reposition only a few times at each site and would be hauled along existing routes, the risk to unidentified artifacts or resources at restoration sites would be less under this alternative when compared to Alternative A, and only slightly greater than under Alternative C.

Maintaining Traditional Skills
This alternative would not maintain traditional skills.

Special Provisions
N/A

Time Constraints
The specialized tools and equipment needed to complete restoration of springs and playas under this alternative are readily available and with necessary funding, work could be completed within the 10- to 15-year timeframe of the Sheldon Refuge CCP/EIS preferred alternative. Once fence materials are at the restoration site, construction of wood rail or metal pipe exclosures can be completed in a much shorter amount of time than a traditional wire and t-post fence exclosure of the same size.

Additional Wilderness-specific Comparison Criteria
Increased use of wood rail or metal pipe rail fence for protective spring exclosures under this alternative would have a number of added benefits when compared with Alternative A. Both wood and pipe rail are more durable than wire and as a result require less maintenance and last longer when

properly maintained. Unlike wire fence, if wood or metal fencing does fail or collapse, the materials do not become an entanglement hazard for wildlife. Even though materials are more bulky than wire and metal t-posts, the natural color of wood and rusted metal blend surprisingly well into the surrounding landscape, which is covered with sagebrush, grass, and rock. Construction does not require posts be placed into the ground, and materials are easily dismantled, removed, and reassembled for reuse at other locations.

Safety of Visitors, Personnel, and Contractors

Backhoes and small excavators are specifically designed to allow a single skilled operator to safely and efficiently move large amounts of material in a relatively short amount of time. When compared to the increased risks associated with working around teams of horses and mules, the greater number of skilled people needed, and the longer amount of time necessary to move the same amount of material, this alternative would be considerably safer than Alternative A.

Transporting large amounts of debris and fence materials by vehicle under this alternative would be safer than transport by helicopter as proposed under Alternative C.

Alternative C

Description

Under this alternative developed springs and playas would be restored and rehabilitated using a combination of hand tools as described under Alternative A and helicopter transport of debris and fence materials when removal with primitive tools is not practicable. The use of a helicopter to remove debris from some springs would also make the use of metal pipe or wooden rail fence materials possible.

Access for work crews and transport of most tools, equipment, supplies, and debris to and from restoration sites would be on foot or horseback.

Helicopters would be used to transport suspended loads of fence materials for protective spring exclosures and to haul out large heavy debris such as converted aircraft engine container water troughs. At each site where fence materials are to be flown in, a load of debris would be prepared in advance to be hauled out on the return trip. Where it is determined a helicopter would be necessary for restoration of several springs in the same general vicinity, debris and materials would be prepared in advance and transported to/from all sites consecutively. In this way the length of time and amount of helicopter use within wilderness would be minimized, and the number of people and amount of time required to conduct restoration work would be minimized. Except in the case of emergency or for pilot safety, this alternative would not require the landing of aircraft within the proposed wilderness areas.

Filling and recontouring dug-outs, stock ponds, and small reservoirs for complete site restoration would not be conducted within the proposed wilderness areas under this alternative. We expect most dug-outs would continue to function for the foreseeable future but eventually will refill and revegetate through the natural processes of erosion, sedimentation, and plant community succession. Stock ponds are expected to recover more quickly than dug-outs as loose material used for constructing the impoundment berms is eroded away, allowing water to flow unimpeded. In many cases this has already occurred. A separate minimum tool analysis would be conducted on a case-by-

case basis for playa restoration if results from proposed restoration efforts conducted outside wilderness indicate refilling and recontouring is necessary to restore biological health, diversity, and integrity to these habitats.

We anticipate the amount of time to remove materials and complete restoration of springs with minimal development and near access roads would likely be completed by four people in a single day similar to Alternatives A and B. Where helicopters are determined necessary, we anticipate a crew of two people could prepare debris and materials for transport in less than one day and transport with the helicopter could be completed in less than one hour. Construction of temporary fence exclosures around spring sources would be accomplished within one day by a crew of four to six people using hand tools. Under this alternative debris would be removed from springs and playas, but dug-outs, stock ponds, and small reservoirs at these sites would not be refilled as under Alternatives A and B. Instead, dug-outs would be allowed to naturally refill with sediment, or would be breached to prevent catastrophic failure and allow the flow of water back to riparian habitats where feasible. We expect this alternative would meet the Sheldon Refuge CCP/EIS preferred alternative objective to restore at least 20% of playas and 20 springs over the next 15 years.

Effects

Wilderness Character

"Untrammeled"
Under this alternative, the number of people and amount of time required to complete restoration work would be less than under Alternative A or B. Consequently the impacts to untrammeled wilderness condition would also less than those under Alternatives A and B. Long-term trammeling of wilderness character from management efforts to rehabilitate and restore natural condition to these sites within proposed wilderness was evaluated in the Sheldon Refuge CCP/EIS.

"Undeveloped"
The removal of permanent structures and debris would improve the undeveloped character of all eight proposed wilderness areas, similar to Alternatives A and B. Under this alternative debris and other abandoned items would be removed from springs and playas, but we would not refill areas excavated for stock ponds, dug-outs, or small reservoirs. As a result, some playas may continue to appear developed, but with debris removed, we anticipate remaining disturbances would be substantially unnoticeable to the casual observer due to natural filling through erosion and regrowth of vegetation. Impacts from temporary crew campsites anticipated under Alternatives A and B would not occur under this alternative.

"Natural"
Stock ponds, dug-outs, and small reservoirs would appear more natural in the short term when compared with more visible impacts of restoration under Alternatives A and B. In addition, the risk of spreading invasive weeds under this alternative is avoided due to the absences of soil disturbance, temporary work camps, and the need for repeated stock use. Over the long term, we anticipate natural hydrology and habitat composition would be restored under this alternative, but would occur at a much slower rate than under Alternatives A and B. Because the ecology of playa habitats is poorly understood we cannot determine if allowing natural erosion and recovery processes would restore natural playa function and ecology under this alternative. Results from playa restoration efforts planned for sites outside the proposed wilderness areas will provide the information needed to determine if such actions are the minimum necessary to restore wilderness character in the future.

Many existing routes within the proposed wilderness areas have naturally grown in with vegetation over time. Minimal access either on foot or horseback to restoration sites under this alternative would result in little or no noticeable impact to the current condition of existing routes compared with the repeated use of these routes for access either on foot or by horseback as proposed under Alternative A or by motorized vehicles as proposed under Alternative B. This alternative would leave routes looking more natural than under Alternative A or B and would not make these routes more visible and more susceptible to trespass vehicle use in the future.

"Outstanding Opportunities for Solitude or a Primitive and Unconfined Type of Recreation"
Opportunities for solitude would be directly affected by the presence of work crews as large as six people and the sights and sounds of helicopters within the proposed wilderness area where work is conducted, and possibly within other nearby proposed wilderness areas. We anticipate noise from a single helicopter flight to drop off and pick up a load of materials or debris would impact wilderness solitude for less than one hour. Overall, noise impacts to wilderness solitude under this alternative would be more intense and would affect a larger area than larger work crews using hand tools as proposed in Alternative A, or motorized vehicles as proposed under Alternative B, but these impacts would last for a shorter length of time.

As discussed under Alternative A, impacts would be greatest if restoration efforts are conducted during the fall hunting seasons when recreation use is greatest within the proposed wilderness areas.

Other Unique Components that Reflect the Character of this Wilderness

Heritage and Cultural Resources
Because no soil disturbance would occur under this alternative, we expect no adverse impact to cultural or historic resources.

Maintaining Traditional Skills
This alternative would maintain some traditional skills, but not to the degree of Alternative A.

Special Provisions
N/A

Time Constraints
The specialized tools and equipment needed to implement this alternative are readily available and necessary funding is available. The less intensive restoration efforts under this alternative would require less time and funding than either Alternative A or B, and work could be completed within the 10- to 15-year timeframe of the Sheldon Refuge CCP/EIS preferred alternative.

Additional Wilderness-specific Comparison Criteria
The benefits of constructing protective fence exclosures with wood rails or metal pipe at some springs where helicopters are used would be as described under Alternative B.

Safety of Visitors, Personnel, and Contractors

Using helicopters to transport large, irregular shaped, bulky loads of fence materials or debris would increase risks to safety. Because only two people are typically associated with such operations, this alternative is expected to be somewhat less safe than using motorized excavation equipment under

Alternative B, but somewhat safer than using teams of horses or mules to pull excavation equipment under Alternative A.

Comparison of Alternatives

	Alternative A	Alternative B	Alternative C
Untrammeled	+	+	+
Undeveloped	+	+	-
Natural	+/-	+/-	+
Solitude or Primitive Recreation	++	--	+/-
Unique Components			
Wilderness Character	+	+/-	+/-

	Alternative A	Alternative B	Alternative C
Heritage and Cultural Resources	-	+/-	+
Maintaining Traditional Skills	+	-	-
Special Provisions	N/A	N/A	N/A
Time	-	+	+
Additional Wilderness Criteria	-	+	+
Other Criteria Summary	-	+	+

	Alternative A	Alternative B	Alternative C
Safety	-	+/-	+

Safety Criteria

Aircraft present a unique set of safety hazards which can be mitigated through the use of proper protective equipment, specialized training, and the use of qualified and experienced pilots and flight crews.

Documentation

Broyles, B. 1995. Desert wildlife water developments: Questioning use in the southwest. Wildlife Society Bulletin. 23(4):663-675.

Step 2 Decision: What is the <u>Minimum</u> Activity/Minimum Tool?

Selected Alternative

Alternative C

<u>Rationale</u> for Selecting this Alternative (Including Documentation of Safety Criterion, If Appropriate)

Alternative C would accomplish removal of permanent developments from all eight proposed wilderness areas with the least amount of short-term impacts to natural conditions, the least risk for introduction and spread of invasive non-native plants, the least risk for additional impact to cultural resources, and the shortest duration of impacts to opportunities for wilderness solitude and primitive recreation.

Alternative C would restore natural appearance and function to springs and other areas developed for livestock over a longer period of time, but with much less trammeling of wilderness character when compared with Alternative A or B.

It is our determination the impact to wilderness solitude from the short-term low-altitude use of helicopters is outweighed by avoiding other longer-term adverse impacts but achieving the beneficial impacts of restoring natural appearance, condition, and opportunities for solitude free from evidence of people and their activities.

Monitoring and reporting requirements:

Check Any Wilderness Act Section 4(c) Uses Approved in this Alternative

- ☒ mechanical transport
- ☐ motorized equipment
- ☐ motor vehicles
- ☐ motorboats
- ☐ landing of aircraft
- ☐ temporary road
- ☐ structure or installation

Record and report any authorizations of Wilderness Act Section 4(c) uses according to agency procedures.

Approvals	Signature	Name	Position	Date
Prepared by:		Adam P. Collins	Park Ranger	9/25/12
Recommended:		John W. Kusbohm	Project Leader	9/25/12
Approved:		Charles J. Houghten	Regional Wilderness Coord.	9/27/12

G.5 Final Minimum Requirements Decision and Analysis for Maintenance of Wildlife Guzzlers

Step 1: Determine if any administrative action is necessary. (Refer to the Sheldon Refuge CCP/EIS and preferred alternative.)

Management direction for wildlife guzzlers was evaluated through a range of alternatives included in the Sheldon Refuge CCP/EIS. The CCP/EIS preferred alternative for guzzler maintenance has been determined necessary for management of Sheldon Refuge and the proposed wilderness areas.

Step 2: Determine the minimum activity/minimum tool.

Description of Alternatives

Permanent water developments for wildlife (a.k.a. guzzlers) were previously constructed and are located within the Round Mountain (bighorn sheep guzzler), Big Mountain (three bighorn sheep guzzlers and three small game guzzlers), and Big Spring Table (one bighorn sheep guzzler and four small game guzzlers) Proposed Wilderness Areas.

The preferred alternative identified in the Sheldon Refuge Final CCP/EIS would retain all guzzlers, including those within the proposed wilderness areas (Refer to CCP/EIS Figure 5.1 for guzzler locations). To ensure guzzlers remain functional, periodic monitoring and maintenance are required. Materials needed for maintenance include small items such as fence wire, fence posts, and plastic gutter, as well as very large and heavy items such as sheet metal, fiberglass water catchments, and storage tanks.

This analysis evaluates the minimum activity necessary within the proposed wilderness areas to accomplish the management direction of the preferred alternative. This analysis is programmatic in nature, and the decision is intended to provide for the types of monitoring and maintenance expected to occur over the course of the next 10 to 15 years. Unforeseen circumstances or conditions may require activities otherwise prohibited within the proposed wilderness areas that were not evaluated through this analysis. The decision to conduct such activities would require a site- and case-specific minimum requirements decision and analysis, with public involvement as required by Service policy.

Alternative A

Description

All maintenance of guzzlers within proposed wilderness would be conducted using non-mechanized and non-motorized tools and equipment. Access and transport of tools, equipment, and materials would be by foot, horseback, pack stock, or other non-mechanized and non-motorized means.

Under this alternative, periodic monitoring and minor maintenance could be completed by a single person or small crews of four to six people within a single day. Large items such as catchment basins and water tanks would be repaired on-site.

For major repairs requiring replacement, teams of horses or mules could be used to pack sheet metal or drag catchment basins used for small game guzzlers, and we anticipate crews could complete replacement within two days. Due to their size and weight, we do not expect replacement of large

water storage tanks used for bighorn sheep guzzlers would be possible using non-mechanized means as proposed under this alternative.

Materials used for maintenance and replacement would be selected and/or modified to blend with the surrounding terrain. The most noticeable element of guzzlers is their metal roofs. Replacement roofing would be painted camouflage/natural colors to better blend with the ground.

Effects

Wilderness Character

"Untrammeled"
The presence of work crews for one or two days within the same general location is expected to alter wildlife behavior and habitat use until maintenance efforts are completed. Continued long-term trammeling of wilderness character from altered numbers, movements, and distribution of wildlife populations due to the construction of artificial sources of water was evaluated in the Sheldon Refuge CCP/EIS.

"Undeveloped"
Maintenance under this alternative would retain permanent structures within the three proposed wilderness areas. Over the long term, most bighorn sheep guzzlers could not be fully maintained and would likely be removed.

"Natural"
Maintenance of guzzlers using materials that blend with the surrounding landscape would somewhat reduce the unnatural appearance of guzzlers.

"Outstanding Opportunities for Solitude or a Primitive and Unconfined Type of Recreation"
The presence of small work crew for one or two days would have little or no impact on opportunities for solitude or unconfined types of recreation. Reduced visibility of guzzlers should improve opportunities for primitive recreation.

Other Unique Components that Reflect the Character of this Wilderness

Heritage and Cultural Resources
N/A

Maintaining Traditional Skills
The routine use of hand tools and the occasional use of horse or mule teams to transport materials would maintain traditional skills.

Special Provisions
N/A

Time Constraints
The use of non-mechanized and non-motorized tools and equipment for minor repairs and maintenance under this alternative would not substantially increase the amount of time to complete similar maintenance when compared with the other alternatives. For most guzzlers, initial construction was completed using helicopters to transport tools and materials, and completing major maintenance or repairs using stock for transport of tools and equipment would not be feasible.

Additional Wilderness-specific Comparison Criteria
N/A

Safety of Visitors, Personnel, and Contractors

The use of hand tools and horse or mule teams to drag materials under this alternative does not present a great deal of risk. Other risks and potential safety issues encountered within proposed wilderness are generally no greater than those encountered in other remote areas of Sheldon Refuge.

Alternative B

Description

Under this alternative, routine site visits for monitoring and minor maintenance of guzzlers within proposed wilderness would be conducted using non-mechanized and non-motorized tools and equipment. Access and transport of tools, equipment, and materials for routine site and minor maintenance would be by foot, horseback, pack stock, or other non-mechanized and non-motorized means as under Alternative A.

The transport of sheet metal, catchments, and water tanks for major maintenance and repairs would be conducted using non-motorized vehicles such as wagons and carts along existing routes. Water tanks used at bighorn sheep guzzlers are typically buried and would need to be excavated for replacement. Under this alternative we anticipate a single trip using a non-motorized vehicle would occur at each guzzler no more than once every 10 years.

In order to accomplish management objectives for guzzler maintenance it is likely multiple crews of four to eight people would work up to six days depending upon terrain, the size of guzzler, and the maintenance needed. Most guzzlers are located in very rocky steep terrain, and tools and materials were transported for initial construction to most sites by helicopter. It is unlikely major maintenance could be completed at all guzzlers using stock or non-motorized vehicles as proposed under this alternative and Alternative A. At bighorn sheep guzzlers farthest from road access, it is expected short-term tent camps for as many as eight people would be used for periods up to six days. All supplies for temporary camps would be transported with tools, equipment, and materials required for major maintenance.

Access routes would be photographed and inventoried prior to use to measure vegetative cover, and to identify noxious weeds and other invasive non-native plants. No maintenance or surface disturbance would be allowed to improve access routes. Transport of tools, equipment, and materials would be accomplished using one vehicle making a single trip to the project and/or campsite and a single trip out.

Upon completion of maintenance operations, all waste, materials, and structures would be removed. Once the management objective has been achieved, campsites would be restored to their prior condition using standard wilderness rehabilitation and restoration methods. Access routes and campsites would be photographed and monitored following the first full growing season to document impacts from use and the effectiveness of restoration efforts, as well as to detect any newly introduced noxious weeds or other non-native species. Subsequent monitoring would be conducted as needed to document route and campsite recovery and document new vehicle trespass into proposed wilderness areas.

Effects

Wilderness Character

"Untrammeled"
The presence of crews working up to six days within the same general location is expected to alter wildlife behavior and habitat use until maintenance is completed. Continued long-term trammeling of wilderness character from altered numbers, movements, and distribution of wildlife populations due to the construction of artificial sources of water was evaluated in the Sheldon Refuge CCP/EIS.

"Undeveloped"
Maintenance under this alternative would retain permanent structures within the three proposed wilderness areas. The presence of tents and other temporary structures at work camps would affect the undeveloped character of the three areas for up to six days.

"Natural"
Maintenance of guzzlers using materials that blend with the surrounding landscape would somewhat reduce the unnatural appearance of guzzlers. The use of vehicles would trample vegetation and make existing routes more visible and more susceptible to unauthorized vehicle use in the future.

"Outstanding Opportunities for Solitude or a Primitive and Unconfined Type of Recreation"
The presence of small work crew for up to six days would have minor impacts on opportunities for solitude or unconfined types of recreation. Reduced visibility of guzzlers should improve opportunities for primitive recreation.

Other Unique Components that Reflect the Character of this Wilderness

Heritage and Cultural Resources
N/A

Maintaining Traditional Skills
The use of mechanized equipment under this alternative would not maintain traditional skills to the extent of Alternative A, but would better maintain traditional skills when compared with alternatives C and D.

Special Provisions
N/A

Time Constraints
For guzzlers that were initially constructed using vehicles, use of non-mechanized and non-motorized tools and equipment for minor repairs and maintenance under this alternative would not substantially increase the amount of time to complete similar maintenance when compared with the other alternatives. For most guzzlers, initial construction was completed using helicopters to transport tools and materials, and completing major maintenance or repairs using non-motorized vehicles for transport of tools and equipment would not be feasible.

Additional Wilderness-specific Comparison Criteria
N/A

Safety of Visitors, Personnel, and Contractors

The use of hand tools, horse or mule teams, and non-motorized vehicles under this alternative does not present a great deal of risk. Other risks and potential safety issues encountered within proposed wilderness are generally no greater than those encountered in other remote areas of Sheldon Refuge.

Alternative C

Description

Under this alternative, routine site visits for monitoring to assess condition and maintenance needs for guzzlers would be conducted either on foot, by horseback, or by low level helicopter overflight (i.e., without landing). Monitoring would be conducted as needed to annually prioritize and schedule repairs for at least 10% of non-functioning guzzlers as identified in the Sheldon CCP/EIS Objective 3f. We anticipate a single trip on foot, by horseback, or by helicopter overflight to each guzzler would likely occur every three to five years, but not more than once per year.

Minor maintenance of guzzlers within proposed wilderness would be conducted using non-mechanized and non-motorized tools and equipment. Access and transport of tools, equipment, and materials for routine and minor maintenance would be by foot, horseback, pack stock, or other non-mechanized and non-motorized means as under Alternative A.

The transport of sheet metal, catchments, water tanks, or other large items needed for major maintenance or repairs and not typically transported by pack stock or backpack would be conducted by helicopter. Helicopters would be used to transport suspended loads of materials. At each site where materials are to be flown in, the items being replaced would be prepared in advance to be hauled out on the return trip. In this way, helicopter use would maximize efficiency, and the number of people and amount of time required for maintenance would be minimized. Except in the case of emergency or for pilot safety, this alternative would not require the landing of aircraft within the proposed wilderness areas; personnel and work crews would not be transported by helicopter.

Tools and smaller items could be combined with other loads of materials and for transport by helicopter. Under this alternative, helicopter use would occur as necessary to meet management objectives identified in the Sheldon Refuge CCP, but we anticipate a single trip using a helicopter would typically occur at each guzzler once every 10 years.

Work would normally be completed using primitive tools consistent with the principles of wilderness management. Under this alternative, battery-powered hand tools may be permitted when it is determined that such uses would reduce the number of days required to complete maintenance and repairs within the proposed wilderness area and that such use would minimize impacts to wilderness solitude and undeveloped character from reduced presence of work crews. However, such uses would not be permitted for convenience, comfort, or only negligible benefits to efficiency for conducting maintenance or repairs.

Similar to Alternative B, water tanks used at bighorn sheep guzzlers are typically buried and would need to be excavated for replacement.

Campsites would be photographed and monitored following the first full growing season to document impacts from use and the effectiveness of restoration efforts, as well as to detect any newly

introduced noxious weeds or other non-native species. Subsequent monitoring would be conducted as needed to document campsite recovery.

Effects

Wilderness Character

"Untrammeled"
We expect the nature of impacts to untrammeled wilderness character would be similar to, but less intensive than, those from alternatives A and D. Annual helicopter overflights and the presence of crews working up to six days within the same general location are expected to alter wildlife behavior and habitat use until maintenance is completed.

The use of helicopters would reduce the amount of time required for monitoring and would eliminate the need for personnel to travel cross-country through the wilderness areas. However, unlike impacts from foot or horseback travel under other alternatives, the impacts of helicopter use under this alternative would occur over a much larger area as flights occur between landing areas outside the wilderness and various guzzlers. These activities could potentially impact a greater number of wildlife than activities under alternatives A and B would, and would only be slightly less than impacts under Alternative D, which also proposes to transport maintenance crews by helicopter.

Continued long-term trammeling of wilderness character from altered numbers, movements, and distribution of wildlife populations due to the construction of artificial sources of water was evaluated in the Sheldon Refuge CCP/EIS.

"Undeveloped"
Impacts to undeveloped wilderness character would be as described for Alternative B with the use of temporary structures (i.e., tents) at some sites for periods up to six days. Battery-powered hand tools would only be used for major maintenance and repairs to improve efficiency and would reduce the number of days needed for work crews in the field, resulting in slightly less adverse impact to undeveloped wilderness character than Alternative B or D.

"Natural"
Impacts to natural conditions would be similar to those under Alternative A. Maintenance of guzzlers using materials that blend with the surrounding landscape would somewhat reduce the unnatural appearance of guzzlers. Access by work crews on foot or by horseback would occur approximately once every 10 years and would result in some trampling of vegetation. However, impacts from such use are expected to be negligible and not observable or measurable after one growing season.

"Outstanding Opportunities for Solitude or a Primitive and Unconfined Type of Recreation"
The use of a helicopter under this alternative would have a direct impact on opportunities for wilderness solitude. Due to the noise and visibility of helicopters, these impacts would occur over a larger area than those anticipated under either Alternative A or B. Use of battery-powered hand tools for major maintenance and repairs would reduce the amount of time needed for work crews to complete repairs and maintenance and would result in less adverse impact to opportunities for wilderness solitude.

Other Unique Components that Reflect the Character of this Wilderness

Heritage and Cultural Resources
N/A

Maintaining Traditional Skills
This alternative would not maintain traditional skills and would further diminish the use of traditional skill through the use of modern motorized hand tools. This alternative would eliminate most use of primitive tools or traditional methods of travel and work for monitoring and maintenance of guzzlers within the wilderness areas and would further diminish the use of traditional skills through use of aircraft and modern motorized hand tools.

Special Provisions
N/A

Time Constraints
If all guzzlers are flown consecutively, monitoring by helicopter overflight could be completed within a single day. This would save time when compared to monitoring on foot or by horseback, which we expect could be completed within three days. However, personnel equipped with proper hand tools and minimal supplies as proposed under Alternative A and B would complete routine and minor maintenance in conjunction with monitoring, which would require fewer site visits and less time when considering both monitoring and minor maintenance. Use of non-mechanized and non-motorized tools and equipment for minor repairs and maintenance under this alternative would not substantially increase the amount of time needed to complete similar maintenance when compared with the other alternatives. In some cases, the use of battery-powered hand tools would be used and would reduce the amount of time needed to complete repairs or maintenance by at least one full day, as this would be the criteria for allowing their use. This alternative is likely to complete all necessary maintenance and repairs to all guzzlers within the proposed wilderness areas.

Additional Wilderness-specific Comparison Criteria
N/A

Safety of Visitors, Personnel, and Contractors

Using helicopters for low level overflights and to transport large, irregular shaped, bulky loads would increase risks to safety. Because only two people are typically associated with such operations, this alternative is expected to be only somewhat less safe than using horse or mule teams and non-motorized equipment as under Alternative B.

Alternative D

Description

Under this alternative, site visits for monitoring and maintenance would be completed using helicopters, motorized equipment, and non-motorized tools and equipment.

Access for routine site visits for monitoring and to conduct maintenance would be conducted by low level helicopter overflights and landing. It is anticipated that crews of one to six people would be needed in the majority of cases and could be transported to the guzzler in a single trip. Sheet metal, catchments, water tanks, tools, and other items needed for maintenance or repairs would also be

transported by helicopter. At each site where materials are to be flown in, the items being replaced would be prepared in advance to be hauled out on the return trip. Tools and smaller items could be combined with other loads of materials for transport by helicopter. In this way, helicopter use would maximize efficiency, and the number of people and amount of time required for maintenance would be minimized.

Under this alternative, helicopter use would occur as necessary to accomplish monitoring and maintenance objectives identified in the Sheldon Refuge CCP, and we anticipate a single flight to each guzzler by helicopter would typically occur every three to five years, but not more than once per year, with multiple trips to each guzzler for maintenance approximately every 10 years.

Work would normally be completed using a combination of primitive tools, battery-powered hand tools, electric or air-powered tools, and gas-powered generator and/or motorized air compressor. Motorized tools and equipment may be permitted when it is determined such uses would reduce the number of days required to complete maintenance and repairs within the proposed wilderness area.

Similar to Alternative B, water tanks used at bighorn sheep guzzlers are typically buried and would need to be excavated for replacement.

Permanent helicopter landing sites (helispots) would be located near each guzzler. A wind detector (such as a small flag) and identifiable markings (such as rock painted contrasting colors), and dust abatement as necessary would be required at each site (see Departmental Manual 351 DM 1 and Chapter 8.5 of the *Interagency Helicopter Operations Guide*). We anticipate some clearing of brush and removal of rocks and possibly minor excavation to create a level landing surface near each guzzler would be necessary to establish a long-term helispot safe for multiple landings and take-offs.

Effects

Wilderness Character

"Untrammeled"
We expect impacts to untrammeled wilderness character would be similar to those anticipated under Alternative A. Similar to impacts from the presence of work crews described under Alternative A, the annual use of helicopters for access and multiple flights for transport of tools and materials to guzzlers is expected to alter wildlife behavior and habitat use until maintenance efforts are completed. The use of helicopters, motorized equipment, and motorized tools would reduce the amount of time required for work crews and would eliminate the need for temporary campsites within the wilderness areas. However, unlike impacts from the presence of work crews near guzzler under other alternatives, helicopter use under this alternative would occur over a much larger area as multiple flight would occur between staging areas and guzzler landing sites to transport work crews, tools, equipment, and materials. These activities could potentially impact a greater number of wildlife than activities under the other alternatives would.

Continued long-term trammeling of wilderness character from altered numbers, movements, and distribution of wildlife populations due to the construction of artificial sources of water was evaluated in the Sheldon Refuge CCP/EIS.

"Undeveloped"
Impacts to undeveloped wilderness character from the necessary clearing, leveling, and marking of helispots to create suitable permanent helicopter landing sites would result in slightly greater impact to undeveloped wilderness character than under Alternative B or C.

"Natural"
Maintenance of guzzlers using materials that blend with the surrounding landscape would somewhat reduce the unnatural appearance of guzzlers. Impacts to natural conditions from the creation and maintenance of permanent helicopter landing sites would be similar to, but longer lasting than, those under Alternative B or C from the use of temporary campsites.

"Outstanding Opportunities for Solitude or a Primitive and Unconfined Type of Recreation"
Overflights and noise from helicopter use under this alternative would have a direct impact on opportunities for wilderness solitude. Due to the annual, and in some years multiple, trips anticipated to each guzzler, these impacts would occur more often, resulting in greater impact than under all other alternatives. Use of motorized and mechanized tools and equipment for maintenance and repairs would reduce the amount of time needed for work crews to complete repairs and maintenance, but would further add to impacts from noise and would result in a greater adverse impact to opportunities for wilderness solitude or a primitive and unconfined type of recreation than would the other alternatives.

Other Unique Components that Reflect the Character of this Wilderness

Heritage and Cultural Resources
N/A

Maintaining Traditional Skills
This alternative would eliminate most use of primitive tools or traditional methods of travel and work for monitoring and maintenance of guzzlers within the wilderness areas and would further diminish the use of traditional skills through reliance on use of aircraft, modern motorized hand tools, and modern mechanized equipment.

Special Provisions
N/A

Time Constraints
The use of aircraft and motorized tools and equipment under this alternative would not substantially reduce the amount of time needed to complete similar maintenance when compared with Alternative C. The variety of battery-powered hand tools available under Alternative C would afford convenience and time savings similar to those from similar generator-powered tools. Work accomplished with larger generator or air compressor–powered tools such as a jackhammer can often be accomplished more quickly and result in a more natural appearance through the use of traditional tools such as explosives.

Additional Wilderness-specific Comparison Criteria
N/A

Safety of Visitors, Personnel, and Contractors

Using helicopters to transport work crews and large, irregular shaped, bulky loads would increase risks to safety. Efforts to establish permanent landing sites would reduce some risk associated with off-airport landings, but multiple helicopter flights to transport work crews under this alternative would pose a greater risk to their safety than would the other alternatives, which rely on access by foot or horseback and would not require helicopter landings.

Comparison of Alternatives

It may be useful to compare each alternative's positive and negative effects to each of the criteria in tabular form, keeping in mind the law's mandate to "preserve wilderness character."

	Alternative A	Alternative B	Alternative C	Alternative D
Untrammeled	-	-	-	--
Undeveloped	+/-	-	-	-
Natural	+	-	+	-
Solitude or Primitive Recreation	+	+	-	--
Unique Components	N/A	N/A	N/A	N/A
Wilderness Character	+	-	-	---

	Alternative A	Alternative B	Alternative C	Alternative D
Heritage and Cultural Resources	N/A	N/A	N/A	N/A
Maintaining Traditional Skills	+	-	-	---
Special Provisions	N/A	N/A	N/A	N/A
Time	-	-	+	++
Additional Wilderness Criteria	N/A	N/A	N/A	N/A
Other Criteria Summary	+/-	-	+/-	-

	Alternative A	Alternative B	Alternative C	Alternative D
Safety	+	+	-	---

Safety Criteria

Aircraft present a unique set of safety hazards, which can be mitigated through the use of proper protective equipment, specialized training, and the use of qualified and experienced pilots and flight crews. To provide adequate safety for pilots, personnel, and work crews, helispots must comply with interagency guidelines.

Step 3 Decision: What is the <u>Minimum</u> Activity/Minimum Tool?

Selected Alternative

Alternative C

<u>Rationale</u> for Selecting this Alternative (Including Documentation of Safety Criterion, If Appropriate)

Alternative C would use the tools and techniques that have the least impact to natural conditions while achieving management objectives. Impacts to wilderness solitude are greater under Alternative

C than either Alternative A or B (which both use more primitive tools) due to helicopter overflights from monitoring and the use of helicopters approximately once every 10 years at each guzzler, but landing would not be required and impacts to solitude would be short term and less intrusive over the long term than the use of wheeled vehicles as proposed under Alternative B or multiple helicopter flights and landings proposed under Alternative D.

Work crews have regularly accessed work sites within designated wilderness on foot, by horseback, and with the use of pack stock for nearly 50 years. Use of these primitive modes of travel and related equipment are core wilderness principles and are preferable to the use of mechanical transport for conducting activities within wilderness. The proper choice of access routes and use of minimum-impact camping techniques during short-term (one week) maintenance and construction projects have proven effective in minimizing impacts to wilderness character and often result in no visible or measurable impact after the next growing season. While cross-country travel through steep, rough, and rocky terrain on foot or by horseback does pose some safety risk, the risk can be minimized through the use of proper technique, equipment, and training. Related injuries are typically minor and can usually be treated in the field.

Alternative A would be less intrusive than either Alternative B or C, but due to the steep, rough, and rocky terrain where most guzzlers are located, neither Alternative A or B would be able to transport large materials required for major maintenance or repairs in order to accomplish maintenance of all guzzlers, including replacement of large water tanks or sheet metal at bighorn sheep guzzlers—which has been determined the minimum administrative action necessary.

The use of helicopters as proposed under Alternative D would reduce impacts to vegetation from cross-country travel and use of temporary campsites as described under the selected Alternative C. However, these impacts described for Alternative C are expected to be negligible. Therefore, the adverse impacts from permanent helispots, from helicopter overflights, and from associated noise are greater than the vegetation impacts that would be avoided. Use of helicopters for transport would also reduce the amount of time needed for work crews to access guzzlers. We anticipate all guzzlers could be monitored during a single day by helicopter, while monitoring on foot or by horseback would require three days. However travel on foot or by horseback could reduce the amount of time needed when only minor maintenance or repairs are carried out, as these could be completed with minimal hand tools and supplies.

The use of helicopters for transport of work crews to primitive landing sites is inherently dangerous and poses safety risks. There is a low probability for accident or injury with the use of experienced pilots, and proper equipment, maintenance, and training. However unlike injuries received during backcountry travel by foot or on horseback, when helicopter accidents do occur, related injuries are typically more severe and are more often life-threatening or fatal. Therefore the convenience and efficiency afforded by the use of helicopters for monitoring and transport of work crews does not outweigh the increased level of risk and additional impacts to wilderness character.

Monitoring and Reporting Requirements

Except as specifically described in the alternative selected, no use of motorized vehicles or equipment may occur without prior written determination by the Sheldon-Hart Mountain Refuge Complex Project Leader. All areas where the use of motorized vehicles and temporary structures occur will be monitored and degradation of natural conditions reported.

Check Any Wilderness Act Section 4(c) Uses Approved in this Alternative

- ☒ mechanical transport
- ☒ motorized equipment
- ☐ motor vehicles
- ☐ motorboats
- ☐ landing of aircraft
- ☐ temporary road
- ☐ structure or installation

Record and report any authorizations of Wilderness Act Section 4(c) uses according to agency procedures.

Approvals	Signature	Name	Position	Date
Prepared by:		Aaron P. Collins	Park Ranger	9/25/12
Recommended:		John W. Kasbohm	Project Leader	9/25/12
Approved:		Charles J. Houghten	Regional Wilderness Coord.	9/27/12

G.6 Final Minimum Requirements Decision and Analysis for Refuge Studies, Inventory, Monitoring, and Research

Step 1: Determine if any administrative action is necessary. (Refer to the Sheldon Refuge CCP/EIS and preferred alternative).

Management direction for inventory and monitoring was evaluated through a range of alternatives included in the Sheldon Refuge CCP/EIS. The CCP/EIS preferred alternative for the use of studies, inventory, monitoring and research has been determined necessary for management of Sheldon Refuge and the proposed wilderness areas.

Step 2: Determine the minimum activity/minimum tool.

Description of Alternatives

Fulfilling the purposes for Sheldon National Wildlife Refuge and implementation of Sheldon Refuge CCP/EIS preferred alternative would require continued inventory, monitoring, research, and other studies related to both biological resources and social issues within all eight of the proposed wilderness areas. The majority of studies, inventory, monitoring, and research conducted within Sheldon Refuge and identified through the Sheldon Refuge CCP/EIS would be conducted using methods and tools not otherwise prohibited by the Wilderness Act or Service policy for management of proposed wilderness areas.

The majority of inventory, monitoring, and research conducted within Sheldon Refuge require observation, collection of small samples, or basic measurements and could be accomplished by staff, volunteers, and partners using primitive tools and would not require access by motorized vehicle or aircraft. However, due to concerns for animal welfare, accepted study protocols, and limited times of day, season, or year when activities can be accomplished, some prohibited uses, such as the use of helicopters to capture and/or transport animals, need to be evaluated for use within the proposed wilderness areas.

The study, inventory, monitoring, and research of large animals within Sheldon Refuge and the proposed wilderness, particularly to inventory populations, population trends, animal movements, and migration patterns of large mammals, could be completed using a variety of tools and methods including the use of helicopters. Helicopters have traditionally been used for such activities and are evaluated through this minimum tool analysis as one alternative. Alternatives to using helicopters include a variety of non-motorized and non-mechanized ground-based capture methods, which are also evaluated as part of this minimum tool analysis.

Alternative A

Description

All inventory, monitoring, and research would be conducted on foot or by horseback using non-motorized equipment and traditional primitive tools.

With the exception of basic monitoring efforts, most projects would require the establishment of temporary field camps to support crews of two to eight people for a period of one to 12 weeks

depending upon the type of project and specific inventory, monitoring, and research protocols. We anticipate no more than two temporary seasonal field camps would be used at any given time.

Temporary field camps and latrine sites would be selected in advance. Sites would be capable of supporting one or more projects. Access routes for seasonal camps or campsites anticipated to be used for multiple seasons would also be identified in advance. Both access routes and campsites would be photographed and inventoried prior to use in conjunction with a cultural resource inventory to document wildlife present, measure vegetative cover, and identify noxious weeds and other invasive non-native plants. No maintenance or surface disturbance would be allowed to improve access routes. Rocks and other obstacles could be temporarily moved to provide suitable tent sites. Temporary latrines for burial of waste would be excavated to the minimum depth and size necessary.

Upon project completion, all materials and structures would be removed and campsites would be restored to their prior appearance using standard wilderness rehabilitation and restoration methods and primitive tools. Access routes and campsites would be photographed and monitored following the first full growing season to document impacts from use and the effectiveness of restoration efforts, as well as to detect any newly introduced noxious weeds or other non-native species. Subsequent monitoring would be conducted as needed to document wildlife use and campsite recovery.

Capture of large animals for fitting with radio or GPS collars and the collection of blood or tissue samples would be conducted using a wide variety of methods dictated by a variety of factors including project objectives; species of animal; terrain and distance; and time of year. Methods designed to capture individual animals could include baiting or attracting animals into temporary box traps, temporary corrals, or leg-hold snares. These methods require nearby temporary field camps to allow repeated visits to the trap site to release non-target animals and to minimize the length of time animals are in captivity.

Other methods designed to capture multiple animals involve the use of herders either on foot or horseback to drive animals into large nets, temporary traps or corrals, or other confined areas where target animals can be selected and then sedated or captured by hand. These methods reduce the potential for capturing non-target species but increase the number of non-target individuals captured and increase the length of time animals are kept in captivity when compared with other capture methods. The length of time from when animals are initially herded until the time they are release is highly variable using these techniques, but can be up to 12 hours.

For construction of some temporary traps, holes would be dug to place post or anchors. Monitoring populations and locating animals in preparation of capture operations would include aircraft overflights to count and record locations, but no landing of aircraft within the proposed wilderness areas would occur.

Effects

Wilderness Character

<u>"Untrammeled"</u>
The presence of temporary traps, field camps, and crews for periods of several weeks or months within the same general location is expected to alter wildlife behavior and habitat use until projects are completed.

Herding animals for a single capture operation is not likely to result in long-term changes to animal behavior, migration, or habitat use. If repeated capture efforts are necessary, the use of the methods and techniques under this alternative would likely affect both animal behavior and habitat use as animals become conditioned to the activity (either by avoiding capture areas or by becoming habituated to the activity). Using herders to capture live animals typically requires moving entire groups of animals into the net, trap, or confined area where individuals are then selected. As a result, impacts are likely to affect entire groups within the larger wildlife population.

The most common types of injuries that occur during live animal captures include falling, tripping, being trampled by other animals, or suffering from shock. Injuries typically occur when slower, smaller animals are trampled by faster, larger animals as they are driven or herded, when animals are tripped and tangled in nets during captures at running speeds, while trying to escape from traps or other confined spaces as people try to restrain and remove a single animal from the group; or from adverse reaction to immobilization drugs used for capture, or from a physiological response to being captured, referred to as "capture myopathy."

When compared with the use of use of helicopters, the herding or driving of groups of animals into nets or traps increases the risk of injury to non-target individuals both because of the greater number of animals captured and the longer amount of time required both for completing the capture and processing, and the length of time animals are kept in captivity.

Long-term trammeling of wilderness character from inventory, monitoring, and research was evaluated in the Sheldon Refuge CCP/EIS.

"Undeveloped"
Temporary field camps consisting of small and large tents would affect the undeveloped character of small portions of the proposed wilderness areas. Following campsite removal and restoration, little or no noticeable evidence of temporary developments would remain. Use along identified access routes would be noticeable but would appear as undeveloped and unmaintained trails.

"Natural"
Use of access routes and campsites would result in damage to vegetation, including shrubs and other perennials, and these impacts would be noticeable for several years. In areas where longer-term temporary field camps are constructed and used, vegetation would be trampled and some areas of bare ground would occur. It is anticipated these impacts would affect areas less than 1 acre in size in and around field camp locations.

Live animal captures would temporarily affect the natural behavior and movements of animals. The placement of tracking devices such as radio and GPS collars would temporarily affect the natural appearance of these animals.

"Outstanding Opportunities for Solitude or a Primitive and Unconfined Type of Recreation"
Opportunities for solitude would be directly impacted by seasonal field camps consisting of several tents and groups of up to eight people for periods lasting several weeks or months. Management objectives, weather, and availability of staff, contractors, and equipment influence the time of year large animal captures are conducted. While capture efforts would be conducted during periods of low public use when possible, it is likely some projects would be conducted when public use of the proposed wilderness areas is greatest (i.e., during the fall hunting seasons).

Other Unique Components that Reflect the Character of this Wilderness

Heritage and Cultural Resources
N/A

Maintaining Traditional Skills
In today's increasingly modern technical work environment, the basic skills necessary for conducting extended inventory, monitoring, and research within large wilderness areas have become increasingly rare. The primitive and traditional skills required for living daily life in a remote field camp setting would be maintained under this alternative.

Special Provisions
A purpose for all wilderness areas is to administer such areas for the gathering and dissemination of information regarding their use and enjoyment as wilderness. Most proposed wilderness areas within Sheldon Refuge contain ecological features of scientific and educational value. The study, inventory, monitoring, and research of large animals and other ecological features are necessary both for the preservation and protection of natural and untrammeled wilderness character and for the long-term conservation of fish, wildlife, plants, and their habitats within Sheldon Refuge.

Time Constraints
Completion of some inventory, monitoring, and research activities considered as part of this alternative may require multiple field crews, multiple seasons, or multiple years. All else being equal, the use of methods under this alternative to inventory, monitor, and research certain species of large mammals would take considerably longer to achieve project and management objectives when compared with the use of helicopters described under Alternative B. Due to the rugged terrain of Sheldon Refuge and the difficulty of herding large wildlife from horseback or on foot, we anticipate these methods would not result in the capture of a sufficient number of animals to meet project objectives in some instances.

Additional Wilderness-specific Comparison Criteria
N/A

Safety of Visitors, Personnel, and Contractors

The terrain of Sheldon Refuge is very rugged, rocky, and difficult to traverse by foot or on horseback. Capture of live animals using the tools and techniques under this alternative would include safety risks for staff or contractors conducting the work. People could be injured during live animal captures by falling or tripping, or by being kicked, trampled, or gored by animals.

Alternative B

Description

The appropriate methods for live capture of large mammals are most often determined by project objectives, species of animal, animal density, time of year, terrain, and a variety of other factors. In many cases, the methods described for Alternative A are the most efficient and result in the least amount of risk to wildlife and would be used. We anticipate inventory, monitoring, and research requiring live capture of animals, including certain capture of large mammals, within Sheldon Refuge

would be conducted as described under Alternative A. This alternative considers the use of helicopters in addition to other methods considered under Alternative A.

In certain cases, live capture of large animals can be conducted with fewer people, in less time, and with less impact to fewer animals with the use of a helicopter. Under this alternative, helicopters could be used for live capture of large animals. Helicopter captures typically require spotting animals from the air and then using the aircraft to isolate a single target animal, which can then be quickly immobilized using a tranquilizing dart gun or net gun. Once the animal has been immobilized, the helicopter lands nearby so that information and samples can be collected and any marking or collaring completed before the animal is released. The length of time between initial spotting of the animal and release of the animal is typically less than 30 minutes.

Effects

Wilderness Character

"Untrammeled"
When compared with herding or driving of groups of animals into nets or traps as described under Alternative A, the use of helicopters under this alternative would reduce the risk of injury to non-target individuals because target animals can more quickly and easily be singled out for capture, the amount of time required for completing the capture is less, and the length of time animals are kept in captivity is shorter.

"Undeveloped"
The use of helicopters under this alternative when compared with other methods would eliminate the need for field camps and the need for temporary traps or corrals.

"Natural"
The use of helicopters under this alternative when compared with other methods would reduce the amount of ground disturbance and impacts to vegetation from temporary field camps and use of access routes.

Impacts to the natural appearance of animals from marking or collaring would be as described under Alternative A.

"Outstanding Opportunities for Solitude or a Primitive and Unconfined Type of Recreation"
Helicopter activities would limit opportunities for solitude for periods of less than one week in areas where activities are conducted. When compared with the use of temporary field camps, traps, and corrals for several weeks as proposed under Alternative A, the use of helicopters would impact opportunities within a larger area due to the distances over which helicopters would be seen and heard. Impacts to opportunities for solitude would not last as long as those described for Alternative A due to the shorter amount of time necessary to conduct live animal captures using helicopters. We anticipate helicopters would be used at various times of the year, including during fall hunting seasons depending upon project objectives and impacts could affect the majority of visitors within any particular proposed wilderness area.

Other Unique Components that Reflect the Character of this Wilderness

Heritage and Cultural Resources
N/A

Maintaining Traditional Skills
The use of helicopters under this alternative would not maintain traditional skills.

Special Provisions
N/A

Time Constraints
When compared with the herding or driving of animals described under Alternative A, we anticipate the use of helicopters would result in the capture of a sufficient number of animals to accomplish objectives for most or all types of possible projects.

Additional Wilderness-specific Comparison Criteria
N/A

Safety of Visitors, Personnel, and Contractors

The use of helicopters at low altitudes to conduct live animal captures does increase the level of risk when compared with standard point-to-point helicopter use. Captures are planned based on the identification and avoidance of hazards such as terrain, fencelines, and powerlines to minimize risk to the extent possible. Risks associated with capture activities under Alternative A do not necessarily differ from those under this alternative, but the greater number of people and animals involved does increase the probability for injury or accident when compared with the use of a single helicopter pilot and two-person crew under this alternative.

Comparison of Alternatives

It may be useful to compare each alternative's relative positive and negative effects to each of the criteria in tabular form, keeping in mind the law's mandate to "preserve wilderness character."

	Alternative A	Alternative B
Untrammeled	-	-
Undeveloped	-	+
Natural	-	+
Solitude or Primitive Recreation	--	-
Unique Components		
Wilderness Character	-	-

	Alternative A	Alternative B
Heritage and Cultural Resources	N/A	N/A
Maintaining Traditional Skills	+	-
Special Provisions	+	+
Time	-	+
Additional Wilderness Criteria	N/A	N/A
Other Criteria Summary	+	+

	Alternative A	Alternative B
Safety	-	+

Safety Criteria

Capture of large wild animals by herding and driving in rough terrain and in confined spaces is inherently dangerous and has a high risk for injury both to the animals and the handlers and herders. The most common potential injuries include broken bones, fractures, contusions, punctures, lacerations, and head injuries from falling, being trampled, kicked, or gored. These risks can be reduced but not eliminated by using protective equipment such as chest protectors, eye protection, and helmets. The number of people required to implement these methods as proposed under Alternative A and the number of animals involved would increase the overall potential for injury.

Capture of large animals with the use of helicopters at low levels is also inherently dangerous. The use of proper aircraft for the specific type of flight operations, the use of experienced pilots and crews, use of specialized fire-resistant clothing and helmets, and proper pre-flight briefings to identify and avoid hazards and obstacles can minimize but not eliminate the potential for accidents and injuries. While injuries sustained from low-level helicopter accidents are typically more severe than would be expected from herding and driving animals on foot or by horseback, the shorter amount of time, fewer people required, and the smaller number of animals to be captured as proposed under Alternative B would decrease the overall potential for injury.

Step 2 Decision: What is the Minimum Activity/Minimum Tool?

Selected Alternative

Alternative B

Rationale for Selecting this Alternative (Including Documentation of Safety Criterion, If Appropriate)

Capture of large animals by driving and herding on foot or by horseback as described under Alternative A would avoid the landing of aircraft, which is otherwise prohibited within the proposed wilderness areas, but would not necessarily be the least intrusive method. The use of field camps for periods of several weeks, disturbance and stress caused to more animals than is otherwise necessary, and the greater risk to both employee and staff safety and to the health of animals being captured would have greater impact on wilderness character than would Alternative B. The use and landing of helicopters as proposed under Alternative B would occasionally diminish opportunities for wilderness solitude for short periods of time, but when compared with seasonal field crews living in longer-term temporary wilderness camps as proposed under Alternative A, helicopter impacts are expected to be less intrusive overall.

Helicopters have proven to be an efficient and effective tool for the quick capture and release of a number of species for the purposes of wildlife research and management. In contrast, herding and driving under Alternative A would not only pose more safety risks, but due to terrain and logistical difficulties, we anticipate some efforts would be unsuccessful and would therefore not meet management objectives.

Alternative B would minimize impacts to wilderness character to the extent practicable while providing a high probability for full implementation of the minimum administrative action necessary. Alternative B is also determined to be the safest and most efficient alternative evaluated.

Check Any Wilderness Act Section 4(c) Uses Approved in this Alternative

- ☐ mechanical transport
- ☐ motorized equipment
- ☐ motor vehicles
- ☐ motorboats
- ☒ landing of aircraft
- ☐ temporary road
- ☐ structure or installation

Record and report any authorizations of Wilderness Act Section 4(c) uses according to agency procedures.

Approvals	Signature	Name	Position	Date
Prepared by:		Aaron P. Collins	Park Ranger	9/25/12
Recommended:		John W. Kasbohm	Project Leader	9/25/12
Approved:		Charles J. Houghton	Regional Wilderness Coord.	9/27/12

Appendix H. Standard Operating Procedures for Horse and Burro Population Control Methods

Gathers will be conducted by using contractors or U.S. Fish and Wildlife Service (Service) personnel. The following procedures for gathering and handling horses and burros will apply whether contractors or Service personnel conduct a gather.

Prior to any gathering operation, the Service will provide for a pre-capture evaluation of existing conditions in the gather area(s). The evaluation will include animal conditions, prevailing temperatures, drought conditions, soil conditions, road conditions, and a topographic map with wilderness boundaries, cultural resources, the location of fences, other physical barriers, and acceptable trap (corral) locations in relation to animal distribution. The evaluation will determine whether the proposed activities will necessitate the on-site presence of a veterinarian during operations, versus on call. If it is determined that capture operations necessitate the services of a veterinarian, one will be obtained before the capture will proceed. If applicable, the contractor will be apprised of all conditions and will be given instructions regarding the capture and handling of animals to ensure their health and welfare is protected.

Trap (corral) sites and temporary holding sites will be located to reduce the likelihood of undue injury and stress to the animals, and to minimize potential damage to the natural resources of the area. These sites will be located on or near existing roads.

The primary capture methods used in the performance of gather operations include:

1. Helicopter Drive Trapping. This capture method involves utilizing a helicopter to herd horses and burros into a temporary trap (corral).
2. Helicopter Assisted Roping. This capture method involves utilizing a helicopter to herd horses or burros to ropers.
3. Horse-back Gather. This capture method uses horse-back wranglers to draw or drive horses into a temporary trap (corral).
4. Bait Trapping (corralling). This capture method involves utilizing bait (water or feed) to lure primarily burros into a temporary trap (corral) (may include horses).

Capture Methods used in the Performance of Gather Contract Operations

1. The primary concern of the contractor is the safe and humane handling of all animals captured. All capture attempts shall incorporate the following:

   All trap (corral) and holding facility locations must be approved by the Refuge Manager (RM) prior to construction. The title Refuge Manager covers the Project Leader, Deputy Project Leader and the Refuge Manager. The Contractor may also be required to change or move trap (corral) locations as determined by the RM. All traps (corrals) and holding facilities not located on public land must have prior written approval of the landowner.

2. The rate of movement and distance the animals travel shall not exceed limitations set by the RM who will consider terrain, physical barriers, weather, condition of the animals and other factors.

3. All traps (corrals), wings, and holding facilities shall be constructed, maintained and operated to handle the animals in a safe and humane manner and be in accordance with the following:

    a. Traps (corrals) and holding facilities shall be constructed of portable panels, the top of which shall not be less than 72 inches high for horses and 60 inches for burros, and the bottom rail of which shall not be more than 12 inches from ground level. All traps (corrals) and holding facilities shall be oval or round in design.

    b. All loading chute sides shall be a minimum of 6 feet high and shall be fully covered, plywood, metal without holes.

    c. All runways shall be a minimum of 30 feet long and shall be covered with plywood, burlap, plastic snow fence or like material a minimum of 1 foot through 5 feet above ground level for burros and 1 foot through 6 feet for horses. The location of the government furnished portable fly chute to restrain, age, or provide additional care for the animals shall be placed in the runway in a manner as instructed by or in concurrence with the RM.

    d. All crowding pens including the gates leading to the runways shall be covered with a material which prevents the animals from seeing out (plywood, burlap, plastic snow fence, etc.) and shall be covered a minimum of 1 foot through 5 feet above ground level for burros and 2 feet through 6 feet for horses

    e. All pens and runways used for the movement and handling of animals shall be connected with hinged self-locking gates.

4. No modification of existing fences will be made without authorization from the RM. The Contractor shall be responsible for restoration of any fence modification that he has made.

5. When dust conditions occur within or adjacent to the trap (corral) or holding facility, the Contractor shall be required to wet down the ground with water.

6. Alternate pens, within the holding facility shall be furnished by the Contractor to separate mares or jennies with small foals, sick and injured animals, and strays from the other animals. Animals shall be sorted as to age, number, size, temperament, sex, and condition when in the holding facility so as to minimize, to the extent possible, injury due to fighting and trampling. Under normal conditions, the government will require that animals be restrained for the purpose of determining an animal's age, sex, or other necessary procedures. In these instances, a portable restraining chute may be necessary and will be provided by the Contractor. Alternate pens shall be furnished by the Contractor to hold animals if the specific gathering requires that animals be released back into the capture area(s). In areas requiring one or more satellite traps (corrals), and where a centralized holding facility is utilized, the contractor may be required to provide additional holding pens to segregate animals transported from remote locations so they may be returned to their traditional ranges. Either segregation or temporary marking and later segregation will be at the discretion of the RM.

7. Horses or burros held in the traps (corrals) and/or holding facilities shall be provided with a continuous supply of fresh, clean water at a minimum rate of 10 gallons per animal per day. Animals may occasionally be temporarily without access to water while being moved between pens, during capture operations and loading, during other types of handling procedures, or as prescribed by a licensed veterinarian. If water is not accessible to the animals at all times, it will be provided as often as is necessary for the health and comfort of the animal. Consistent with 9 Code of Federal Regulations (CFR) 3.130, frequency of watering shall consider the weather conditions, age, species, condition, size, and type of the animal. Animals held for 10 hours or more in the traps (corrals) or holding facilities shall be provided good-quality hay at the rate of not less than 2 pounds of hay per 100 pounds of estimated body weight per day. An animal that is held at a temporary holding facility after 5 p.m. and through the night is defined as a horse/burro feed day. An animal that is held for only a portion of a day and is shipped or released does not constitute a feed day.

8. It is the responsibility of the Contractor to provide security to prevent loss, injury or death of captured animals until delivery to final destination.

9. The Contractor shall restrain sick or injured animals if treatment is necessary. The RM will determine if injured animals must be destroyed and provide for euthanasia of such animals in a humane fashion. A veterinarian will be available on site or on call for consultation or treatment of animals as needed. The Contractor may be required to humanely euthanize animals in the field and to dispose of the carcasses as directed by the RM.

10. Animals shall be transported to final destination from temporary holding facilities within 24 hours after capture unless prior approval is granted by the RM for unusual circumstances. Animals to be released back onto the Refuge following gather operations may be held up to 21 days or as directed by the RM. Animals shall not be held in traps (corrals) and/or temporary holding facilities on days when there is no work being conducted except as specified by the RM. Animals shall not be allowed to remain standing on trucks while not in transport for a combined period of greater than three (3) hours. Animals that are to be released back into the capture area may need to be transported back to the original trap (corral) site. This determination will be at the discretion of the RM.

Capture Methods That May Be Used in the Performance of a Gather

1. Capture attempts may be accomplished by utilizing bait (feed or water) to lure animals into a temporary trap (corral). If the contractor selects this method, the following applies:

    a. Finger gates shall not be constructed of materials such as "T" posts, sharpened willows, etc., which may be injurious to animals.

    b. All trigger and/or trip gate devices must be approved by the RM prior to capture of animals.

    c. Traps (corrals) shall be checked a minimum of once every 24 hours.

2. Capture attempts may be accomplished by utilizing a helicopter to drive animals into a temporary trap (corral). If the contractor selects this method, the following applies:

    a. A minimum of two saddle-horses shall be immediately available at the trap (corral) site to accomplish roping if necessary. Roping shall be done as determined by the RM. Under no circumstances shall animals be tied down for more than one hour.

    b. The contractor shall assure that foals shall not be left behind, and orphaned.

3. Capture attempts may be accomplished by utilizing a helicopter to drive animals to ropers. If the contractor with the approval of the RM selects this method, the following applies:

    a. Under no circumstances shall animals be tied down for more than one hour.

    b. The contractor shall assure that foals shall not be left behind, or orphaned.

    c. The rate of movement and distance the animals travel shall not exceed limitations set by the RM who will consider terrain, physical barriers, weather, condition of the animals and other factors.

Use of Motorized Equipment

1. All motorized equipment employed in the transportation of captured animals shall be in compliance with appropriate State and Federal laws and regulations applicable to the humane transportation of animals. The Contractor shall provide the RM with a current safety inspection (less than one year old) for all motorized equipment and tractor-trailers used to transport animals to final destination.

2. All motorized equipment, tractor-trailers, and stock trailers shall be in good repair, of adequate rated capacity, and operated so as to ensure that captured animals are transported without undue risk or injury.

3. Only tractor-trailers or stock trailers with a covered top shall be allowed for transporting animals from trap (corral) site(s) to temporary holding facilities, and from temporary holding facilities to final destination(s). Sides or stock racks of all trailers used for transporting animals shall be a minimum height of 6 feet 6 inches from the floor. Single deck tractor-trailers 40 feet or longer shall have two (2) partition gates providing three (3) compartments within the trailer to separate animals. Tractor-trailers less than 40 feet shall have at least one partition gate providing two (2) compartments within the trailer to separate the animals. Compartments in all tractor-trailers shall be of equal size plus or minus 10 percent. Each partition shall be a minimum of 6 feet high and shall have a minimum 5 foot wide swinging gate. Consistent with 9 CFR 88.3, horses or burros will not be transported in any conveyance that has the animal cargo space divided into two or more stacked levels.

4. All tractor-trailers used to transport animals to final destination(s) shall be equipped with at least one (1) door at the rear end of the trailer that is capable of sliding either

horizontally or vertically. The rear door(s) of tractor-trailers and stock trailers must be capable of opening the full width of the trailer. Panels facing the inside of all trailers must be free of sharp edges or holes that could cause injury to the animals. The material facing the inside of all trailers must be strong enough so that the animals cannot push their hooves through the side. The RM shall do final approval of tractor-trailers and stock trailers used to transport animals.

5. Floors of tractor-trailers, stock trailers and loading chutes shall be covered and maintained with wood shavings to prevent the animals from slipping.

6. Animals to be loaded and transported in any trailer shall be as directed by the RM and may include limitations on numbers according to age, size, sex, temperament and animal condition. The following minimum square feet per animal shall be allowed in all trailers:

    11 square feet per adult horse (1.4 linear foot in an 8 foot wide trailer);
    8 square feet per adult burro (1.0 linear foot in an 8 foot wide trailer);
    6 square feet per horse foal (.75 linear foot in an 8 foot wide trailer);
    4 square feet per burro foal (.50 linear feet in an 8 foot wide trailer).

7. The RM shall consider the condition and size of the animals, weather conditions, distance to be transported, or other factors when planning for the movement of captured animals. Unless otherwise approved by the RM, transportation shall be limited in sequence to a maximum of 24 hours followed by a minimum of 5 hours of on-the-ground rest with adequate feed and water. The RM shall provide for any brand and/or inspection services required for the captured animals.

8. If the RM determines that dust conditions are such that the animals could be endangered during transportation, the Contractor will be instructed to adjust speed.

Safety and Communications

1. The Contractor shall have the means to communicate with the RM and all contractor personnel engaged in the capture of wild horses and burros utilizing a VHF/FM Transceiver or VHF/FM portable Two-Way radio. If communications are ineffective the government will take steps necessary to protect the welfare of the animals.

    a. The proper operation, service and maintenance of all contractor furnished property is the responsibility of the Contractor. The Service reserves the right to remove from service any contractor personnel or contractor furnished equipment which, in the opinion of the RM violate contract rules, are unsafe or otherwise unsatisfactory. In this event, the Contractor will be notified in writing to furnish replacement personnel or equipment within 48 hours of notification. All such replacements must be approved in advance of operation by the RM or his/her representative.

    b. The Contractor shall obtain the necessary FCC licenses for the radio system

    c. All accidents occurring during the performance of any task order shall be immediately reported to the RM.

2. Should the contractor choose to utilize a helicopter the following will apply:

    a. The Contractor must operate in compliance with Federal Aviation Regulations, Part 91. Pilots provided by the Contractor shall comply with the Contractor's Federal Aviation Certificates, applicable regulations of the State in which the gather is located.

    b. Fueling operations shall not take place within 1,000 feet of animals.

Requirements for Adoption Agents and Adoptees

All potential adoption agents must have a favorable background check conducted and contract/cooperative agreement established before receiving any horses or burros. Background checks will include the following:

1. A site visit will be completed by Refuge staff to assure that facilities are adequate to prevent escape or injury to the animals or visitors during holding, viewing, feeding, loading and unloading.
2. A determination will be made by the Refuge Manager as to whether or not the agent has the necessary skills and knowledge of horses and burros to safely handle, feed, and load and unload them.
3. A list of adopters will be required and certification and follow up will be conducted by Refuge Staff to ensure proper placement.
4. Refuge staff will also conduct phone interviews with at least two character witnesses and receive a recommendation from a local veterinarian regarding the Agent's ability to accomplish the adoption process.

Adoption agents are required to make a reasonable effort to prevent horses and burros from going to slaughter and to screen potential adoptees for good homes. Agents must meet all applicable State and Federal regulations for transport and exchange of livestock and equines.

Archaeological and Historical Site Clearances

1. Personnel working at gather sites will be advised of the illegality of collecting artifacts.
2. Prior to setting up a trap (corral) or temporary holding facility, Service will conduct all necessary clearances (archaeological, T&E, etc). All proposed site(s) must be inspected by Service staff. The regional archaeologist will be notified of the selected site if cultural or historic artifacts are observed. Once archaeological clearance has been obtained, the trap (corral) or temporary holding facility may be set up. Said clearance shall be arranged for by the RM or other Service employees.
3. Gather sites and temporary holding facilities will not be constructed on wetlands or riparian zones.

Animal Characteristics and Behavior

When animals are released onto Sheldon Refuge in unfamiliar areas, releases will occur near available water.

Public Participation

Opportunities for public viewing (i.e., media, interested public) of gather operations will be made available to the extent possible. However, the primary consideration will be to protect the health and welfare staff/contractors and the animals being gathered. The public must adhere to guidance from the on-site Service representative. It is Service policy that the public will not be allowed to come into direct contact with horses or burros being held in Service facilities. Only authorized Service personnel or its contractors may enter the corrals or directly handle the animals. The general public may not enter the corrals or directly handle the animals at anytime or for any reason during Service operations.

Responsibility and Lines of Communication

Lakeview Office – Project Leader
Lakeview Office - Deputy Project Leader
Sheldon Refuge – Refuge Manager

The RM has the direct responsibility to ensure the Contractor's compliance with the contract stipulations. The RM will take an active role to ensure the appropriate lines of communication are established between the field and the Lakeview Office. All employees involved in the gathering operations will keep the best interests of the animals and safety of personnel at the forefront at all times.

All publicity, formal public contact and inquiries will be handled through the Project Leader. This individual will be the primary contact and will coordinate the contract to ensure animals are being transported from the capture site in a safe and humane manner and are arriving in good condition.

The contract specifications require humane treatment and care of the animals during removal operations. These specifications are designed to minimize the risk of injury and death during and after capture of the animals. The specifications will be vigorously enforced.

Should the Contractor show negligence and/or not perform according to contract stipulations, they will be issued written instructions, issued a stop work order, or other appropriate measures.

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Appendix I. Sheldon Refuge Establishing and Acquisition Authorities

Establishment Authorities

Sheldon National Wildlife Refuge was established by Executive Order (EO). The key source for the Refuge establishment authorities is as follows:

With **EO 5141 (20 June 1929)** President Hoover temporarily withdrew 31,399 acres of present-day Little Sheldon from "settlement, location, sale or entry, subject to prior valid claims, for classification as to their suitability for game refuge purposes" on recommendation by the Department of Agriculture and Department of the Interior.

In 1931 President Hoover signed the EO officially establishing the Charles Sheldon Wildlife Refuge. **EO 5540 (26 January 1931)** "reserved and set apart for use of the Dept. of Agriculture" the same area as described in EO 5141 "as a refuge and breeding ground for wild animals and birds, subject to existing valid rights." EO 5540 declared that "It is unlawful within this reservation (a) to hunt, trap, capture, willfully disturb, or kill any wild animal or bird of any kind whatever, to take or destroy the nests or eggs of any wild bird, to occupy or use any part of the reservation, or to enter thereon for any purpose, except under such rules and regulation as may be prescribed by the Secretary of Agriculture; (b) to cut, burn, or destroy any timber, underbrush, grass, or other natural growth; (c) willfully to leave fire or to suffer it to burn unattended near any forest, timber, or other inflammable material; (d) after building a fire in or near any forest, timber, or other inflammable material, to leave it without totally extinguishing it; and (e) willfully to injure, molest, or destroy any property of the United States." The EO designated the name of this land as the "Charles Sheldon Wild Life Refuge."

EO 6910 (26 November 1934) withdrew 3,840 acres for "classification and other purposes all vacant, unreserved, and unappropriated public lands in the states of Nevada and Oregon and certain other states." (Currently we do not have a copy of EO 6910 but will continue the research.)

EO 7178 (6 September 1935) set aside the lands for the Hart Mountain Game Range, which included the present-day Hart Mountain National Antelope Range and Big Sheldon: "it is ordered that the following described lands, insofar as title thereto is in the United States, be, and they are hereby withdrawn from settlement, location, sale, or entry and reserved and set apart for the conservation and development of natural wildlife resources.…for wild-life conservation purposes such lands shall become part of the preserve, but the grazing rights thereon shall accrue primarily to the use of wild-life, and such lands shall not be homesteaded, sold, exchanged, or patented under any law or regulation relating to public lands or the establishment of wild-life refuges."

EO 7364 (6 May 1936) states that "in order to effectuate further the purposes of the Migratory Bird Conservation Act (45 stat. 1222), it is ordered that, subject to valid existing rights, all the public lands of the United States in the following-described area be, and they are hereby, withdrawn from settlement, location, sale, entry, or other form of appropriation and reserved and set apart for the use of the Department of Agriculture as an addition to the existing Charles Sheldon Wildlife Refuge, established by" EO 5540. It further states that "The reservation made by this order supersedes as to the above-described lands the temporary withdrawl [sic] for classification and other purposes made by EO 6910 of November 26, 1934, as amended." This land was added so the area could be fenced

effectively, according to Rudolf Dieffenbach, Chief of the Division of Land Acquisition, in a letter to Doren Woodward dated 10 October 1935.

EO 7522 (21 December 1936) revoked the lands in Nevada established as the Hart Mountain Game Range under EO 7178 and established them as the Charles Sheldon Antelope Range.

> Section 1: "Executive Order No. 7178 of September 6, 1935, which reserved and set apart certain lands in Oregon and Nevada as the Hart Mountain Game Range, is Hereby revoked as to the following lands in Nevada:"
>
> Section 2: "Subject to the condition expressed in the above-mentioned acts and to all existing valid rights, the lands described in section 1 of this order are hereby withdrawn from settlement, location, sale, or entry and reserved and set apart for the conservation and development of natural wildlife resources and for the protection and improvement of public grazing lands and natural forage resources; Provided, That nothing herein contained shall restrict prospecting, locating, developing, mining, entering, leasing, or patenting the mineral resources of the lands under the applicable laws: Provided further, That any lands within the described area that are otherwise withdrawn or reserved will be affected hereby only so far as may be consistent with the uses and purposes for which such prior withdrawal or reservation was made: And provided further, That upon the termination of any private right to, or appropriation of, any public lands within the exterior limits of the area included in this order, or upon the revocation of prior withdrawals unless expressly otherwise provided in the order of revocation, the lands involved shall become part of this preserve."
>
> Section 3: "This range or preserve, so far as it relates to conservation and development of wildlife, shall be under the joint jurisdiction of the Secretaries of the Interior and Agriculture, and they shall have power jointly to make such rules and regulation for its protection, administration, regulation, and improvement, and for the removal and disposition of surplus game animals, as they may deem necessary to accomplish its purposes, and the range or preserve, being within a grazing district duly established pursuant to the provisions of the act of June 28, 1934 (ch. 865, 48 stat. 1269) , as amended by the act of June 26, 1936 (Public No. 827, 74th Congress), shall under the exclusive jurisdiction of the Secretary of the Interior so far as it relates to the public grazing lands and natural forage resources thereof; Provided, however, That the natural forage resources therein shall be first utilized for the purpose of sustaining in a healthy condition a maximum of three thousand five hundred (3500) antelope, the primary species, and such nonpredatory secondary species in such numbers as may be necessary to maintain a balanced wildlife population, but in no case shall the consumption of forage by the combined population of the wildlife species be allowed to increase the burden of the range dedicated to the primary species: Provided further, That all the forage resources within this range or preserve shall be available, except as herein otherwise provided with respect to wildlife, for domestic livestock under rules and regulation promulgated by the Secretary of the Interior under the authority of the aforesaid act of June 28, 1934, as amended: And provided further, That land within the exterior limits of the area herein described, acquired and to be acquired by the United States for the use of the Department of Agriculture for conservation of migratory birds and other wildlife, shall be and remain under the exclusive administration of the Secretary of Agriculture and may be utilized for public grazing purposes only to such extent as may be determined by the said Secretary to be compatible with the utilization of said lands for the purposes for which they were acquired as aforesaid under regulations prescribed by him."

Section 4: "This preserve shall be known as the Charles Sheldon Antelope Range."

Proclamation 2416 (30 July 1940) changed the name of Charles Sheldon Wildlife Refuge to Sheldon National Antelope Refuge.

On December 4, 1974, the President transmitted the Sheldon Wilderness proposal to the U.S. Congress (**House Document No. 93-403**). The initial proposal at that time (prior to the August 1974 modifications) encompassed 277,200 acres in 11 areas. The President recommended designating 20,100 acres at that time and remanding the remainder to study under a mineral survey. Public hearings and further review modified (August 1974) the wilderness proposal to include 341,500 acres in nine areas on Sheldon Refuge, which was included in the 1974 transmittal to Congress. Further action on the wilderness proposal was suspended until a mineral survey was completed and the mineral estate was withdrawn on areas considered for wilderness designation. The mineral survey was completed by the U.S. Geological Survey and published in 1984 (Geological Survey Bulletin 1538). The Service completed an environmental assessment on the proposed mineral withdrawal, with a Finding of No Significant Impact issued in February 1984. The action culminated with a Public Land Order (PLO) for the withdrawal of 445,766 acres of the mineral estate for Sheldon Refuge from claims under the 1872 Mining Law (see PLO 6849 below). We found no further action on the Sheldon Wilderness Proposal, neither Record of Decision nor Final Environmental Impact Statement nor congressional action.

PLO 5497 (25 April 1975) transferred management of the Charles Sheldon Antelope Range "to the sole jurisdiction of the Bureau of Land Management".

The **Game Range Act (Public Law 94-223, February 27, 1976)** amended the Refuge System Administration Act of 1966 to give sole jurisdiction for management of refuges to the Secretary of Interior through the Fish and Wildlife Service. The Act states: "For the purpose of consolidating the authorities relating to the various categories of areas that are administered by the Secretary of the Interior for the conservation of fish and wildlife, including species that are threatened with extinction, all lands, waters, and interests therein administered by the Secretary as wildlife refuges, areas for the protection and conservation of fish and wildlife that are threatened with extinction, wildlife ranges, game ranges, wildlife management areas, or waterfowl production areas are hereby designated as the 'National Wildlife Refuge System' which shall be subject to the provisions of this section and shall be administered by the Secretary through the United States Fish and Wildlife Service."

The Congressional reports that define each branch's intent for the law (**House Report No. 94-334; Senate Report No. 94-593**) emphasize the priority for wildlife (over grazing or other uses) and specifically name several species as the purpose of the game ranges. For example, House Report 94-334 states: "During the 1930's President Franklin D. Roosevelt established four wildlife ranges as part of the National Wildlife Refuge System in order to protect species such as the desert big-horn sheep, the pronghorn antelope, the bald eagle, the peregrine falcon and the prairie falcon." The report then names Cabeza Prieta, Charles M. Russell, Charles Sheldon, and Kofa Game Range refuges. Pronghorn were named as the primary species for management at Sheldon Refuge in its establishing executive order, and it is the only refuge of the four listed where prairie falcons are common.

PLO 5634 (25 April 1978) 1(a) revoked PLO 5497 and transferred sole jurisdiction of the Charles Sheldon Antelope Range to the USFWS: (b) "the operation and administration of the Charles

Sheldon Antelope Range, including grazing, was to be administered, and is now being administered, in accordance with the National Wildlife Refuge System Administration Act…" (NWRSAA), "except that, those holding grazing privileges validly issued by the BLM and in effect on February 27, 1976, are permitted to continue such privileges under term and conditions imposed by the Taylor Grazing Act, and implementing regulations, until those privileges expire. The renewal or initiation of grazing privileges subsequent to February 27, 1976, is in accordance with the NWRSAA and implementing regulations"; (c) EO 7522 .... [was] modified to the extent necessary for it to conform to the provisions of (a) and (b) above."

PLO 6849 (22 April 1991) withdrew approximately 445,766 acres of the Sheldon National Wildlife Refuge from mining location in order for the USFWS to protect the wildlife habitat and unique resource values of the refuge lands.

> 1. "Subject to valid existing rights, the following described Sheldon National Wildlife refuge lands are hereby withdrawn from location under the United States mining code (30 U.S.C. Chapter 2), but not from leasing under the mineral leasing laws, to protect the wildlife habitat and unique resource values."
>
> 2. The PLO describes private lands of "3145.7 acres" that are within Sheldon Refuge, that if the United States "subsequently acquires the private lands with the mineral interests through purchase, exchange, or donation, the mineral estate will be subject" to the withdrawal specified in the PLO.
>
> 3. "This withdrawal will expire 20 years from the effective date of this order unless, as a result of a review conducted before the expiration date pursuant to section 204(f) of the Federal Land Policy and Management Act of 1976, U.S.C. 1714 (f), the Secretary determines that the withdrawal shall be extended, except that the withdrawal on any land in this order that Congress does not designate as wilderness will expire 1 year after Congress has completed action on the Sheldon National Wildlife Refuge wilderness proposal."

Land Exchange (3 August 1994) finalized the Harry Wilson Land Exchange adding 2,240 acres to Sheldon Refuge. The Acquisition Authority was the Endangered Species Act.

The 2006 Fiscal Year Summary states that Sheldon Refuge encompasses 572,876.15 acres (Annual Report of Lands Under Control of the U.S. Fish and Wildlife Service as of September 30, 2006).

Summary of Land Acquisition for Sheldon National Wildlife Refuge as of 9/30/2006

Reserved From Public Domain	Device or Gift	Purchased	Total
514,356.82	4,775.66	25,745.67	572,876.15

Refuge Establishment and Purposes

The following are establishment and purpose excerpts from statutes, executive orders, public land orders, and other supporting documents:

EO 5141 (20 June 1929): "under and pursuant to the provisions of the act of Congress approved June 25, 1910 (36 Stat. 847), as amended by the act of August 24, 1912 (37 Stat. 497), hereby ordered that the public lands within the following described area [Sheldon Refuge] in Nevada be, and

they are hereby, temporarily withdrawn from settlement, location, sale or entry, subject to prior valid clams, for classification as to their suitability for game refuge purposes."

EO 5540 (26 January 1931): "It is hereby ordered that the following described area [Sheldon Refuge] be ….reserved and set apart for the use ….as a refuge and breeding ground for wild animals and birds, subject to existing valid rights. It is unlawful within this reservation (a) to hunt, trap, capture, willfully disturb, or kill any wild animal or bird of any kind whatever, to take or destroy the nests or eggs of any wild bird, to occupy or use any part of the reservation, or to enter thereon for any purpose, except under such rules and regulation as may be prescribed by the Secretary of Agriculture; (b) to cut, burn, or destroy any timber, underbrush, grass, or other natural growth; (c) willfully to leave fire or to suffer it to burn unattended near any forest, timber, or other inflammable material; (d) after building a fire in or near any forest, timber, or other inflammable material, to leave it without totally extinguishing it; and (e) willfully to injure, molest, or destroy any property of the United States."

The Refuge shall be known as the Charles Sheldon Wildlife Refuge.

EO 7178 (6 September 1935), which reserved and set apart certain lands in Nevada [Sheldon Refuge]: "Subject to the conditions expressed and to all existing valid rights, it is ordered that the following described lands, insofar as title thereto is in the United States, be, and they are hereby withdrawn from settlement, location, sale, or entry and reserved and set apart for the conservation and development of natural wildlife resources and for the protection and improvement of public grazing lands and natural forage resources; Provided, That upon the termination of any private right to, or appropriation of, any public lands within the exterior limits of the area included in this order, such lands shall become part of this preserve: And provided further, That upon the acquisition by the United States of title to any private lands within such limits for wild-life conservation purposes such lands shall become part of the preserve, but the grazing rights thereon shall accrue primarily to the use of wild-life, and such lands shall not be homesteaded, sold, exchanged, or patented under any law or regulation relating to public lands or the establishment of wild-life refuges or grazing districts."

EO 7522 (21 December 1936): "This range or preserve, so far as it relates to conservation and development of wildlife" and "so far as it relates to the public grazing lands and natural forage resources thereof; Provided, however, That the natural forage resources therein shall be first utilized for the purpose of sustaining in a healthy condition a maximum of three thousand five hundred (3,500) antelope, the primary species, and such non-predatory secondary species in such numbers as may be necessary to maintain a balanced wildlife population, but in no case shall the consumption of forage by the combined population of the wildlife species be allowed to increase the burden of the range dedicated to the primary species: Provided, further, That all the forage resources within this range or preserve shall be available, except as herein otherwise provided with respect to wildlife, for domestic livestock under rules and regulations promulgated by the Secretary of the Interior under the authority of the aforesaid act of June 28, 1934. Land within the exterior limits of the area herein described, acquired and to be acquired by the United States for the use of the Department of Agriculture for conservation of migratory birds and other wildlife, shall be and remain under the exclusive administration of the Secretary of Agriculture for conservation of migratory birds and other wildlife …and may be utilized for public grazing purposes only to such extent as may be determined by the said Secretary to be compatible with the utilization of said lands for the purposes for which they were acquired as aforesaid under regulations prescribed by him."

The following **EO 7364** is recorded in The National Archives Federal Register, Volume I, Number 41, dated May 6, 1936: "By virtue of and pursuant to the authority vested in me by the Act of June 25, 1910, c. 421, 36 Stat. 847, as amended by the Act of August 24, 1912, c. 369, 37 Stat. 497, and as President of the United States, and in order to effectuate further the purposes of the Migratory Bird Conservation Act (45 Stat. 1222) , it is ordered that, subject to valid existing rights, all the public lands of the United States in the following-described area [Sheldon Refuge] be, and they are hereby, withdrawn from settlement, location, sale, entry, or other form of appropriation and reserved and set apart for the use of the Department of Agriculture as an addition to the existing Charles Sheldon Wildlife Refuge, established by Executive Order No. 5540 of January 26,1931."

An early memorandum **(Memorandum Number 9, ca. 1937)** stated: "The Charles Sheldon Antelope Refuge was established in September 1936 as an addition to the already existing Charles Sheldon Wildlife Refuge. The primary purpose of this area is the conservation of antelope. An excellent opportunity is also afforded, however, for the restoration in suitable numbers of native deer, sage grouse, and fur-bearing animals, and for the development of desirable feeding and nesting places for migratory waterfowl."

Another early memorandum **(Memorandum No. 14, January 12, 1937)** stated: "The Charles Sheldon Wildlife Refuge as originally established [EO 5540, 26 January 1931] embraced 31,399 acres of public land. Through Executive Order [thought to be EO 7364 May 6, 1936] in September 1936 the Charles Sheldon Antelope Range was established under joint jurisdiction of the Secretaries of Agriculture and Interior.

"The purchase of the alienated lands within these antelope ranges is to control the water and hay producing areas essential to the perpetuation of the antelope and other wildlife. While these areas are primarily for the conservation of antelope, they also offer great opportunity to restore in suitable numbers the native deer, prairie chickens, sage grouse, and fur animals. There is also excellent opportunity to develop extensive waterfowl nesting and feeding places."

In **Memorandum Number 9 (ca. 1937)** it states: "At the January 1937 meeting one ownership (Dufurrena) involving 17,984 acres was approved for purchase. An 80 acre tract in the same ownership, which was overlooked when the other lands were optioned, is now being presented for consideration."

Proclamation No. 2416 by President Franklin D. Roosevelt on 30 July 1940 in the Federal Register states: "Whereas certain areas of land and water in the United States, [Sheldon Refuge] have been reserved and set aside from time to time as refuges and breeding grounds for native birds, migratory waterfowl, wild animals, and other forms of wildlife, on which it is unlawful for any person to hunt, trap, capture, willfully disturb or kill any bird or wild animal of any kind whatsoever to take or destroy the nests or eggs of any wild bird, or to occupy or use any part of such reservations or to enter thereon for any purpose except as permitted by law or by rules and regulations of the Secretary of the Interior in order that the conservation and development of the natural wildlife resources may contribute to the economic welfare of the Nation and provide opportunities for wholesome recreation to the citizens of the United States."

March 25, 1941: Sheldon National Antelope Refuge and Range was enlarged by a gift of 2,495.66 acres from the Audubon Society, and the Migratory Bird Conservation Commission approved purchase of 23,328.76 acres. Executive orders have set aside for refuge purposes a total of 556,399.48 acres of public domain.

The Game Range Act (Public Law 94-223, February 27, 1976) amended the Refuge System Administration Act of 1966 to give sole jurisdiction for management of refuges to the Secretary of Interior through the Fish and Wildlife Service. The Act states: "For the purpose of consolidating the authorities relating to the various categories of areas that are administered by the Secretary of the Interior for the conservation of fish and wildlife, including species that are threatened with extinction, all lands, waters, and interests therein administered by the Secretary as wildlife refuges, areas for the protection and conservation of fish and wildlife that are threatened with extinction, wildlife ranges, game ranges, wildlife management areas, or waterfowl production areas are hereby designated as the 'National Wildlife Refuge System' which shall be subject to the provisions of this section and shall be administered by the Secretary through the United States Fish and Wildlife Service."

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On December 4, 1974, the President transmitted the Sheldon Wilderness proposal to Congress **(House Document No. 93-403)**. The initial proposal (prior to the August 1974 modifications) encompassed 277,200 acres in 11 areas. The President recommended designating 20,100 acres at that time and remanding the remainder to study under a mineral survey. Public hearings and further review modified (August 1974) the wilderness proposal to include 341,500 acres in nine areas on Sheldon Refuge, which was included in the 1974 transmittal to Congress. Further action on the wilderness proposal was suspended until a mineral survey was completed and the mineral estate was withdrawn on areas considered for wilderness designation.

CFR Public Land Order 6849 (22 April 1991) Mineral Withdrawal of a Portion of the Sheldon National Wildlife Refuge; Nevada: This order withdraws approximately 445,766 acres of the Sheldon Refuge from mining location for the Fish and Wildlife Service to protect the wildlife habitat and unique resource values of the refuge lands. The lands have been and remain open to mineral leasing.

March 8, 1994: The Harry Wilson Land Exchange encompassing 2,240 acres was purchased by the Conservation Fund. The Acquisition Authority was the Endangered Species Act. Service personnel inspected the lands offered and desired in the exchange and determined the exchange would be biologically beneficial to Sheldon Refuge. With this land in refuge status, the Service would have the authority needed to exercise the control deemed necessary over migratory bird, wildlife, and land management objectives relative to this area. The Service would receive the water and water rights appurtenant to the Wilson lands. These lands are ecologically unique on Sheldon Refuge and have been proposed for classification as a wilderness area. One primitive road leads partway into the area, which provides vistas and other wilderness qualities that are extraordinary. The area has abundant wildlife with representative examples such as birds, bighorn sheep, mountain lions, mule deer, and native fishes and amphibians. Archaeologically, the area is rich; one site alone contains the greatest lithic scatter of all sites on Sheldon Refuge. With the above acres in refuge status or in combined

refuge-wilderness status, the longstanding problem of the Service's inability to exert any control over migratory bird, wildlife, and land management objectives relative to this area was resolved.

Appendix J. Legal and Policy Guidance

International Treaties

The international treaties that affect Sheldon Refuge are migratory bird treaties with Canada, Mexico, Japan, and Russia, and the Convention on Nature Protection and Wildlife Conservation in the Western Hemisphere. These treaties differ in emphasis and species of primary concern, but collectively provide clear mandates for identifying and protecting important habitats and ecosystems, and protecting and managing certain species.

Treaties for migratory bird protection include management provisions such as:

- Prohibiting disturbance of nesting colonies
- Directing each nation to undertake, to the maximum extent possible, measures necessary to protect and enhance migratory bird environments and prevent and abate pollution or detrimental alteration of their habitats
- Requiring each nation to provide immediate notification to the other when pollution or destruction of habitats occurs or is expected
- Stipulation that each nation shall, to the extent possible, establish preserves, refuges, protected areas, and facilities for migratory birds and their habitats and manage them to preserve and restore natural ecosystems
- Stipulating that special habitats outside the jurisdictional boundaries (territorial limits) may be designated in which, to the maximum extent, persons under each nation's jurisdiction shall act in accordance with the principles of the treaty (for instance, this stipulation might require U.S. oil tankers to avoid or prevent pollution of special seabird areas on the high seas)
- Providing that protective measures under the treaty may be applied to species and subspecies not listed in the specific convention, but which belong to one of the families containing listed species. Of the migratory bird species of concern in the treaties, those that use the Sheldon Refuge include swans, geese, ducks, hawks, eagles, harriers, falcons, cranes, plovers, sandpipers, gulls, owls, and passerines.

Laws and Acts

National Wildlife Refuge System Administration Act of 1966, as amended by the National Wildlife Refuge System Improvement Act of 1997 (16 U.S.C. 668dd-668ee; Refuge Administration Act)

Of all the laws governing activities on National Wildlife Refuges, the National Wildlife Refuge System Improvement Act (Improvement Act) undoubtedly exerts the greatest influence. The Improvement Act amended the Refuge System Administration Act of 1966, by including a unifying mission for all National Wildlife Refuges to be managed as a System, a new process for determining compatible uses on refuges, and a requirement that each refuge will be managed under a comprehensive conservation plan, developed in an open public process.

The Improvement Act states that the Secretary of the Interior shall provide for the conservation of fish, wildlife and plants, and their habitats within the Refuge System as well as ensure that the biological integrity, diversity, and environmental health of the Refuge System are maintained. House Report 105–106 accompanying the Improvement Act states ‘‘…the fundamental mission of our

System is wildlife conservation: wildlife and wildlife conservation must come first.'' Biological integrity, diversity, and environmental health are critical components of wildlife conservation. As later explained in the Biological Integrity, Diversity and Environmental Health Policy (see section 1.5B), "the highest measure of biological integrity, diversity, and environmental health is viewed as those intact and self-sustaining habitats and wildlife populations that existed during historic conditions."

Under the Improvement Act, each refuge must be managed to fulfill the Refuge System mission as well as the specific purposes for which it was established. The Act requires the Service to monitor the status and trends of fish, wildlife, and plants in each refuge.

Additionally, the Act identifies six priority wildlife dependent recreational uses ("Big Six"). These uses are hunting, fishing, wildlife observation and photography, environmental education, and interpretation. Through the Improvement Act, the U.S. Congress directed the Service to grant these six wildlife-dependent public uses special consideration in the planning for, management of, and establishment and expansion of units of the Refuge System. In addition, when determined compatible on a refuge-specific basis, these six uses assume priority status over any other uses proposed or occurring on a refuge. The Service is to make extra efforts to facilitate priority wildlife-dependent public use opportunities.

When preparing a CCP, Refuge Managers must re-evaluate the compatibility of all general public, recreational, and economic uses (even those occurring to further refuge habitat management goals) proposed or occurring on a refuge. No activity may be allowed or continued unless it is determined to be an appropriate refuge use and compatible with the mission of the National Wildlife Refuge System and the purposes for the refuge. A compatible use is one that, in the sound professional judgment of the Director, will not materially interfere with or detract from the fulfillment of the mission of the Refuge System or the purposes of the refuge. The authority to make the determination is delegated to the Refuge Manager. Updated compatibility determinations for existing and new uses for Sheldon Refuge are in Appendix D of this CCP.

The Improvement Act also required that, in addition to formally established guidance, the CCP must be developed with the participation of the public. Issues and concerns articulated by the public play a role in guiding alternatives considered during the development of the CCP, and with the formal guidance, can play a role in selection of the preferred alternative.

The Endangered Species Act of 1973 as amended (16 U.S.C. 1231-1544)

The Endangered Species Act provides for the conservation of threatened and endangered species of fish, wildlife, plants, and their critical habitats by Federal action and by encouraging the establishment of state programs. Although not specifically addressing the System, it does directly affect management activities on national wildlife refuges. It directs Federal agencies to take actions that would further the purposes of the act and to ensure that actions they carry out, authorize, or fund do not jeopardize endangered species or their critical habitat (Section 7).

The Refuge Recreation Act of 1998 (16 U.S.C. 460k-460k-4, as amended)

This act requires that any recreational use on areas of the National Wildlife Refuge System be compatible with the primary purpose(s) for which the area was acquired or established. This act also

requires that sufficient funding be available for the development, operation, and maintenance of recreational uses that are not directly related to the area's primary purpose(s).

National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. 4321-4347), and the Council on Environmental Quality's (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 CFR 1500-1508)

NEPA is the basic national charter for protection of the environment. The procedural provisions in CEQ regulations require Federal agencies to integrate the NEPA process with other planning at the earliest possible time whenever taking a major Federal action that may significantly affect the human environment in order to provide a systematic interdisciplinary approach; identify and analyze the environmental effects of their actions; describe appropriate alternatives to the proposal; involve the affected state and Federal agencies, tribal governments, and the affected public in the planning and decision-making process; and fully integrate all refuge proposals that may have an impact on the environment with the provisions of NEPA (40 CFR 1501.2). Implementation of any one of the alternatives in this CCP for managing Sheldon Refuge is such an action. Therefore, this planning process is subject to NEPA requirements.

Federal Water Pollution Control Act of 1972, as amended by the Clean Water Act of 1977, (Public Law [P.L.] 95-217; 33 U.S.C. 1251-1387, et seq., as amended; 33 CFR 320 ff; 40 CFR 15, 100-400, 220-233, 400-471)

This act regulates the discharge of pollutants into waters of the United States. The act protects fish and wildlife, establishes operation permits for all major sources of water pollution, and limits the discharge of pollutants or toxins into water. The act makes it unlawful for any person to discharge any pollutant from a point source into navigable waters unless a permit is obtained under the Clean Water Act.

Clean Air Act of 1990 as amended (42 USC 7401-7661)

This act established Federal standards for various pollutants from both stationary and mobile sources and to provide for the regulation of polluting emissions via state implementation plans. In addition, the amendments are designed to prevent significant deterioration in certain areas where air quality exceeds national standards, and to provide for improved air quality in areas which do not meet Federal standards ("nonattainment" areas).

This act also requires Federal agencies to prevent significant deterioration of air quality and, in particular, to preserve air quality in national parks, national wilderness areas, national monuments, and national seashores (42 U.S.C. 7470).

Antiquities Act (16 U.S.C. 431-433); Archaeological Resources Protection Act of 1979 (P.L. 96-95; 16 U.S.C. 470as, et seq., as amended; 43 CFR 50-58); and the National Historic Preservation Act of 1966 (P.L. 89-665; 16 U.S.C. 470 et seq., as amended)

These laws make reference to cultural resources or govern the management of cultural resources on Federal lands. The various historic preservation laws, in general, do the following:

- Vest ownership of historic and prehistoric properties and of materials collected from such sites with the state and Federal governments.

- Protect archeological and historic sites from unauthorized disturbance and prescribe penalties for individual who damage (or collect from) such sites.
- Provide for issuing of permits to qualified individuals and institutions to conduct scientific research.
- Mandate the inventory and evaluation of all sites on government-owned and managed lands. Inventory is the responsibility of the individual Federal agency involved.
- Require that all projects with state or Federal involvement be conducted in such a way as to protect any significant cultural resources that may be present. This includes, but is not limited to, the performance of archeological surveys, site evaluations, and, if necessary, mitigation of adverse impacts on such resources.

Native American Graves Protection and Repatriation Act (P.L. 101-601; 25 U.S.C. 3001-13; 104 Stat. 3042)

- Establishes requirements for the treatment of Native American human remains and sacred or cultural objects found on Federal land.
- Requires Federal agencies to provide notice to affected Tribes of any such item is found that can be associated with a specific Tribe or groups of Tribes.
- Requires that such items be returned upon request to an associated Tribe or Tribes.

General Mining Act of 1872, as amended (30 U.S.C. 21 et seq.)

- Commonly known as the Mining Law of 1872, this Act the foundation of the existing system for acquiring rights in public mineral lands, and is solely applicable to "locatable" minerals.
- Provides for locating and patenting mining claims where a discovery has been made for locatable minerals on public lands.

Mineral Lands Leasing Act of 1920 as amended (30 U.S.C. 181 et seq.)

- Also known as the Mineral Leasing Act of 1920, this Act is solely applicable to "leasable" minerals. Among the laws affecting the exploration and development of leasable minerals are the Act of July 31, 1947, as amended (30 U.S.C. 601 et seq.); the Mineral Leasing Act for Acquired Lands, as amended (30 U.S.C. 351 et seq.); the Geothermal Steam Act of 1970, as amended (30 U.S.C. 1001-1027); and the Surface Mining Control and Reclamation Act of 1977, as amended (30 U.S.C. 1201 et seq.).

Many other laws govern the U.S. Fish and Wildlife Service and Refuge System lands. A list and brief description of each can be found at http://laws.fws.gov.

Executive Orders

Executive Order 11644 as amended (42 U.S.C. Sec 4321 et seq.)

Section 1. Purpose. It is the purpose of this order to establish policies and provide for procedures that will ensure that the use of off-road vehicles on public lands will be controlled and directed so as to protect the resources of those lands, to promote the safety of all users of those lands, and to minimize conflicts among the various uses of those lands.

Sec. 3. Zones of Use. (a) Each respective agency head shall develop and issue regulations and administrative instructions, within six months of the date of this order, to provide for administrative designation of the specific areas and trails on public lands on which the use of off-road vehicles may be permitted, and areas in which the use of off-road vehicles may not be permitted, and set a date by which such designation of all public lands shall be completed. Those regulations shall direct that the designation of such areas and trails will be based upon the protection of the resources of the public lands, promotion of the safety of all users of those lands, and minimization of conflicts among the various uses of those lands. The regulations shall further require that the designation of such areas and trails shall be in accordance with the following –

(1) Areas and trails shall be located to minimize damage to soil, watershed, vegetation, or other resources of the public lands.

(2) Areas and trails shall be located to minimize harassment of wildlife or significant disruption of wildlife habitats.

(3) Areas and trails shall be located to minimize conflicts between off-road vehicle use and other existing or proposed recreational uses of the same or neighboring public lands, and to ensure the compatibility of such uses with existing conditions in populated areas, taking into account noise and other factors.

(4) Areas and trails shall not be located in officially designated Wilderness Areas or Primitive Areas. Areas and trails shall be located in areas of the National Park system, Natural Areas, or National Wildlife Refuges and Game Ranges only if the respective agency head determines that off-road vehicle use in such locations will not adversely affect their natural, aesthetic, or scenic values.

Regulation

50 CFR Sec. 27.31 General provisions regarding vehicles

Travel in or use of any motorized or other vehicles, including those used on air, water, ice, snow, is prohibited on national wildlife refuges except on designated routes of travel, as indicated by the appropriate traffic control signs or signals and in designated areas posted or delineated on maps by the refuge manager and subject to the following requirements and limitations…

(f) The operation of a vehicle which does not bear valid license plates and is not properly certified, registered, or inspected in accordance with applicable State laws is prohibited.

(g) Driving or permitting another person to drive a vehicle without valid license is prohibited. A valid driver's or operator's license must be displayed upon the request of any authorized official…

(l) A motor vehicle shall not be operated at anytime without proper brakes and brake lights, or from sunset to sunrise without working headlights and taillights which comply with the regulations for operation on the roads of the State within whose boundaries the refuge is located.

Policy

U.S. Fish and Wildlife Service management direction for all national wildlife refuges is contained in the Refuge Manual chapters, Director's orders, national policy issuances, handbooks, Director's memoranda, and Regional directives. Some of the Refuge Manual chapters relevant to the CCP include feral horse and burro management (7 RM 6); off-road vehicle management (8 RM 7); and management of non-wildlife-dependent public uses (8 RM 9). Over the last few years, the Service has developed or revised numerous policies and Director's Orders to reflect the mandates and intent of the Improvement Act. Some of these key policies include the Biological Integrity, Diversity, and Environmental Health Policy (601 FW 3); the Compatibility Policy; the Refuge Planning Policy; Mission, Goals, and Purposes (601 FW 1), Appropriate Refuge Uses (603 FW 1); Wildlife-Dependent Public Uses (605 FW 1); Wilderness Stewardship Policy (610 FW 1); and the Director's Order for Coordination and Cooperative Work with State Fish and Wildlife Agency Representatives on Management of the National Wildlife Refuge System. These policies and others in draft or under development can be found at http://refuges.fws.gov/policymakers/nwrpolicies.html.

In developing a CCP, a refuge must consider these broader laws and policies as well as Refuge System and ecosystem goals and visions. The CCP must be consistent with these and also with the refuge purpose.

Biological Integrity, Diversity, and Environmental Health Policy (601 FW 3)

Section 4(a)(4)(B) of the Refuge Improvement Act states, "in administering the [NWRS], the Secretary shall…ensure that the biological integrity, diversity, and environmental health of the [NWRS] are maintained for the benefit of present and future generations of Americans." This legislative mandate represents an additional directive to be followed while achieving refuge purposes and the NWRS mission. The Act requires the consideration and protection of a broad spectrum of fish, wildlife, plant, and habitat resources found on a refuge. Service policy guiding implementation of this statutory requirement provides a refuge manager with an evaluation process to analyze his/her refuge and recommend the best management direction to prevent further degradation of environmental conditions and, where appropriate, and in concert with refuge purposes and NWRS mission, to restore lost or severely degraded resource components. Within the Biological Integrity, Diversity, and Environmental Health Policy (601 FW 3[3.7B]), the relationships among biological integrity, diversity, and environmental health; NWRS mission; and refuge purposes are explained as follows: "each refuge will be managed to fulfill refuge purpose(s) as well as to help fulfill the [NWRS] mission, and we will accomplish the purpose(s) and our mission by ensuring that the biological integrity, diversity, and environmental health of each refuge are maintained and where appropriate, restored."

When evaluating the appropriate management direction for refuges, refuge managers will use sound professional judgment to determine their refuge's contribution to biological integrity, diversity, and environmental health at multiple landscape scales. Sound professional judgment incorporates field experience, an understanding of the refuge's role within an ecosystem, and the knowledge of refuge resources, applicable laws, and best available science, including consultation with resource experts both inside and outside the Service.

The priority public uses of the NWRS are not in conflict with this policy when they have been determined to be compatible. The directives of this policy do not envision or necessitate the exclusion of visitors or the elimination of visitor use structures from refuges; however, maintenance

and/or restoration of biological integrity, diversity, and environmental health may require spatial or temporal zoning of visitor use programs and associated infrastructures. General success in maintaining or restoring biological integrity, diversity, and environmental health will produce higher-quality opportunities for providing wildlife-dependent recreational uses.

Feral Horse and Burro Policy (7 RM 6)

6.2 Policy. It is the policy of the Service that feral horse and burro populations will not be maintained on Sheldon, Hart Mountain, and Kofa National Wildlife Refuges. Feral horses and burros on these refuges will be removed in accordance with the provision of 50 CFR 30.12 and Section 6.9, below.

6.9 On Sheldon, Hart Mountain, and Kofa National Wildlife Refuges, the preferred methods of control are biological control or live capture. If neither is feasible, surplus animals may be destroyed, provided the methods are approved by the regional director. All control activities will be conducted as humanely as possible.

Exotic Species Policy (7 RM 8)

8.1 Policy. The National Wildlife Refuge System exists for the protection and management of plants and animals native to the United States. The policy of the Service is to prevent further introduction of exotic species on national wildlife refuges except where and exotic species would have value as a biological control agent and would be compatible with the objectives of the refuge. The continued existence, or management of exotic plants and animals on refuge lands will be permitted only if:

A. An exotic species has become established and its elimination, while desirable, is no longer practicable, or

B. An exotic species has become established and maintained on a non-augmented basis for at least 25 years and does not conflict with refuge objectives.

Wilderness Stewardship Policy (610 FW 1)

This policy provides guidance on administrative and public activities on wilderness areas, proposed wilderness areas, and wilderness study areas within the NWRS. The purpose of the policy is to provide "an overview and foundation for implementing the Wilderness Act and the National Wildlife Refuge System Administration Act of 1966, as amended (Administration Act)" (610 FW 1 1.1A). The policy states that we will manage proposed wilderness areas as if they were designated wilderness (610 FW 1 1.5T).

1.4 What are the priorities in implementing this policy? We will consider three main priorities in the following order when administering refuge wilderness areas: The Administration Act, the Endangered Species Act, and the Wilderness Act. We initially determine what needs to be accomplished to meet refuge purposes, then ensure that these activities comply with the Endangered Species Act, and then ensure that these activities comply with the Wilderness Act.

1.14 What are the principles for administering wilderness? We observe five key principles in administering wilderness:

A. Accomplish Administration Act purposes, refuge purposes, including Wilderness Act purposes, and the Refuge System mission. The Administration Act, refuge purposes, and Wilderness Act purposes tell us what to accomplish on a refuge. The Wilderness Act, however, may affect how we accomplish these purposes and the Refuge System mission.

B. Secure "an enduring resource of wilderness" by maintaining and, where appropriate, restoring, a wilderness area's biological integrity, diversity, environmental health, and wilderness character.

C. Administer wilderness areas to provide a wide variety of public benefits "for the use and enjoyment of the American people" (Wilderness Act, section 2(a)) in a manner that is appropriate and compatible with the Administration Act, refuge purposes, including Wilderness Act purposes, and the Refuge System mission; retains wilderness character; is consistent with the nondegradation principle; and leaves the areas "unimpaired for future use and enjoyment as wilderness."

D. Use restraint in our administration of wilderness. As a place "where the earth and its community of life are untrammeled by man," we minimize actions for administration of wilderness areas. We may allow exceptions to the generally prohibited uses if the uses are the minimum requirement for administering the area as wilderness and are necessary to accomplish the purposes of the refuge, including Wilderness Act purposes. We may limit even nonmotorized refuge management activities to protect wildness.

E. Provide opportunities for primitive recreation, giving priority to compatible wildlife-dependent activities that are enhanced by a wilderness setting. Provide physical, social, and administrative settings that are conducive to experiencing opportunities for solitude, adventure, challenge, inspiration, and other aspects of wilderness character that the American people can use and enjoy.

1.16 What activities does the Service prohibit in wilderness?

A. Section 4(c) of the Wilderness Act prohibits commercial enterprises and permanent roads within wilderness, except as specifically provided by legislation and subject to existing private rights. Section 4(d)(6) of the Wilderness Act, however, allows commercial services in wilderness, but only when they are "necessary for activities which are proper for realizing the recreational or other wilderness purposes of the areas." We may allow commercial services, such as outfitter and guide services, in wilderness where they are necessary to accomplish the purposes of the refuge, including Wilderness Act purposes. (See 610 FW 2 for more information about what we allow and prohibit in wilderness.)

B. Section 4(c) of the Wilderness Act also lists a number of generally prohibited uses in wilderness, subject to existing private rights:

(1) "[E]xcept as necessary to meet minimum requirements for the administration of the area for the purpose of this Act (including measures required in emergencies involving the health and safety of persons within the area), there shall be no temporary road, no use of motor vehicles, motorized equipment or motorboats, no landing of aircraft, no other form of mechanical transport, and no structure or installation within any such area."

(2) We may allow exceptions to the generally prohibited uses for refuge management activities if the prohibited uses are the minimum requirement for administering the area as wilderness and are necessary to accomplish the purposes of the refuge, including Wilderness Act purposes. (See section 1.18.)

C. Area-specific wilderness legislation may permit uses that the Wilderness Act generally prohibits, and we comply with the provisions of those laws.

1.17 How do refuge managers accomplish both the establishing purpose(s) of a refuge and the purposes of the Wilderness Act?

A. The wilderness portion of a refuge is encompassed both within the Refuge System and the National Wilderness Preservation System. Refuge System laws, regulations, and policies apply to refuge wilderness, but we carry them out in ways that preserve wilderness character and comply with the Wilderness Act's prohibitions. Refuge purposes and Wilderness Act purposes tell us what to accomplish on a refuge. The Wilderness Act, however, may affect how we accomplish these purposes and the Refuge System mission.

(1) For instance, on a refuge established for migratory birds, the refuge manager may conduct a census on foot within designated wilderness, while using motor vehicles on other portions of the refuge.

(2) We continue to fulfill the establishing purposes of the refuge and the mission of the Refuge System while complying with the Wilderness Act, and we adjust our management strategies and techniques to prevent degradation of the wilderness character.

B. We adhere to a much stricter standard than usual for approving actions in wilderness so that we maintain the natural and untrammeled condition of the wilderness. We do not authorize generally prohibited uses in refuge wilderness **except** when the use is:

(1) Allowed under the terms of the area-specific wilderness legislation and the Wilderness Act;

(2) The minimum requirement for administering the area as wilderness and necessary to accomplish the purposes of the refuge, including Wilderness Act purposes; or

(3) An emergency involving the health and safety of a person or people within the area.

1.18 How does the Service determine if a proposed refuge management activity is the minimum requirement for administering the area as wilderness and necessary to accomplish the purposes of the refuge, including Wilderness Act purposes? We conduct and document a minimum requirement analysis (MRA) for all proposed refuge management activities that involve a generally prohibited use (also see section 1.19). The MRA clarifies the need for and impacts of a proposed action. We authorize an activity only if we demonstrate that it is necessary to meet the minimum requirement for administering the area as wilderness and necessary to accomplish the purposes of the refuge, including Wilderness Act purposes.

A. We identify and analyze alternative ways to accomplish refuge purposes, including Wilderness Act purposes, in order to determine whether the proposed refuge management

activity is necessary and to identify the techniques that will minimize impacts to the wilderness resource. At a minimum, we evaluate the impacts of:

(1) An alternative where we take no management action,

(2) An alternative allowing no generally prohibited uses, and

(3) Alternative(s) to conduct the activities inside the wilderness and outside the wilderness.

B. We consider the full range of wilderness values and character when evaluating the alternatives. These values include the undeveloped and untrammeled natural condition of wilderness, cultural resources, outstanding opportunities for solitude, the potential for the public to have a primitive and unconfined type of recreational experience, and other components of wilderness character.

C. We consider the direct impacts of the proposed refuge management activity under each of the alternatives. We also consider the indirect impacts associated with the action and the cumulative impacts of the action when it is conducted in conjunction with other existing or planned uses or actions within or adjacent to and affecting the wilderness areas. Under the nondegradation principle, the conditions prevailing in an area at the time of wilderness designation establish a benchmark for assessing the significance of a proposed action's beneficial and adverse impacts on wilderness character.

D. Our refuge management activities preserve wilderness character and only rarely involve generally prohibited uses. The alternative that has the least impact on the area's wilderness character, including intangible aspects of wilderness character, and accomplishes refuges purposes, including wilderness purposes, constitutes the minimum requirement. We do not use cost or convenience as a factor in determining the minimum requirement or minimum tool. We use primitive tools when possible.

1.22 What effects do emergencies involving the health and safety of people have on the uses generally prohibited by the Wilderness Act? In an emergency involving the health and safety of people, we may use or authorize the use of motorized vehicles and equipment, mechanical transport, or aircraft. A Minimum Requirements Analysis is not required, but we take all reasonable measures to minimize impacts on the wilderness character.

Appropriate Use Policy (603 FW 1)

1.4 What are the objectives of this chapter?

A. Refuges are first and foremost national treasures for the conservation of wildlife. Through careful planning, consistent Refuge Systemwide application of regulations and policies, diligent monitoring of the impacts of uses on wildlife resources, and preventing or eliminating uses not appropriate to the Refuge System, we can achieve the Refuge System conservation mission while also providing the public with lasting opportunities to enjoy quality, compatible, wildlife-dependent recreation.

B. Through consistent application of this policy and these procedures, we will establish an administrative record and build public understanding and consensus on the types of public uses that are legitimate and appropriate within the Refuge System.

A. Appropriate Use.

A proposed or existing use on a refuge that meets at least one of the following four conditions.

(1) The use is a wildlife-dependent recreational use as identified in the Improvement Act.

(2) The use contributes to fulfilling the refuge purpose(s), the Refuge System mission, or goals or objectives described in a refuge management plan approved after October 9, 1997, the date the Improvement Act was signed into law.

(3) The use involves the take of fish and wildlife under State regulations.

(4) The use has been found to be appropriate as specified in section 1.11.

1.8 What is the relationship between appropriateness and compatibility? This policy describes the initial decision process the refuge manager follows when first considering whether or not to allow a proposed use on a refuge. The refuge manager must find a use is appropriate before undertaking a compatibility review of the use. This policy clarifies and expands on the compatibility policy (603 FW 2.10D(1)), which describes when refuge managers should deny a proposed use without determining compatibility. If we find a proposed use is not appropriate, we will not allow the use and will not prepare a compatibility determination. By screening out proposed uses not appropriate to the refuge, the refuge manager avoids unnecessary compatibility reviews. By following the process for finding the appropriateness of a use, we strengthen and fulfill the Refuge System mission. Section 1.11 describes the appropriateness finding process. Although a refuge use may be both appropriate and compatible, the refuge manager retains the authority to not allow the use or modify the use. For example, on some occasions, two appropriate and compatible uses may be in conflict with each other. In these situations, even though both uses are appropriate and compatible, the refuge manager may need to limit or entirely curtail one of the uses in order to provide the greatest benefit to refuge resources and the public. See the compatibility policy (603 FW 2.11G) for information concerning resolution of these conflicts.

Compatibility Policy (603 FW 2)

Lands within the NWRS are different from other multiple-use public lands in that they are closed to all public uses unless specifically and legally opened. The Refuge Improvement Act states that "the Secretary shall not initiate or permit a new use of a Refuge or expand, renew, or extend an existing use of a [refuge], unless the Secretary has determined that the use is a compatible use and that the use is not inconsistent with public safety." The Refuge Improvement Act also states that "compatible wildlife-dependent recreational uses [hunting, fishing, wildlife observation and photography, or environmental education and interpretation] are the priority general public uses of the [NWRS] and shall receive priority consideration in [refuge] planning and management."

In accordance with the Refuge Improvement Act, the Service has adopted a Compatibility Policy (603 FW 2) that includes guidelines for determining if a use proposed on a national wildlife refuge is compatible with the purposes for which the refuge was established. A compatible use is defined in the policy as a proposed or existing wildlife-dependent recreational use or any other use of an national wildlife refuge that, based on sound professional judgment, will not materially interfere with or detract from the fulfillment of the NWRS mission or the purposes for which the refuge was established and contributes to the maintenance of biological integrity, diversity, and environmental

health. The policy also includes procedures for documentation and periodic review of existing refuge uses.

The Compatibility Policy does not apply to overflights above a refuge or to activities authorized, funded, or conducted by a Federal agency (other than the Service) that has primary jurisdiction over a refuge or portion of a refuge, if the management of those activities is in accordance with a Memorandum of Understanding between the Secretary or the Director and the head of the Federal agency with primary jurisdiction over the refuge governing the use of the refuge.

The first step in determining if a use is compatible is to determine if the use is appropriate (refer to previous discussion of 603 FW 1). If a use is not appropriate, the use is not further considered, and a compatibility determination is not required. If a use is determined to be appropriate, the Service must prepare a compatibility determination. When a determination is made as to whether a proposed use is compatible or not, this determination is provided in writing and is referred to as a compatibility determination.

An opportunity for public review and comment is required for all compatibility determinations. For compatibility determinations prepared concurrently with a CCP or step-down management plan, the opportunity for public review and comment is provided during the public review period for the draft plan and associated NEPA document. Appropriateness findings and the compatibility determinations prepared in association with this CCP are provided in Appendices C and D.

Fishery Resource Management Policy (7 RM 10)

10.6 Stocking refuge waters. Stocking of fish in refuge waters would be limited to measures aimed at maintaining balanced fish populations or replacing populations decimated by unusually severe or atypical losses due to climatic or environmental factors. (See 7 RM 12, Propagation and Stocking.)

Stocking refuge waters with catchable-size sport fish specifically to support recreational fishing is prohibited. Such a practice conflicts with the objectives of providing a quality, wildlife-oriented experience.

Appendix K. Planning Team Members and Work Experience

Name	Position (USFWS Start and End Dates)	CCP Roles and Responsibilities	Education	Experience
Gail Collins	Complex Supervisory Wildlife Biologist (April 2007-present)	Affected environment for wildlife, water resources; environmental consequences; Wilderness Minimum Tool Analysis review	M.S. Wildlife Biology	Wildlife biology 16 years
Aaron Collins	Complex Park Ranger (July 2009-present)	Lead planner; affected environment for public uses; environmental consequences for public uses, cultural resources; wilderness review; Wilderness Minimum Tool Analysis	B.S. Natural Resource Science	Conservation planning 11 years, outdoor recreation management 9 years, wilderness management 6 years, botany 2 years
Brian Day	Sheldon Refuge Manager (September 2006-present)	Facilities, public use, fish and wildlife, habitat, compatibility determinations, wilderness inventory and study, environmental consequences	B.S. Wildlife Biology	Wildlife biology 6 years, refuge management 15 years
Andy Goheen	Complex Fire Management Officer (September 2006-September 2009)	Fire management, fire ecology, cultural resources	B.S. Environmental Management	Fire management 13 years, fire ecology 10 years, cultural resource management 8 years
Sue Goheen	Complex Natural Resource Planner (September 2006-July 2009)	CCP team lead, wilderness inventory and study, soils, geology	B.S. Natural Resource Management, B.S. Soil Science	Soil science 21 years, biological and physical sciences 6 years, natural resource planning 3 years, recreation management 1 year
John Kasbohm	Project Leader (2011- present)	Final proposed action and Preferred Alternative, appropriateness determinations, compatibility determinations	Ph.D. Wildlife Science, M.S. Entomology, B.S. Biology	Refuge management 16 years, wildlife biology 25 years, threatened and endangered species recovery 5 years
Damien Miller	Deputy Project Leader (January 2010-April 2012)	Refuge management alternatives	M.S. Wildlife Science, B.S. Wildlife Management	Supervision 13years, project management 13 years, habitat management 7 years, wildlife research 6 years, Endangered

Name	Position (USFWS Start and End Dates)	CCP Roles and Responsibilities	Education	Experience
				Species Act 5 years, National Environmental Policy Act 1 year
Betsy Schenk	Complex Fire Management Officer (March 2010-present)	Fire management, fire ecology, Wilderness Minimum Tool Analysis review	B.S. Supervision, B.S. Wildlife and Forest Management	Wildland fire 19 years, fuels management 9 years
Paul Steblein	Complex Project Leader (September 2006-October 2010)	Management alternatives, feral horses and burros	M.S. Biology, B.S. Wildlife Science	Refuge Management 7 years, wildlife biology 3 years, wildlife research 9 years

Appendix L. Recreation Opportunity Spectrum Setting Criteria

Adapted from the U.S. Forest Service 1982 ROS Users Guide

Remoteness Criteria*

Primitive	Semi-Primitive Non-Motorized	Semi-Primitive Motorized	Roaded Natural	Rural	Urban
At least 3 miles from all roads or trails with motorized use	½-3 miles from all roads or trails with motorized use	Within ½ mile of primitive roads or trails with motorized use	Within ½ mile of improved roads	No distance criteria	No distance criteria

*Natural barriers, screening, and other features can be used to modify these criteria.

Evidence of Humans

Primitive	Semi-Primitive Non-Motorized	Semi-Primitive Motorized	Roaded Natural	Rural	Urban
Setting is essentially an unmodified natural environment; evidence of humans is not noticeable to the casual observer or visitor	Setting may have subtle modifications that are noticeable but do not draw the attention of the casual observer	Setting may be moderately altered, but alterations would not draw the attention of motorized observers	Modifications to the environment range from easily noticeable to dominating the setting, but are generally not noticeable from more primitive setting areas	Human modifications dominate the setting, but most are primarily modifications to land use and appearance rather than constructed buildings and features	Setting is dominated by the influence of human use and activity and is almost entirely altered from its natural condition through development and construction
Structures are extremely rare	Structures are rare and isolated	Structures are rare and isolated	Structures are generally scattered, remaining visually subordinate or unnoticed to the casual observer; structures may include power lines, cell phone towers, etc.	Structures are readily apparent and may range from scattered to small, dominant clusters including power lines, cell phone towers, ski areas, and recreation sites	Structures dominate the setting and include major building complexes, towns, industrial sites, and large resort developments

Social Setting*

Primitive	Semi-Primitive Non-Motorized	Semi-Primitive Motorized	Roaded Natural	Rural	Urban
Usually less than 6 parties per day encountered on trails and less than 3 parties visible from campsites	Usually 6-15 parties per day encountered on trails and 6 or fewer parties visible from campsites	Frequency of contact with other visitors low to moderate	Frequency of contact with other visitors moderate to high on roads, but low to moderate on trails and away from roads	Frequency of contact with other visitors moderate to high in and around developed sites, but moderate away from developed sites	Frequent contact with other visitors; large number of users on-site and in nearby areas

*Criteria apply during the typical use season. Peak use days or seasons may exceed these limits.

Managerial Setting

Primitive	Semi-Primitive Non-Motorized	Semi-Primitive Motorized	Roaded Natural	Rural	Urban
Control* and regulation of visitor use is primarily off-site; few or no on-site controls apparent	On-site control of visitor use present but subtle	On-site control of visitor use present but subtle	On-site control of visitor use noticeable but in harmony with the natural environment	On-site control of visitor use obvious and numerous but largely in harmony with the constructed environment	On-site control of visitor use obvious and numerous

*Controls may be physical (i.e., barriers) or regulatory (i.e., permits).

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Appendix N. Comments Received During Public/Agency Review Period and Service Responses

The comment period for the draft comprehensive conservation plan/environmental impact statement (CCP/EIS) consisted of both an informal comment period following release of the preliminary draft CCP/EIS alternatives in July 2011, and a formal public comment period upon release of the Draft CCP/EIS in September 2011.

The Service issued a planning update summarizing the CCP/EIS preliminary draft alternatives for public comment and input on July 13, 2011. Through this planning update, the Service informed the public that comments and suggestions would be addressed along with other comments received during the formal public comment period required by the National Environmental Policy Act (NEPA). The Service received 520 comment submissions between July 13 and September 8, 2011.

The Service released the Draft CCP/EIS on September 9, 2011, for formal public review and comment. This comment period closed November 8, 2011. During the formal comment period, the Service received 401 comment responses from 1,709 agencies, organizations, and individuals[1].

Comments received focused on the significant issues identified through public scoping and on the alternatives developed through public input. A large proportion of comments focused on respondents' opinions toward one or more alternatives presented in the Draft CCP/EIS for management of feral horses and burros, management and manipulation of habitats, public access to public lands within Sheldon Refuge, sport hunting opportunities, and wilderness recommendations. Where the opinion expressed provided some level of detail or was based on a real or perceived fact, the Service has provided a response. Where the comment expressed solely an opinion and was not supported by any assertion, the Service considered the comment in selection of the preferred alternative, but did not respond to the comment in this appendix, other than to thank the writers for expressing their opinions and thoughts.

A much smaller, but significant proportion of comments provided factual information (both real and perceived), questioned statements and facts presented in the Draft CCP/EIS, suggested additional actions for inclusion in one or more alternatives, or questioned the accuracy of information used in formulating the alternatives and/or conducting analyses as part of the EIS.

Comments received were groups into 12 categories based upon management actions considered in the Draft CCP/EIS alternatives or based on topics of particular interest as indicated by comments themselves. These categories are: Coordination; Upland Habitat Management; Wildlife Population Management; Fisheries Population Management; Feral Horse and Burro Management; Invasive Species Management; Climate; Transportation Management; Wilderness Recommendations and Management; Landscape Level Planning and Land Acquisition; Miscellaneous Comments; and Editorial Comments. Comments as presented in this appendix have been paraphrased from the originals, and in some cases consolidated with others where the Service's response is the same.

[1] Identical copies of responses were submitted by 1,308 individuals.

Coordination

1. **Comment:** Several comments requested that the Service coordinate with other agencies and partners for future management of resources within Sheldon Refuge.

   Response: We agree that continued coordination between the Service and key partner agencies such as the Nevada Department of Wildlife (NDOW), Oregon Department of Fish and Wildlife (ODFW), Bureau of Land Management (BLM), Summit Lake Paiute Tribe, and others responsible for resource management is essential. We will continue to work collaboratively on a wide range of projects throughout Sheldon Refuge for the benefit of not only natural resources and the public, but also the partnerships between agencies.

Upland Habitat Management

2. **Comments:** Several comments questioned the rationale for selecting management goals and objectives for habitats such as sagebrush-steppe communities or mountain mahogany and western juniper woodland, and asked how the Service would measure progress toward those goals and objectives.

   Response: Percentages presented for habitat management objectives presented under each alternative primarily represent Service estimates of effects associated with feral horse and burro management under corresponding alternatives and the amounts of each habitat type that could be restored given available resources. As noted in the rationale for habitat objectives, the precise conditions of habitats throughout Sheldon Refuge have not been quantified, but based on the results of vegetation surveys, site visits, and ongoing research projects, the primary factors currently influencing habitat conditions within Sheldon Refuge are feral horses and burros. The differences in management alternatives for horses and burros are reflected in the percentage of each habitat type that would meet the stated objective. In response to comments, a more detailed discussion of the relationship between horse and burro management and percentages of each habitat type the Service estimates would meet objectives for each alternative were included in the Final CCP/EIS.

   The Service estimates western juniper is encroaching upon 8,000 to 10,000 acres of sagebrush habitat located primarily in the western portion of Sheldon Refuge (Section 4.2.7.2). The objective for removal of an average of 1,500 acres per year will allow for annual variability in accomplishments, while still meeting the overall stated objective for restoration of sagebrush-steppe habitats during the lifetime of the plan.

3. **Comment:** Standards and thresholds in CCP objectives are not scientifically supported and do not constitute the habitat type, natural plant communities, or a healthy ecosystem.

   Response: Standards and thresholds presented are not intended to represent all components of a particular habitat type, plant community, or healthy ecosystem. The standards presented characterize those aspects of each particular habitat type that, in the Service's opinion, will meet habitat requirements identified for key indicator species and other benefiting species, will be most responsive and most directly affected by management actions, and could be most accurately and efficiently monitored. Standards and thresholds were developed through professional experience, review of available information and literature, and consultation and review by NDOW and other management agencies and experts. For additional explanation and clarification, we included references used to support the selection of thresholds in the rationale for each habitat objective in the Final CCP/EIS.

4. **Comment:** One comment requested that the Service identify specific results from vegetation surveys and site visits cited in the rationale for several management objectives.

   Response: There are three primary sources of vegetation survey and site visit information. Figure 4.2 in the CCP/EIS represents the most recent and comprehensive landscape assessment of vegetation habitat types across the entire Sheldon Refuge using analysis of satellite and National Agriculture Imagery Program (NAIP) imagery. More detailed site-specific data are presented primarily in three papers referenced in Appendix M: Barnett 2002; Collins 2009; and LaRouche 2007.

5. **Comment:** Statements and assertions made in a variety of comments indicate some respondents believe the Service allows the grazing of livestock within Sheldon Refuge, and that management for livestock is the rationale for actions in the preferred alternative, including removal of feral horses and burros.

   Response: While livestock grazing did historically occur throughout much of Sheldon Refuge, all grazing permits were purchased by a third party, donated, and retired by the Service in 1994. Since that time no commercial livestock grazing has been authorized within Sheldon Refuge. The Service is not proposing to allow livestock grazing in the future.

6. **Comment:** A number of comments expressed support or opposition for management actions such as mowing, thinning, fire suppression, prescribed burning, natural processes, fuel breaks, etc. to restore or maintain various habitats under one or more alternatives presented in the Draft CCP/EIS.

   Response: The Service appreciates the range of opinions expressed.

7. **Comment:** Several comments suggested we prioritize our management objectives and strategies presented in the Draft CCP/EIS for habitat protection and restoration, particularly for habitats considered less resilient, more significantly impacted, or at greater risk from threats such as feral animals, invasive plants, wildfire, and changes in climate.

   Response: One purpose of the CCP is to identify long-term directions and priorities for management. The objectives and strategies presented for each goal, including strategies for habitat protection and restoration, represent resource management priorities for Sheldon Refuge over the next 10 to 15 years.

8. **Comment:** Various comments suggested studies indicate mowing of sagebrush can have detrimental effects and requested an explanation of when, why, and how sagebrush removal would occur.

   Response: As stated in the rationale for objectives 2b and 3a, a reduction in disturbance events has increased sagebrush encroachment into Great Basin wildrye stands and into emergent marsh and wet meadow habitats. Mechanical habitat treatments such as mowing or thinning would be emphasized in these habitats over other methods to reduce encroachment, increase native grass and forb production, reduce shrub cover, and maintain a low density of invasive plants. The preferred alternative emphasizes mowing along roads rather than grading or blading as has been done in the past to control invasive plants and provided added protection from wildfire. However, as stated in the description of the preferred alternative (page 2-7 of the Draft CCP/EIS), the major emphasis would be the removal of juniper encroaching into sagebrush habitat, primarily within the western portion of Sheldon Refuge. Manipulation of emergent marsh and wet meadow habitat would be suspended until objectives for horses and burros are achieved. Therefore, we anticipate sagebrush would be

removed from a small proportion of the acres stated under the objectives. In response to comments, management strategies for Great Basin wildrye were discussed separately in the Final CCP/EIS for clarification.

9. **Comment:** Several comments requested specific inventory and monitoring be conducted in conjunction with restoration actions proposed in the preferred alternative

   Response: The CCP is intended to provide overall long-term management direction for fulfilling the purposes of Sheldon Refuge, the mission of the National Wildlife Refuge System, and for addressing significant issues. While we agree that monitoring is critical to determining success and informing adaptive decision making, detailed discussion of monitoring strategies is beyond the scope of the CCP. We will develop and incorporate specific inventory and monitoring methodologies, protocols, and techniques as part of future step-down management plans, as identified in the CCP, including a habitat management plan and a cold-water fisheries management plan for Sheldon Refuge.

Upland Habitat Management—Wildland Fire

10. **Comment:** A few comments suggested the Service reconsider management direction to conduct thinning or prescribed fire in mountain mahogany woodland habitat.

    Response: The Service recognizes that mountain mahogany provides key habitat for a number of sensitive wildlife species, is susceptible to fire, and is slow to reestablish and recover after disturbance such as fire. Our intent is to use prescribed fire and thinning of vegetation *in areas adjacent to* mountain mahogany, not within stands, in an effort to provide additional long-term protection for these stands. Management direction for mountain mahogany was edited in the Final CCP/EIS to clarify our intent.

11. **Comment:** Comments questioned the effectiveness of fuel breaks and other methods for achieving habitat management goals and objectives and requested clarification of when and why fuel breaks would be used, including full analysis of associated impacts.

    Response: As stated in the rationale for Objective 7a and explained in Chapter 4, fire is a natural process that has helped shape the Sheldon Refuge ecosystem. However, fire can also be a threat to the safety of the public, natural and cultural resources, and, considering the presence of cheatgrass and other invasive plant species, the continued existence of the present ecosystem. Natural fire now has the potential to burn more intensely, more rapidly, and over larger areas than if overgrazing and continued fire suppression had not occurred—making fire management more difficult.

    Inevitably, some wildfires will burn within Sheldon Refuge despite even the most aggressive fire suppression efforts. The Service believes that well-planned and strategic creation of fire fuel breaks within Sheldon Refuge using a combination of fire-resistant natural features (rock cliffs and outcroppings, past fire scars, water bodies and wet riparian areas, etc.), areas with reduced fire fuels (created by mowing, cutting, thinning, etc.), and areas where fuels have been eliminated (e.g., roads) is one of the safest, most efficient, and most predictable ways in which to influence the size, pattern, and intensity of fire disturbance toward restoration of desired conditions across the landscape while at the same time achieving stated habitat objectives.

    Analysis of the effects from creating and maintaining fuel breaks and from mechanically removing vegetation was evaluated and presented in the Environmental Consequences chapter (Chapter 6) of the Draft CCP/EIS.

12. **Comment:** Several comments asked for clarification and definition of the term "appropriate management response."

    Response: Appropriate management response is the response to a wildland fire based on an evaluation of risks to firefighter and public safety, the circumstances under which the fire occurs, including weather and fuel conditions, natural and cultural resource management objectives, protection priorities, and values to be protected. The evaluation must also include an analysis of the context of the specific fire within the overall local, geographic area or national wildland fire situation. The range of potential responses to wildfire includes anything from observation to aggressive direct fire suppression action with use of all resources and equipment available. We clarified the meaning of this term as used in the Final CCP/EIS.

13. **Comment:** Comments noted that past fires at Sheldon Refuge in the early 1990s, including prescribed fires, replaced shrub communities with grass, displaced sagebrush-obligate species, altered habitats (particularly winter habitat and habitat for sage-grouse), and were followed by increases in cheatgrass and other non-native weed presence. Comments stated that because these changes would likely continue, additional prescribed burning should not be conducted or repeated. Others questioned whether negative effects from prescribed fires were weighed against ecological benefits.

    Response: The Service agrees that disturbance from past fires has altered the size and distribution of habitats at various stages of plant community succession across Sheldon Refuge, and that these changes have affected the distribution of wildlife populations. However, as noted in the Draft CCP/EIS, it has been the *lack of fire as a result of fire suppression* that has contributed to adverse impacts to refuge habitats. At the scale of Sheldon Refuge, the disturbance of fire that maintains an irregular mosaic of habitats at various stages of plant community succession is beneficial to both individual species and ecosystem biodiversity providing long-term invasion by non-native plant species (e.g., cheatgrass) does not occur.

    The Service evaluated a full range of alternatives, including an alternative with emphasis on prescribed burning, an alternative with emphasis on natural wildfire, and the preferred alternative with emphasis on protection of key habitat types from large fires through increased use of mechanical means to remove fire fuels. Adverse and beneficial impacts both directly and indirectly resulting from prescribed burning were evaluated in the EIS (refer to Chapter 6 of the CCP/EIS). Factors considered as part of the analyses included effects to soil, air, water, climate, habitats, fish, wildlife, plants, invasive species, cultural and historic resources, recreation opportunity, visual resource values, and wilderness resource values.

    The CCP serves to provide overall long-term direction for management action, including the use of fire, to achieve specified habitat objectives. More detailed planning and site-specific analysis would be conducted as part of future habitat and fire management step-down plans. Individual site-specific prescribed fire prescriptions would also be developed per Service policy to maximize the likelihood of achieving desired conditions while minimizing or eliminating potential for adverse impacts.

Wildlife Population Management

14. **Comment:** Several comments stated the purpose for Sheldon Refuge was to manage for a maximum number of 3,500 antelope as stated in Executive Order 7522.

Response: As stated in Executive Order 7522, Sheldon Refuge was established as an area "…set apart for the conservation and development of natural wildlife resources and for the protection and improvement of public grazing lands and natural forage resources…."

While maintaining a healthy pronghorn population is clearly important, the Service does not consider sustaining 3,500 pronghorn as a primary purpose for Sheldon Refuge. This population figure was included in Executive Order 7522 specifically to allocate a maximum amount of forage for pronghorn and other wildlife, with the remainder available for domestic livestock pursuant to the Taylor Grazing Act of 1934. Because Sheldon Refuge has not been administered by the BLM and pursuant to the Taylor Grazing Act since 1976, and livestock grazing no longer occurs within Sheldon Refuge, the allocation of forage is neither appropriate nor necessary and the reference in the Executive Order is no longer applicable. The Service will continue to work to manage healthy wildlife populations within a natural range of variability consistent with Service policy for biological integrity, diversity, and ecological heath.

15. **Comment:** Numerous comments suggested that altering wildlife species composition through removal of feral horses and burros, and reintroductions to augment and maintain unnaturally high populations of large animals, such as pronghorn and bighorn sheep, is not appropriate and appears to be conducted primarily to benefit trophy big-game hunters, rather than to maintain or restore biological integrity, diversity, and environmental health.

    Response: The Service does not propose to reintroduce, augment, or alter wildlife species composition or increase hunting harvest under any of the alternatives presented in the CCP/EIS. Following their extirpation from Sheldon Refuge in the late 1920s due to a variety of human influences (refer to Section 4.2.5.3 of the Sheldon Refuge CCP/EIS), California bighorn sheep were reintroduced when natural recolonization was determined unlikely to occur. Bighorn sheep populations thrived and eventually reached a level where the Service and NDOW determined that relocating some animals to assist reintroduction efforts outside Sheldon Refuge and hunting for a relatively small number of animals would be compatible with the purposes for Sheldon Refuge and the long-term health and viability of the population. Currently, limited hunting for pronghorn, bighorn sheep, and mule deer is only allowed for about 95 days each year, while a large portion of Sheldon Refuge remains closed to all hunting. As discussed in Chapter 5, the majority of visitors to Sheldon Refuge participate in wildlife viewing, which occurs year-round and generates a much greater economic benefit to the region and surrounding communities than both hunting and fishing combined (see Section 6.5.2 of the Draft CCP/EIS).

    The Service evaluated three alternatives for management of feral horses and burros, including an alternative to maintain populations of feral horses and burros. Selection of the preferred alternative to remove horse and burro populations was based on the need to fulfill the mission of the National Wildlife Refuge System, achieve the purposes for Sheldon Refuge, and eliminate the negative impacts of these non-native feral species to the biological integrity, diversity, and ecological health of all native fish, wildlife, plants, and their habitats within Sheldon Refuge.

16. **Comment:** A number of comments suggested that control of large predators (e.g., mountain lion, bobcat, and coyote) is required by Section 3 of Executive Order 7522 and must be conducted to benefit wildlife within Sheldon Refuge. Other comments inferred that management of predators (either within or adjacent to the refuge) is adversely impacting prey populations within the Sheldon Refuge and should be addressed in the CCP/EIS.

Response: Section 3 of the Executive Order allocated forage resources to pronghorn and other non-predatory species and to domestic livestock pursuant to the Taylor Grazing Act. Because forage resources are no longer managed by the BLM or pursuant to the Taylor Grazing Act, and livestock grazing no longer occurs within Sheldon Refuge, the Service generally considers referenced portions in Section 3 of the Executive Order no longer applicable or appropriate and moot.

The Service considers populations of wildlife, including pronghorn, bighorn sheep, and mule deer, within Sheldon Refuge to be healthy and within the natural range of population variability. As discussed in the rationale for Objective 6b, wildlife population numbers experience natural fluctuation and variability over time, but observation and research increasingly demonstrate the primary influences on prey populations within Sheldon Refuge are habitat quality/quantity and weather—not predation. Therefore, the Service believes that management actions including changes to big-game harvest levels and, specifically, reduction of predator populations are not necessary to maintain healthy prey populations and would be contrary to Service policies regarding maintaining biological diversity, biological integrity, environmental health, and wilderness character.

17. **Comment:** Numerous comments suggested artificial water sources such as playa dug-outs, livestock water troughs, and water guzzlers are necessary to support wildlife populations, and the removal of water developments would be detrimental to sage-grouse, pronghorn, and other wildlife species.

    Response: Sheldon Refuge is somewhat unique within the Great Basin due to the number of water sources present. As stated in Chapter 6, the Service does not dispute that wildlife use and may benefit from free-standing water when available. However, the majority of these artificial water sources were specifically developed for commercial livestock use—a use that no longer exists. Further, as referenced in the CCP, research and studies indicate that wildlife native to the Great Basin are particularly well adapted to the relatively dry conditions and periodic drought that occur on the Refuge.

    Based on professional analysis and review of available information, scientific study, and literature, we have determined the removal of artificial water sources within Sheldon Refuge would restore the natural hydrology and be of greater benefit to a wider range of native wildlife species, and that such artificial water sources are not required to sustain currently healthy viable wildlife populations within their natural range of variability. Therefore, it is the Service's opinion that the preferred alternative would best restore the biological integrity of spring, spring brook, stream, and playa habitats damaged and degraded from past development for commercial livestock use to achieve the stated objectives of the CCP for the long-term benefit of a full range and diversity of native wildlife and plant species. As stated in the rationale for Objective 3b, spring, spring brook, and stream restoration efforts would be determined by evaluation of individual site characteristics.

18. **Comment:** A few comments stated the Service should not remove any water developments as long as horses and burros remain within Sheldon Refuge and until site-specific analysis and planning is conducted for each development.

    Response: We recognize that trade-offs may exist for any management action and that restoration efforts benefitting some species may be detrimental to others. For these reasons, we agree that further evaluation and review of specific water development removals and playa restoration efforts are warranted before individual projects are initiated. With assistance from NDOW and other partners, we would develop spring and playa restoration

prescription(s) that further identify and analyze impacts of possible water development removal options, and we added appropriate strategies under the relevant Final CCP/EIS objectives to reflect our intent. In addition, we included additional explanation and rationale for Objective 3c strategies under the preferred alternative (page 2-29 of the Draft CCP/EIS) to clarify the Service's intent to conduct playa restoration only if methods are demonstrated to be effective in restoring natural habitat conditions for the benefit of native wildlife and plants.

With respect to the timing of potential water development removal projects, we intend to retain the majority of existing water sources until horse and burro populations are significantly reduced. Timeframes for strategies under objectives 3b and 3c were intended to allow for removal of horses and burros prior to completing restoration of most springs, spring brooks, streams, and playas. Additional explanation of the relationship between the proposed schedules for horse and burro removal and habitat restoration efforts were included in the rationale for these objectives.

19. **Comment:** A few comments suggested the Draft CCP/EIS does not contain adequate information about wildlife population numbers that inhabit Sheldon Refuge and therefore suggest that the plan does not comply with NEPA.

    Response: Sheldon Refuge is remote and largely undeveloped, with relatively little public use and hunting. Overall, wildlife populations are primarily influenced by natural conditions such as habitat, weather, and the occurrence of non-native species (e.g., feral horses and burros). While general discussions of these influences and their effects on wildlife population trends for some species are included in Chapter 4, management direction in the CCP is intended to influence habitat conditions under the assumption that changes in habitat would indirectly influence all wildlife populations within their natural range of variability, not only those for whom population data exist. Therefore, precise population data and statistics for most species are not considered necessary for making informed decisions with respect to the alternatives and are not included in the CCP/EIS.

20. **Comment:** A few comments stated management direction and the evaluation of the effects from fences, especially to Greater sage-grouse, are not adequate and should be further examined.

    Response: The Service anticipates Sheldon Refuge would have no interior wire fences by the end of 2012. Maintaining a wildlife-friendly boundary fence is a management priority identified in the management objectives to prevent the further movement of horses, burros, and livestock onto the Refuge. The Service would consider a full range of fencing materials and devices to minimize disturbance and injury to wildlife, including flagging, reflectors, and use of materials other than barbed wire. In response to comments, a more complete definition of wildlife-friendly fencing was included in the Final CCP/EIS.

21. **Comment:** One comment suggested the Service use nonlethal methods to estimate sage-grouse population parameters.

    Response: The Service coordinates with NDOW to collect population data using a combination of lethal and nonlethal methods. Sage-grouse lek attendance data are collected through observation for use in developing population size and trend estimates. Data collected from wings submitted by hunters are used in developing population sex and age ratios. Despite the limitations of wing data, they provide a means for assessing the effects of management actions on production at the state or local population management unit scale.

However, if Greater sage-grouse harvest data are determined insufficient to accurately and precisely measure identified population parameters in the future, Sheldon Refuge would be closed to sport hunting for Greater sage-grouse.

22. **Comment:** One comment suggested direct count of animals is not appropriate, and other methods should be used to more accurately census horses, burros, and wildlife.

    Response: The Service does not use direct count data to estimate horses, burros, and wildlife population size, but rather to monitor trends in sex ratios, productivity, and population over time. In coordination with BLM, a simultaneous double-count with sightability bias correction and other statistically robust methods are used to estimate population size for feral horse populations within Sheldon Refuge.

23. **Comment:** Several comments asserted that pronghorn, bighorn sheep, mule deer, and elk are reintroduced native species that were killed or almost killed to extinction by humans or died off during the last ice age.

    Response: Fossil records show pronghorn, bighorn sheep, mule deer, and elk have been continuously present on the North American continent for at least 100,000 years—well before the last ice age (the Wisconsin glaciations, which occurred between 11,150 and 35,000 years before present). Bighorn sheep were locally extirpated by human influences and reintroduced to Sheldon Refuge, but are considered native wildlife. The reader is referred to various articles printed in *Mammalian Species* for additional information (http://www.science.smith.edu/msi/msiaccounts.html).

24. **Comment:** One comment requested the Service identify State of Nevada status for species listed in Appendix B.

    Response: We amended Appendix B in the Final CCP/EIS to indicate state status for various species.

Fisheries Population Management

25. **Comment:** Comments suggested stocking of fish within Sheldon Refuge is not appropriate and appears to be conducted primarily to benefit anglers rather than to maintain or restore biological integrity, diversity, and environmental health, and should no longer be allowed.

    Response: Three alternatives were considered for management of fish populations within Sheldon Refuge, including an alternative to end stocking for recreation opportunity. Based on the analysis of effects from these alternatives, the Service has determined that continued limited stocking of appropriate fish populations to constructed ponds and reservoirs for sport fishing within Sheldon Refuge does not present significant risk to the health, diversity, or biological integrity of native fish, wildlife, plants, or their habitats. The Service will continue to coordinate closely with NDOW to ensure future stocking and augmentations remain compatible with the purposes, management goals, and objectives for Sheldon Refuge.

26. **Comment:** Some comments suggested Alvord cutthroat (either pure or hybrid strains) be considered for trout stocking efforts within Sheldon Refuge.

    Response: The Service recognizes that while both redband and Lahontan cutthroat trout naturally occur within nearby watersheds, neither species is endemic to Sheldon Refuge. Therefore, we agree it is appropriate to consider Alvord cutthroat trout strains when coordinating future stocking efforts with NDOW. As in the past, any particular watershed

would only be stocked with a single species to avoid unwanted hybridization. In response to comments, Alvord cutthroat trout were included in Objective 8b of the Final CCP/EIS.

27. **Comment:** One comment suggested managing stream reaches capable of producing cobble and gravel bottoms as such and not as soft-bottom sediment as currently stated in Objective 3b. Managing for natural cobble and gravel bottoms would better support trout populations and reduce the need for re-stocking.

    Response: The Service's intent for management of in-channel habitat included in Objective 3b is to recognize management for native species (e.g., Sheldon tui chub, amphibians, and endemic invertebrates) as a priority for Sheldon Refuge. However, we did not intend to imply that we would convert natural cobble and gravel stream bottoms to soft-bottom sediment. In response to comments, additional clarification of management priorities, intent for habitat management objectives, and species affected were included in the Final CCP/EIS. In addition we will work with NDOW to identify those stream channel reaches appropriate for various management objectives, including restoration.

28. **Comment:** One comment stated impacts to trout-rearing habitat from erosion as a result of overgrazing were overlooked in the analysis.

    Response: Causes for erosion and other impacts to stream and riparian habitats were discussed in Chapter 4; feral horses and burros were identified as a primary contributing factor. The Draft CCP/EIS identified continued erosion and turbidity as adverse impacts that would result from the continued presence of horses and burros under Alternative 1.

29. **Comment:** Various comments suggested delaying eradication and not using piscicides to eradicate rainbow trout from Big Spring Reservoir.

    Response: As stated in the Draft CCP/EIS, Big Spring Reservoir has been dry for several years and no rainbow trout are currently present. The Service does not propose the use of piscicides to eliminate trout from any waters within Sheldon Refuge under any alternative in the CCP/EIS.

30. **Comment:** The Service's recommendation to develop Gooch Lake as a fishery should not be pursued.

    Response: The Service did not consider developing Gooch Lake as a fishery under any alternative in the CCP/EIS.

Feral Horse and Burro Management

31. **Comment:** Numerous submissions expressed either support or opposition to alternatives presented in the Draft CCP/EIS, including the Service's preferred alternative for removal of horses and burros from Sheldon Refuge within five years.

    Response: The Service acknowledges and appreciates these comments.

32. **Comment:** Several comments referenced the Wild Free Roaming Horses and Burros Act of 1971 and related court decisions, or indicated horses and burros within Sheldon Refuge either are or should be managed under this Act.

    Response: The Wild Free Roaming Horses and Burros Act of 1971 applies only to management of horses and burros within specific public lands managed by the BLM and the U.S. Forest Service.

33. **Comment:** One comment requested the Service provide annual population and management data for feral horses and burros including population size, mortality, numbers gathered, and numbers adopted as required by NEPA.

    Response: Population information was presented in Section 4.1.1 of the Draft CCP/EIS. With respect to feral horses and burros, evaluation of the alternatives and selection of the preferred alternative were based on fulfillment of the mission of the National Wildlife Refuge System, achieving the purposes for Sheldon Refuge, and overall impact from the presence of feral horses and burros within Sheldon Refuge. Therefore, more detailed annual population information was not considered necessary for evaluating the effects of the alternatives presented or for making an informed decision in selecting the preferred alternative to remove all horses and burros from Sheldon Refuge.

34. **Comment:** Several comments asserted horses and burros are reintroduced species, native to North America, that fill an ecological niche in the high desert environment.

    Response: Based on the fossil record and historical information, it is widely accepted that all horses in North America became extinct at least 8,000 to 10,000 years before present and that all horses found in North America today are descended from imported domesticated animals and are therefore, by definition, not native. Because native plants, wildlife, and their habitats continued to adapt and evolve for more than 8,000 years following the extinction of horses, there is no longer an ecological niche for these animals to fill.

    Even in the absence of prehistoric information, horses and burros within Sheldon Refuge are in fact feral. As noted in Section 4.1.1 of the Draft CCP/EIS, it is well documented that horses and burros were first released onto Sheldon Refuge and the surrounding area as domestic animals and were raised for ranch stock and sale to the U.S. Cavalry during the late 1800s and early 1900s. Following the advent of motorized vehicles and mechanization of the Cavalry, the animals were simply abandoned.

35. **Comment:** One comment asked when a non-native or introduced species such as horses or burros would be considered native.

    Response: By definition, the Service considers all species not presently or historically occurring in the United States except through the intervention of humans, intentionally or otherwise, to be non-indigenous exotic species (Refuge Manual 7 RM 8.4). Because horses and burros occur within the United States and Sheldon Refuge through the intentional intervention of humans, the Service will not consider them native.

36. **Comment:** Several comments objected to the Service's determination that feral horses and burros must be removed, while other non-native introduced species (e.g., chukar, trout, perch)—especially those determined to be causing adverse impact to Refuge resources—can remain on Sheldon Refuge.

    Response: Based upon evaluation of the alternatives and the impact analyses conducted, it is the Service's opinion that allowing horses or burros to remain would interfere with accomplishing the purposes for Sheldon Refuge, and therefore action must be taken. Consistent with Refuge System policy for management of feral horses and burros within Sheldon Refuge, these populations must be removed rather than simply reduced. We have determined other non-native introduced wildlife species are causing adverse impacts, but it is also our opinion that those impacts are relatively minor and not likely reach the threshold of interfering with our ability to accomplish the purposes for Sheldon Refuge. The Service requires no action to reduce or eradicate self-sustaining populations of non-native, non-

invasive species (e.g., chukar) unless those species interfere with accomplishing refuge purpose(s). We do not, however, manage habitats to increase populations of these species unless such habitat management supports accomplishing refuge purposes (Service Manual 601 FW 3).

37. **Comment:** Multiple comments offered anecdotal information and observation of the impacts to wildlife, plants, and their habitats caused by feral horses and burros.

    Response: The Service appreciates first-hand observation and confirmation of numerous scientific studies and evaluations that have quantified adverse impacts caused by horses and burros (pages 6-9 through 6-11 and page 4-4 of the Draft CCP/EIS). These impacts to native fish, wildlife, plants, and their habitats within Sheldon Refuge were primary considerations in the selection of the Service's preferred alternative.

38. **Comment:** Some comments suggested horses and burros enhance the ecosystem, complement grazing species within Sheldon Refuge, and do not require management by the Service because populations are naturally controlled.

    Response: An alternative that left horse and burro populations unmanaged was analyzed in the 2008 *Horse and Burro Management Environmental Assessment* (U.S. Fish and Wildlife Service [USFWS] 2008a) and was determined to be contrary to Service statutes, policy, and refuge purposes. For these reasons, a similar alternative was considered but not evaluated in detail in the Draft CCP/EIS.

    There are no predators found at Sheldon Refuge that are capable of limiting horse or burro populations, and there is no scientific evidence to support the idea that horses will naturally limit their own populations. Regular gathers conducted by the Service from the 1970s until the mid-1990s maintained populations near 400 animals. Due to a lack of sufficient funding for continued removal, the population increased rapidly to an estimated 2,000 animals in less than 10 years—at which time regular gathers resumed. If left unchecked, nature would regulate the horse and burro population through a boom-and-bust cycle, where the population increases dramatically, food and water becomes scarce, and the population crashes through dehydration and starvation—resulting in even greater and more lasting impacts to plants, their habitats, and the fish and wildlife that depend upon them.

39. **Comment:** Comments stated the existing Sheldon Refuge perimeter fence is not adequate to prevent ingress or egress of horses. Maintenance of this fence should be a priority and modifications should be made to better prevent horse movement into and out of the refuge.

    Response: The Service identified maintenance of the Sheldon Refuge perimeter fence as a high priority for management under Objective 1a. Damage and vandalism of fences can allow horse movement. Efforts are continual and ongoing to monitor, repair, and modify the fence to reduce damage and limit horse movement into and out of Sheldon Refuge to the maximum extent practicable and allowed by available funding and staff.

40. **Comment:** Some comments suggested the use of specific management strategies for maintaining natural horse and burro sex ratios, herd behavior, social structure, family units, and long-term genetic viability and herd health within Sheldon Refuge.

    Response: The Service considered Alternative 1 (the no action alternative) for long-term management of horses and burros within Sheldon Refuge. However, because the preferred alternative requires only short-term management of the animals, the Service determined that

strategies to maintain specific population parameters or herd dynamics are not necessary or feasible.

41. **Comment:** Several comments suggested using chemical fertility control porcine zona pellucida (PZP) vaccine to minimize horse and burro population growth.

    Response: Each alternative considered in the Draft CCP/EIS, including the preferred alternative will allow the use of safe, humane, and effective fertility controls to limit population growth.

42. **Comment:** One comment stated that by evaluating only the current management alternative and two alternatives to remove horses and burros, the Draft CCP/EIS failed to consider a full range of alternatives.

    Response: In evaluating short-term management for horses and burros, a range of population sizes were considered under alternatives in the *2008 Horse and Burro Management at Sheldon Refuge* environmental assessment (USFWS 2008a). In evaluating long-term management, the Service determined that any action alternative that does not include removal of horses and burros would fail to achieve the purposes and management goals and objectives for Sheldon Refuge. Therefore, while other alternatives (in addition to the no action alternative) that included long-term management for horses and burros were considered, these additional alternatives were not evaluated in further detail.

43. **Comment:** A few comments requested that the Service use lethal control to eliminate horses and burros.

    Response: As noted in the Draft CCP/EIS, an alternative including lethal control was considered, but the Service determined the use of lethal control to be unnecessary to meet horse and burro population objectives. As a result, this alternative was not evaluated in further detail.

44. **Comment:** Various comments stated that elimination of horses and burros does not have credible scientific justification, is environmentally unnecessary, and is unwarranted.

    Response: Based upon the review of scientific literature and assessment of conditions within Sheldon Refuge presented in the Draft CCP/EIS, it is the Service's opinion there is sufficient credible scientific and empirical evidence to justify the preferred alternative to remove horses and burros from Sheldon Refuge.

45. **Comment:** Some comments stated the Service's preferred alternative to remove horses and burros is arbitrary.

    Response: To be arbitrary, a decision must be based on perception or feeling rather than objective fact, reasons, or principles. The reasons for the Service's selection of the preferred alternative are to fulfill the mission of the National Wildlife Refuge System; to achieve the purposes for Sheldon Refuge; and to maintain consistency with Service policy. The underlying principles for the preferred alternative are restoring biological integrity, diversity, and environmental health toward conservation of native fish, wildlife, plants, and their habitats. These principles are supported by facts and analyses presented in the CCP/EIS that demonstrate that feral horses and burros are causing significant adverse impact to fish, wildlife, plants, and their habitats within Sheldon Refuge.

46. **Comment:** Some comments requested the Service make public adoption of horses and burros easier and include incentives such as tax credits.

Response: Due to limited facilities, staff, and adoption demand at Sheldon Refuge, we select qualified organizations and businesses to provide extended care, advertise, and find suitable homes for 100% of horses and burros made available for adoption. We also issue press releases and updates to announce when gathers are conducted and where the public can request horses and burros for adoption. The Service does not have the authority to modify tax law to provide incentives for adoption.

47. **Comment:** One comment suggested the Service conduct additional public outreach and communicate details regarding feral horse and burro gathers.

    Response: The Service has issued public announcements, press releases, interviews, fact sheets, and other information related to management of horses and burros at Sheldon Refuge through a variety of media. We strive to provide regular and consistent communication in the future.

48. **Comment:** A few comments requested the Service identify potential consequences for horses or burros sold at auction if adoption were no longer a viable option.

    Response: The Service is committed to finding adoptive homes for as many horses and burros as possible. We have spent millions of dollars and many thousands of staff hours to provide veterinary care, and public outreach and advertising to find homes for 100% of the more than 3,500 horses and burros from Sheldon Refuge made available for adoption. However, in the future, we anticipate homes might not be found for all animals because of the age, appearance, or health of an animal or because economic conditions prevent large numbers of horses from being placed. In these situations, it would then be necessary to sell these animals at auction. The Service would ensure animals are sent to reputable auctions and receive adequate and humane care. As with adoption, horses bought at auction would become private property, no longer under the control or jurisdiction of the Service, and it is possible animals could be bought at auction for slaughter. For this reason, the sale of horses at auction would be used only as a last resort.

49. **Comment:** A few comments requested the Service designate horse and burro populations as historical and cultural resources and seek necessary legislative changes needed.

    Response: The no action alternative included long-term management for horses and burros within Sheldon Refuge. As stated in response to similar comments received on the 2008 Horse and Burro Management Plan (USFWS 2008a), horses and burros themselves cannot be considered for protection as a cultural or historical resource, and the Service has determined horses and burros within Sheldon Refuge do not contribute to the significance of any historic properties; therefore, removal of these animals has no effect on cultural resources eligible for the National Register of Historic Places. Service action to propose legislation or propose changes to legislation that would provide legal protections would not fulfill the purposes of the Refuge or the mission of the National Wildlife Refuge System.

50. **Comment:** Some comments requested the Service include details regarding how horse and burro gathers would be conducted, how and where animals would be transported, and where animals would be held for sorting and while awaiting adoption.

    Response: Appendix H of the CCP/EIS details the standard operating procedures for horse and burro population control methods, including gathers, transportation, and adoption. During sorting, animals are cared for by the Service under supervision of licensed veterinarians at facilities within Sheldon Refuge. Both the care and facilities provided are

periodically reviewed by independent observers. Additional details are provided in the 2008 Horse and Burro Management Plan (USFWS 2008a).

51. **Comment:** One comment stated the cost of horse and burro removal and adoption is excessive and is far greater than revenues received through adoption.

    Response: As displayed in Figure 6.1 of the Draft CCP/EIS, costs for implementing the preferred alternative for management of horses and burros are expected to be less than half those of the other two alternatives considered. When the full costs are considered, including long-term impacts to fish, wildlife, plants, and their habitats, the cost of the preferred alternative is much less. The Service does not collect any fees or revenues through horse and burro adoptions.

52. **Comment:** A number of comments stated wild horses and burros are imperiled, threatened, near extinction, or in jeopardy.

    Response: Wild horses and burros are managed by BLM and the U.S. Forest Service on 199 Herd Management Areas encompassing 26.9 million acres of public lands outside Sheldon Refuge. There are 42 Herd Management Areas and Herd Areas within the region, including 14 Herd Management Areas encompassing more than 1.27 million acres immediately adjacent to Sheldon Refuge, where BLM manages for long-term protection of 1,477 wild horses and 65 wild burros under the Wild Free Roaming Horses and Burros Act of 1971 (BLM 2011; USFWS 2008a). Actual population information shows wild horses and burros are not imperiled, in jeopardy, or at risk of extinction. The current on-the-range population of wild horses and burros (approximately 38,000) is greater than the number found roaming in 1971 (about 25,300) when wild horses first received Federal protection under the Wild Free Roaming Horses and Burros Act (BLM 2012).

53. **Comment:** Numerous comments stated public observation and photography of horses and burros provides recreation opportunity and benefit to the local economy similar to wildlife observation and photography, and thus should be supported by the Service. Comments stated that the impacts to opportunity for viewing and photography of horses and burros from the Service's preferred alternative were not adequately addressed.

    Response: We acknowledge that horses and burros provide opportunities for viewing and photography. Section 6.3.4 of the Draft CCP/EIS discussed impacts from the three alternatives to these opportunities in the context of priority opportunities for viewing and photographing native wildlife within Sheldon Refuge and similar opportunities to view and photograph horses and burros in adjacent BLM Herd Management Areas. We determined that impacts to horse and burro viewing and photography from each of the alternatives would be minor to negligible in this context, but that opportunities for the priority public use of wildlife observation and photography would be greatly enhanced by the preferred alternative.

Invasive Species Management

54. **Comment:** Some comments questioned why some proven and effective strategies for the control of weeds and other invasive species, particularly the use of non-native seed for restoration and rehabilitation efforts, were included in some alternatives, but not the preferred alternative.

    Response: Strategies identified for each alternative under Objective 5a (page 2-41) were intended to illustrate differences in management emphasis and were not intended to preclude the use of other strategies when and where they are determined more appropriate through

adaptive management. The primary difference under the preferred alternative is a more systematic approach to detect and treat a substantially larger number of acres, rather than the minimal, opportunistic, and sometimes inconsistent approach that has been used in the past. In response to comments, wording of strategies and the objective rationale for the control of invasive species was changed to clarify differences between management emphases in the three alternatives.

After further consideration and in response to comments, we modified our strategy for seeding under Objective 7b for the preferred alternative in the Final CCP/EIS to allow the use of non-native seed under specific and limited circumstances; however, we will maintain the management priority for the use of native seed whenever possible—especially for large-scale rehabilitation efforts and within proposed wilderness.

55. **Comment:** A number of comments suggested specific restoration actions or requested the Service identify what rehabilitation and restoration techniques and tools would be used to meet the stated objectives, particularly with respect to riparian and stream channel habitats and threats from non-native weeds.

    Response: The Service proposes to allow a full range of habitat restoration and rehabilitation tools. Given the proportion of Sheldon Refuge that is managed to also preserve wilderness resources values, emphasis would be placed on the use of the least intrusive means necessary. Each restoration effort would likely require a review of the information and research available, a site-specific evaluation, and actions best suited to the particular conditions and concerns identified for the site. Therefore, it is the Service's opinion that a general prescription for the rehabilitation and restoration of a particular habitat type, or following a particular type of event, is not appropriate for inclusion in the CCP/EIS, and identification of specific restoration tools and techniques without site-specific information and evaluation is premature.

56. **Comment:** Some comments suggested the Service identify criteria for the use of weed control methods, such as avoiding or prohibiting broadcast herbicide application, identifying specific control methods, and specifying where and when methods would be used.

    Response: Decisions to use particular tools and techniques and criteria for their use are based on numerous factors and considerations (particular species being targeted, associated habitat types, proximity to sensitive resources and adjacent lands, etc.). While the CCP provides overall direction and priority for the control of invasive species, inclusion of specific treatments in the CCP/EIS is not appropriate and without site-specific information and assessment would be premature. As referenced in the rationale for Objective 5a, regional integrated pest management strategies, including procedures for evaluating pesticide use were incorporated as part of the CCP/EIS. We included further summary and explanation of the referenced integrated pest management strategies in the Final CCP/EIS. We also provided a complete copy of the referenced integrated pest management document for public review on our planning website (http://www.fws.gov/pacific/planning/main/docs/NV/docssheldon.htm).

57. **Comment:** One comment suggested the use of volunteers and partnerships should be included as a management strategy for invasive species.

    Response: Volunteers and partnerships have become increasingly important for implementation of nearly all refuge management activities, including the inventory, control, and monitoring of weeds and other invasive species. Through Objective 8g we identified

increased involvement of volunteers and partnerships as a priority for management of Sheldon Refuge, including for the control of invasive species.

58. **Comment:** One comment suggested the analysis in the EIS of impacts from the use of herbicides to treat up to 1,000 acres per year was not adequate.

    Response: Strategies identified under the preferred alternative for Objective 5a in the CCP/EIS state that a variety of methods (including herbicides) would be used to treat up to 1,000 acres per year. The Service has not identified what proportion of acres might be treated with herbicide, but presumably it would be more than under the no action alternative, which identifies 50 to 100 acres for treatment per year.

    Consistent with the Service's integrated pest management policy, a pesticide use proposal must be approved before any herbicide can be used within Sheldon Refuge. Pesticide use proposals require site-specific analysis, evaluation of chemical profiles, and evaluation of likely environmental effects. Based on scientific information and analyses documented in chemical profiles for pesticide use proposals, pesticides allowed for use on refuge lands would be of relatively low risk to non-target organisms as a result of low toxicity or short persistence in the environment. Thus, potential impacts to refuge resources and neighboring natural resources from pesticide applications under all alternatives are expected to be minor, temporary, or localized in nature.

    In response to comments, we included additional explanation of our process for completing and approving pesticide use proposals. We also included additional discussion of potential impacts associated with herbicide use with other analyses in Chapter 6 of the Final CCP/EIS. We provided a complete copy of the integrated pest management guidance document, which was incorporated by reference in the Draft CCP/EIS, for public review on our planning website (http://www.fws.gov/pacific/planning/main/docs/NV/docssheldon.htm).

59. **Comment:** One comment suggested livestock grazing should be used to reduce fire danger and control invasive weeds.

    Response: As stated in Sections 4.1 and 4.2.4.2 of the Draft CCP/EIS, overgrazing by livestock and feral horses and burros has resulted in significant adverse impacts to refuge habitats. Therefore, the Service does not consider additional grazing an appropriate management strategy for achieving habitat management goals and objectives as part of the CCP/EIS.

60. **Comment:** Bur buttercup (*Ranunculus testiculatus*) was not listed in Appendix B.

    Response: Bur buttercup has several synonyms (USDA 2012), and is listed in Appendix B as curveseed butterwort (*Ceratocephala testiculata*).

Climate

61. **Comment:** A few comments requested explanation of how climatic changes and influences on habitat distribution, wildlife migration, natural fire regime, and wildlife populations were considered. Additional comments requested explanation of how anticipated influences of climate change were considered when evaluating impacts from the alternatives.

    Response: As discussed in Section 3.2, changes in climate are expected to exacerbate current threats such as cheatgrass and other non-native invasive species; fire size, frequency, and intensity; and habitat impacts from long-term wildfire suppression and feral horses and burros. We anticipate climate change would also magnify or enhance impacts from various

actions proposed under the alternatives. These influences were considered in the development of the alternatives, analyses of the impacts, and selection of the preferred alternative, which places greater emphasis on minimizing impacts from public uses, control of invasive species, long-term and proactive measures such as fire breaks and removal of encroaching juniper to minimize the size and intensity of wildfire, increased protection and restoration of mountain mahogany and deciduous woodland habitats considered sensitive to changing conditions, and removal of environmental stressors and significant threats to refuge habitats—primarily feral horses and burros.

Transportation Management

62. **Comment:** Numerous comments expressed support or opposition for the alternatives, including the Service's preferred alternative to designate roads and routes for public vehicle use throughout Sheldon Refuge.

    Response: The Service acknowledges and appreciates these comments.

63. **Comment:** Several comments stated all-terrain vehicles and other off-highway vehicles (OHVs) should not be allowed, or should not be allowed off-road, or that only non-motorized vehicles should be allowed within Sheldon Refuge.

    Response: The Service considers the use of motorized vehicles on designated open routes appropriate for facilitating public access to remote portions of Sheldon Refuge and for providing a range of wildlife-dependent recreation opportunity settings.

    Many of the comments appear to have misinterpreted the actions included in the alternatives evaluated in the Draft CCP/EIS. Each of the three alternatives considers the designation of existing roads and routes for public use of vehicles. Such uses would be consistent with state laws and regulations for the use of motorized vehicles. None of the alternatives propose to allow vehicle use off-road or in areas other than on designated roads and routes, nor do any of the alternatives propose the establishment or construction of new roads or routes.

    There are three unpaved county roads within Sheldon Refuge. In accordance with Nevada statute (NRS 490.090), the operation of OHVs on public land, trails, ways, or unpaved county roads is authorized unless prohibited by a governmental entity having jurisdiction. The Service included designation of these roads for public vehicle use, including the use of OHVs, under each alternative evaluated in the CCP/EIS, which is consistent with state statute.

64. **Comment:** A number of comments stated the system of vehicle routes proposed under the three alternatives evaluated were essentially the same, and therefore the CCP/EIS did not include an adequate range of management alternatives. Other alternatives for a much smaller number of roads and routes should have been evaluated.

    Response: As stated in Section 4.1.5.3, the Service estimates 850 miles of roads, routes, and trails currently exist within Sheldon Refuge. This includes 134 miles of state and county roads authorized by rights-of-way, several hundred miles of trails within proposed wilderness, remnants of abandoned roads rarely used, and closed roads. Furthermore, a large number of routes and roads provide access for private property, mining claims, and refuge administration—not for public use.

    The no action alternative included only roads and routes where vehicle use would be consistent with existing rights for use and access, proposed wilderness, and other closure to

vehicle use, and that provide access for wildlife-dependent public use of Sheldon Refuge. The 134 miles of state and county roads, which are subject to existing rights, were designated under all alternatives. Therefore, of the 850 miles of roads, routes, and trails within Sheldon Refuge, only 231 miles were evaluated under all three alternatives.

As stated in the rationale for Objective 8n, alternatives were developed based upon evaluation of a number of criteria—including erosion potential, habitats sensitive to disturbance and/or important for wildlife (e.g., riparian areas, aspen stands, mountain mahogany stands, and sage-grouse leks), wildlife disturbance, impacts to cultural and historic resources, natural appearance and revegetation, route restoration or modifications needed to minimize resource impacts, impacts to other recreation opportunities, redundancy with other routes, and connection to other routes (including trailheads). Based on an evaluation of each route using these criteria, fewer routes were proposed in the preferred alternative and Alternative 3 than in the no action alternative. It is the Service's opinion the three alternatives evaluated provide a reasonable range of alternatives that include an appropriate balance between protecting and conserving wildlife and their habitats while maintaining adequate access to facilitate compatible wildlife-dependent recreation.

65. **Comment:** A few comments stated the compatibility determinations prepared in conjunction with the Draft CCP/EIS do not adequately address road density or vehicle disturbance impacts from the Service's preferred alternative. These comments also questioned how the Service determined that impacts under the preferred alternative would be less than under the no action alternative and requested additional justification for finding vehicle access under the preferred alternative compatible with the purposes for Sheldon Refuge.

    Response: Impacts from roads and motorized vehicle use to fish, wildlife, plants, and their habitats were discussed in Section 6.1.2.1 of the Draft CCP/EIS. The discussion included an evaluation of direct and indirect impacts both from the network of roads and vehicle use of roads. Alternatives were developed based upon evaluation of several criteria listed in the rationale for Objective 8n by a planning team with more than 70 years of professional experience and first-hand knowledge of routes and vehicle use within Sheldon Refuge. It is the Service's opinion that the preferred alternative provides an appropriate amount of vehicle access to support wildlife-dependent recreation, which is compatible with the purposes for Sheldon Refuge and is consistent with Service policies and directives.

    Effects from the action alternatives are evaluated in relation to those anticipated from the no action alternative. Because the preferred alternative proposes fewer roads, re-routing of roads out of sensitive areas, and seasonal closures to protect resources, and additional signage to inform the public of regulations and closures when compared to the no action alternative, we expect fewer impacts. In response to these and other comments, descriptions of public use activities and associated impacts in the Draft CCP/EIS were incorporated into the appropriate final compatibility determinations for Sheldon Refuge, which were included with the Final CCP/EIS as Appendix D.

66. **Comment:** One comment stated that impacts from the proposed road system to wilderness character were not addressed in the Draft CCP/EIS.

    Response: Section 6.6 includes an analysis of impacts to wilderness character from each alternative, including impacts to naturalness, solitude, and opportunities for primitive and unconfined recreation from roads and road use.

67. **Comment:** One comment asserted that impacts from OHVs are greater than those from other vehicles, and therefore should be specifically addressed in the compatibility determinations.

    Response: Because OHV use would not be allowed off-road, the effects from OHVs were considered similar to those from other motorized vehicles when analyzing impacts. Therefore, we did not differentiate between impacts from OHVs and other vehicles when evaluating the alternatives in the CCP/EIS.

68. **Comment:** One comment suggested using concessionaires to provide vehicle access for visitors, especially to sensitive areas.

    Response: Roads in sensitive areas and the amount of vehicle use occurring within Sheldon Refuge were considered in development of the alternatives and in the analysis of associated impacts included in the CCP/EIS. Based on these analyses, it is the Service's opinion that the amount of public vehicle use expected to occur on roads designated under the preferred alternative would have only minor, localized adverse impacts. If vehicle use exceeds these impacts in the future, the Service would consider additional actions, including limiting the number or type of vehicles or seasonal closure.

69. **Comment:** One comment requested explanation of how wildlife migration corridors and influences of changing climate were considered in evaluation of the transportation management alternatives.

    Response: The impact of roads and vehicle use on wildlife migration corridors was discussed on page 6-17 of the Draft CCP/EIS.

70. **Comment:** Numerous comments requested the Service impose greater penalties and increase law enforcement efforts to deter off-road driving and other violations.

    Response: The Service anticipates that increased public outreach, better signage for designated routes, detailed maps, and increased law enforcement as proposed under the preferred alternative would reduce off-road driving and other violations. Changes to fines and penalties for violations of Federal regulations and laws are outside the scope of the CCP.

71. **Comment:** One comment stated that because the State of Nevada already requires the registration of OHVs, the Service's proposal to require registration of OHVs for use on refuge roads is not necessary.

    Response: We acknowledge the State of Nevada does require registration of OHVs. However, this registration system had not been implemented at the time the Draft CCP/EIS was finalized. We updated the preferred alternative to reflect recent funding and implementation of the Nevada OHV registration program, and will allow use of registered OHVs on designated vehicle routes.

72. **Comment:** One comment expressed additional concern about potential impacts to pronghorn and mule deer in the area of Catnip Mountain and impacts to sensitive mountain mahogany and brush habitats on Blowout Mountain. The comment suggested the Service not recommend these routes be re-opened to vehicle use if the Service's wilderness recommendation under Alternative 2 is eventually accepted and approved.

    Response: Impacts to wildlife and sensitive habitats were noted in our evaluation of both routes identified by the comment, and we identified several segments of these routes that would require realignment, rerouting, and/or rehabilitation before vehicle use could be allowed. We agree that continuing to allow only existing access on foot and by horseback to

Catnip Mountain and Blowout Mountain would minimize impacts to the wildlife species and sensitive habitats identified and would avoid additional impacts from vehicle use such as increased soil erosion and rutting. In response to the comment, Alternative 2 (the Service's preferred alternative) was modified and no longer proposes these routes be re-opened. Because both routes are currently within areas proposed for wilderness designation, this change does not affect roads that would be designated open for public use as part of the Service's final decision.

Public Use

73. **Comment:** One comment stated the Service should give equal consideration to the desires of all Americans instead of catering to hunters in developing management objectives.

    Response: Our priority to conserve wildlife for the benefit of all Americans requires all public uses, including sport hunting, must first be determined compatible. The compatibility determinations for sport hunting and commercial guiding within Sheldon Refuge include a number of regulations, restrictions, and limitations to ensure those uses do not substantially interfere with other wildlife-dependent public uses and do not materially interfere with or detract from fulfillment of the National Wildlife Refuge System mission or the purposes for Sheldon Refuge.

74. **Comment:** Several comments stated the Service does not have jurisdiction to regulate hunting or fishing within Sheldon Refuge.

    Response: Considering the intent and actions of Congress (i.e., the National Wildlife Refuge System Administration Act, as amended [16 United States Code [U.S.C.] 668dd-ee]) and Department of Interior and Service regulations and policies (e.g., 43 Code of Federal Regulations [CFR] 24), the Service maintains the authority to manage wildlife species, set hunting and fishing regulations, and open or close public uses on National Wildlife Refuge System lands provided we do so to the extent practicable and consistent with state laws, regulations, and management plans. Service authorities notwithstanding, we fully intend to continue close cooperation with NDOW to maintain consistency whenever possible between state and Federal regulations for public uses occurring within Sheldon Refuge and when promulgating Federal regulations for hunting and fishing.

75. **Comment:** Some comments asserted the current regulations for hunting, fishing, and trapping within Sheldon Refuge, and particularly the fact that Service regulations do not allow hunting and trapping opportunities for mountain lion, cottontail rabbits, jackrabbits, badgers, skunks, fox, coyote, and bobcat, are inconsistent with regulations for the rest of Nevada, which do allow hunting and are therefore inconsistent with the Refuge Improvement Act and should be authorized.

    Response: Federal and state regulations for hunting, fishing, and trapping within Sheldon Refuge are consistent. Nevada state regulation (NAC 504.340) states hunting, fishing, and trapping are authorized on designated areas within Sheldon Refuge pursuant to 50 CFR 32.47 (Federal regulations for fishing and hunting within Sheldon Refuge). No areas within Sheldon Refuge have been designated for trapping. The Service will continue to closely coordinate with the State of Nevada to determine appropriate and compatible opportunities for hunting, trapping, and fishing and to maintain consistency whenever possible between state and Federal regulations for public uses occurring within the Refuge and when promulgating Federal regulations for hunting and fishing within the Refuge.

76. **Comment:** A number of comments requested hunting seasons and trapping opportunities for additional wildlife species be established for Sheldon Refuge.

    Response: Alternatives that established hunting and trapping seasons for additional wildlife species were considered, but were not evaluated in detail. As explained in Section 2.1.1 of the Draft CCP/EIS, additional wildlife species such as coyote (*Canis latrans*), bobcat (*Felis rufus*), or mountain lion (*Felis concolor*) may be used for sport hunting or trapping within a National Wildlife Refuge (50 CFR 31). However, key demographic data for these populations and the associated habitat requirements on the Refuge for these additional species have not been determined and are insufficient to determine what level of sport hunting, if any, would be compatible with the mission of the Refuge System and the purposes for Sheldon Refuge. The Service anticipates that information gathered to meet management objectives identified in the CCP would be sufficient to make such a compatibility determination in the future.

77. **Comment:** Several comments requested the Service develop additional campgrounds or campground capacity (more campsites) to accommodate more use, including use by miners in Virgin Valley. Other comments requested the Service eliminate campgrounds from Sheldon Refuge altogether.

    Response: Campgrounds and campground capacity are maintained to facilitate and support the amount and types of public uses found compatible with the purposes for Sheldon Refuge; that is, we consider camping to be a secondary use that would be authorized only to the extent that it supports compatible wildlife-dependent public uses (such as hunting, fishing, wildlife photography, wildlife observation, environmental education, and environmental interpretation) or otherwise approved uses. The Service considers the current amount of wildlife-dependent public use, including overnight use, to be compatible with the purposes for Sheldon Refuge, and we do not anticipate that changes in these uses as proposed under the preferred alternative would require additional campgrounds or campground capacity.

    Mining claims and associated activities are considered economic uses. The Service does not consider public campgrounds to facilitate economic activities appropriate or compatible with the purposes for Sheldon Refuge.

78. **Comment:** A few comments suggested the Virgin Valley Campground belongs to Humboldt County and is operated by the Service under a memorandum of understanding.

    Response: Virgin Valley Campground is owned and operated by the Service. Humboldt County provides limited funding to offset maintenance and administrative costs associated with operation of the campground.

79. **Comment:** One comment suggested we consider a less expensive alternative under which we would not repair or replace facilities such as the visitor contact center at the Refuge Headquarters at Dufurrena, or repair the Catnip Reservoir dam.

    Response: Maintaining habitat suitable for Lahontan cutthroat trout at Catnip Reservoir was identified as a priority for management of Sheldon Refuge in Objective 3d for all alternatives. It is the opinion of both the Service and NDOW that repair or replacement of the Catnip Reservoir dam is necessary to meet this objective.

    As a less expensive option, the no action alternative (Alternative 1) does not include costs associated with replacement or construction of several visitor facilities proposed in the Service's preferred alternative. It is the Service's opinion the converted mobile home that

serves as the Refuge headquarters does not provide an appropriate or adequate space for visitor contact, and therefore should be replaced in order to manage public use and visitation and effectively interpret Refuge wildlife resources and priorities.

80. **Comment:** One comment suggested strategies to manage public use and minimize impacts at particular campgrounds and campsites.

    Response: The purpose for the CCP is to provide overall long-term management direction. Specific management strategies for relocation of campgrounds, improvement of campground facilities, and protection of sensitive sites will be developed as part of the Visitor Services step-down plan. The Service acknowledges the comments and will incorporate them as appropriate into the Visitor Services step-down plan.

81. **Comment:** One comment stated collection of rocks and minerals should not be limited to surface finds.

    Response: Only surface collection of rocks and minerals within Sheldon Refuge has been found compatible with the purposes for Sheldon Refuge. Surface disturbance or excavation would be in violation of Federal regulations (50 CFR 34.47 and 50 CFR 27.61 through 27.65) and is therefore not appropriate and incompatible.

Wilderness Recommendations and Management

82. **Comment:** Numerous comments expressed support or opposition for the alternatives, including the Service's preferred alternative to recommend 341,495 acres within Sheldon Refuge for designation as wilderness.

    Response: The Service acknowledges and appreciates these comments.

83. **Comment:** A number of comments objected to prior establishment of proposed wilderness areas and the determination for wilderness study areas (WSAs) suitable for designation in the Draft CCP/EIS. Comments stated that management to preserve wilderness character limits the Service's ability to meet the purposes for Sheldon Refuge.

    Response: Congress has determined the designation of wilderness within units of the National Wildlife Refuge System is appropriate, and Service policy requires a review during the comprehensive conservation planning process to identify those areas within the Refuge that are suitable for future wilderness designation. Through past proposals, the director of the USFWS, the Secretary of the Interior, and the president have already determined that areas within Sheldon Refuge meet the requirements to be designated as wilderness. The Service is committed to managing fish, wildlife, plants, and their habitats within Sheldon Refuge to fulfill the mission of the National Wildlife Refuge System, the purposes for Sheldon Refuge, and, where applicable, wilderness stewardship.

    Service policy and proposed management direction for wilderness in the Draft CCP/EIS do not automatically prohibit the use of management tools within proposed wilderness or WSAs. As stated in the Draft CCP (pages 2-6, 2-9, and Appendix G), the Service has allowed, and intends to continue allowing, a variety of otherwise prohibited uses within proposed wilderness areas and WSAs of Sheldon Refuge to meet Refuge objectives (see Appendix J, pages J-7 through J-9). Service policy allows for uses otherwise prohibited by the Wilderness Act and Service Wilderness Stewardship Policy when those activities are determined to be the minimum necessary for meeting the purposes for Sheldon Refuge, including wilderness purposes.

84. **Comment:** Several comments suggested the Service include alternatives that would remove the current wilderness proposal, recommend no areas be designated as wilderness, or recommend all acres found suitable be designated as wilderness.

    Response: As noted in Section 2.1.1 of the Final CCP/EIS, alternatives that recommend no areas be designated and that recommend all suitable areas be designated were considered but were not evaluated in detail. As noted in Section 5.6.5, it is Service policy that all proposed wilderness areas be managed consistently with policy and guidance for designated wilderness until further action is taken by Congress. Removal of the current wilderness proposal is outside the scope of the CCP.

85. **Comment:** Several comments requested clarification or justification for changes, adjustments, or exclusion of areas previously proposed for designation or previously found suitable for wilderness study from the wilderness recommendations under the preferred alternative.

    Response: Within certain areas of Sheldon Refuge, we propose to implement a variety of management actions that are intended to alter natural conditions and that would require repeated and noticeable manipulation of habitats. While some areas possess wilderness character, the Service does not consider the intensive management proposed to be consistent with preserving wilderness character, and therefore recommends they not be designated as wilderness at this time. For other areas, the preferred alternative reflects wilderness boundaries included in the original 1974 recommendation submitted by the Service, which were revised in the final proposal submitted to Congress. A summary of the 2011 wilderness inventory and review was included as Appendix F to the Draft CCP/EIS. The summary includes explanation and justification for the Service's wilderness recommendation for lands found suitable and designated as WSAs during the wilderness review process. The entire 2011 wilderness inventory and review was provided for public review in conjunction with the Draft CCP/EIS, and is available at: http://www.fws.gov/pacific/planning/main/docs/NV/docssheldon.htm.

86. **Comment:** One comment requested minimum requirement analyses be included with the Final CCP/EIS for activities such as wildfire suppression, law enforcement, habitat protection, habitat restoration, or new structures and developments.

    Response: Suppression of wildfire (and other activities such as the pursuit of dangerous criminals) is typically considered an emergency action necessary to protect human life or property. During such emergencies, Service policy allows the refuge manager to determine and implement the action(s) necessary to effectively address the issue without conducting a minimum requirement analysis. As stated under Objective 7a (page 2-48 of the Draft CCP/EIS), the Service intends to prepare a formal minimum requirements and minimum tool analysis to evaluate pre-approval for generally prohibited uses during wildfire suppression.

    For other actions not specifically addressed as part of the CCP, the Service will continue to consider activities and otherwise prohibited uses within proposed wilderness on a case-by-case basis and allow such activities when determined to be the minimum management action necessary.

    In response to comments, we included additional wilderness policy excerpts in Appendix J of the Final CCP and clarified under Objective 7a how emergency activities (including those related to fire suppression and law enforcement) are conducted and approved within proposed wilderness areas.

87. **Comment:** One comment requested the Service allow mountain bikes within proposed wilderness because they have less impact than horseback riding.

    Response: One purpose for wilderness is to provide opportunities for primitive recreation. For this reason mechanical transport such as mountain bikes are prohibited within proposed wilderness areas (Service Manual 610 FW 1.16.B and 610 FW 1.5.L). We allow primitive transport such as pack and saddle stock within Sheldon Refuge consistent with the compatibility determinations included in Appendix D of the Final CCP/EIS.

88. **Comment:** One comment stated wilderness reduces public and recreation use and denies recreation opportunity.

    Response: One of the stated purposes for wilderness is to provide opportunities for solitude or a primitive and unconfined type of recreation. Public uses and recreation are subject to refuge-wide regulations, and the Sheldon Refuge CCP/EIS does not propose to restrict or limit the amount of visitation or types of access within proposed wilderness differently from other backcountry areas of Sheldon Refuge. Primitive recreation is but one type of opportunity provided in managing for a spectrum of compatible recreation opportunities within Sheldon Refuge; the CCP allows for semi-primitive non-motorized, semi-primitive motorized, roaded, and rural recreation opportunities (refer to Appendix L of the Final CCP/EIS).

Landscape-level Planning and Land Acquisition

89. **Comment:** A number of comments requested the Service consider acquisition or conservation easements for lands outside the Sheldon Refuge administrative boundary.

    Response: As stated in Section 1.8.1.2 of the Final CCP/EIS, inclusion of lands outside the Sheldon Refuge boundary was evaluated and determined to be outside the scope of the CCP/EIS.

90. **Comment:** Some comments suggested private lands within Refuge boundary should be prioritized for acquisition as part of Sheldon Refuge.

    Response: Management direction for Sheldon Refuge as specified under Objective 6e is to acquire inholdings from willing sellers through purchase or exchange. Due to the small number and size of inholdings within Sheldon Refuge, the Service has determined there would be little long-term benefit from prioritizing these parcels for acquisition.

Miscellaneous Comments

91. **Comment:** One comment requested the Service inventory all structures, facilities, and general improvements for damage before the [Ruby] pipeline project is released from any commitment they may have. If any damage associated with pipeline construction has occurred on Sheldon Refuge, the builders should be held accountable.

    Response: An EIS was prepared for pipeline construction with supplemental NEPA planning and a Finding of No Significant Impact. A Special Use Permit was issued by the Service in 2010 for road access and associated activities occurring within Sheldon Refuge. Copies of the decision document, including stipulations for road maintenance, signage, invasive species control, and monitoring by Ruby Pipeline LLC are available at: http://www.fws.gov/sheldonhartmtn/sheldon/rod.html.

    Additional action related to pipeline construction is outside the scope of the CCP/EIS.

Editorial Comments

92. **Comment:** Page 1-16 incorrectly states rainbow trout have been stocked to Catnip Reservoir

    Response: The reference to stocking of rainbow trout in Catnip Reservoir was removed from the Final CCP/EIS.

93. **Comment:** Lahontan cutthroat trout in Catnip Reservoir are subject to special rule under section 4(d) of the Endangered Species Act, but are not considered an experimental population as stated in the Draft CCP/EIS.

    Response: Wording in the Final CCP/EIS was edited to reflect the special rule for Lahontan cutthroat trout in Catnip Reservoir, which authorizes take in accordance with state laws.

94. **Comment:** Acreage figures in the Draft CCP/EIS for wilderness study areas do not match.

    Response: The document was reviewed and the figures reconciled.

95. **Comment:** Dates for Last Supper Cave differ on pages 5-17 and 5-22.

    Response: The document was reviewed and the figures reconciled.

96. **Comment:** Due to the time elapsed, the phrase "recently" should be removed from the reference to the status of the cave collection on page 5-22.

    Response: Change was made.

97. **Comment:** There is no reference to definitions of rock art, cairns, rings, walls on page 5-23. These structures can have spiritual connections (see Haynal 2000 and Chartkoff 1983).

    Response: Reference to spiritual connection and citation were included in the Final CCP/EIS.

Appendix O. Integrated Pest Management (IPM) Program

O.1 Background

IPM is an interdisciplinary approach utilizing methods to prevent, eliminate, contain, and/or control pest species in concert with other management activities on refuge lands and waters to achieve wildlife and habitat management goals and objectives. IPM is also a scientifically based, adaptive management process where available scientific information and best professional judgment of the refuge staff as well as other resource experts will be used to identify and implement appropriate management strategies that can be modified and/or changed over time to ensure effective, site-specific management of pest species to achieve desired outcomes. In accordance with 43 CFR 46.145, adaptive management will be particularly relevant where long-term impacts may be uncertain and future monitoring will be needed to make adjustments in subsequent implementation decisions. After a tolerable pest population (threshold) is determined considering achievement of refuge resource objectives and the ecology of pest species, one or more methods, or combinations thereof, will be selected that are feasible, efficacious, and most protective of non-target resources, including native species (fish, wildlife, and plants), and Service personnel, Service authorized agents, volunteers, and the public. Staff time and available funding will be considered when determining feasibility/practicality of various treatments.

IPM techniques to address pests are presented as CCP strategies (refer to Sections 2.1.2 and 2.2.5 of the Sheldon Refuge CCP) in an adaptive management context to achieve refuge resource objectives. In order to satisfy requirements for IPM planning as identified in the Director's Memo (dated September 9, 2004) entitled *Integrated Pest Management Plans and Pesticide Use Proposals: Updates, Guidance, and an Online Database*, the following elements of an IPM program have been incorporated into this CCP:

- Habitat and/or wildlife objectives that identify pest species and appropriate thresholds to indicate the need for and successful implementation of IPM techniques; and
- Monitoring before and/or after treatment to assess progress toward achieving objectives including pest thresholds.

Where pesticides would be necessary to address pests, this Appendix provides a structured procedure to evaluate potential effects of proposed uses involving ground-based applications to refuge biological resources and environmental quality in accordance with effects analyses presented in Chapter 6 (Environmental Consequences) of the Sheldon Refuge Final CCP/EIS. Only pesticide uses that likely would cause minor, temporary, or localized effects to refuge biological resources and environmental quality with appropriate BMPs, where necessary, would be allowed for use on the refuge.

This Appendix does not describe the more detailed process to evaluate potential effects associated with aerial applications of pesticides. However, the basic framework to assess potential effects to refuge biological resources and environmental quality from aerial application of pesticides would be similar to the process described in this Appendix for ground-based treatments of other pesticides.

O.2 Pest Management Laws and Policies

In accordance with Service policy 569 FW 1 (Integrated Pest Management), plant, invertebrate, and vertebrate pests on units of the National Wildlife Refuge System can be controlled to ensure balanced wildlife and fish populations in support of refuge-specific wildlife and habitat management objectives. Pest control on federal (refuge) lands and waters also is authorized under the following legal mandates:

- National Wildlife Refuge System Administration Act of 1966, as amended (16 USC 668dd-668ee);
- Plant Protection Act of 2000 (7 USC 7701 *et seq*.);
- Noxious Weed Control and Eradication Act of 2004 (7 USC 7781-7786, Subtitle E);
- Federal Insecticide, Fungicide, and Rodenticide Act of 1996 (7 USC 136-136y);
- National Invasive Species Act of 1996 (16 USC 4701);
- Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (16 USC 4701);
- Food Quality Protection Act of 1996 (7 USC 136);
- Executive Order 13148, Section 601(a);
- Executive Order 13112; and
- Animal Damage Control Act of 1931 (7 USC 426-426c, 46 Stat. 1468).

Pests are defined as "…living organisms that may interfere with the site-specific purposes, operations, or management objectives or that jeopardize human health or safety" from Department policy 517 DM 1 (Integrated Pest Management Policy). Similarly, 569 FW 1 defines pests as "…invasive plants and introduced or native organisms, that may interfere with achieving our management goals and objectives on or off our lands, or that jeopardize human health or safety." 517 DM 1 also defines an invasive species as "a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health." Throughout the remainder of this CCP, the terms pest and invasive species are used interchangeably because both can prevent/impede achievement of refuge wildlife and habitat objectives and/or degrade environmental quality.

In general, control of pests (vertebrate or invertebrate) on the refuge would conserve and protect the nation's fish, wildlife, and plant resources as well as maintain environmental quality. From 569 FW 1, animal or plant species, which are considered pests, may be managed if the following criteria are met:

- Threat to human health and well being or private property, the acceptable level of damage by the pest has been exceeded, or State or local government has designated the pest as noxious;
- Detrimental to resource objectives as specified in a refuge resource management plan (e.g., comprehensive conservation plan, habitat management plan), if available; and
- Control would not conflict with attainment of resource objectives or the purposes for which the refuge was established.

The specific justifications for pest management activities on the refuge are the following:

- Protect human health and well being;
- Prevent substantial damage to important to refuge resources;
- Protect newly introduced or re-establish native species;

- Control non-native (exotic) species in order to support existence for populations of native species;
- Prevent damage to private property; and
- Provide the public with quality, compatible wildlife-dependent recreational opportunities.

In accordance with Service policy 620 FW 1 (Habitat Management Plans), there are additional management directives regarding invasive species found on the refuge:

- "We are prohibited by Executive Order, law, and policy from authorizing, funding, or carrying out actions that are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere."
- "Manage invasive species to improve or stabilize biotic communities to minimize unacceptable change to ecosystem structure and function and prevent new and expanded infestations of invasive species. Conduct refuge habitat management activities to prevent, control, or eradicate invasive species..."

Animal species damaging/destroying federal property and/or detrimental to the management program of a refuge may be controlled as described in 50 CFR 31.14 (Official Animal Control Operations)**.** For example, the incidental removal of beaver damaging refuge infrastructure (e.g., clogging with subsequent damaging of water control structures) and/or negatively affecting habitats (e.g., removing woody species from existing or restored riparian) managed on refuge lands may be conducted without a pest control proposal. We recognize beavers are native species and most of their activities or refuge lands represent a natural process beneficial for maintaining wetland habitats. Exotic nutria, whose denning and burrowing activities in wetland dikes causes cave-ins and breaches, can be controlled using the most effective techniques considering site-specific factors without a pest control proposal. Along with the loss of quality wetland habitats associated with breaching of impoundments, the safety of refuge staffs and public (e.g. auto tour routes) driving on structurally compromised levees and dikes can be threatened by sudden and unexpected cave-ins.

Trespass and feral animals also may be controlled on refuge lands. Based upon 50 CFR 28.43 (Destruction of Dogs and Cats), dogs and cats running at large on a national wildlife refuge and observed in the act of killing, injuring, harassing or molesting humans or wildlife may be disposed of in the interest of public safety and protection of the wildlife. Feral animals should be disposed by the most humane method(s) available and in accordance with relevant Service directives (including Executive Order 11643). Disposed wildlife specimens may be donated or loaned to public institutions. Donation or loans of resident wildlife species will only be made after securing State approval (50 CFR 30.11 [Donation and Loan of Wildlife Specimens]). Surplus wildlife specimens may be sold alive or butchered, dressed and processed subject to federal and state laws and regulations (50 CFR 30.12 [Sale of Wildlife Specimens]).

O.3 Strategies

To fully embrace IPM as identified in 569 FW 1, the following strategies, where applicable, would be carefully considered on the refuge for each pest species:

- **Prevention.** This would be the most effective and least expensive long-term management option for pests. It encompasses methods to prevent new introductions or the spread of the established pests to un-infested areas. It requires identifying potential routes of invasion to

reduce the likelihood of infestation. Hazard Analysis and Critical Control Points (HACCP) planning can be used to determine if current management activities on a refuge may introduce and/or spread invasive species in order to identify appropriate BMPs for prevention. See http://www.haccp-nrm.org/ for more information about HACCP planning.

Prevention may include source reduction, using pathogen-free or weed-free seeds or fill; exclusion methods (e.g., barriers) and/or sanitation methods (e.g., wash stations) to prevent re-introductions by various mechanisms including vehicles, personnel, livestock, and horses. Because invasive species are frequently the first to establish newly disturbed sites, prevention would require a reporting mechanism for early detection of new pest occurrences with quick response to eliminate any new satellite pest populations. Prevention would require consideration of the scale and scope of land management activities that may promote pest establishment within un-infested areas or promote reproduction and spread of existing populations. Along with preventing initial introduction, prevention would involve halting the spread of existing infestations to new sites (Mullin et al. 2000). The primary reason for prevention would be to keep pest-free lands or waters from becoming infested. Executive Order 11312 emphasizes the priority for prevention with respect to managing pests.

The following would be methods to prevent the introduction and/or spread of pests on refuge lands:

- Before beginning ground-disturbing activities (e.g., disking, scraping), inventory and prioritize pest infestations in project operating areas and along access routes. Refuge staff would identify pest species on-site or within reasonably expected potential invasion vicinity. Where possible, the refuge staff would begin project activities in un-infested areas before working in pest-infested areas.
- The refuge staff would locate and use pest-free project staging areas. They would avoid or minimize travel through pest-infested areas, or restrict to those periods when spread of seed or propagules of invasive plants would be least likely.
- The refuge staff would determine the need for, and when appropriate, identify sanitation sites where equipment can be cleaned of pests. Where possible, the refuge staff would clean equipment before entering lands at on-refuge approved cleaning site(s). This practice does not pertain to vehicles traveling frequently in and out of the project area that will remain on roadways. Seeds and plant parts of pest plants would need to be collected, where practical. The refuge staff would remove mud, dirt, and plant parts from project equipment before moving it into a project area.
- The refuge staff would clean all equipment, before leaving the project site, if operating in areas infested with pests. The refuge staff would determine the need for, and when appropriate, identify sanitation sites where equipment can be cleaned.
- Refuge staffs, their authorized agents, and refuge volunteers would, where possible, inspect, remove, and properly dispose of seed and parts of invasive plants found on their clothing and equipment. Proper disposal means bagging the seeds and plant parts and then properly discarding of them (e.g., incinerating).
- The refuge staff would evaluate options, including closure, to restrict the traffic on sites with on-going restoration of desired vegetation. The refuge staff would revegetate disturbed soil (except travel ways on surfaced projects) to optimize plant establishment for each specific site. Revegetation may include topsoil replacement, planting, seeding, fertilization, liming, and weed-free mulching as necessary. The refuge staff would use native material, where appropriate and feasible. The refuge

staff would use certified weed-free or weed-seed-free hay or straw where certified materials are reasonably available.

- The refuge staff would provide information, training, and appropriate pest identification materials to permit holders and recreational visitors. The refuge staff would educate them about pest identification, biology, impacts, and effective prevention measures.
- The refuge staff would require grazing permittees to utilize preventative measures for their livestock while on refuge lands.
- The refuge staff would inspect borrow material for invasive plants prior to use and transport onto and/or within refuge lands.
- The refuge staff would consider invasive plants in planning for road maintenance activities.
- The refuge staff would restrict off-road travel to designated routes.

The following would be methods to prevent the introduction and/or spread of pests into refuge waters:

- The refuge staff would inspect boats (including air boats), trailers, and other boating equipment. Where possible, the refuge staff would remove any visible plants, animals, or mud before leaving any waters or boat launching facilities. Where possible, the refuge staff would drain water from motor, live well, bilge, and transom wells while on land before leaving the site. If possible, the refuge staff would wash and dry boats, downriggers, anchors, nets, floors of boats, propellers, axles, trailers, and other boating equipment to kill pests not visible at the boat launch.
- Where feasible, the refuge staff would maintain a 100-foot buffer of aquatic pest-free clearance around boat launches and docks or quarantine areas when cleaning around culverts, canals, or irrigation sites. Where possible, the refuge staff would inspect and clean equipment before moving to new sites or one project area to another.

These prevention methods to minimize/eliminate the introduction and/or spread of pests were taken verbatim or slightly modified from Appendix E of US Forest Service (2005).

- **Mechanical/Physical Methods.** These methods would remove and destroy, disrupt the growth of, or interfere with the reproduction of pest species. For plants species, these treatments can be accomplished by hand, hand tool (manual), or power tools (mechanical) and include pulling, grubbing, digging, tilling/disking, cutting, swathing, grinding, shearing, girdling, mowing, and mulching of the pest plants.

  For animal species, Service employees or their authorized agents could use mechanical/physical methods (including trapping) to control pests as a refuge management activity. Based upon 50 CFR 31.2, trapping can be used on a refuge to reduce surplus wildlife populations for a "balanced conservation program" in accordance with federal or state laws and regulations. In some cases, non-lethally trapped animals would be relocated to off-refuge sites with prior approval from the state.

  Each of these tools would be efficacious to some degree and applicable to specific situations. In general, mechanical controls can effectively control annual and biennial pest plants. However, to control perennial plants, the root system has to be destroyed or it would resprout and continue to grow and develop. Mechanical controls are typically not capable of

destroying a perennial plant's root system. Although some mechanical tools (e.g., disking, plowing) may damage root systems, they may stimulate regrowth producing a denser plant population that may aid in the spread depending upon the target species (e.g., Canada thistle). In addition, steep terrain and soil conditions would be major factors that can limit the use of many mechanical control methods.

Some mechanical control methods (e.g., mowing), which would be used in combination with herbicides, can be a very effective technique to control perennial species. For example, mowing perennial plants followed sequentially by treating the plant regrowth with a systemic herbicide often would improve the efficacy of the herbicide compared to herbicide treatment only.

- **Cultural Methods.** These methods would involve manipulating habitat to increase pest mortality by reducing its suitability to the pest. Cultural methods would include water-level manipulation, mulching, winter cover crops, changing planting dates to minimize pest impact, prescribed burning (facilitate revegetation, increase herbicide efficacy, and remove litter to assist in emergence of desirable species), flaming with propane torches, trap crops, crop rotations that would include non-susceptible crops, moisture management, addition of beneficial insect habitat, reducing clutter, proper trash disposal, planting or seeding desirable species to shade or out-compete invasive plants, applying fertilizer to enhance desirable vegetation, prescriptive grazing, and other habitat alterations.

- **Biological Control Agents.** Classical biological control would involve the deliberate introduction and management of natural enemies (parasites, predators, or pathogens) to reduce pest populations. Many of the most ecologically or economically damaging pest species in the United States originated in foreign countries. These newly introduced pests, which are free from natural enemies found in their country or region of origin, may have a competitive advantage over cultivated and native species. This competitive advantage often allows introduced species to flourish, and they may cause widespread economic damage to crops or out compete and displace native vegetation. Once the introduced pest species population reaches a certain level, traditional methods of pest management may be cost prohibitive or impractical. Biological controls typically are used when these pest populations have become so widespread that eradication or effective control would be difficult or no longer practical.

  Biological control has advantages as well as disadvantages. Benefits would include reducing pesticide usage, host specificity for target pests, long-term self-perpetuating control, low cost/acre, capacity for searching and locating hosts, synchronizing biological control agents to hosts' life cycles, and the unlikelihood that hosts will develop resistance to agents. Disadvantages would include the following: limited availability of agents from their native lands, the dependence of control on target species density, slow rate at which control occurs, biotype matching, the difficulty and expense of conflicts over control of the target pest, and host specificity when host populations are low.

  A reduction in target species populations from biological controls is typically a slow process, and efficacy can be highly variable. It may not work well in a particular area although it does work well in other areas. Biological control agents would require specific environmental conditions to survive over time. Some of these conditions are understood; whereas, others are only partially understood or not at all.

Biological control agents would not eradicate a target pest. When using biological control agents, residual levels of the target pest typically are expected; the agent population level or survival would be dependent upon the density of its host. After the pest population decreases, the population of the biological control agent would decrease correspondingly. This is a natural cycle. Some pest populations (e.g., invasive plants) would tend to persist for several years after a biological control agent becomes established due to seed reserves in the soil, inefficiencies in the agents search behavior, and the natural lag in population buildup of the agent.

The full range of pest groups potentially found on refuge lands and waters would include diseases, invertebrates (insects, mollusks), vertebrates and invasive plants (the most common group). Often it is assumed that biological control would address many if not most of these pest problems. There are several well-documented success stories of biological control of invasive weed species in the Pacific Northwest including Mediterranean sage, St. Johnswort (Klamath weed) and tansy ragwort. Emerging success stories include Dalmatian toadflax, diffuse knapweed, leafy spurge, purple loosestrife and yellow star thistle. However, historically, each new introduction of a biological control agent in the United States has only about a 30% success rate (Coombs et al. 2004). Refer to Coombs et al. (2004) for the status of biological control agents for invasive plants in the Pacific Northwest.

Introduced species without desirable close relatives in the United States would generally be selected as biological controls. Natural enemies that are restricted to one or a few closely related plants in their country of origin are targeted as biological controls (Center et al. 1997, Hasan and Ayres 1990).

The refuge staff would ensure introduced agents are approved by the applicable authorities. Except for a small number of formulated biological control products registered by USEPA under FIFRA, most biological control agents are regulated by the US Department of Agriculture (USDA)-Animal Plant Health Inspection Service, Plant Protection and Quarantine (APHIS-PPQ). State departments of agriculture and, in some cases, county agricultural commissioners or weed districts, have additional approval authority.

Federal permits (USDA-APHIS-PPQ Form 526) are required to import biocontrols agents from another state. Form 526 may be obtained by writing:

USDA-APHIS-PPQ
Biological Assessment and Taxonomic Support
4700 River Road, Unit 113
Riverdale, MD 20737
or
through the internet at:
http://www.aphis.usda.gov/ppq/permits/bioligical/weedbio.html.
The Service strongly supports the development, and legal and responsible use of appropriate, safe, and effective biological control agents for nuisance and non-indigenous or pest species.

State and county agriculture departments may also be sources for biological control agents or they may have information about where biological control agents may be obtained. Commercial sources should have an Application and Permit to Move Live Plant Pests and

Noxious Weeds (USDA-PPQ Form 226 USDA-APHIS-PPQ, Biological Assessment and Taxonomic Support, 4700 River Road, Unit 113, Riverdale, MD 20737) to release specific biological control agents in a state and/or county. Furthermore, certification regarding the biological control agent's identity (genus, specific epithet, sub-species and variety) and purity (e.g., parasite free, pathogen free, and biotic and abiotic contaminants) should be specified in purchase orders.

Biological control agents are subject to 7 RM 8 (Exotic Species Introduction and Management). In addition, the refuge staff would follow the International Code of Best Practice for Classical Biological Control of Weeds (http://sric.ucdavis.edu/exotic/exotic.htm) as ratified by delegates to the X International Symposium on Biological Control of Weeds, Bozeman, MT, July 9, 1999. This code identifies the following:

- Release only approved biological control agents,
- Use the most effective agents,
- Document releases, and
- Monitor for impact to the target pest, non-target species and the environment.

Biological control agents formulated as pesticide products and registered by the USEPA (e.g., *Bti*) are also subject to PUP review and approval (see below).

A record of all releases would be maintained with date(s), location(s), and environmental conditions of the release site(s); the identity, quantity, and condition of the biological control agents released; and other relevant data and comments such as weather conditions. Systematic monitoring to determine the establishment and effectiveness of the release is also recommended.

NEPA documents regarding biological and other environmental effects of biological control agents prepared by another federal agency, where the scope is relevant to evaluation of releases on refuge lands, would be reviewed. Possible source agencies for such NEPA documents include the Bureau of Land Management, US Forest Service, National Park Service, US Department of Agriculture-Animal and Plant Health Inspection Service, and the military services. It might be appropriate to incorporate by reference parts or all of existing document(s) from the review. Incorporating by reference (43 CFR 46.135) is a technique used to avoid redundancies in analysis. It also can reduce the bulk of a Service NEPA document, which only must identify the documents that are incorporated by reference. In addition, relevant portions must be summarized in the Service NEPA document to the extent necessary to provide the decision maker and public with an understanding of relevance of the referenced material to the current analysis.

- **Pesticides.** The selective use of pesticides would be based upon pest ecology (including mode of reproduction), the size and distribution of its populations, site-specific conditions (e.g., soils, topography), known efficacy under similar site conditions, and the capability to utilize best management practices (BMPs) to reduce/eliminate potential effects to non-target species, sensitive habitats, and potential to contaminate surface and groundwater. All pesticide usage (pesticide, target species, application rate, and method of application) would comply with the applicable federal (FIFRA) and state regulations pertaining to pesticide use, safety, storage, disposal, and reporting. Before pesticides can be used to eradicate, control, or contain pests on refuge lands and waters, pesticide use proposals (PUPs) would be prepared

and approved in accordance with 569 FW 1. PUP records would provide a detailed, time-, site-, and target-specific description of the proposed use of pesticides on the refuge. All PUPs would be created, approved or disapproved, and stored in the Pesticide Use Proposal System (PUPS), which is a centralized database only accessible on the Service's intranet (https://systems.fws.gov/pups). Only Service employees would be authorized to access PUP records for a refuge in this database.

Application equipment would be selected to provide site-specific delivery to target pests while minimizing/eliminating direct or indirect (e.g., drift) exposure to non-target areas and degradation of surface and groundwater quality. Where possible, target-specific equipment (e.g., backpack sprayer, wiper) would be used to treat target pests. Other target-specific equipment to apply pesticides would include soaked wicks or paint brushes for wiping vegetation and lances, hatchets, or syringes for direct injection into stems. Granular pesticides may be applied using seeders or other specialized dispensers. In contrast, aerial spraying (e.g., fixed wing or helicopter) would only be used where access is difficult (remoteness) and/or the size/distribution of infestations precludes practical use of ground-based methods.

Because repeated use of one pesticide may allow resistant organisms to survive and reproduce, multiple pesticides with variable modes of action would be considered for treatments on refuge lands and waters. This is especially important if multiple applications within years and/or over a growing season likely would be necessary for habitat maintenance and restoration activities to achieve resource objectives. Integrated chemical and non-chemical controls also are highly effective, where practical, because pesticide-resistant organisms can be removed from the site.

Cost may not be the primary factor in selecting a pesticide for use on a refuge. If the least expensive pesticide would potentially harm natural resources or people, then a different product would be selected, if available. The most efficacious pesticide available with the least potential to degrade environment quality (soils, surface water, and groundwater) as well as least potential effect to native species and communities of fish, wildlife, plants, and their habitats would be acceptable for use on refuge lands in the context of an IPM approach.

- **Habitat Restoration/Maintenance.** Restoration and/or proper maintenance of refuge habitats associated with achieving wildlife and habitat objectives would be essential for long-term prevention, eradication, or control (at or below threshold levels) of pests. Promoting desirable plant communities through the manipulation of species composition, plant density, and growth rate is an essential component of invasive plant management (Masters et al. 1996, Masters and Sheley 2001, Brooks et al. 2004). The following three components of succession could be manipulated through habitat maintenance and restoration: site availability, species availability, and species performance (Cox and Anderson 2004). Although a single method (e.g., herbicide treatment) may eliminate or suppress pest species in the short term, the resulting gaps and bare soil create niches that are conducive to further invasion by the species and/or other invasive plants. On degraded sites where desirable species are absent or in low abundance, revegetation with native/desirable grasses, forbs, and legumes may be necessary to direct and accelerate plant community recovery, and achieve site-specific objectives in a reasonable time frame. The selection of appropriate species for revegetation would be dependent on a number of factors including resource objectives and site-specific, abiotic factors (e.g., soil texture, precipitation/temperature regimes, and shade

conditions). Seed availability and cost, ease of establishment, seed production, and competitive ability also would be important considerations.

O.4 Priorities for Treatments

For many refuges, the magnitude (number, distribution, and sizes of infestations) of pest problems is too extensive and beyond the available capital resources to effectively address during any single field season. To manage pests in the refuge, it would be essential to prioritize treatment of infestations. Highest priority treatments would be focused on early detection and rapid response to eliminate infestations of new pests, if possible. This would be especially important for aggressive pests potentially impacting species, species groups, communities, and/or habitats associated refuge purpose(s), NWRS resources of concern (federally listed species, migratory birds, selected marine mammals, and interjurisdictional fish), and native species for maintaining/restoring biological integrity, diversity, and environmental health.

The next priority would be treating established pests that appear in one or more previously un-infested areas. Moody and Mack (1988) demonstrated through modeling that small, new outbreaks of invasive plants eventually would infest an area larger than the established, source population. They also found that control efforts focusing on the large, main infestation rather than the new, small satellites reduced the chances of overall success. The lowest priority would be treating large infestations (sometimes monotypic stands) of well-established pests. In this case, initial efforts would focus upon containment of the perimeter followed by work to control/eradicate the established infested area. If containment and/or control of a large infestation is not effective, then efforts would focus upon halting pest reproduction or managing source populations. Maxwell et al. (2009) found treating fewer populations that are sources represents an effective long-term strategy to reduce of total number of invasive populations and decreasing meta-population growth rates.

Although state-listed noxious weeds would always of high priority for management, other pest species known to cause substantial ecological impact would also be considered. For example, cheatgrass may not be listed by a state as noxious, but it can greatly alter fire regimes in shrub steppe habitats resulting in large monotypic stands that displace native bunch grasses, forbs, and shrubs. Pest control would likely require a multi-year commitment from the refuge staff. Essential to the long-term success of pest management would be pre- and post-treatment monitoring, assessment of the successes and failures of treatments, and development of new approaches when proposed methods do not achieve desired outcomes.

O.5 Best Management Practices (BMPs)

BMPs can minimize or eliminate possible effects associated with pesticide usage to non-target species and/or sensitive habitats as well as degradation of water quality from drift, surface runoff, or leaching. Based upon the Department of Interior Pesticide Use Policy (517 DM 1) and the Service Integrated Pest Management policy (569 FW 1), the use of applicable BMPs (where feasible) also would likely ensure that pesticide uses may not adversely affect federally listed species and/or their critical habitats through determinations made using the process described in 50 CFR part 402.

The following are BMPs pertaining to mixing/handling and applying pesticides for all ground-based treatments of pesticides, which would be considered and utilized, where feasible, based upon target- and site-specific factors and time-specific environmental conditions. Although not listed below, the

most important BMP to eliminate/reduce potential impacts to non-target resources would be an IPM approach to prevent, control, eradicate, and contain pests.

O.5.1 Pesticide Handling and Mixing

- As a precaution against spilling, spray tanks would not be left unattended during filling.
- All pesticide containers would be triple rinsed and the rinsate would be used as water in the sprayer tank and applied to treatment areas.
- All pesticide spray equipment would be properly cleaned. Where possible, rinsate would be used as part of the make-up water in the sprayer tank and applied to treatment areas.
- The refuge staff would triple rinse and recycle (where feasible) pesticide containers.
- All unused pesticides would be properly discarded at a local "safe send" collection.
- Pesticides and pesticide containers would be lawfully stored, handled, and disposed of in accordance with the label and in a manner safeguarding human health, fish, and wildlife and prevent soil and water contaminant.
- The refuge staff would consider the water quality parameters (e.g., pH, hardness) that are important to ensure greatest efficacy where specified on the pesticide label.
- All pesticide spills would be addressed immediately using procedures identified in the refuge spill response plan.

O.5.2 Applying Pesticides

- Pesticide treatments would only be conducted by or under the supervision of Service personnel and non-Service applicators with the appropriate, state or BLM certification to safely and effectively conduct these activities on refuge lands and waters.
- The refuge staff would comply with all federal, state, and local pesticide use laws and regulations as well as Departmental, Service, and NWRS pesticide-related policies. For example, the refuge staff would use application equipment and apply rates for the specific pest(s) identified on the pesticide label as required under FIFRA.
- Before each treatment season and prior to mixing or applying any product for the first time each season, all applicators would review the labels, MSDSs, and Pesticide Use Proposal (PUPs) for each pesticide, determining the target pest, appropriate mix rate(s), PPE, and other requirements listed on the pesticide label.
- A 1-foot no-spray buffer from the water's edge would be used, where applicable and where it does not detrimentally influence effective control of pest species.
- Use low-impact herbicide application techniques (e.g., spot treatment, cut stump, oil basal, Thinvert system applications) rather than broadcast foliar applications (e.g., boom sprayer, other larger tank wand applications), where practical.
- Use low-volume rather than high-volume foliar applications where low-impact methods above are not feasible or practical, to maximize herbicide effectiveness and ensure correct and uniform application rates.
- Applicators would use and adjust spray equipment to apply the coarsest droplet size spectrum with optimal coverage of the target species while reducing drift.
- Applicators would use the largest droplet size that results in uniform coverage.
- Applicators would use drift reduction technologies such as low-drift nozzles, where possible.
- Where possible, spraying would occur during low (average<7 mph and preferably 3 to 5 mph) and consistent direction wind conditions with moderate temperatures (typically <85°F).

- Where possible, applicators would avoid spraying during inversion conditions (often associated with calm and very low wind conditions) that can cause large-scale herbicide drift to non-target areas.
- Equipment would be calibrated regularly to ensure that the proper rate of pesticide is applied to the target area or species.
- Spray applications would be made at the lowest height for uniform coverage of target pests to minimize/eliminate potential drift.
- If windy conditions frequently occur during afternoons, spraying (especially boom treatments) would typically be conducted during early morning hours.
- Spray applications would not be conducted on days with >30% forecast for rain within 6 hours, except for pesticides that are rapidly rain fast (e.g., glyphosate in 1 hour) to minimize/eliminate potential runoff.
- Where possible, applicators would use drift retardant adjuvants during spray applications, especially adjacent to sensitive areas.
- Where possible, applicators would use a non-toxic dye to aid in identifying target area treated as well as potential over spray or drift. A dye can also aid in detecting equipment leaks. If a leak is discovered, the application would be stopped until repairs can be made to the sprayer.
- For pesticide uses associated with cropland and facilities management, buffers, as appropriate, would be used to protect sensitive habitats, especially wetlands and other aquatic habitats.
- When drift cannot be sufficiently reduced through altering equipment set up and application techniques, buffer zones may be identified to protect sensitive areas downwind of applications. The refuge staff would only apply adjacent to sensitive areas when the wind is blowing the opposite direction.
- Applicators would utilize scouting for early detection of pests to eliminate unnecessary pesticide applications.
- The refuge staff would consider timing of application so native plants are protected (e.g., senescence) while effectively treating invasive plants.
- Rinsate from cleaning spray equipment after application would be recaptured and reused or applied to an appropriate pest plant infestation.
- Application equipment (e.g., sprayer, ATV, tractor) would be thoroughly cleaned and PPE would be removed/disposed of on-site by applicators after treatments to eliminate the potential spread of pests to un-infested areas.

O.6 Safety

O.6.1 Personal Protective Equipment

All applicators would wear the specific personal protective equipment (PPE) identified on the pesticide label. The appropriate PPE will be worn at all times during handling, mixing, and applying. PPE can include the following: disposable (e.g., Tyvek) or laundered coveralls; gloves (latex, rubber, or nitrile); rubber boots; and/or an NIOSH-approved respirator. Because exposure to concentrated product is usually greatest during mixing, extra care should be taken while preparing pesticide solutions. Persons mixing these solutions can be best protected if they wear long gloves, an apron, footwear, and a face shield.

Coveralls and other protective clothing used during an application will be laundered separately from other laundry items. Transporting, storing, handling, mixing and disposing of pesticide containers will be consistent with label requirements, USEPA and OSHA requirements, and Service policy.

If a respirator is necessary for a pesticide use, then the following requirements would be met in accordance with Service safety policy: a written Respirator Program, fit testing, physical examination (including pulmonary function and blood work for contaminants), and proper storage of the respirator.

O.6.2 Notification

The restricted entry interval (REI) is the time period required after the application at which point someone may safely enter a treated area without PPE. Refuge staff, authorized management agents of the Service, volunteers, and members of the public who could be in or near a pesticide treated area within the stated re-entry time period on the label would be notified about treatment areas. Posting would occur at any site where individuals might inadvertently become exposed to a pesticide during other activities on the refuge. Where required by the label and/or state-specific regulations, sites would also be posted on its perimeter and at other likely locations of entry. The refuge staff would also notify appropriate private property owners of an intended application, including any private individuals who have requested notification. Special efforts would be made to contact nearby individuals who are beekeepers or who have expressed chemical sensitivities.

O.6.3 Medical Surveillance

Medical surveillance may be required for Service personnel and approved volunteers who mix, apply, and/or monitor use of pesticides (see 242 FW 7 [Pesticide Users] and 242 FW 4 [Medical Surveillance]). In accordance with 242 FW 7.12A, Service personnel would be medically monitoring if one or more of the following criteria is met: exposed or may be exposed to concentrations at or above the published permissible exposure limits or threshold limit values (see 242 FW 4); use pesticides in a manner considered "frequent pesticide use"; or use pesticides in a manner that requires a respirator (see 242 FW 14 for respirator use requirements). In 242 FW 7.7A, "**Frequent Pesticide Use** means when a person applying pesticide handles, mixes, or applies pesticides, with a Health Hazard rating of 3 or higher, for 8 or more hours in any week or 16 or more hours in any 30-day period." Under some circumstances, individuals may be medically monitored who use pesticides infrequently (see Section O.7.7), experience an acute exposure (sudden, short term), or use pesticides with a health hazard ranking of 1 or 2. This decision would consider the individual's health and fitness level, the pesticide's specific health risks, and the potential risks from other pesticide-related activities. Refuge cooperators (e.g., cooperative farmers) and other authorized agents (e.g., state and county employees) would be responsible for their own medical monitoring needs and costs.

Standard examinations (at refuge expense) of appropriate refuge staff would be provided by the nearest certified occupational health and safety physician as determined by Federal Occupational Health.

O.6.4 Certification and Supervision of Pesticide Applicators

Appropriate refuge staff or approved volunteers handling, mixing, and/or applying or directly supervising others engaged in pesticide use activities would be trained and state or federally (BLM)

licensed to apply pesticides to refuge lands or waters. In accordance with 242 FW 7.18A and 569 FW 1.10B, certification is required to apply restricted use pesticides based upon USEPA regulations. For safety reasons, all individuals participating in pest management activities with general use pesticides also are encouraged to attend appropriate training or acquire pesticide applicator certification. The certification requirement would be for a commercial or private applicator depending upon the state. New staff unfamiliar with proper procedures for storing, mixing, handling, applying, and disposing of herbicides and containers would receive orientation and training before handling or using any products. Documentation of training would be kept in the files at the refuge office.

O.6.5 Record Keeping

O.6.5.1 Labels and Material Safety Data Sheets

Pesticide labels and material safety data sheets (MSDSs) would be maintained at the refuge shop and laminated copies in the mixing area. These documents also would be carried by field applicators, where possible. A written reference (e.g., note pad, chalk board, dry erase board) for each tank to be mixed would be kept in the mixing area for quick reference while mixing is in progress. In addition, approved PUPs stored in the PUPS database typically contain website links (URLs) to pesticide labels and MSDSs.

O.6.5.2 Pesticide Use Proposals (PUPs)

A PUP would be prepared for each proposed pesticide use associated with annual pest management on refuge lands and waters. A PUP would include specific information about the proposed pesticide use including the common and chemical names of the pesticide(s), target pest species, size and location of treatment site(s), application rate(s) and method(s), and federally listed species determinations, where applicable.

In accordance with Service guidelines (Director's memo [December 12, 2007]), a refuge staff may receive up to five-year approvals for Washington Office and field reviewed proposed pesticide uses based upon meeting identified criteria including an approved IPM plan, where necessary (see http://www.fws.gov/contaminants/Issues/IPM.cfm). For a refuge, an IPM plan (requirements described herein) can be completed independently or in association with a CCP or a habitat management plant (HMP) if IPM strategies and potential environmental effects are adequately addressed within appropriate NEPA documentation.

PUPs would be created, approved or disapproved, and stored as records in the Pesticide Use Proposal System (PUPS), which is centralized database on the Service's intranet (https://systems.fws.gov/pups). Only Service employees can access PUP records in this database.

O.6.5.3 Pesticide Usage

In accordance with 569 FW 1, the refuge Project Leader would be required to maintain records of all pesticides annually applied on lands or waters under refuge jurisdiction. This would encompass pesticides applied by other federal agencies, state and county governments, non-government applicators including cooperators and their pest management service providers with Service permission. For clarification, pesticide means all insecticides, insect and plant growth regulators,

desiccants, herbicides, fungicides, rodenticides, acaricides, nematicides, fumigants, avicides, and piscicides.

The following usage information can be reported for approved PUPs in the PUPS database:

- Pesticide trade name(s)
- Active ingredient(s)
- Total acres treated
- Total amount of pesticides used (lbs. or gallons)
- Total amount of active ingredient(s) used (lbs.)
- Target pest(s)
- Efficacy (% control)

To determine whether treatments are efficacious (eradicating, controlling, or containing the target pest) and achieving resource objectives, habitat and/or wildlife response would be monitored both pre- and post-treatment, where possible. Considering available annual funding and staffing, appropriate monitoring data regarding characteristics (attributes) of pest infestations (e.g., area, perimeter, degree of infestation-density, % cover, density) as well as habitat and/or wildlife response to treatments may be collected and stored in a relational database (e.g., Refuge Habitat Management Database), preferably a geo-referenced data management system (e.g., Refuge Lands GIS) to facilitate data analyses and subsequent reporting. In accordance with adaptive management, data analysis and interpretation would allow treatments to be modified or changed over time, as necessary, to achieve resource objectives considering site-specific conditions in conjunction with habitat and/or wildlife responses. Monitoring could also identify short- and long-term impacts to natural resources and environmental quality associated with IPM treatments in accordance with adaptive management principles identified in 43 CFR 46.145.

O.7 Evaluating Pesticide Use Proposals

Pesticides would only be used on refuge lands for habitat management as well as croplands/facilities maintenance after approval of a PUP. In general, proposed pesticide uses on refuge lands would only be approved where there would likely be minor, temporary, or localized effects to fish and wildlife species as well as minimal potential to degrade environmental quality. Potential effects to listed and non-listed species would be evaluated with quantitative ecological risk assessments and other screening measures. Potential effects to environmental quality would be based upon pesticide characteristics of environmental fate (water solubility, soil mobility, soil persistence, and volatilization) and other quantitative screening tools. Ecological risk assessments as well as characteristics of environmental fate and potential to degrade environmental quality for pesticides would be documented in Chemical Profiles (see Section O.7.5). These profiles would include threshold values for quantitative measures of ecological risk assessments and screening tools for environmental fate that represent minimal potential effects to species and environmental quality. In general, only pesticide uses with appropriate BMPs (see Section O.4) for habitat management and cropland/facilities maintenance on refuge lands that would potentially have minor, temporary, or localized effects on refuge biological and environmental quality (threshold values not exceeded) would be approved.

O.7.1 Overview of Ecological Risk Assessment

An ecological risk assessment process would be used to evaluate potential adverse effects to biological resources as a result of a pesticide(s) proposed for use on refuge lands. It is an established quantitative and qualitative methodology for comparing and prioritizing risks of pesticides and conveying an estimate of the potential risk for an adverse effect. This quantitative methodology provides an efficient mechanism to integrate best available scientific information regarding hazard, patterns of use (exposure), and dose-response relationships in a manner that is useful for ecological risk decision-making. It would provide an effective way to evaluate potential effects where there is missing or unavailable scientific information (data gaps) to address reasonable, foreseeable adverse effects in the field as required under 40 CFR Part 1502.22. Protocols for ecological risk assessment of pesticide uses on the refuge were developed through research and established by the US Environmental Protection Agency (2004). Assumptions for these risk assessments are presented in Section O.7.2.3.

The toxicological data used in ecological risk assessments are typically results of standardized laboratory studies provided by pesticide registrants to the USEPA to meet regulatory requirements under FIFRA. These studies assess the acute (lethality) and chronic (reproductive) effects associated with short- and long-term exposure to pesticides on representative species of birds, mammals, freshwater fish, aquatic invertebrates, and terrestrial and aquatic plants. Other effects data publicly available would also be utilized for risk assessment protocols described herein. Toxicity endpoint and environmental fate data are available from a variety of resources. Some of the more useful resources can be found in Section O.7.5.

Table O-1. Ecotoxicity Tests Used to Evaluate Potential Effects to Birds, Fish, and Mammals to Establish Toxicity Endpoints for Risk Quotient Calculations

Species Group	Exposure	Measurement Endpoint
Bird	Acute	Median Lethal Concentration (LC_{50})
	Chronic	No Observed Effect Concentration (NOEC) or No Observed Adverse Effect Concentration (NOAEC)[1]
Fish	Acute	Median Lethal Concentration (LC_{50})
	Chronic	No Observed Effect Concentration (NOEC) or No Observed Adverse Effect Concentration (NOAEC)[2]
Mammal	Acute	Oral Lethal Dose (LD_{50})
	Chronic	No Observed Effect Concentration (NOEC) or No Observed Adverse Effect Concentration (NOAEC)[3]

[1]Measurement endpoints typically include a variety of reproductive parameters (e.g., number of eggs, number of offspring, eggshell thickness, and number of cracked eggs).
[2]Measurement endpoints for early life stage/life cycle typically include embryo hatch rates, time to hatch, growth, and time to swim-up.
[3]Measurement endpoints include maternal toxicity, teratogenic effects or developmental anomalies, evidence of mutagenicity or genotoxicity, and interference with cellular mechanisms such as DNA synthesis and DNA repair.

O.7.2 Determining Ecological Risk to Fish and Wildlife

The potential for pesticides used on the refuge to cause direct adverse effects to fish and wildlife would be evaluated using USEPA's Ecological Risk Assessment Process (US Environmental Protection Agency 2004). This deterministic approach, which is based upon a two-phase process involving estimation of environmental concentrations and then characterization of risk, would be used for ecological risk assessments. This method integrates exposure estimates (estimated environmental concentration [EEC] and toxicological endpoints [e.g., LC_{50} and oral LD_{50}]) to

evaluate the potential for adverse effects to species groups (birds, mammals, and fish) representative of legal mandates for managing units of the NWRS. This integration is achieved through risk quotients (RQs) calculated by dividing the EEC by acute and chronic toxicity values selected from standardized toxicological endpoints or published effect (Table O-1).

$$RQ = EEC/Toxicological\ Endpoint$$

The level of risk associated with direct effects of pesticide use would be characterized by comparing calculated RQs to the appropriate Level of Concern (LOC) established by US Environmental Protection Agency (1998 [Table 2]). The LOC represents a quantitative threshold value for screening potential adverse effects to fish and wildlife resources associated with pesticide use. The following are four exposure-species group scenarios that would be used to characterize ecological risk to fish and wildlife on the refuge: acute-listed species, acute-nonlisted species, chronic-listed species, and chronic-nonlisted species.

Acute risk would indicate the potential for mortality associated with short-term dietary exposure to pesticides immediately after an application. For characterization of acute risks, median values from LC_{50} and LD_{50} tests would be used as toxicological endpoints for RQ calculations. In contrast, chronic risks would indicate the potential for adverse effects associated with long-term dietary exposure to pesticides from a single application or multiple applications over time (within a season and over years). For characterization of chronic risks, the no observed concentration (NOAEC) or no observed effect concentration (NOEC) for reproduction would be used as toxicological endpoints for RQ calculations. Where available, the NOAEC would be preferred over a NOEC value.

Listed species are those federally designated as threatened, endangered, or proposed in accordance with the Endangered Species Act of 1973 (16 USC 1531-1544, 87 Stat. 884, as amended-Public Law 93-205). For listed species, potential adverse effects would be assessed at the individual level because loss of individuals from a population could detrimentally impact a species. In contrast, risks to nonlisted species would consider effects at the population level. A RQ<LOC would indicate the proposed pesticide use "may affect, not likely to adversely affect" individuals (listed species) and it would not pose an unacceptable risk for adverse effects to populations (non-listed species) for each taxonomic group (Table O-2). In contrast, an RQ>LOC would indicate a "may affect, likely to adversely affect" for listed species and it would also pose unacceptable ecological risk for adverse effects to nonlisted species.

Table O-2. Presumption of Unacceptable Risk for Birds, Fish, and Mammals (US Environmental Protection Agency 1998)

Risk Presumption		Level of Concern	
		Listed Species	Non-listed Species
Acute	Birds	0.1	0.5
	Fish	0.05	0.5
	Mammals	0.1	0.5
Chronic	Birds	1.0	1.0
	Fish	1.0	1.0
	Mammals	1.0	1.0

O.7.2.1 Environmental Exposure

Following release into the environment through application, pesticides would experience several different routes of environmental fate. Pesticides which would be sprayed can move through the air

(e.g., particle or vapor drift) and may eventually end up in other parts of the environment such as non-target vegetation, soil, or water. Pesticides applied directly to the soil may be washed off the soil into nearby bodies of surface water (e.g., surface runoff) or may percolate through the soil to lower soil layers and groundwater (e.g., leaching) (Baker and Miller 1999, Pope et al. 1999, Butler et al. 1998, Ramsay et al. 1995, EXTOXNET 1993). Pesticides which would be injected into the soil may also be subject to the latter two fates. The aforementioned possibilities are by no means complete, but it does indicate movement of pesticides in the environment is very complex with transfers occurring continually among different environmental compartments. In some cases, these exchanges occur not only between areas that are close together, but it also may involve transportation of pesticides over long distances (Barry 2004, Woods 2004).

O.7.2.1.1 Terrestrial Exposure

The ECC for exposure to terrestrial wildlife would be quantified using an USEPA screening-level approach (US Environmental Protection Agency 2004). This screening-level approach is not affected by product formulation because it evaluates pesticide active ingredient(s). This approach would vary depending upon the proposed pesticide application method: spray or granular.

O.7.2.1.1.1 Terrestrial-spray Application

For spray applications, exposure would be determined using the Kanaga nomogram method (US Environmental Protection Agency 2005a, US Environmental Protection Agency 2004, Pfleeger et al. 1996) through the USEPA's Terrestrial Residue Exposure model (T-REX) version 1.2.3 (US Environmental Protection Agency 2005b). To estimate the maximum (initial) pesticide residue on short grass (<20 cm tall) as a general food item category for terrestrial vertebrate species, T-REX input variables would include the following from the pesticide label: maximum pesticide application rate (pounds active ingredient [acid equivalent]/acre) and pesticide half-life (days) in soil. Although there are other food item categories (tall grasses; broadleaf plants and small insects; and fruits, pods, seeds and large insects), short grass was selected because it would yield maximum EECs (240 ppm per lb. ai/acre) for worst-case risk assessments. Short grass is not representative of forage for carnivorous species (e.g., raptors), but it would characterize the maximum potential exposure through the diet of avian and mammalian prey items. Consequently, this approach would provide a conservative screening tool for pesticides that do not biomagnify.

For RQ calculations in T-REX, the model would require the weight of surrogate species and Mineau scaling factors (Mineau et al. 1996). Body weights of bobwhite quail and mallard are included in T-REX by default, but body weights of other organisms (Table O-3) would be entered manually. The Mineau scaling factor accounts for small-bodied bird species that may be more sensitive to pesticide exposure than would be predicted only by body weight. Mineau scaling factors would be entered manually with values ranging from 1 to 1.55 that are unique to a particular pesticide or group of pesticides. If specific information to select a scaling factor is not available, then a value of 1.15 would be used as a default. Alternatively, zero would be entered if it is known that body weight does not influence toxicity of pesticide(s) being assessed. The upper bound estimate output from the T-REX Kanaga nomogram would be used as an EEC for calculation of RQs. This approach would yield a conservative estimate of ecological risk.

Table O-3. Average Body Weight of Selected Terrestrial Wildlife Species Frequently Used in Research to Establish Toxicological Endpoints (Dunning 1984)

Species	Body Weight (kg)
Mammal (15 g)	0.015
House sparrow	0.0277
Mammal (35 g)	0.035
Starling	0.0823
Red-winged blackbird	0.0526
Common grackle	0.114
Japanese quail	0.178
Bobwhite quail	0.178
Rat	0.200
Rock dove (aka pigeon)	0.542
Mammal (1000 g)	1.000
Mallard	1.082
Ring-necked pheasant	1.135

O.7.2.1.1.2 Terrestrial – Granular Application

Granular pesticide formulations and pesticide-treated seed would pose a unique route of exposure for avian and mammalian species. The pesticide is applied in discrete units which birds or mammals might ingest accidentally with food items or intentionally as in the case of some bird species actively seeking and picking up gravel or grit to aid digestion or seed as a food source. Granules may also be consumed by wildlife foraging on earthworms, slugs or other soft-bodied soil organisms to which the granules may adhere.

Terrestrial wildlife RQs for granular formulations or seed treatments would be calculated by dividing the maximum milligrams of active ingredient (a.i.) exposed (e.g., EEC) on the surface of an area equal to 1 square foot by the appropriate LD_{50} value multiplied by the surrogate's body weight (Table 3). An adjustment to surface area calculations would be made for broadcast, banded, and in-furrow applications. An adjustment also would be made for applications with and without incorporation of the granules. Without incorporation, it would be assumed that 100% of the granules remain on the soil surface available to foraging birds and mammals. Press wheels push granules flat with the soil surface, but they are not incorporated into the soil. If granules are incorporated in the soil during band or T-band applications or after broadcast applications, it would be assumed only 15% of the applied granules remain available to wildlife. It would be assumed that only 1% of the granules are available on the soil surface following in-furrow applications.

EECs for pesticides applied in granular form and as seed treatments would be determined considering potential ingestion rates of avian or mammalian species (e.g., 10-30% body weight/day). This would provide an estimate of maximum exposure that may occur as a result of granule or seed treatment spills such as those that commonly occur at end rows during application and planting. The availability of granules and seed treatments to terrestrial vertebrates would also be considered by calculating the loading per unit area (LD_{50}/ft^2) for comparison to USEPA Level of Concerns (US Environmental Protection Agency 1998). The

T-REX version 1.2.3 (US Environmental Protection Agency 2005b) contains a submodel which automates Kanaga exposure calculations for granular pesticides and treated seed.

The following formulas will be used to calculate EECs depending upon the type of granular pesticide application:

- In-furrow applications assume a typical value of 1% granules, bait, or seed remain unincorporated.

$$mg\ a.i./ft.^2 = [(lbs.\ product/acre)(\%\ a.i.)(453{,}580\ mg/lbs)(1\%\ exposed))] / \{[(43{,}560\ ft.^2/acre)/(row\ spacing\ (ft.))] / (row\ spacing\ (ft.)\}$$

or

$$mg\ a.i./ft^2 = [(lbs\ product/1{,}000\ ft.\ row)(\%\ a.i.)(1{,}000\ ft\ row)(453{,}580\ mg/lb.)(1\%\ exposed)$$

$$EEC = [(mg\ a.i./ft.^2)(\%\ of\ pesticide\ biologically\ available)]$$

- Incorporated banded treatments assume that 15% of granules, bait, and seeds are unincorporated.

$$mg\ a.i./ft.^2 = [(lbs.\ product/1{,}000\ row\ ft.)(\%\ a.i.)(453{,}580\ mg/lb.)(1-\%\ incorporated)] / (1{,}000\ ft.)(band\ width\ (ft.))$$

$$EEC = [(mg\ a.i./ft.^2)(\%\ of\ pesticide\ biologically\ available)]$$

- Broadcast treatment without incorporation assumes 100% of granules, bait, seeds are unincorporated.

$$mg\ a.i./ft.^2 = [(lbs.\ product/acre)(\%\ a.i.)(453{,}590\ mg/lb.)] / (43{,}560\ ft.^2/acre)$$

$$EEC = [(mg\ a.i./ft.^2)(\%\ of\ pesticide\ biologically\ available)]$$

Where:

- % of pesticide biologically available = 100% without species specific ingestion rates
- Conversion for calculating mg a.i./ft.^{2} using ounces: 453,580 mg/lb. /16 = 28,349 mg/oz.

The following equation would be used to calculate an RQ based on the EEC calculated by one of the above equations. The EEC would be divided by the surrogate LD_{50} toxicological endpoint multiplied by the body weight (Table O-3) of the surrogate.

$$RQ = EEC / [LD_{50}\ (mg/kg)\ *\ body\ weight\ (kg)]$$

As with other risk assessments, an RQ>LOC would be a presumption of unacceptable ecological risk. An RQ<LOC would be a presumption of acceptable risk with only minor, temporary, or localized effects to species.

O.7.2.1.2 Aquatic Exposure

Exposures to aquatic habitats (e.g., wetlands, meadows, ephemeral pools, water delivery ditches) would be evaluated separately for ground-based pesticide treatments of habitats managed for fish and wildlife compared with cropland/facilities maintenance. The primary exposure pathway for aquatic organisms from any ground-based treatments likely would be particle drift during the pesticide

application. However, different exposure scenarios would be necessary as a result of contrasting application equipment and techniques as well as pesticides used to control pests on agricultural lands (especially those cultivated by cooperative farmers for economic return from crop yields) and facilities maintenance (e.g., roadsides, parking lots, trails) compared with other managed habitats on the refuge. In addition, pesticide applications may be done <25 feet of the high water mark of aquatic habitats for habitat management treatments; whereas, no-spray buffers (≥25 feet) would be used for croplands/facilities maintenance treatments.

O.7.2.1.2.1 Habitat Treatments

For the worst-case exposure scenario to non-target aquatic habitats, EECs (Table O-4) would be would be derived from Urban and Cook (1986) that assumes an intentional overspray to an entire, non-target water body (1-foot depth) from a treatment <25 feet from the high water mark using the max application rate (acid basis [see above]). However, use of BMPs for applying pesticides (see Section O.4.2) would likely minimize/eliminate potential drift to non-target aquatic habitats during actual treatments. If there would be unacceptable (acute or chronic) risk to fish and wildlife with the simulated 100% overspray (RQ>LOC), then the proposed pesticide use may be disapproved or the PUP would be approved at a lower application rate to minimize/eliminate unacceptable risk to aquatic organisms (RQ=LOC).

Table O-4. Estimated Environmental Concentrations (ppb) of Pesticides in Aquatic Habitats (1 foot depth) Immediately After Direct Application (Urban and Cook 1986)

Lbs/acre	EEC (ppb)
0.10	36.7
0.20	73.5
0.25	91.9
0.30	110.2
0.40	147.0
0.50	183.7
0.75	275.6
1.00	367.5
1.25	459.7
1.50	551.6
1.75	643.5
2.00	735.7
2.25	827.6
2.50	919.4
3.00	1103.5
4.00	1471.4
5.00	1839
6.00	2207
7.00	2575
8.00	2943
9.00	3311
10.00	3678

O.7.2.1.2.2 Cropland/Facilities Maintenance Treatments

Field drift studies conducted by the Spray Drift Task Force, which is a joint project of several agricultural chemical businesses, were used to develop a generic spray drift database. From this database, the AgDRIFT computer model was created to satisfy USEPA pesticide registration spray

drift data requirements and as a scientific basis to evaluate off-target movement of pesticides from particle drift and assess potential effects of exposure to wildlife. Several versions of the computer model have been developed (i.e., v2.01 through v2.10). The Spray Drift Task Force AgDRIFT® model version 2.01 (SDTF 2003, AgDRIFT 2001) would be used to derive EECs resulting from drift of pesticides to refuge aquatic resources from ground-based pesticide applications >25 feet from the high water mark. The Spray Drift Task Force AgDRIFT model is publicly available at http://www.agdrift.com. At this website, click "AgDRIFT 2.0" and then click "Download Now" and follow the instructions to obtain the computer model.

The AgDRIFT model is composed of submodels called tiers. Tier I Ground submodel would be used to assess ground-based applications of pesticides. Tier outputs (EECs) would be calculated with AgDRIFT using the following input variables: max application rate (acid basis [see above]), low boom (20 inches), fine to medium droplet size, EPA-defined wetland, and a ≥25-foot distance (buffer) from treated area to water.

O.7.2.2 Use of Information on Effects of Biological Control Agents, Pesticides, Degradates, and Adjuvants

NEPA documents regarding biological and other environmental effects of biological control agents, pesticides, degradates, and adjuvants prepared by another federal agency, where the scope would be relevant to evaluation of effects from pesticide uses on refuge lands, would be reviewed. Possible source agencies for such NEPA documents would include the Bureau of Land Management, US Forest Service, National Park Service, US Department of Agriculture-Animal and Plant Health Inspection Service, and the military services. It might be appropriate to incorporate by reference parts or all of existing document(s). Incorporating by reference (40 CFR 1502.21) is a technique used to avoid redundancies in analysis. It also would reduce the bulk of a Service NEPA document, which only would identify the documents that are incorporated by reference. In addition, relevant portions would be summarized in the Service NEPA document to the extent necessary to provide the decision maker and public with an understanding of relevance of the referenced material to the current analysis.

In accordance with the requirements set forth in 43 CFR 46.135, the Service would specifically incorporate through reference ecological risk assessments prepared by the US Forest Service (http://www.fs.fed.us/r6/invasiveplant-eis/Risk-Assessments/Herbicides-Analyzed-InvPlant-EIS.htm) and Bureau of Land Management (http://www.blm.gov/wo/st/en/prog/more/veg_eis.html). These risk assessments and associated documentation also are available in total with the administrative record for the Final Environmental Impact Statement entitled *Pacific Northwest Region Invasive Plant Program – Preventing and Managing Invasive Plants* (US Forest Service 2005) and *Vegetation Treatments Using Herbicides on Bureau of Land Management Lands in 17 Western States Programmatic EIS (PEIS)* (Bureau of Land Management 2007). In accordance with 43 CFR 46.120(d), use of existing NEPA documents by supplementing, tiering to, incorporating by reference, or adopting previous NEPA environmental analyses would avoid redundancy and unnecessary paperwork.

As a basis for completing "Chemical Profiles" for approving or disapproving refuge PUPs, ecological risk assessments for the following herbicide and adjuvant uses prepared by the US Forest Service would be incorporated by reference:

- 2,4-D

- Chlorsulfuron
- Clopyralid
- Dicamba
- Glyphosate
- Imazapic
- Imazapyr
- Metsulfuron methyl
- Picloram
- Sethoxydim
- Sulfometuron methyl
- Triclopyr
- Nonylphenol polyethylate (NPE) based surfactants

As a basis for completing "Chemical Profiles" for approving or disapproving refuge PUPs, ecological risk assessments for the following herbicide uses as well as evaluation of risks associated with pesticide degradates and adjuvants prepared by the Bureau of Land Management would be incorporated by reference:

- Bromacil
- Chlorsulfuron
- Diflufenzopyr
- Diquat
- Diuron
- Fluridone
- Imazapic
- Overdrive (diflufenzopyr and dicamba)
- Sulfometuron methyl
- Tebuthiuron
- Pesticide degradates and adjuvants (Appendix D – Evaluation of risks from degradates, polyoxyethylene-amine (POEA) and R-11, and endocrine disrupting chemicals)

O.7.2.3 Assumptions for Ecological Risk Assessments

There are a number of assumptions involved with the ecological risk assessment process for terrestrial and aquatic organisms associated with utilization of the US Environmental Protection Agency's (2004) process. These assumptions may be risk neutral or may lead to an over- or under-estimation of risk from pesticide exposure depending upon site-specific conditions. The following describes these assumptions, their application to the conditions typically encountered, and whether or not they may lead to recommendations that are risk neutral, underestimate, or overestimate ecological risk from potential pesticide exposure.

- Indirect effects would not be evaluated by ecological risk assessments. These effects include the mechanisms of indirect exposure to pesticides: consuming prey items (fish, birds, or small mammals), reductions in the availability of prey items, and disturbance associated with pesticide application activities.

- Exposure to a pesticide product can be assessed based upon the active ingredient. However, exposure to a chemical mixture (pesticide formulation) may result in effects that are similar or substantially different compared to only the active ingredient. Non-target organisms may be exposed directly to the pesticide formulation or only various constituents of the formulation as they dissipate and partition in the environment. If toxicological information for both the active ingredient and formulated product are available, then data representing the greatest potential toxicity would be selected for use in the risk assessment process (US Environmental Protection Agency 2004). As a result, this conservative approach may lead to an overestimation of risk characterization from pesticide exposure.
- Because toxicity tests with listed or candidate species or closely related species are not available, data for surrogate species would be most often used for risk assessments. Specifically, bobwhite quail and mallard duck are the most frequently used surrogates for evaluating potential toxicity to federally listed avian species. Bluegill sunfish, rainbow trout, and fathead minnow are the most common surrogates for evaluating toxicity for freshwater fishes. However, sheep's head minnow can be an appropriate surrogate marine species for coastal environments. Rats and mice are the most common surrogates for evaluating toxicity for mammals. Interspecies sensitivity is a major source of uncertainty in pesticide assessments. As a result of this uncertainty, data are selected for the most sensitive species tested within a taxonomic group (birds, fish, and mammals) given the quality of the data is acceptable. If additional toxicity data for more species of organisms in a particular group are available, the selected data will not be limited to the species previously listed as common surrogates.
- The Kanaga nomogram outputs maximum EEC values that may be used to calculate an average daily concentration over a specified interval of time, which is referred to as a time-weighted-average (TWA). The maximum EEC would be selected as the exposure input for both acute and chronic risk assessments in the screening-level evaluations. The initial or maximum EEC derived from the Kanaga nomogram represents the maximum expected instantaneous or acute exposure to a pesticide. Acute toxicity endpoints are determined using a single exposure to a known pesticide concentration typically for 48 to 96 hours. This value is assumed to represent ecological risk from acute exposure to a pesticide. On the other hand, chronic risk to pesticide exposure is a function of pesticide concentration and duration of exposure to the pesticide. An organism's response to chronic pesticide exposure may result from either the concentration of the pesticide, length of exposure, or some combination of both factors. Standardized tests for chronic toxicity typically involve exposing an organism to several different pesticide concentrations for a specified length of time (days, weeks, months, years or generations). For example, avian reproduction tests include a 10-week exposure phase. Because a single length of time is used in the test, time response data are usually not available for inclusion into risk assessments. Without time response data it is difficult to determine the concentration which elicited a toxicological response.
- Using maximum EECs for chronic risk estimates may result in an overestimate of risk, particularly for compounds that dissipate rapidly. Conversely, using TWAs for chronic risk estimates may underestimate risk if it is the concentration rather than the duration of exposure that is primarily responsible for the observed adverse effect. The maximum EEC would be used for chronic risk assessments although it may result in an overestimate of risk. TWAs may be used for chronic risk assessments, but they will be applied judiciously considering the potential for an underestimate or overestimate of risk. For example, the number of days exposure exceeds a Level of Concern may influence the suitability of a pesticide use. The greater the number of days the EEC exceeds the Level of Concern

translates into greater the ecological risk. This is a qualitative assessment, and is subject to reviewer's expertise in ecological risk assessment and tolerance for risk.

- The length of time used to calculate the TWA can have a substantial effect on the exposure estimates and there is no standard method for determining the appropriate duration for this estimate. The T-REX model assumes a 21-week exposure period, which is equivalent to avian reproductive studies designed to establish a steady-state concentration for bioaccumulative compounds. However, this does not necessarily define the true exposure duration needed to elicit a toxicological response. Pesticides, which do not bioaccumulate, may achieve a steady-state concentration earlier than 21 weeks. The duration of time for calculating TWAs will require justification and it will not exceed the duration of exposure in the chronic toxicity test (approximately 70 days for the standard avian reproduction study). An alternative to using the duration of the chronic toxicity study is to base the TWA on the application interval. In this case, increasing the application interval would suppress both the estimated peak pesticide concentration and the TWA. Another alternative to using TWAs would be to consider the number of days that a chemical is predicted to exceed the LOC.
- Pesticide dissipation is assumed to be first-order in the absence of data suggesting alternative dissipation patterns such as bi-phasic. Field dissipation data would generally be the most pertinent for assessing exposure in terrestrial species that forage on vegetation. However, these data are often not available and it can be misleading particularly if the compound is prone to "wash-off". Soil half-life is the most common degradation data available. Dissipation or degradation data that would reflect the environmental conditions typical of refuge lands would be utilized, if available.
- For species found in the water column, it would be assumed that the greatest bioavailable fraction of the pesticide active ingredient in surface waters is freely dissolved in the water column.
- Actual habitat requirements of any particular terrestrial species are not considered, and it is assumed that species exclusively and permanently occupy the treated area, or adjacent areas receiving pesticide at rates commensurate with the treatment rate. This assumption would produce a maximum estimate of exposure for risk characterization. This assumption would likely lead to an overestimation of exposure for species that do not permanently and exclusively occupy the treated area (US Environmental Protection Agency 2004).
- Exposure through incidental ingestion of pesticide contaminated soil is not considered in the USEPA risk assessment protocols. Research suggests <15% of the diet can consist of incidentally ingested soil depending upon species and feeding strategy (Beyer et al. 1994). An assessment of pesticide concentrations in soil compared to food item categories in the Kanaga nomogram indicates incidental soil ingestion will not likely increase dietary exposure to pesticides. Inclusion of soil into the diet would effectively reduce the overall dietary concentration compared to the present assumption that the entire diet consists of a contaminated food source (Fletcher et al. 1994). An exception to this may be soil-applied pesticides in which exposure from incidental ingestion of soil may increase. Potential for pesticide exposure under this assumption may be underestimated for soil-applied pesticides and overestimated for foliar-applied pesticides. The concentration of a pesticide in soil would likely be less than predicted on food items.
- Exposure through inhalation of pesticides is not considered in the USEPA risk assessment protocols. Such exposure may occur through three potential sources: spray material in droplet form at time of application, vapor phase with the pesticide volatilizing from treated surfaces, and airborne particulates (soil, vegetative matter, and pesticide dusts). The USEPA (1990) reported exposure from inhaling spray droplets at the time of application is not an

appreciable route of exposure for birds. According to research on mallards and bobwhite quail, respirable particle size (particles reaching the lung) in birds is limited to maximum diameter of 2 to 5 microns. The spray droplet spectra covering the majority of pesticide application scenarios indicate that less than 1% of the applied material is within the respirable particle size. This route of exposure is further limited because the permissible spray drop size distribution for ground pesticide applications is restricted to ASAE medium or coarser drop size distribution.

- Inhalation of a pesticide in the vapor phase may be another source of exposure for some pesticides under certain conditions. This mechanism of exposure to pesticides occurs post application, and it would pertain to those pesticides with a high vapor pressure. The USEPA is currently evaluating protocols for modeling inhalation exposure from pesticides including near-field and near-ground air concentrations based upon equilibrium and kinetics-based models. Risk characterization for exposure with this mechanism is unavailable.
- The effect from exposure to dusts contaminated with the pesticide cannot be assessed generically as partitioning issues related to application site soils and chemical properties of the applied pesticides render the exposure potential from this route highly situation specific.
- Dermal exposure may occur through three potential sources: direct application of spray to terrestrial wildlife in the treated area or within the drift footprint, incidental contact with contaminated vegetation, or contact with contaminated water or soil. Interception of spray and incidental contact with treated substrates may pose risk to avian wildlife (Driver et al. 1991). However, available research related to wildlife dermal contact with pesticides is extremely limited, except dermal toxicity values are common for some mammals used as human surrogates (rats and mice). The USEPA is currently evaluating protocols for modeling dermal exposure. Risk characterization may be underestimated for this route of exposure, particularly with high risk pesticides such as some organophosphates or carbamate insecticides. If protocols are established by the USEPA for assessing dermal exposure to pesticides, they will be considered for incorporation into pesticide assessment protocols.
- Exposure to a pesticide may occur from consuming surface water, dew or other water on treated surfaces. Water soluble pesticides have the potential to dissolve in surface runoff and puddles in a treated area may contain pesticide residues. Similarly, pesticides with lower organic carbon partitioning characteristics and higher solubility in water have a greater potential to dissolve in dew and other water associated with plant surfaces. Estimating the extent to which such pesticide loadings to drinking water occurs is complex and would depend upon the partitioning characteristics of the active ingredient, soils types in the treatment area, and the meteorology of the treatment area. In addition, the use of various water sources by wildlife is highly species-specific. Currently, risk characterization for this exposure mechanism is not available. The USEPA is actively developing protocols to quantify drinking water exposures from puddles and dew. If and when protocols are formally established by the USEPA for assessing exposure to pesticides through drinking water, these protocols will be incorporated into pesticide risk assessment protocols.
- Risk assessments are based upon the assumption that the entire treatment area would be subject to pesticide application at the rates specified on the label. In most cases, there is potential for uneven application of pesticides through such plausible incidents such as changes in calibration of application equipment, spillage, and localized releases at specific areas in or near the treated field that are associated with mixing and handling and application equipment as well as applicator skill. Inappropriate use of pesticides and the occurrence of spills represent a potential underestimate of risk. It is likely not an important factor for risk characterization. All pesticide applicators are required to be certified by the state in which

they apply pesticides. Certification training includes the safe storage, transport, handling, and mixing of pesticides; equipment calibration; and proper application with annual continuing education.

- The USEPA relies on Fletcher (1994) for setting the assumed pesticide residues in wildlife dietary items. The USEPA (2004) "believes that these residue assumptions reflect a realistic upper-bound residue estimate, although the degree to which this assumption reflects a specific percentile estimate is difficult to quantify". Fletcher's (1994) research suggests that the pesticide active ingredient residue assumptions used by the USEPA represent a 95th percentile estimate. However, research conducted by Pfleeger et al. (1996) indicates USEPA residue assumptions for short grass was not exceeded. Baehr and Habig (2000) compared USEPA residue assumptions with distributions of measured pesticide residues for the USEPA's UTAB database. Overall residue selection level will tend to overestimate risk characterization. This is particularly evident when wildlife individuals are likely to have selected a variety of food items acquired from multiple locations. Some food items may be contaminated with pesticide residues whereas others are not contaminated. However, it is important to recognize differences in species feeding behavior. Some species may consume whole above-ground plant material, but others will preferentially select different plant structures. Also, species may preferentially select a food item although multiple food items may be present. Without species specific knowledge regarding foraging behavior characterizing ecological risk other than in general terms is not possible.
- Acute and chronic risk assessments rely on comparisons of wildlife dietary residues with LC_{50} or NOEC values expressed as concentrations of pesticides in laboratory feed. These comparisons assume that ingestion of food items in the field occurs at rates commensurate with those in the laboratory. Although the screening assessment process adjusts dry-weight estimates of food intake to reflect the increased mass in fresh-weight wildlife food intake estimates, it does not allow for gross energy and assimilative efficiency differences between wildlife food items and laboratory feed. Differences in assimilative efficiency between laboratory and wild diets suggest that current screening assessment methods are not accounting for a potentially important aspect of food requirements.
- There are several other assumptions that can affect non-target species not considered in the risk assessment process. These include possible additive or synergistic effects from applying two or more pesticides or additives in a single application, co-location of pesticides in the environment, cumulative effects from pesticides with the same mode of action, effects of multiple stressors (e.g., combination of pesticide exposure, adverse abiotic and biotic factors) and behavioral changes induced by exposure to a pesticide. These factors may exist at some level contributing to adverse effects to non-target species, but they are usually characterized in the published literature in only a general manner limiting their value in the risk assessment process.
- It is assumed that aquatic species exclusively and permanently occupy the water body being assessed. Actual habitat requirements of aquatic species are not considered. With the possible exception of scenarios where pesticides are directly applied to water, it is assumed that no habitat use considerations specific for any species would place the organisms in closer proximity to pesticide use sites. This assumption produces a maximum estimate of exposure or risk characterization. It would likely be realistic for many aquatic species that may be found in aquatic habitats within or in close proximity to treated terrestrial habitats. However, the spatial distribution of wildlife is usually not random because wildlife distributions are often related to habitat requirements of species. Clumped distributions of wildlife may result

in an under- or over-estimation of risk depending upon where the initial pesticide concentration occurs relative to the species or species habitat.

- For species found in the water column, it would be assumed that the greatest bioavailable fraction of the pesticide active ingredient in surface waters is freely dissolved in the water column. Additional chemical exposure from materials associated with suspended solids or food items is not considered because partitioning onto sediments likely is minimal. Adsorption and bioconcentration occurs at lower levels for many newer pesticides compared with older more persistent bioaccumulative compounds. Pesticides with RQs close to the listed species level of concern, the potential for additional exposure from these routes may be a limitation of risk assessments, where potential pesticide exposure or risk may be underestimated.
- Mass transport losses of pesticide from a water body (except for losses by volatilization, degradation and sediment partitioning) would not be considered for ecological risk assessment. The water body would be assumed to capture all pesticide active ingredients entering as runoff, drift, and adsorbed to eroded soil particles. It would also be assumed that pesticide active ingredient is not lost from the water body by overtopping or flow-through, nor is concentration reduced by dilution. In total, these assumptions would lead to a near maximum possible water-borne concentration. However, this assumption would not account for the potential to concentrate pesticide through the evaporative loss. This limitation may have the greatest impact on water bodies with high surface-to-volume ratios such as ephemeral wetlands, where evaporative losses are accentuated and applied pesticides have low rates of degradation and volatilization.
- For acute risk assessments, there would be no averaging time for exposure. An instantaneous peak concentration would be assumed, where instantaneous exposure is sufficient in duration to elicit acute effects comparable to those observed over more protracted exposure periods (typically 48 to 96 hours) tested in the laboratory. In the absence of data regarding time-to-toxic event, analyses and latent responses to instantaneous exposure, risk would likely be overestimated.
- For chronic exposure risk assessments, the averaging times considered for exposure are commensurate with the duration of invertebrate life-cycle or fish-early life stage tests (e.g., 21-28 days and 56-60 days, respectively). Response profiles (time to effect and latency of effect) to pesticides likely vary widely with mode of action and species and should be evaluated on a case-by-case basis as available data allow. Nevertheless, because the USEPA relies on chronic exposure toxicity endpoints based on a finding of no observed effect, the potential for any latent toxicity effects or averaging time assumptions to alter the results of an acceptable chronic risk assessment prediction is limited. The extent to which duration of exposure from water-borne concentrations overestimate or underestimate actual exposure depends on several factors. These include the following: localized meteorological conditions, runoff characteristics of the watershed (e.g., soils, topography), the hydrological characteristics of receiving waters, environmental fate of the pesticide active ingredient, and the method of pesticide application. It should also be understood that chronic effects studies are performed using a method that holds water concentration in a steady state. This method is not likely to reflect conditions associated with pesticide runoff. Pesticide concentrations in the field increase and decrease in surface water on a cycle influenced by rainfall, pesticide use patterns, and degradation rates. As a result of the dependency of this assumption on several undefined variables, risk associated with chronic exposure may in some situations underestimate risk and overestimate risk in others.

- There are several other factors that can affect non-target species not considered in the risk assessment process. These would include the following: possible additive or synergistic effects from applying two or more pesticides or additives in a single application, co-location of pesticides in the environment, cumulative effects from pesticides with the same mode of action, effects of multiple stressors (e.g., combination of pesticide exposure, adverse abiotic [not pesticides] and biotic factors), and sub-lethal effects such as behavioral changes induced by exposure to a pesticide. These factors may exist at some level contributing to adverse effects to non-target species, but they are not routinely assessed by regulatory agencies. Therefore, information on the factors is not extensive limiting their value for the risk assessment process. As this type of information becomes available, it would be included, either quantitatively or qualitatively, in this risk assessment process.
- USEPA is required by the Food Quality Protection Act to assess the cumulative risks of pesticides that share common mechanisms of toxicity, or act the same within an organism. Currently, USEPA has identified four groups of pesticides that have a common mechanism of toxicity requiring cumulative risk assessments. These four groups are: the organophosphate insecticides, N-methyl carbamate insecticides, triazine herbicides, and chloroacetanilide herbicides.

O.7.3 Pesticide Mixtures and Degradates

Pesticide products are usually a formulation of several components generally categorized as active ingredients and inert or other ingredients. The term active ingredient is defined by the FIFRA as preventing, destroying, repelling, or mitigating the effects of a pest, or it is a plant regulator, defoliant, desiccant, or nitrogen stabilizer. In accordance with FIFRA, the active ingredient(s) must be identified by name(s) on the pesticide label along with its relative composition expressed in percentage(s) by weight. In contrast, inert ingredient(s) are not intended to affect a target pest. Their role in the pesticide formulation is to act as a solvent (keep the active ingredient is a liquid phase), an emulsifying or suspending agent (keep the active ingredient from separating out of solution), or a carrier (such as clay in which the active ingredient is impregnated on the clay particle in dry formulations). For example, if isopropyl alcohol would be used as a solvent in a pesticide formulation, then it would be considered an inert ingredient. FIFRA only requires that inert ingredients identified as hazardous and associated percent composition, and the total percentage of all inert ingredients must be declared on a product label. Inert ingredients that are not classified as hazardous are not required to be identified.

The USEPA (September 1997) issued Pesticide Regulation Notice 97-6, which encouraged manufacturers, formulators, producers, and registrants of pesticide products to voluntarily substitute the term “other ingredients” for “inert ingredients” in the ingredient statement. This change recognized that all components in a pesticide formulation potentially could elicit or contribute to an adverse effect on non-target organisms and, therefore, are not necessarily inert. Whether referred to as “inerts” or “other ingredients,” these constituents within a pesticide product have the potential to affect species or environmental quality. The USEPA categorizes regulated inert ingredients into the following four lists (http://www.epa.gov/opprd001/inerts/index.html):

- List 1 – Inert Ingredients of Toxicological Concern
- List 2 – Potentially Toxic Inert Ingredients
- List 3 – Inerts of Unknown Toxicity
- List 4 – Inerts of Minimal Toxicity

Several of the List 4 compounds are naturally-occurring earthen materials (e.g., clay materials, simple salts) that would not elicit toxicological response at applied concentrations. However, some of the inerts (particularly the List 3 compounds and unlisted compounds) may have moderate to high potential toxicity to aquatic species based on MSDSs or published data.

Comprehensively assessing potential effects to non-target fish, wildlife, plants, and/or their habitats from pesticide use is a complex task. It would be preferable to assess the cumulative effects from exposure to the active ingredient, its degradates, and inert ingredients as well as other active ingredients in the spray mixture. However, it would only be feasible to conduct deterministic risk assessments for each component in the spray mixture singly. Limited scientific information is available regarding ecological effects (additive or synergistic) from chemical mixtures that typically rely upon broadly encompassing assumptions. For example, the US Forest Service (2005) found that mixtures of pesticides used in land (forest) management likely would not cause additive or synergistic effects to non-target species based upon a review of scientific literature regarding toxicological effects and interactions of agricultural chemicals (ATSDR 2004). Moreover, information on inert ingredients, adjuvants, and degradates is often limited by the availability of and access to reliable toxicological data for these constituents.

Toxicological information regarding "other ingredients" may be available from sources such as the following:

- TOMES (a proprietary toxicological database including USEPA's IRIS, the Hazardous Substance Data Bank, the Registry of Toxic Effects of Chemical Substances [RTECS]).
- USEPA's ECOTOX database, which includes AQUIRE (a database containing scientific papers published on the toxic effects of chemicals to aquatic organisms).
- TOXLINE (a literature searching tool).
- Material Safety Data Sheets (MSDSs) from pesticide suppliers.
- Other sources such as the Farm Chemicals Handbook.

Because there is a lack of specific inert toxicological data, inert(s) in a pesticide may cause adverse ecological effects. However, inert ingredients typically represent only a small percentage of the pesticide spray mixture, and it would be assumed that negligible effects would be expected to result from inert ingredient(s).

Although the potential effects of degradates should be considered when selecting a pesticide, it is beyond the scope of this assessment process to consider all possible breakdown chemicals of the various product formulations containing an active ingredient. Degradates may be more or less mobile and more or less hazardous in the environment than their parent pesticides (Battaglin et al. 2003). Differences in environmental behavior (e.g., mobility) and toxicity between parent pesticides and degradates would make assessing potential degradate effects extremely difficult. For example, a less toxic and more mobile, bioaccumulative, or persistent degradate may have potentially greater effects on species and/or degrade environmental quality. The lack of data on the toxicity of degradates for many pesticides would represent a source of uncertainty for assessing risk.

A USEPA-approved label specifies whether a product can be mixed with one or more pesticides. Without product-specific toxicological data, it would not possible to quantify the potential effects of these mixtures. In addition, a quantitative analysis could only be conducted if reliable scientific information allowed a determination of whether the joint action of a mixture would be additive, synergistic, or antagonistic. Such information would not likely exist unless the mode of action would

be common among the chemicals and receptors. Moreover, the composition of and exposure to mixtures would be highly site- and/or time-specific and, therefore, it would be nearly impossible to assess potential effects to species and environmental quality.

To minimize or eliminate potential negative effects associated with applying two or more pesticides as a mixture, the use would be conducted in accordance with the labeling requirements. Labels for two or more pesticides applied as a mixture should be completely reviewed, where products with the least potential for negative effects would be selected for use on the refuge. This is especially relevant when a mixture would be applied in a manner that may already have the potential for an effect(s) associated with an individual pesticide (e.g., runoff to ponds in sandy watersheds). Use of a tank mix under these conditions would increase the level of uncertainty in terms of risk to species or potential to degrade environmental quality.

Adjuvants generally function to enhance or prolong the activity of pesticide. For terrestrial herbicides, adjuvants aid in the absorption into plant tissue. Adjuvant is a broad term that generally applies to surfactants, selected oils, anti-foaming agents, buffering compounds, drift control agents, compatibility agents, stickers, and spreaders. Adjuvants are not under the same registration requirements as pesticides and the USEPA does not register or approve the labeling of spray adjuvants. Individual pesticide labels identify types of adjuvants approved for use with it. In general, adjuvants compose a relatively small portion of the volume of pesticides applied. Selection of adjuvants with limited toxicity and low volumes would be recommended to reduce the potential for the adjuvant to influence the toxicity of the pesticide.

O.7.4 Determining Effects to Soil and Water Quality

The approval process for pesticide uses would consider potential to degrade water quality on and off refuge lands. A pesticide can only affect water quality through movement away from the treatment site. After application, pesticide mobilization can be characterized by one or more of the following (Kerle et al. 1996):

- Attach (sorb) to soil, vegetation, or other surfaces and remain at or near the treated area;
- Attach to soil and move off-site through erosion from runoff or wind;
- Dissolve in water that can be subjected to runoff or leaching.

As an initial screening tool, selected chemical characteristics and rating criteria for a pesticide can be evaluated to assess potential to enter ground and/or surface waters. These would include the following: persistence, sorption coefficient (K_{oc}), groundwater ubiquity score (GUS), and solubility.

Persistence, which is expressed as half-life ($t_{½}$), represents the length of time required for 50% of the deposited pesticide to degrade (completely or partially). Persistence in the soil can be categorized as the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days (Kerle et al. 1996). Half-life data are usually available for aquatic and terrestrial environments.

Another measure of pesticide persistence is dissipation time (DT_{50}). It represents the time required for 50% of the deposited pesticide to degrade and move from a treated site; whereas, half-life describes the rate for degradation only. As for half-life, units of dissipation time are usually expressed in days. Field or foliar dissipation time is the preferred data for use to estimate pesticide concentrations in the environment. However, soil half-life is the most common persistence data cited in published literature. If field or foliar dissipation data are not available, soil half-life data may be

used. The average or representative half-life value of most important degradation mechanism will be selected for quantitative analysis for both terrestrial and aquatic environments.

Mobility of a pesticide is a function of how strongly it is adsorbed to soil particles and organic matter, its solubility in water, and its persistence in the environment. Pesticides strongly adsorbed to soil particles, relatively insoluble in water, and not environmentally persistent would be less likely to move across the soil surface into surface waters or to leach through the soil profile and contaminate groundwater. Conversely, pesticides that are not strongly adsorbed to soil particles, are highly water soluble, and are persistent in the environment would have greater potential to move from the application site (off-site movement).

The degree of pesticide adsorption to soil particles and organic matter (Kerle et al. 1996) is expressed as the soil adsorption coefficient (K_{oc}). The soil adsorption coefficient is measured as micrograms of pesticide per gram of soil (µg/g) that can range from near zero to the thousands. Pesticides with higher K_{oc} values are strongly sorbed to soil and, therefore, would be less subject to movement.

Water solubility describes the amount of pesticide that will dissolve in a known quantity of water. The water solubility of a pesticide is expressed as milligrams of pesticide dissolved in a liter of water (mg/L or parts per million [ppm]). Pesticide with solubility <0.1 ppm are virtually insoluble in water, 100-1000 ppm are moderately soluble, and >10,000 ppm highly soluble (US Geological Survey 2000). As pesticide solubility increases, there would be greater potential for off-site movement.

The Groundwater Ubiquity Score (GUS) is a quantitative screening tool to estimate a pesticide's potential to move in the environment. It utilizes soil persistence and adsorption coefficients in the following formula.

$$GUS = \log_{10}(t_{½}) \times [4 - \log_{10}(K_{oc})]$$

The potential pesticide movement rating would be based upon its GUS value. Pesticides with a GUS <0.1 would considered to have an extremely low potential to move toward groundwater. Values of 1.0-2.0 would be low, 2.0-3.0 would be moderate, 3.0-4.0 would be high, and >4.0 would have a very high potential to move toward groundwater.

Water solubility describes the amount of pesticide dissolving in a specific quantity of water, where it is usually measured as mg/L or ppm. Solubility is useful as a comparative measure because pesticides with higher values are more likely to move by runoff or leaching. GUS, water solubility, $t_{½}$, and K_{oc} values are available for selected pesticides from the OSU Extension Pesticide Properties Database at http://npic.orst.edu/ppdmove.htm. Many of the values in this database were derived from the SCS/ARS/CES Pesticide Properties Database for Environmental Decision Making (Wauchope et al. 1992).

Soil properties influence the fate of pesticides in the environment. The following six properties are mostly likely to affect pesticide degradation and the potential for pesticides to move off-site by leaching (vertical movement through the soil) or runoff (lateral movement across the soil surface).

- Permeability is the rate of water movement vertically through the soil. It is affected by soil texture and structure. Coarse textured soils (e.g., high sand content) have a larger pore size and they are generally more permeable than fine textured soils (i.e., high clay content). The

more permeable soils would have a greater potential for pesticides to move vertically down through the soil profile. Soil permeability rates (inches/hour) are usually available in county soil survey reports.

- Soil texture describes the relative percentage of sand, silt, and clay. In general, greater clay content with smaller the pore size would lower the likelihood and rate water that would move through the soil profile. Clay also serves to adsorb (bind) pesticides to soil particles. Soils with high clay content would adsorb more pesticide than soils with relatively low clay content. In contrast, sandy soils with coarser texture and lower water holding capacity would have a greater potential for water to leach through them.
- Soil structure describes soil aggregation. Soils with a well-developed soil structure have looser, more aggregated, structure that would be less likely to be compacted. Both characteristics would allow for less restricted flow of water through the soil profile resulting in greater infiltration.
- Organic matter would be the single most important factor affecting pesticide adsorption in soils. Many pesticides are adsorbed to organic matter which would reduce their rate of downward movement through the soil profile. Also, soils high in organic matter would tend to hold more water, which may make less water available for leaching.
- Soil moisture affects how fast water would move through the soil. If soils are already wet or saturated before rainfall or irrigation, excess moisture would runoff rather than infiltrate into the soil profile. Soil moisture also would influence microbial and chemical activity in soil, which affects pesticide degradation.
- Soil pH would influence chemical reactions that occur in the soil which in turn determines whether or not a pesticide will degrade, rate of degradation, and, in some instances, which degradation products are produced.

Based upon the aforementioned properties, soils most vulnerable to groundwater contamination would be sandy soils with low organic matter. In contrast, the least vulnerable soils would be well-drained clayey soils with high organic matter. Consequently, pesticides with the lowest potential for movement in conjunction with appropriate best management practices (see below) would be used in an IPM framework to treat pests while minimizing effects to non-target biota and protecting environmental quality.

Along with soil properties, the potential for a pesticide to affect water quality through runoff and leaching would consider site-specific environmental and abiotic conditions including rainfall, water table conditions, and topography (Huddleston 1996).

- Water is necessary to separate pesticides from soil. This can occur in two basic ways. Pesticides that are soluble move easily with runoff water. Pesticide-laden soil particles can be dislodged and transported from the application site in runoff. The concentration of pesticides in the surface runoff would be greatest for the first runoff event following treatment. The rainfall intensity and route of water infiltration into soil, to a large extent, determine pesticide concentrations and losses in surface runoff. The timing of the rainfall after application also would have an effect. Rainfall interacts with pesticides at a shallow soil depth (¼ to ½ inch), which is called the mixing zone (Baker and Miller 1999). The pesticide/water mixture in the mixing zone would tend to leach down into the soil or runoff depending upon how quickly the soil surface becomes saturated and how rapidly water can infiltrate into the soil. Leaching would decrease the amount of pesticide available near the

soil surface (mixing zone) to runoff during the initial rainfall event following application and subsequent rainfall events.

- Terrain slope would affect the potential for surface runoff and the intensity of runoff. Steeper slopes would have greater potential for runoff following a rainfall event. In contrast, soils that are relatively flat would have little potential for runoff, except during intense rainfall events. In addition, soils in lower areas would be more susceptible to leaching as a result of receiving excessive water from surrounding higher elevations.
- Depth to groundwater would be an important factor affecting the potential for pesticides to leach into groundwater. If the distance from the soil surface to the top of the water table is shallow, pesticides would have less distance to travel to reach groundwater. Shallower water tables that persist for longer periods would be more likely to experience groundwater contamination. Soil survey reports are available for individual counties. These reports provide data in tabular format regarding the water table depths and the months during which it is persists. In some situations, a hard pan exists above the water table that would prevent pesticide contamination from leaching.

O.7.5 Determining Effects to Air Quality

Pesticides may volatilize from soil and plant surfaces and move from the treated area into the atmosphere. The potential for a pesticide to volatilize is determined by the pesticide's vapor pressure which would be affected by temperature, sorption, soil moisture, and the pesticide's water solubility. Vapor pressure is often expressed in mm Hg. To make these numbers easier to compare, vapor pressure may be expressed in exponent form ($I \times 10^{-7}$), where I represents a vapor pressure index. In general, pesticides with $I<10$ would have a low potential to volatilize; whereas, pesticides with $I>1,000$ would have a high potential to volatilize (Oregon State University 1996). Vapor pressure values for pesticides are usually available in the pesticide product MSDS or the USDA Agricultural Research Service (ARS) pesticide database.

O.7.6 Preparing a Chemical Profile

The following instructions would be used by Service personnel to complete Chemical Profiles for pesticides. Specifically, profiles would be prepared for pesticide active ingredients (e.g., glyphosate, imazapic) that would be contained in one or more trade name products that are registered and labeled with USEPA. All information fields under each category (e.g., Toxicological Endpoints, Environmental Fate) would be completed for a Chemical Profile. If no information is available for a specific field, then "No data are available in references" would be recorded in the profile. Available scientific information would be used to complete Chemical Profiles. Each entry of scientific information would be shown with applicable references.

Completed Chemical Profiles would provide a structured decision-making process utilizing quantitative assessment/screening tools with threshold values (where appropriate) that would be used to evaluate potential biological and other environmental effects to refuge resources. For ecological risk assessments presented in these profiles, the "worst-case scenario" would be evaluated to determine whether a pesticide could be approved for use considering the maximum single application rate specified on pesticide labels for habitat management and croplands/facilities maintenance treatments pertaining to refuges. Where the "worst-case scenario" likely would only result in minor, temporary, and localized effects to listed and non-listed species with appropriate BMPs (see Section O.5), the proposed pesticide's use in a PUP would have a scientific basis for approval under any

application rate specified on the label that is at or below rates evaluated in a Chemical Profile. In some cases, the Chemical Profile would include a lower application rate than the maximum labeled rate in order to protect refuge resources. As necessary, Chemical Profiles would be periodically updated with new scientific information or as pesticides with the same active ingredient are proposed for use on the refuge in PUPs.

Throughout this section, threshold values (to prevent or minimize potential biological and environmental effects) would be clearly identified for specific information presented in a completed Chemical Profile. Comparison with these threshold values provides an explicit scientific basis to approve or disapprove PUPs for habitat management and cropland/facilities maintenance on refuge lands. In general, PUPs would be approved for pesticides with Chemical Profiles where there would be no exceedances of threshold values. However, BMPs are identified for some screening tools that would minimize/eliminate potential effects (exceedance of the threshold value) as a basis for approving PUPs.

Date: Service personnel would record the date when the Chemical Profile is completed or updated. Chemical Profiles (e.g., currently approved pesticide use patterns) would be periodically reviewed and updated, as necessary. The most recent review date would be recorded on a profile to document when it was last updated.

Trade Name(s): Service personnel would accurately and completely record the trade name(s) from the pesticide label, which includes a suffix that describes the formulation (e.g., WP, DG, EC, L, SP, I, II or 64). The suffix often distinguishes a specific product among several pesticides with the same active ingredient. Service personnel would record a trade name for each pesticide product with the same active ingredient.

Common chemical name(s): Service personnel would record the common name(s) listed on the pesticide label or material safety data sheet (MSDS) for an active ingredient. The common name of a pesticide is listed as the active ingredient on the title page of the product label immediately following the trade name, and the MSDS, Section 2: Composition/ Information on Ingredients. A Chemical Profile is completed for each active ingredient.

Pesticide Type: Service personnel would record the type of pesticide for an active ingredient as one of the following: herbicide, desiccant, fungicide, fumigant, growth regulator, insecticide, piscicide, or rodenticide.

EPA Registration Number(s): This number (EPA Reg. No.) appears on the title page of the label and MSDS, Section 1: Chemical Product and Company Description. It is not the EPA Establishment Number that is usually located near it. Service personnel would record the EPA Reg. No. for each trade name product with an active ingredient based upon PUPs.

Pesticide Class: Service personnel would list the general chemical class for the pesticide (active ingredient). For example, malathion is an organophosphate and carbaryl is a carbamate.

CAS (Chemical Abstract Service) Number: This number is often located in the second section (Composition/Information on Ingredients) of the MSDS. The MSDS table listing components usually contains this number immediately prior to or following the % composition.

Other Ingredients: From the most recent MSDS for the proposed pesticide product(s), Service personnel would include any chemicals in the pesticide formulation not listed as an active ingredient that are described as toxic or hazardous, or regulated under the Superfund Amendments and Reauthorization Act (SARA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Toxic Substances Control Act (TSCA), Occupational Safety and Health Administration (OSHA), State Right-to-Know, or other listed authorities. These are usually found in MSDS sections titled "Hazardous Identifications", "Exposure Control/Personal Protection", and "Regulatory Information". If concentrations of other ingredients are available for any compounds identified as toxic or hazardous, then Service personnel would record this information in the Chemical Profile by trade name. MSDS(s) may be obtained from the manufacturer, manufacturer's website or from an on-line database maintained by Crop Data Management Systems, Inc. (see list below).

Toxicological Endpoints

Toxicological endpoint data would be collected for acute and chronic tests with mammals, birds, and fish. Data would be recorded for species available in the scientific literature. If no data are found for a particular taxonomic group, then "No data available in references" would be recorded as the data entry. Throughout the Chemical Profile, references (including toxicological endpoint data) would be cited using parentheses (#) following the recorded data.

Mammalian LD_{50}: For test species in the scientific literature, Service personnel would record available data for oral lethal dose (LD_{50}) in mg/kg-bw (body weight) or ppm-bw. Most common test species in scientific literature are the rat and mouse. The lowest LD_{50} value found for a rat would be used as a toxicological endpoint for dose-based RQ calculations to assess acute risk to mammals (see Table 1 in Section O.7.1).

Mammalian LC_{50}: For test species in the scientific literature, Service personnel would record available data for dietary lethal concentration (LC_{50}) as reported (e.g., mg/kg-diet or ppm-diet). Most common test species in scientific literature are the rat and mouse. The lowest LC_{50} value found for a rat would be used as a toxicological endpoint for diet-based RQ calculations to assess acute risk (see Table O-1 in Section O.7.1).

Mammalian Reproduction: For test species listed in the scientific literature, Service personnel would record the test results (e.g., Lowest Observed Effect Concentration [LOEC], Lowest Observed Effect Level [LOEL], No Observed Adverse Effect Level [NOAEL], No Observed Adverse Effect Concentration [NOAEC]) in mg/kg-bw or mg/kg-diet for reproductive test procedure(s) (e.g., generational studies [preferred], fertility, new born weight). Most common test species available in scientific literature are rats and mice. The lowest NOEC, NOAEC, NOEL, or NOAEL test results found for a rat would be used as a toxicological endpoint for RQ calculations to assess chronic risk (see Table O-1 in Section O.7.1).

Avian LD_{50}: For test species available in the scientific literature, Service personnel would record values for oral lethal dose (LD_{50}) in mg/kg-bw or ppm-bw. Most common test species available in scientific literature are the bobwhite quail and mallard. The lowest LD_{50} value found for an avian species would be used as a toxicological endpoint for dose-based RQ calculations to assess acute risk (see Table O-1 in Section O.7.1).

Avian LC_{50}: For test species available in the scientific literature, Service personnel would record values for dietary lethal concentration (LC_{50}) as reported (e.g., mg/kg-diet or ppm-diet). Most common test species available in scientific literature are the bobwhite quail and mallard. The lowest LC_{50} value found for an avian species would be used as a toxicological endpoint for dietary-based RQ calculations to assess acute risk (see Table O-1 in Section O.7.1).

Avian Reproduction: For test species available in the scientific literature, Service personnel would record test results (e.g., LOEC, LOEL, NOAEC, NOAEL) in mg/kg-bw or mg/kg-diet consumed for reproductive test procedure(s) (e.g., early life cycle, reproductive). Most common test species available in scientific literature are the bobwhite quail and mallard. The lowest NOEC, NOAEC, NOEL, or NOAEL test results found for an avian species would be used as a toxicological endpoint for RQ calculations to assess chronic risk (see Table O-1 in Section O.7.1).

Fish LC_{50}: For test freshwater or marine species listed in the scientific literature, Service personnel would record a LC_{50} in ppm or mg/L. Most common test species available in the scientific literature are the bluegill, rainbow trout, and fathead minnow (marine). Test results for many game species may also be available. The lowest LC_{50} value found for a freshwater fish species would be used as a toxicological endpoint for RQ calculations to assess acute risk (see Table O-1 in Section O.7.1).

Fish Early Life Stage (ELS)/Life Cycle: For test freshwater or marine species available in the scientific literature, Service personnel would record test results (e.g., LOEC, NOAEL, NOAEC, LOAEC) in ppm for test procedure(s) (e.g., early life cycle, life cycle). Most common test species available in the scientific literature are bluegill, rainbow trout, and fathead minnow. Test results for other game species may also be available. The lowest test value found for a fish species (preferably freshwater) would be used as a toxicological endpoint for RQ calculations to assess chronic risk (see Table O-1 in Section O.7.1).

Other: For test invertebrate as well as non-vascular and vascular plant species available in the scientific literature, Service personnel would record $LC_{50,}$ $LD_{50,}$ LOEC, LOEL, NOAEC, NOAEL, or EC_{50} (environmental concentration) values in ppm or mg/L. Most common test invertebrate species available in scientific literature are the honey bee and the water flea (*Daphnia magna*). Green algae (*Selenastrum capricornutum*) and pondweed (*Lemna minor*) are frequently available test species for aquatic non-vascular and vascular plants, respectively.

Ecological Incident Reports: After a site has been treated with pesticide(s), wildlife may be exposed to these chemical(s). When exposure is high relative to the toxicity of the pesticides, wildlife may be killed or visibly harmed (incapacitated). Such events are called ecological incidents. The USEPA maintains a database (Ecological Incident Information System) of ecological incidents. This database stores information extracted from incident reports submitted by various federal and state agencies and non-government organizations. Information included in an incident report is date and location of the incident, type and magnitude of effects observed in various species, use(s) of pesticides known or suspected of contributing to the incident, and results of any chemical residue and cholinesterase activity analyses conducted during the investigation.

Incident reports can play an important role in evaluating the effects of pesticides by supplementing quantitative risk assessments. All incident reports for pesticide(s) with the active ingredient and associated information would be recorded.

Environmental Fate

Water Solubility: Service personnel would record values for water solubility (S_w), which describes the amount of pesticide that dissolves in a known quantity of water. S_w is expressed as mg/L (ppm). Pesticide S_w values would be categorized as one of the following: insoluble <0.1 ppm, moderately soluble = 100 to 1000 ppm, highly soluble >10,000 ppm (US Geological Survey 2000). As pesticide S_w increases, there would be greater potential to degrade water quality through runoff and leaching.

Sw would be used to evaluate potential for bioaccumulation in aquatic species [see **Octanol-Water Partition Coefficient (K_{ow})** below].

Soil Mobility: Service personnel would record available values for soil adsorption coefficient (K_{oc} [µg/g]). It provides a measure of a chemical's mobility and leaching potential in soil. K_{oc} values are directly proportional to organic content, clay content, and surface area of the soil. K_{oc} data for a pesticide may be available for a variety of soil types (e.g., clay, loam, sand).

K_{oc} values would be used in evaluating the potential to degrade groundwater by leaching (see **Potential to Move to Groundwater** below).

Soil Persistence: Service personnel would record values for soil half-life ($t_{½}$), which represents the length of time (days) required for 50% of the deposited pesticide to degrade (completely or partially) in the soil. Based upon the $t_{½}$ value, soil persistence would be categorized as one of the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days (Kerle et al. 1996).

Threshold for Approving PUPs:

If soil $t_{½} \leq 100$ days, then a PUP would be approved without additional BMPs to protect water quality.

If soil $t_{½} > 100$ days, then a PUP would only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following would be included in the **Specific Best Management Practices (BMPs) section** to minimize potential surface runoff and leaching that can degrade water quality:

- Do not exceed one application per site per year.
- Do not use on coarse-textured soils where the ground water table is <10 feet and average annual precipitation >12 inches.
- Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.

Along with K_{oc}, soil $t_{½}$ values would be used in evaluating the potential to degrade groundwater by leaching (see **Potential to Move to Groundwater** below).

Soil Dissipation: Dissipation time (DT_{50}) represents the time required for 50% of the deposited pesticide to degrade and move from a treated site; whereas, soil $t_{½}$ describes the rate for degradation only. As for $t_{½}$, units of dissipation time are usually expressed in days. Field dissipation time would be the preferred data for use to estimate pesticide concentrations in the environment because it is based upon field studies compared to soil $t_{½}$, which is derived in a laboratory. However, soil $t_{½}$ is the most common persistence data available in the published literature. If field dissipation data are not available, soil half-life data would be used in a Chemical Profile. The average or representative half-life value of most important degradation mechanism would be selected for quantitative analysis for both terrestrial and aquatic environments.

Based upon the DT_{50} value, environmental persistence in the soil also would be categorized as one of the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days.

Threshold for Approving PUPs:

If soil $DT_{50} \leq 100$ days, then a PUP would be approved without additional BMPs to protect water quality.

If soil DT_{50} >100 days, then a PUP would only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following would be included in the **Specific Best Management Practices (BMPs) section** to minimize potential surface runoff and leaching that can degrade water quality:

- Do not exceed one application per site per year.
- Do not use on coarse-textured soils where the ground water table is <10 feet and average annual precipitation >12 inches.
- Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.

Along with K_{oc}, soil DT_{50} values (preferred over soil $t_{½}$) would be used in evaluating the potential to degrade groundwater by leaching (see **Potential to Move to Groundwater** below), if available.

Aquatic Persistence: Service personnel would record values for aquatic $t_{½}$, which represents the length of time required for 50% of the deposited pesticide to degrade (completely or partially) in water. Based upon the $t_{½}$ value, aquatic persistence would be categorized as one of the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days (Kerle et al. 1996).

Threshold for Approving PUPs:

If aquatic $t_{½} \leq 100$ days, then a PUP would be approved without additional BMPs to protect water quality.

If aquatic $t_{½}$ >100 days, then a PUP would only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following would be included in the **Specific Best Management Practices (BMPs) section** to minimize potential surface runoff and leaching that can degrade water quality:

- Do not exceed one application per site per year.
- Do not use on coarse-textured soils where the ground water table is <10 feet and average annual precipitation >12 inches.
- Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.

Aquatic Dissipation: Dissipation time (DT_{50}) represents the time required for 50% of the deposited pesticide to degrade or move (dissipate); whereas, aquatic $t_{½}$ describes the rate for degradation only. As for $t_{½}$, units of dissipation time are usually expressed in days. Based upon the DT_{50} value,

environmental persistence in aquatic habitats also would be categorized as one of the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days.

Threshold for Approving PUPs:

If aquatic $DT_{50} \leq 100$ days, then a PUP would be approved without additional BMPs to protect water quality.

If aquatic $DT_{50} > 100$ days, then a PUP would only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following would be included in the **Specific Best Management Practices (BMPs) section** to minimize potential surface runoff and leaching that can degrade water quality:

- Do not exceed one application per site per year.
- Do not use on coarse-textured soils where the ground water table is <10 feet and average annual precipitation >12 inches.
- Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.

Potential to Move to Groundwater: Groundwater Ubiquity Score (GUS) = $\log_{10}(\text{soil } t_{½}) \times [4 - \log_{10}(K_{oc})]$. If a DT_{50} value is available, it would be used rather than a $t_{½}$ value to calculate a GUS score. Based upon the GUS value, the potential to move toward groundwater would be recorded as one of the following categories: extremely low potential<1.0, low - 1.0 to 2.0, moderate - 2.0 to 3.0, high - 3.0 to 4.0, or very high>4.0.

Threshold for Approving PUPs:

If GUS ≤4.0, then a PUP would be approved without additional BMPs to protect water quality.

If GUS >4.0, then a PUP would only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following would be included in the **Specific Best Management Practices (BMPs) section** to minimize potential surface runoff and leaching that can degrade water quality:

- Do not exceed one application per site per year.
- Do not use on coarse-textured soils where the ground water table is <10 feet and average annual precipitation >12 inches.
- Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.

Volatilization: Pesticides may volatilize (evaporate) from soil and plant surfaces and move off-target into the atmosphere. The potential for a pesticide to volatilize is a function of its vapor pressure that is affected by temperature, sorption, soil moisture, and the pesticide's water solubility. Vapor pressure is often expressed in mm Hg. To make these values easier to compare, vapor pressure would be recorded by Service personnel in exponential form ($I \times 10^{-7}$), where I represents a vapor pressure index. In general, pesticides with I<10 would have low potential to volatilize; whereas, pesticides with I >1,000 would have a high potential to volatilize (Oregon State University 1996).

Vapor pressure values for pesticides are usually available in the pesticide product MSDS or the USDA Agricultural Research Service (ARS) pesticide database (see **References**).

Threshold for Approving PUPs:

If I ≤1,000, then a PUP would be approved without additional BMPs to minimize drift and protect air quality.

If I >1,000, then a PUP would only be approved with additional BMPs specifically to minimize drift and protect air quality. One or more BMPs such as the following would be included in the **Specific Best Management Practices (BMPs) section** to reduce volatilization and potential to drift and degrade air quality:

- Do not treat when wind velocities are <2 or >10 mph with existing or potential inversion conditions.
- Apply the large-diameter droplets possible for spray treatments.
- Avoid spraying when air temperatures >85°F.
- Use the lowest spray height possible above target canopy.
- Where identified on the pesticide label, soil incorporate pesticide as soon as possible during or after application.

Octanol-Water Partition Coefficient (K_{ow}): The octanol-water partition coefficient (K_{ow}) is the concentration of a pesticide in octanol and water at equilibrium at a specific temperature. Because octanol is an organic solvent, it is considered a surrogate for natural organic matter. Therefore, K_{ow} would be used to assess potential for a pesticide to bioaccumulate in tissues of aquatic species (e.g., fish). If K_{ow} >1,000 or S_w<1 mg/L and soil $t_{½}$>30 days, then there would be high potential for a pesticide to bioaccumulate in aquatic species such as fish (US Geological Survey 2000).

Threshold for Approving PUPs:

If there is not a high potential for a pesticide to bioaccumulate in aquatic species, then the PUP would be approved.

If there is a high potential to bioaccumulate in aquatic species (K_{ow}>1,000 or S_w<1 mg/L and soil $t_{½}$>30 days), then the PUP would not approved, except under unusual circumstances where approval would only be granted by the Washington Office.

Bioaccumulation/Bioconcentration: The physiological process where pesticide concentrations in tissue would increase in biota because they are taken and stored at a faster rate than they are metabolized or excreted. The potential for bioaccumulation would be evaluated through bioaccumulation factors (BAFs) or bioconcentration factors (BCFs). Based upon BAF or BCF values, the potential to bioaccumulate would be recorded as one of the following: low – 0 to 300, moderate – 300 to 1,000, or high >1,000 (Calabrese and Baldwin 1993).

Threshold for Approving PUPs:

If BAF or BCF≤1,000, then a PUP would be approved without additional BMPs.

If BAF or BCF>1,000, then a PUP would not approved, except under unusual circumstances where approval would only be granted by the Washington Office.

Worst-Case Ecological Risk Assessment

Max Application Rates (acid equivalent): Service personnel would record the highest application rate of an active ingredient (ae basis) for habitat management and cropland/facilities maintenance treatments in this data field of a Chemical Profile. These rates can be found in Table CP.1 under the column heading "Max Product Rate – Single Application (lbs/acre – AI on acid equiv basis)". This table would be prepared for a Chemical Profile from information specified in labels for trade name products identified in PUPs. If these data are not available in pesticide labels, then write "NS" for "not specified on label" in this table.

EECs: An estimated environmental concentration (ECC) represents potential exposure to fish and wildlife (birds and mammals) from using a pesticide. EECs would be derived by Service personnel using an USEPA screening-level approach (US Environmental Protection Agency 2004). For each max application rate [see description under **Max Application Rates (acid equivalent)**], Service personnel would record 2 EEC values in a Chemical Profile; these would represent the worst-case terrestrial and aquatic exposures for habitat management and croplands/facilities maintenance treatments. For terrestrial and aquatic EEC calculations, see description for data entry under **Presumption of Unacceptable Risk/Risk Quotients**, which is the next field for a Chemical Profile.

Presumption of Unacceptable Risk/Risk Quotients: Service personnel would calculate and record acute and chronic risk quotients (RQs) for birds, mammals, and fish using the provided tabular formats for habitat management and/or cropland/facilities maintenance treatments. RQs recorded in a Chemical Profile would represent the worst-case assessment for ecological risk. See Section O.7.2 for discussion regarding the calculations of RQs.

For aquatic assessments associated with habitat management treatments, RQ calculations would be based upon selected acute and chronic toxicological endpoints for fish and the EEC would be derived from Urban and Cook (1986) assuming 100% overspray to an entire 1-foot deep water body using the max application rate (ae basis [see above]).

For aquatic assessments associated with cropland/facilities maintenance treatments, RQ calculations would be done by Service personnel based upon selected acute and chronic toxicological endpoints for fish and an EEC would be derived from the aquatic assessment in AgDRIFT® model version 2.01 under Tier I ground-based application with the following input variables: max application rate (acid basis [see above]), low boom (20 inches), fine to medium/coarse droplet size, 20 swaths, EPA-defined wetland, and 25-foot distance (buffer) from treated area to water.

See Section O.7.2.1.2 for more details regarding the calculation of EECs for aquatic habitats for habitat management and cropland/facilities maintenance treatments.

For terrestrial avian and mammalian assessments, RQ calculations would be done by Service personnel based upon dietary exposure, where the "short grass" food item category would represent the worst-case scenario. For terrestrial spray applications associated with habitat management and cropland/facilities maintenance treatments, exposure (EECs and RQs) would be determined using the Kanaga nomogram method through the USEPA's T-REX version 1.2.3. T-REX input variables would include the following: max application rate (acid basis [see above]) and pesticide half-life

(days) in soil to estimate the initial, maximum pesticide residue concentration on general food items for terrestrial vertebrate species in short (<20 cm tall) grass.

For granular pesticide formulations and pesticide-treated seed with a unique route of exposure for terrestrial avian and mammalian wildlife, see Section O.7.2.1.1.2 for the procedure that would be used to calculate RQs.

All calculated RQs in both tables would be compared with Levels of Concern (LOCs) established by USEPA (see Table O-2 in Section O.7.2). If a calculated RQ exceeds an established LOC value (in brackets inside the table), then there would be a potential for an acute or chronic effect (unacceptable risk) to federally listed (T&E) species and nonlisted species. See Section O.7.2 for detailed descriptions of acute and chronic RQ calculations and comparison to LOCs to assess risk.

Threshold for approving PUPs:

If RQs≤LOCs, then a PUP would be approved without additional BMPs.

If RQs>LOCs, then a PUP would only be approved with additional BMPs specifically to minimize exposure (ecological risk) to bird, mammal, and/or fish species. One or more BMPs such as the following would be included in the **Specific Best Management Practices (BMPs) section** to reduce potential risk to non-listed or listed species:

- Lower application rate and/or fewer number of applications so RQs≤LOCs
- For aquatic assessments (fish) associated with cropland/facilities maintenance, increase the buffer distance beyond 25 feet so RQs≤LOCs.

Justification for Use: Service personnel would describe the reason for using the pesticide based control of specific pests or groups of pests. In most cases, the pesticide label will provide the appropriate information regarding control of pests to describe in the section.

Specific Best Management Practices (BMPs): Service personnel would record specific BMPs necessary to minimize or eliminate potential effects to non-target species and/or degradation of environmental quality from drift, surface runoff, or leaching. These BMPs would be based upon scientific information documented in previous data fields of a Chemical Profile. Where necessary and feasible, these specific practices would be included in PUPs as a basis for approval.

If there are no specific BMPs that are appropriate, then Service personnel would describe why the potential effects to refuge resources and/or degradation of environmental quality is outweighed by the overall resource benefit(s) from the proposed pesticide use in the BMP section of the PUP. See Section O.4 of this document for a complete list of BMPs associated with mixing and applying pesticides appropriate for all PUPs with ground-based treatments that would be additive to any necessary, chemical-specific BMPs.

References: Service personnel would record scientific resources used to provide data/information for a chemical profile. Use the number sequence to uniquely reference data in a chemical profile.

The following on-line data resources are readily available for toxicological endpoint and environmental fate data for pesticides:

1. California Product/Label Database. Department of Pesticide Regulation, California Environmental Protection Agency. (http://www.cdpr.ca.gov/docs/label/labelque.htm#regprods)

2. ECOTOX database. Office of Pesticide Programs, US Environmental Protection Agency, Washington, DC. (http://cfpub.epa.gov/ecotox/)

3. Extension Toxicology Network (EXTOXNET) Pesticide Information Profiles. Cooperative effort of University of California-Davis, Oregon State University, Michigan State University, Cornell University and University of Idaho through Oregon State University, Corvallis, Oregon. (http://extoxnet.orst.edu/pips/ghindex.html)

4. FAO specifications and evaluations for plant protection products. Pesticide Management Unit, Plant Protection Services, Food and Agriculture Organization, United Nations. (http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPP/Pesticid/)

5. Human health and ecological risk assessments. Pesticide Management and Coordination, Forest Health Protection, US Department of Agriculture, US Forest Service. (http://www.fs.fed.us/foresthealth/pesticide/risk.htm)

6. Pesticide Chemical Fact Sheets. Clemson University Pesticide Information Center. (http://entweb.clemson.edu/pesticid/Document/Labels/factshee.htm)

7. Pesticide Fact Sheets. Published by Information Ventures, Inc. for Bureau of Land Management, Department of Interior; Bonneville Power Administration, U.S. Department of Energy; and Forest Service, US Department of Agriculture. (http://infoventures.com/e-hlth/pesticide/pest-fac.html)

8. Pesticide Fact Sheets. National Pesticide Information Center. (http://npic.orst.edu/npicfact.htm)

9. Pesticide Fate Database. US Environmental Protection Agency, Washington, DC. (http://cfpub.epa.gov/pfate/home.cfm).

10. Pesticide product labels and material safety data sheets. Crop Data Management Systems, Inc. (CDMS) (http://www.cdms.net/pfa/LUpdateMsg.asp) or multiple websites maintained by agrichemical companies.

11. Registered Pesticide Products (Oregon database). Oregon Department of Agriculture. (http://www.oda.state.or.us/dbs/pest_products/search.lasso)

12. Regulatory notes. Pest Management Regulatory Agency, Health Canada, Ontario, Canada. (http://www.hc-sc.gc.ca/pmra-arla/)

13. Reptile and Amphibian Toxicology Literature. Canadian Wildlife Service, Environment Canada, Ontario, Canada. (http://www.cws-scf.ec.gc.ca/nwrc-cnrf/ratl/index_e.cfm)

14. Specific Chemical Fact Sheet – New Active Ingredients, Biopesticide Fact Sheet and Registration Fact Sheet. U.S Environmental Protection Agency, Washington, D.C. (http://www.epa.gov/pestidides/factsheets/chemical_fs.htm)

15. Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas. The Invasive Species Initiative. The Nature Conservancy. (http://tnsweeds.ucdavis.edu/handbook.html)

16. Wildlife Contaminants Online. US Geological Survey, Department of Interior, Washington, D.C. (http://www.pwrc.usgs.gov/contaminants-online/)

17. One-liner database. 2000. US Environmental Protection Agency, Office of Pesticide Programs, Washington, D.C.

Chemical Profile

Date:			
Trade Name(s):		**Common Chemical Name(s):**	
Pesticide Type:		**EPA Registration Number:**	
Pesticide Class:		**CAS Number:**	
Other Ingredients:			

Toxicological Endpoints

Mammalian LD_{50}:	
Mammalian LC_{50}:	
Mammalian Reproduction:	
Avian LD_{50}:	
Avian LC_{50}:	
Avian Reproduction:	
Fish LC_{50}:	
Fish ELS/Life Cycle:	
Other:	

Ecological Incident Reports

Environmental Fate

Water solubility (S_w):	
Soil Mobility (K_{oc}):	
Soil Persistence ($t_{½}$):	
Soil Dissipation (DT_{50}):	

Aquatic Persistence ($t_{½}$):	
Aquatic Dissipation (DT_{50}):	
Potential to Move to Groundwater (GUS score):	
Volatilization (mm Hg):	
Octanol-Water Partition Coefficient (K_{ow}):	
Bioaccumulation/Bioconcentration:	**BAF:`** **BCF:**

Worst Case Ecological Risk Assessment

Max Application Rate (ai lbs/acre – ae basis)	**Habitat Management:** **Croplands/Facilities Maintenance:**
EECs	**Terrestrial (Habitat Management):** **Terrestrial (Croplands/Facilities Maintenance):** **Aquatic (Habitat Management):** **Aquatic (Croplands/Facilities Maintenance):**

Habitat Management Treatments:

Presumption of Unacceptable Risk		**Risk Quotient (RQ)**	
		Listed (T&E) Species	**Nonlisted Species**
Acute	Birds	[0.1]	[0.5]
	Mammals	[0.1]	[0.5]
	Fish	[0.05]	[0.5]
Chronic	Birds	[1]	[1]
	Mammals	[1]	[1]
	Fish	[1]	[1]

Cropland/Facilities Maintenance Treatments:

Presumption of Unacceptable Risk		Risk Quotient (RQ)	
		Listed (T&E) Species	Nonlisted Species
Acute	Birds	[0.1]	[0.5]
	Mammals	[0.1]	[0.5]
	Fish	[0.05]	[0.5]
Chronic	Birds	[1]	[1]
	Mammals	[1]	[1]
	Fish	[1]	[1]

Justification for Use:	
Specific Best Management Practices (BMPs):	
References:	

Table CP.1 Pesticide Name

Trade Name[a]	Treatment Type[b]	Max Product Rate – Single Application (lbs/acre or gal/acre)	Max Product Rate -Single Application (lbs/acre - AI on acid equiv basis)	Max Number of Applications Per Season	Max Product Rate Per Season (lbs/acre/season or gal/acre/season)	Minimum Time Between Applications (Days)

[a]From each label for a pesticide identified in pesticide use proposals (PUPs), Service personnel would record application information associated with possible/known uses on Service lands.

[b]Treatment type: H – habitat management or CF – cropland/facilities maintenance. If a pesticide is labeled for both types of treatments (uses), then record separate data for H and CF applications.

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Appendix P. Statement of Compliance

The following executive orders and legislative acts have been reviewed as they apply to the implementation of the Comprehensive Conservation Plan (CCP) for Sheldon National Wildlife Refuge (Refuge), located in the states of Nevada and Oregon.

National Wildlife Administration Act of 1966, as amended by the National Wildlife Refuge System Improvement Act of 1997 (16 U.S.C. 668dd-668ee). The National Wildlife Refuge System Administration Act (Refuge Administration Act) requires the Service to develop and implement a comprehensive conservation plan for each refuge. The CCP prepared for the Sheldon National Wildlife Refuge identifies and describes the Refuge's purposes; a vision and goals; fish, wildlife, and plant populations and related habitats; archaeological and cultural values; issues that may affect populations and habitats of fish, wildlife, and plants; actions necessary to restore and improve biological diversity; and opportunities for wildlife-dependent recreation, as required by the Refuge Administration Act.

During the CCP process, we evaluated all existing and proposed Refuge uses at Sheldon Refuge. Priority wildlife-dependent uses (hunting, fishing, wildlife observation, wildlife photography, environmental education and interpretation) are considered appropriate under Service policy. The other uses we found to be appropriate on the Refuge (see Appendix C) include: big-game guiding and outfitting; recreational rock collecting; and research, scientific collecting, and survey activities.

Compatibility determinations (Appendix D) have been prepared for the following uses: fishing, hunting, wildlife observation, wildlife photography, environmental education, interpretation, guiding and outfitting, rock collecting, and research, scientific collecting and survey activities. A number of secondary uses (camping, hiking, backpacking, horseback riding, etc.) which support these primary public uses were evaluated and included as part of the various compatibility determinations.

National Environmental Policy Act (1969) (42 U.S.C. 4321 et seq.). The planning process has been conducted in accordance with National Environmental Policy Act (NEPA) Implementing Procedures, U.S. Department of the Interior and Fish and Wildlife Service procedures, and in coordination with the affected public. The requirements of NEPA and its implementing regulations in 40 C.F.R. Parts 1500-1508 have been satisfied in the process we used to reach our decision. Our process included developing a range of management alternatives for the Sheldon Refuge; analyzing the likely effects of each alternative; and encouraging public involvement throughout the planning process. The Draft CCP/EIS was released for a 60-day public comment period. The affected public was notified of the availability of these documents through a Federal Register notice, news releases to local newspapers, the Service's refuge planning website, and a planning update. Copies of the Draft CCP/EIS and/or planning updates were distributed to an extensive mailing list. In addition, the Service hosted five public open houses in 2008. The CCP was revised based on public comments received on the Draft CCP/EIS.

National Historic Preservation Act (1966) (16 U.S. C.470 et seq.). The management of the archaeological and cultural resources of Sheldon Refuge as specified in the CCP will comply

with the regulations of Section 106 of the National Historic Preservation Act. Historic properties would be affected by the CCP based on the criteria of an effect or adverse effect as an undertaking defined in 36 C.F.R. 800.9 and Service Manual 614 FW 2; however, likely effects were addressed in the CCP/EIS and are expected to be beneficial. Determining whether a particular action has the potential to affect cultural resources is an ongoing process that will continue to occur as step-down and site-specific project plans are developed. Should additional historic properties be identified or acquired in the future, the Service will comply with the National Historic Preservation Act if any management actions have the potential to affect Refuge properties.

Endangered Species Act (16 U.S.C. 1531-1544). The Endangered Species Act provides for the conservation of threatened and endangered species of fish, wildlife, and plants by federal action, and by encouraging the establishment of state programs. Section 7 of the Act requires consultation before initiating projects which affect or may affect endangered and threatened species. Consultation in accordance with Service policy and the Act has been completed for the CCP. Required consultations will be completed for step-down plans and site-specific projects as they are developed and implemented.

Wilderness Preservation Act of 1964. The Service has evaluated the suitability of the Refuge for wilderness designation (Appendix F) and has identified areas that are suitable for consideration as wilderness in the CCP. Minimum Requirements Decisions and Analyses (Appendix G) have been completed for horse and burro removal; western juniper thinning; treatment of invasive non-native plants; removal of abandoned livestock developments; maintenance of wildlife guzzlers; and inventory, monitoring and research. Additional Minimum Requirements Decisions and Analyses will be completed as required for step-down plans and site-specific projects as they are developed and implemented.

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority and Low-Income Populations. Under Executive Order (EO) 12898, all federal actions must address and identify, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations, low-income populations, and Indian Tribes in the United States. The CCP was evaluated and no adverse human health or environmental effects were identified for minority or low-income populations, Indian Tribes, or anyone else.

Executive Order 13186, Responsibilities of Federal Agencies to Protect Migratory Birds. EO 13186 directs agencies to take certain actions to further implement the Migratory Bird Treaty Act. A provision of the Order directs federal agencies to consider the impacts of their activities, especially in reference to birds on the Fish and Wildlife Service's list of Birds of Conservation Concern. It also directs agencies to incorporate conservation recommendations and objectives from the North American Waterbird Conservation Plan, and bird conservation plans developed by Partners in Flight, into agency planning as described in Chapter 1. The effects of all alternatives to Refuge habitats used by migratory birds were assessed in the CCP/EIS.

Executive Order 13175, Consultation and Coordination with Indian Tribal Governments. As required under the Secretary of the Interior Order 3206, American Indian Tribal Rights,

Federal-Tribal Responsibilities, and the Endangered Species Act, we notified and consulted interested tribes. The Service consulted with the Summit Lake Paiute Tribe throughout the planning process. Other tribal governments were also notified and were provided information throughout the planning process.

Executive Order 12372, Intergovernmental Review. Coordination and consultation with affected tribal, local, and state governments, other federal agencies, and local interested persons has been completed by Service and Refuge staff members through personal contacts planning updates, and distribution of a Draft and Final CCP/EIS.

Executive Order 11990, Protection of Wetlands. The CCP is consistent with EO 11990. CCP implementation will potentially enhance and restore wetland resources on the Refuge.

Executive Order 11988, Floodplain Management. Under EO 11988, federal agencies "shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains." Implementation of the Sheldon CCP is consistent with this order.

Executive Order 11644, Use of Off-Road Vehicles on Public Lands. Consistent with EO 11644 and Service policy, the CCP ensures the use of off-road vehicles is controlled and directed to protect Refuge resources, promote user safety, and minimize conflicts among Refuge uses.

Integrated Pest Management (IPM), 517 DM 1 and 7 RM 14. In accordance with Department of the Interior Manual section 517 DM 1 and Service Manual section 7 RM 14, an integrated pest management (IPM) approach has been adopted to eradicate, control, or contain pest and invasive species on the Refuge (Appendix O). In accordance with 517 DM 1, only pesticides registered with the U.S. Environmental Protection Agency (USEPA) in full compliance with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), and regulations, orders, or permits issued by USEPA, may be applied on lands and waters under Refuge jurisdiction.

Chief, Division of Planning,
Visitor Services, and Transportation

9/27/12
Date

U.S. Department of the Interior
U.S. Fish & Wildlife Service
Sheldon National Wildlife Refuge
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March 2013

Cover Photo
Pronghorn antelope
USFWS

Inside Cover Photo
Virgin Gorge
USFWS/Gail H Collins

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Washington, D.C. 20240

MAR 22 2013

Dear Interested Reader:

Last spring, I asked each state within the range of the greater sage-grouse to join the U.S. Fish and Wildlife Service (Service) in a first-of-its-kind, collaborative approach to develop range-wide conservation objectives for the sage-grouse, both to inform our upcoming 2015 decision under the Endangered Species Act and to inform the collective conservation efforts of the many partners working to conserve the species. Recognizing that state wildlife agencies have management expertise and management authority for sage-grouse, we convened a Conservation Objectives Team (COT) of state and Service representatives. I asked the team to produce a recommendation regarding the degree to which threats need to be reduced or ameliorated to conserve the greater sage-grouse so that it would no longer be in danger of extinction or likely to become in danger of extinction in the foreseeable future.

The final, peer-reviewed COT report (attached here) delineates such objectives, based upon the best scientific and commercial data available at the time of its release. I would like to clarify here the Service's interpretation of a few issues that I know are of interest to our state partners.

The highest level objective identified in the report is to minimize habitat threats to the species so as to meet the objective of the 2006 Western Association of Fish and Wildlife Agencies' (WAFWA) Greater Sage-grouse Comprehensive Conservation Strategy: reversing negative population trends and achieving a neutral or positive population trend. The Service interprets this recommendation to mean that actions and measures should be put in place now that will eventually arrest what has been a continuing declining trend. Conservation success will be achieved by removing or reducing threats to the species now, such that population trends will eventually be stable or increasing, even if numbers are not restored to historic levels. In addition, while the WAFWA Greater Sage-grouse Comprehensive Conservation Strategy overall objective is tied to ecologically delineated Management Zones for this species, the Service may measure conservation success by evaluating population trends at other appropriate scales.

One key component of this report is the identification of Priority Areas of Conservation (PACs), which were described as key habitats that are essential for sage-grouse conservation. PACs were identified using the best available information at the time of the team's completion of the report. The report acknowledges the uncertainties associated in the delineation of these areas, yet focuses our attention on these areas. These areas were identified as highly important for long term viability of the species and should be a primary focus of our collective conservation efforts. The team, however, expressed in the report that new information may come to light indicating that some areas outside the identified PACs are also highly important. This could be due to their significance for a critical life history phase, or as a link to ensure connectivity to other populations, or to retain opportunities for critical restoration efforts that may come to light in the future. If information comes to light indicating an area outside a PAC is highly important, state and federal partners working to conserve the species should consider its significance as decisions are made that could impact that area.

Therefore, the report encourages, but does not require, that important habitats outside of PACs be conserved to the extent possible. In addition, page 36 of the COT Report indicates that states with state plans developed in conjunction with the Service should follow those plans in making decisions about areas outside of PACs.

The report identifies conservation objectives and measures for each of the habitat threats assessed. For some threats, the team identified examples of actions that could be used to help attain the conservation objectives, and they termed these "conservation options." The Service interprets these "options" as suggestions and examples only, not prescriptive or mandatory actions. These options were provided by the team to stimulate discussions important in the development of conservation planning efforts that will achieve the conservation objectives in the report.

The development of this report reflects a truly collaborative federal-state effort designed to provide a clearer picture of objectives that, if met, will ensure the long-term, robust persistence of this iconic western species. Achieving these conservation objectives will require our continuing collaboration. The Service appreciates the dedication of our colleagues from the western states who joined with us to develop this report.

Sincerely,

DIRECTOR

Greater Sage-grouse

(*Centrocercus urophasianus*)

Conservation Objectives: Final Report

February 2013

PREFACE

This report delineates reasonable objectives, based upon the best scientific and commercial data available at the time of its release, for the conservation and survival of greater sage-grouse. Individual team members contributed by providing technical information and data, participating in critical discussions, providing critical reviews and edits, or authoring sections of the report. While the team tried to achieve consensus it was not always achieved. The report is provided to the Director, USFWS, at his request, to provide additional information for his use and consideration pertinent to future decision making relative to greater sage-grouse. The report will also serve as guidance to federal land management agencies, state sage-grouse teams, and others in focusing efforts to achieve effective conservation for this species.

Team members included:

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Assistance with review and editing of the document was provided by Jesse D'Elia (U.S. Fish and Wildlife Service). We also thank Don Kemner from the Idaho Department of Fish and Game for thoughtful comments.

This report is guidance only; identification of conservation objectives and measures does not create a legal obligation beyond existing legal requirements. Nothing in this plan should be construed as a commitment or requirement that any federal agency obligate or pay funds in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. The objectives in this report are subject to modification as dictated by new findings, changes in species' status, and the completion of conservation actions.

RECOMMENDED CITATION

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1. BACKGROUND AND PURPOSE

On March 23, 2010, the U. S. Fish and Wildlife Service (FWS) determined that the greater sage-grouse (*Centrocercus urophasianus*; sage-grouse) warranted the protections of the Endangered Species Act of 1973, as amended, 1531 *et seq*. (ESA), but that adding it to the List of Endangered and Threatened Wildlife under the ESA was precluded by higher priority listing actions. Species found to be warranted for listing but precluded by higher priority listing actions ("warranted but precluded") are placed on the federal list of candidate species under the ESA.[1] Shortly after the sage-grouse became a candidate species, the FWS entered into a court-approved settlement agreement with several environmental groups which formalized a schedule for making listing determinations on over 200 candidate species nationwide, including the sage-grouse and its Distinct Population Segments (DPSs). The court-approved schedule indicates that a decision on whether to proceed with listing sage-grouse, or withdrawing our warranted finding, is due by September 2015.[2]

Given the broad implications of potentially listing the sage-grouse under the ESA, in December 2011, Wyoming Governor Matt Mead and Secretary of the Interior Ken Salazar co-hosted a meeting to address coordinated conservation of the sage-grouse across its range. Ten states within the range of the sage-grouse were represented[3], as were the U.S. Forest Service (FS), the Natural Resources Conservation Service (NRCS), and the Department of the Interior (DOI) — including representatives from the DOI's Bureau of Land Management (BLM) and U.S. Fish and Wildlife Service (FWS). The primary outcome of the meeting was the creation of a Sage-Grouse Task Force (Task Force) chaired by Governors Mead (WY) and Hickenlooper (CO) and the Director of the BLM. The Task Force was directed to develop recommendations on how to best advance a coordinated, multi-state, range-wide effort to conserve the sage-grouse, including the identification of conservation objectives to ensure the long-term viability of the species.

With the backing of the Task Force, the Director of FWS tasked staff with the development of range-wide conservation objectives for the sage-grouse to define the degree to which threats need to be reduced or ameliorated to conserve sage-grouse so that it is no longer in danger of extinction or likely to become in danger of extinction in the foreseeable future. Recognizing that state wildlife agencies have management expertise and management authority for sage-grouse, the FWS created a Conservation Objectives Team (COT) of state and FWS representatives (see Preface, above) to accomplish this task. Each member was selected by his or her state or agency. This report is the outcome of the COT's efforts.

[1] Two distinct population segments (DPSs) of sage-grouse are also on the candidate list – the Columbia Basin DPS (in Washington State) and the Bi-State population (in California and western Nevada).

[2] A decision on whether or not to proceed with listing the Bi-State population is due by September 2013. A decision on whether or not to proceed with listing the Columbia Basin DPS is due by September 2015.

[3] California, Colorado, Idaho, Montana, Nevada, Oregon, South Dakota, Utah, Washington, and Wyoming

2. SAGE-GROUSE BIOLOGY AND CURRENT STATUS

The greater sage-grouse is the largest North American grouse species and one of only two sage-grouse species in the world; the other is the Gunnison sage-grouse (*Centrocercus minimus*).

Prior to European settlement in the 19th century, sage-grouse inhabited 13 western states and three Canadian provinces, and their potential habitat covered over 1.2 million square kilometers (km^2) (0.46 million square miles (mi^2); Schroeder *et al*. 2004). Sage-grouse have declined across their range due to a variety of causes and now occupy 56 percent of their historic range (Schroeder *et al*. 2004; Figure 1). They currently occur in 11 states and two Canadian provinces (Knick and Connelly 2011). The actual decline in the number of sage-grouse from pre-settlement times is unclear as estimates of greater sage-grouse abundance were mostly anecdotal prior to the implementation of systematic surveys in the 1950s (Braun 1998).

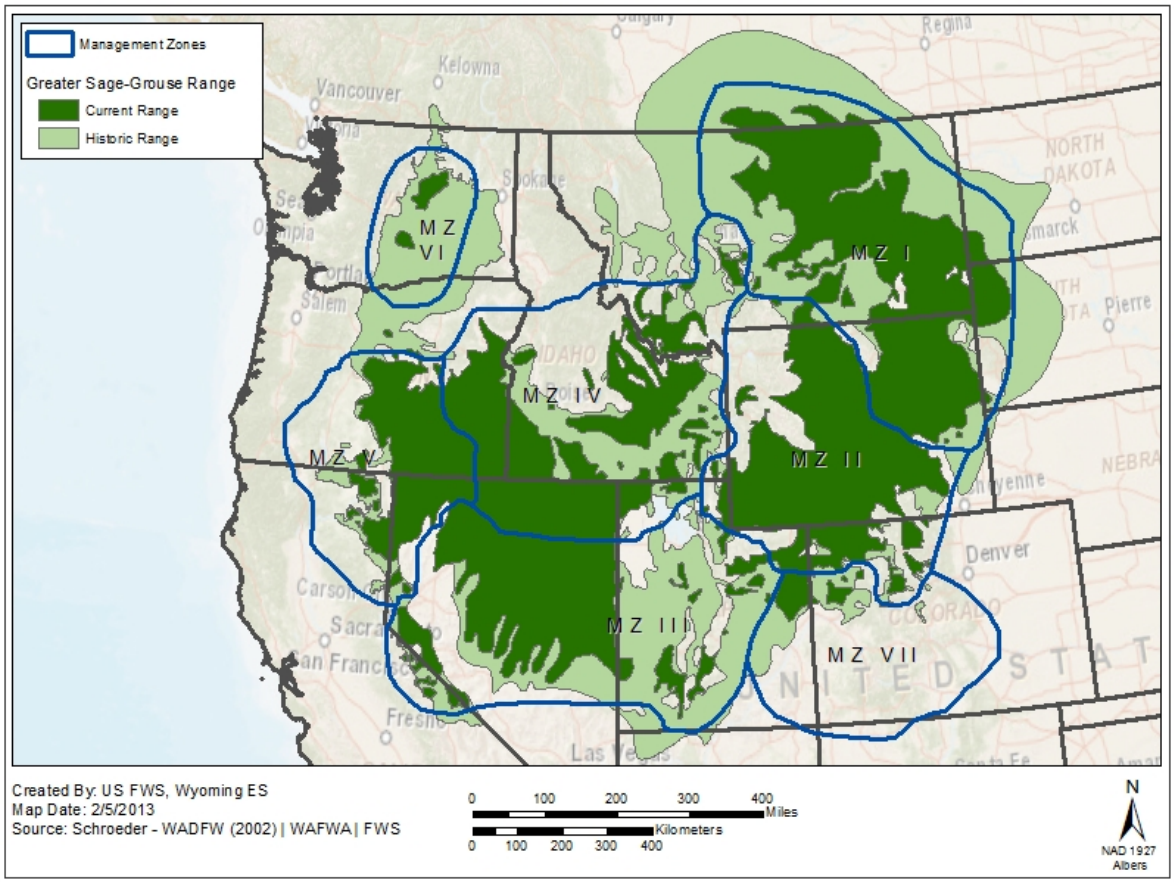

Figure 1. The current (occupied since the late 1990s) and historic (maximum distribution from the 1800s to early 1990s) range of the greater sage-grouse (Schroeder et al. 2004).

Sage-grouse depend on a variety of semiarid shrub-grassland (shrub steppe) habitats throughout their life cycle, and are considered obligate users of sagebrush (e.g., *Artemisia tridentata* ssp. *wyomingensis* (Wyoming big sagebrush), *A. t.* ssp. *vaseyana* (mountain big sagebrush), and *A. t. tridentata* (basin big sagebrush)) (Patterson 1952; Braun *et al.* 1976; Connelly *et al.* 2000;

Connelly *et al.* 2004; Miller *et al.* 2011). Sage-grouse also use other sagebrush species (which can be locally important) such as *A. arbuscula* (low sagebrush), *A. nova* (black sagebrush), *A. frigida* (fringed sagebrush), and *A. cana* (silver sagebrush) (Schroeder *et al.* 1999; Connelly *et al.* 2004). Sage-grouse distribution is strongly correlated with the distribution of sagebrush habitats (Schroeder *et al.* 2004; Connelly *et al*. 2011b). Sage-grouse exhibit strong site fidelity (loyalty to a particular area) to seasonal habitats (i.e., breeding, nesting, brood rearing, and wintering areas) (Connelly *et al.* 2004; Connelly *et al*. 2011a). Adult sage-grouse rarely switch from these habitats once they have been selected, limiting their ability to respond to changes in their local environments (Schroeder *et al*. 1999).

During the breeding season, in spring, male sage-grouse gather together to perform courtship displays on areas called leks. Leks are typically relatively bare areas, where males perform courtship displays to attract females, surrounded by a sagebrush-grassland, which is used for escape cover, nesting, and foraging. The proximity, configuration, and abundance of nesting habitat are key factors influencing lek locations (Connelly *et al.* 1981, Connelly *et al.* 2011a).

Productive nesting areas are typically characterized by sagebrush with an understory of native grasses and forbs, with horizontal and vertical structural diversity that provides an insect prey base, herbaceous forage for pre-laying and nesting hens, and cover for the hen while she is incubating (Gregg 1991; Schroeder *et al.* 1999; Connelly *et al.* 2000; Connelly *et al.* 2004; Connelly *et al.* 2011b). Shrub canopy and grass cover provide concealment for sage-grouse nests and young and are critical for reproductive success (Barnett and Crawford 1994; Gregg *et al.* 1994; DeLong *et al.*1995; Connelly *et al.* 2004). Because average clutch sizes is 7 eggs (Connelly *et al.* 2011a), and sage-grouse exhibit limited re-nesting, there is little evidence that populations of sage-grouse produce large annual surpluses (Connelly *et al.* 2011a).

Most sage-grouse gradually move from sagebrush uplands to more mesic areas (moist areas, such as streambeds or wet meadows) during the late brood-rearing period (three weeks post-hatch) in response to summer desiccation of herbaceous vegetation in the sagebrush uplands (Connelly *et al.* 2000). Summer use areas can include sagebrush habitats as well as riparian areas, wet meadows and alfalfa fields (Schroeder *et al.* 1999). These areas provide an abundance of forbs and insects for both hens and chicks (Schroeder *et al.* 1999; Connelly *et al.* 2000). This is important because forbs and insects are essential nutritional components for chicks (Klebenow and Gray 1968; Johnson and Boyce 1991; Connelly *et al.* 2004; Thompson *et al*. 2006). Late brood-rearing habitats are often associated with sagebrush, but selection is based on the availability of forbs, correlating with a shift in the diet of chicks as they mature (Connelly *et al*. 1988, and references therein; Connelly *et al.* 2011b). As vegetation continues to desiccate through the late summer and fall, sage-grouse shift their diet entirely to sagebrush (Schroeder *et al.* 1999) and depend entirely on sagebrush throughout the winter for both food and cover (Schroeder *et al*. 1999).

Many sage-grouse move between seasonal ranges in response to habitat distribution (Connelly *et al.* 2004; Fedy *et al*. 2012). Movement can occur between winter, breeding, and summer areas; between breeding, summer and winter areas; or, not at all. Movement distances of up to 161 km (100 mi) have been recorded (Patterson 1952; Tack *et al.* 2011; Smith 2013); however,

distances vary depending on the locations of seasonal habitats (Schroeder *et al.* 1999). Information regarding the distribution and characteristics of movement corridors for sage-grouse is very limited (Connelly *et al.* 2004); although, in a few areas monitoring of radio-collared birds has provided some insights into seasonal movement patterns (e.g., Smith 2013). These movement corridors are considered "traditional", as birds do not always select the most proximal habitats (Connelly *et al.* 1988; Connelly *et al*. 2011a). Sage-grouse dispersal (permanent moves to other areas) is poorly understood (Connelly *et al.* 2004) and appears to be sporadic (Dunn and Braun 1986).

Sage-grouse are dependent on large areas of contiguous sagebrush (Patterson 1952; Connelly *et al.* 2004; Connelly *et al.* 2011a; Wisdom *et al.* 2011). Large-scale disturbances (e.g., agricultural conversions) within surrounding landscapes influence sage-grouse habitat selection (Knick and Hanser 2011) and population persistence (Aldridge *et al*. 2008; Wisdom *et al*. 2011). Sagebrush is the most widespread vegetation in the intermountain lowlands of the western United States (West and Young 2000); however, sagebrush is considered one of the most imperiled ecosystems in North America due to continued degradation and lack of protection (Knick *et al.* 2003; Miller *et al.* 2011, and references therein). Not all sagebrush provides suitable habitat for sage-grouse due to fragmentation and degradation (Schroeder *et al.* 2004). Sage-grouse avoid areas where humans have caused sagebrush fragmentation, but not naturally fragmented landscapes (Leu and Hanser 2011). Very little extant sagebrush is undisturbed, with up to 50 to 60 percent having altered understories or having been lost to direct conversions (Knick *et al.* 2003).

Sagebrush is long-lived, with plants of some species surviving at least 150 years (West 1983). Sagebrush has resistance to environmental extremes, with the exception of fire and occasionally defoliating insects (e.g., webworm (*Aroga* spp.); West 1983). Most species of sagebrush are killed by fire (West 1983; Miller and Eddleman 2000; West and Young 2000), and historic fire-return intervals have been as long as 350 years, depending on sagebrush type and environmental conditions (Baker 2011). Natural sagebrush re-colonization in burned areas depends on the presence of adjacent live plants for a seed source or on the seed bank (Miller and Eddleman 2000), and requires decades for full recovery. Due to its low intrinsic resistance to fire and long recovery times, the sagebrush ecosystem is particularly susceptible to increases in fire return intervals.

There is little information available regarding minimum sagebrush patch size required to support populations of sage-grouse. This is due in part to the migratory nature of some, but not all sage-grouse populations; the lack of proximal seasonal habitats; and differences in local, regional and range-wide ecological conditions that influence the distribution of sagebrush and its associated understory. Where home ranges have been reported (Connelly *et al.* 2011a and references therein), they are extremely variable (4 to 615 km^2 (1.5 to 237.5 mi^2)). Home range occupancy is related to multiple variables associated with both local vegetation characteristics and landscape characteristics (Knick *et al.* 2003; Leu and Hanser 2011). Pyke (2011) estimated that greater than 4,000 ha (9,884 ac) was necessary for population sustainability; however, Pyke did not indicate whether this value considered groups of birds that moved long distances between seasonal habitats versus those who can meet all necessary seasonal requirements within a local area, nor if this included juxtaposition of all seasonal habitats. Large seasonal and annual

movements emphasize the need for large, functional landscapes to support viable sage-grouse populations (Knick *et al.* 2003; Connelly *et al.* 2011a).

3. SUMMARY OF THREATS

The following is a brief overview of the threats to sage-grouse and sagebrush habitats. For a more complete discussion, the reader is referred to the FWS 2010 warranted but precluded finding for this species (75 FR 13910).

The loss and fragmentation of sagebrush habitats is a primary cause of the decline of sage-grouse populations (Patterson 1952; Connelly and Braun 1997; Braun 1998; Johnson and Braun 1999; Connelly *et al*. 2000; Miller and Eddleman 2000; Schroeder and Baydack 2001; Johnsgard 2002; Aldridge and Brigham 2003; Beck *et al*. 2003; Pedersen *et al*. 2003; Connelly *et al.* 2004; Schroeder *et al*. 2004; Leu and Hanser 2011; 75 FR 13910). Habitat fragmentation, largely a result of human activities, can result in reductions in lek persistence, lek attendance, population recruitment, yearling and adult annual survival, female nest site selection, nest initiation, and complete loss of leks and winter habitat (Holloran 2005; Aldridge and Boyce 2007; Walker *et al.* 2007; Doherty *et al*. 2008). Functional habitat loss also contributes to habitat fragmentation, as greater sage-grouse avoid areas due to human activities, including noise, even though sagebrush remains intact (Blickley *et al*. 2012). In an analysis of population connectivity, Knick and Hanser (2011) demonstrated that in some areas of the sage-grouse's range, populations are already isolated and at risk for extirpation due to genetic, demographic, and stochastic (i.e., unpredictable) events such as lightning caused wildfire. Habitat loss and fragmentation contribute to the population's isolation and increased risk of extirpation.

Very little sagebrush within the range of the sage-grouse remains undisturbed or unaltered from its condition prior to Euro American settlement in the 1800s (Knick *et al*. 2003, and references therein). Disturbed or altered habitats have less resilience than intact habitats. Due to the disruption of primary patterns, processes and components of sagebrush ecosystems since Euro American settlement (Knick *et al.* 2003; Miller *et al*. 2011), the large range of abiotic variation, the minimal short-lived seed banks, and the long generation time of sagebrush, restoration of disturbed areas is very difficult. Not all areas previously dominated by sagebrush can be restored because alteration of vegetation, nutrient cycles, topsoil, and living (cryptobiotic) soil crusts has exceeded recovery thresholds (Knick *et al*. 2003; Pyke 2011). Additionally, processes to restore healthy native sagebrush communities are relatively unknown (Knick *et al*. 2003). Active restoration activities are often limited by financial and logistic resources (Knick *et al*. 2003; Miller *et al*. 2011) and may require decades or centuries (Knick *et al.* 2003, and references therein). Landscape restoration efforts require a broad range of partnerships (private, state, and federal) due to landownership patterns (Knick *et al*. 2003). Except for areas where active restoration is attempted following disturbance (e.g., mining, wildfire), management efforts in sagebrush ecosystems are usually focused on maintaining the remaining sagebrush (Miller *et al*. 2011; Wisdom *et al*. 2011).

Fire is one of the primary factors linked to loss of sagebrush-steppe habitat and corresponding population declines of greater sage-grouse (Connelly and Braun 1997; Miller and Eddleman 2001). Loss of sagebrush habitat to wildfire has been increasing in the western portion of the greater sage-grouse range due to an increase in fire frequency. The increase in mean fire frequency in sagebrush ecosystems has been facilitated by the incursion of nonnative annual grasses, primarily *Bromus tectorum* (cheatgrass) and *Taeniatherum asperum* (medusahead) (Billings 1994; Miller and Eddleman 2001). The positive feedback loop between exotic annual grasses and fires can preclude the opportunity for sagebrush to become re-established. Exotic annual grasses and other invasive plants also alter habitat suitability for sage-grouse by reducing or eliminating native forbs and grasses essential for food and cover. Annual grasses and noxious perennials continue to expand their range, facilitated by ground disturbances, including wildfire (Miller and Eddleman 2001; Balch *et al.* 2013), improper grazing (Young *et al*. 1972, 1976), agriculture (Benvenuti 2007), and infrastructure associated with energy development (Bergquist *et al*. 2007). Concern with habitat loss and fragmentation due to fire and invasive plants has mostly been focused in the western portion of the species' range. However, climate change may alter the range of invasive plants, potentially expanding the importance of this threat into other areas of the species' range.

Habitat loss is occurring from the expansion of native conifers (e.g., pinyon-pine (*Pinus edulis*) and juniper (*Juniperus* spp.) [pinyon-juniper]), mainly due to changes in fire return intervals and the overstocking of domestic livestock, particularly during the latter 1800's and early 1900's (Miller and Rose 1999); however, these factors may not entirely explain the expansion of western juniper (Soulé and Knapp 1999). Conifer encroachment may be facilitated by increases in global carbon dioxide (CO_2) concentrations, and climate change, but the influence of CO_2 has not been supported by some research (Archer *et al*. 1995).

Sage-grouse populations can be significantly reduced, and in some cases locally extirpated, by non-renewable energy development activities, even when mitigative measures are implemented (Walker *et al.* 2007). The persistent and increasing demand for energy resources is resulting in their continued development within sage-grouse range, and may cause further habitat fragmentation. Although data are limited, impacts resulting from renewable energy development are expected to have negative effects to sage-grouse populations and habitats due to their similarity in supporting infrastructure (Becker *et al.* 2009; Hagen 2010; LeBeau 2012; USFWS 2012). Both non-renewable and renewable energy developments are increasing within the range of sage-grouse, and this growth is likely to continue given current and projected demands for energy.

Other factors associated with habitat loss and fragmentation are summarized by Knick *et al.* (2011) and include conversion of sagebrush habitats for agriculture, the expanding human populations in the western United States and the resulting urban development in sagebrush habitats, vegetation treatments resulting in the alteration or removal of sagebrush to enhance grazing for livestock, and impacts from wild ungulates and free-roaming equids (horses and burros).

Other threats that can negatively affect sage-grouse include, but are not limited to, parasites, infectious diseases, predation, and weather events (e.g., drought or late spring storms). Some of these threats may be localized and of short duration, but may be significant at the local population and habitat level, particularly for small populations. An example of this local effect was the 2008 outbreak of West Nile virus (WNv) in the sage-grouse population of southwestern North Dakota. Having no resistance to this threat (Walker and Naugle 2011), sage-grouse population numbers in North Dakota dropped dramatically following the WNv outbreak. Four years later (2012), the population had improved but not fully recovered to levels seen before the outbreak (North Dakota Game and Fish Department, unpublished data).

Predation is often identified as a potential factor affecting sage-grouse populations, which is understandable given the suite of predators that prey on sage-grouse from egg to adulthood (though no predators specialize on sage-grouse). Predator management has been effective on local scales for short periods, but its efficacy over broad ranges or over long timespans has not been demonstrated (Hagen 2011a). In areas of compromised habitats and high populations of synanthropic predators (predators that live near, and benefit from, an association with humans), predator control may be effective to ensure sage-grouse persistence until habitat conditions improve.

Though threats such as infectious diseases and predation may be significant at a localized level, particularly if habitat quantity and quality is compromised, they were not identified by FWS as significant range-wide threats in our 2010 warranted finding (75 FR 13910).

The occurrence and importance of each of the above threats to sage-grouse varies across the species' range. For example, fire and invasive weeds are the primary issue in the western portion of the species' range, while non-renewable energy development affects primarily the eastern portion of the species' range (75 FR 13910). However, no part of the species' range is immune from any of the primary threats described above. Additionally, the impact of threats on local sage-grouse populations likely varies based on the resilience of that population and its associated habitats. Healthy, robust sagebrush and seasonal habitats and associated sage-grouse populations with few or no other threats are likely to be more resilient than habitats already experiencing a high level of threats, or in poor condition. Natural conditions, such as long-term drought, can also affect habitat and population resilience. To capture the variability in threats and population resilience across the range of the sage-grouse we assessed threats to each population (see section 4, below).

The lack of sufficient regulatory mechanisms to conserve sage-grouse and their habitats was identified as a primary threat leading to our warranted but precluded finding in 2010 (75 FR 13910). While specific regulatory mechanisms are not addressed in this report, federal land management agencies, and many state and local governments across the species' range are working to develop adequate mechanisms to address this threat. For example, Wyoming's Governor Dave Freudenthal was among the first to enact regulatory mechanisms to protect core sage-grouse areas through Executive Order 2010-4. Governor Matt Mead signed an updated version of the Sage-Grouse Core Area Protection Executive Order in 2011 (Executive Order 2011-5). The Wyoming Executive Orders apply to all regulatory actions governed by the State

of Wyoming, and as such, constitute substantial regulatory mechanisms that contribute to the conservation of sage-grouse. These efforts demonstrate the potential for successfully ameliorating the primary threats to sage-grouse and their habitat through the development and implementation of sufficient regulatory mechanisms.

4. CONSERVATION FRAMEWORK

Our conservation framework consisted of (1) identifying sage-grouse population and habitat status and threats (**see Section 2 and 3**, above), (2) defining a broad conservation goal (see **Section 4.2 section**, below), (3) identifying priority areas for conservation (see **this section**, below), and (4) developing specific conservation objectives and measures (see **Section 4.3**, below). We used three parameters—population and habitat representation, redundancy, and resilience (Shaffer and Stein 2010, Redford *et al.* 2011)—as guiding concepts in developing our conservation goal, priority areas for conservation, conservation objectives, and measures.

4.1 Guiding Concepts – Redundancy, Representation, and Resilience

Redundancy is defined as multiple, geographically dispersed populations and habitats across a species' range, such that the loss of one population or one unit of habitat will not result in the loss of the species. Redundancy allows for a margin of safety for a species and/or its habitat to withstand threats, including unforeseen catastrophes.

Representation is defined as the retention of genetic, morphological, physiological, behavioral, habitat, or ecological diversity of the species so its adaptive capabilities are conserved.

Resilience is defined as the ability of the species and/or its habitat to recover from disturbances. In general species are likely to be more resilient if large populations exist in large blocks of high quality habitat across the full breadth of environmental variability to which the species is adapted (Redford *et al*. 2011).

Redundancy, representation, and resilience were examined with respect to sage-grouse populations and their habitat. Populations are defined as a group of individuals occupying an area of sufficient size to permit normal dispersal and/or migration behavior in which numerical changes are largely determined by birth and death processes (Berryman 2002). Sage-grouse populations followed those identified in Garton *et al.* (2011), with the exception of Utah where populations were refined based on local population data provided by the State of Utah.

For sage-grouse, retaining redundancy, representation, and resilience means having multiple and geographically distributed sage-grouse populations across the species' ecological niche and geographic range. Large populations distributed across large areas are generally less vulnerable to extinction than small populations (Soulé 1987, Shaffer and Stein 2010). By conserving well distributed sage-grouse populations across geographic and ecological gradients, species adaptive

traits can be preserved, and populations can be maintained at levels that make sage-grouse more resilient in the face of catastrophes or environmental change.

4.2 Conservation Goal

We defined our conservation goal as the long-term conservation of sage-grouse and healthy sagebrush shrub and native perennial grass and forb communities by maintaining viable, connected, and well-distributed populations and habitats across their range, through threat amelioration, conservation of key habitats, and restoration activities.

4.3 Priority Areas for Conservation

Effective conservation strategies are predicated on identifying key areas across the landscape that are necessary to maintain redundant, representative, and resilient populations. Fortunately, most of the individual states within the range of sage-grouse have already undertaken considerable efforts to identify and map key habitats necessary for sage-grouse conservation in the development of their state management plans for this species. We used these existing maps to identify the most important areas needed for maintaining sage-grouse representation, redundancy, and resilience across the landscape. These areas were named *Priority Areas for Conservation* (PACs) (Figure 2).

Although different techniques and processes were used across states to identify PACs, all used relatively similar population- and habitat-based data sources (Table 1).

Where PACs did not match at state boundaries efforts were made to resolve discrepancies. Most of the discrepancies were the result of mapping errors that were subsequently resolved, management differences that followed state boundaries due to differing regulatory mechanisms, or land ownership patterns between two states. Unresolved boundary concerns are being actively addressed by the states and PAC boundaries will be amended as these discrepancies are resolved.

There is substantial overlap between our PAC map and the preliminary priority habitat maps BLM developed for their range-wide Resource Management Plan revisions. This is because both efforts used maps provided by the states. The primary differences are in Nevada and Utah, where the map developed by these states does not exactly match the preliminary BLM planning map. Where there were unresolved differences, we used state maps to identify PACs, as states have the most complete local information of sage-grouse distribution and habitat use.

PACs do not represent individual populations, but rather key areas that states have identified as crucial to ensure adequate representation, redundancy, and resilience for conservation of its associated population or populations. Additional finer scale planning efforts by states may determine that additional areas outside of PACs are also essential.

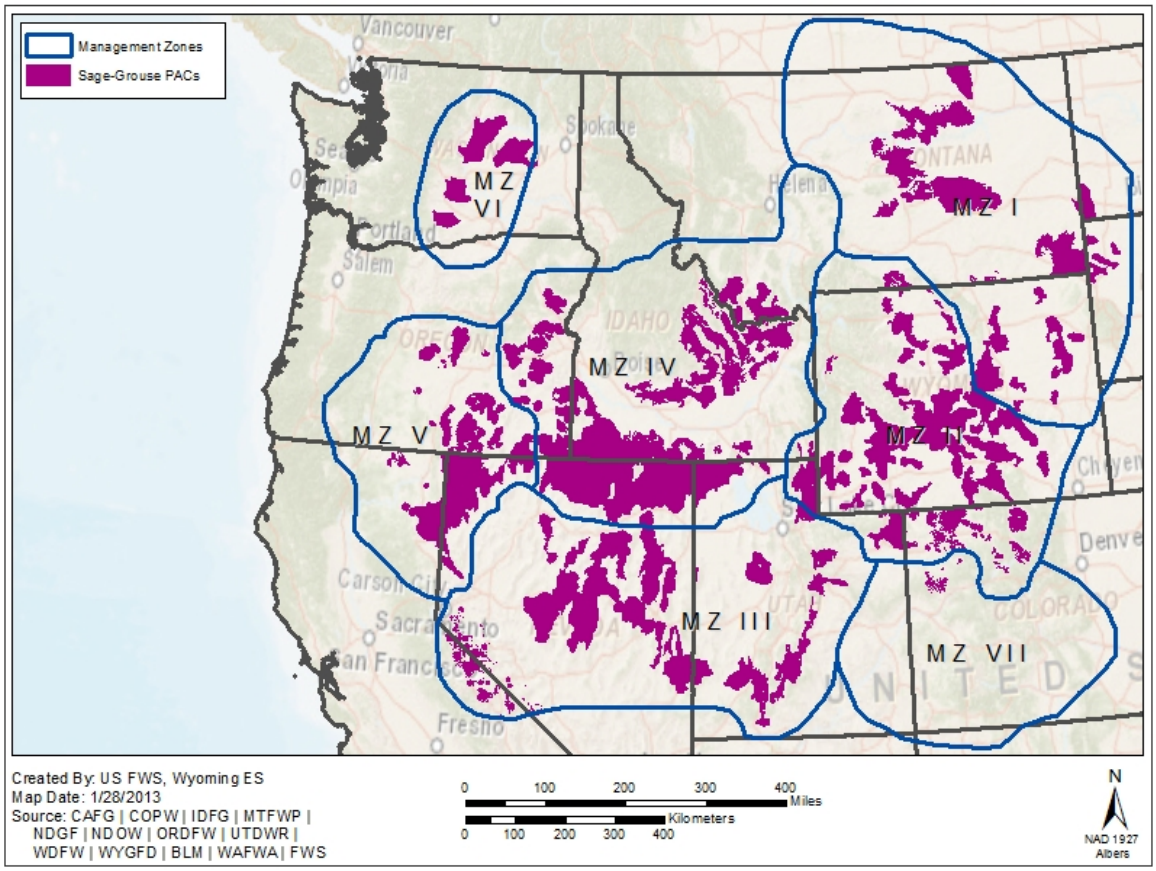

Figure 2. Sage-grouse management zones (Stiver *et al*. 2006) and Priority Areas for Conservation (PACs).

To capture the variability in threats and population resilience across the range of the sage-grouse we assessed the presence of threats to each population (Table 2) based on known occurrence of threats, existing management strategies, and professional experience. Not all threats or conservation needs are known with certainty. Areas of uncertainty include the effects of climate change and renewable energy development, the lack of robust information on population connectivity, the relationship between specific habitat characteristics and demographic parameters, and the lack of understanding of the processes necessary to restore sagebrush communities (Knick *et al*. 2003). These uncertainties do not undermine the foundation of PACs as crucial building blocks of a successful conservation strategy, but mean that some flexibility in our strategy will be necessary to retain options for the long-term conservation of the sage-grouse as new information becomes available.

Table 1. Sources of data used by states to develop Priority Areas for Conservation (PAC) maps for each state.

	CA	CO	ID	MT	ND	NV	OR	SD	UT	WA	WY
Population Based Data											
BBD/Lek Counts[a]	X	X	X	X	X	X	X		X	X	X
Telemetry	X	X	X	X		X	X	X	X	X	X
Nesting Areas	X	X		X	X	X			X	X	X
Known Distribution	X	X	X	X	X		X			X	X
Sightings/ Observations		X	X	X		X		X	X	X	X
Habitat Distribution[b]											
	X	X	X	X	X	X	X	X	X	X	X

[a]Breeding Bird Density (BBD) based on male counts at leks (Doherty *et al.* 2010)
[b]Habitat data included occupied habitat, suitable habitat, seasonal habitat, nesting and brood rearing areas, and connectivity areas or corridors.

Table 2. Sage-grouse quasi-extinction risk (from Garton *et al.* 2011), and threats, by management zone and population. Populations are those defined by Garton *et al*. (2011), although in some cases sub-populations were identified to help refine threat characterization (see Figure 3). Population estimates and quasi-extinction risk estimates are from Garton *et al.* (2011). Threats are characterized as: Y = threat is present and widespread, L = threat present but localized, N = threat is not known to be present, and U = Unknown.

Population	Unit Number	Population Abundance and Estimated Quasi-extinction Risk					Management Zone	Threats												
		<200 Males/500 Birds	% Chance of <50 birds/ 20 males in 2037	% Chance of <500 birds/ 200 males in 2037	% Chance of <50 birds/ 20 males in 2107	% Chance of <500 birds/ 200 males in 2107		Isolated/Small Size	Sagebrush Elimination	Agriculture Conversion	Fire	Conifers	Weeds/Annual Grasses	Energy	Mining	Infrastructure	Grazing	Free-Roaming Equids	Recreation	Urbanization
Management Zone I: Great Plains			***9.5***	***11.1***	***22.8***	***24***														
Dakotas (*ND, SD*)	1	N	4.6	39.5	44.6	66.3	I	Y	L	L	Y	U	L	Y	Y	Y	L	N	N	N
Northern Montana (*MT*)	2	N	0	0	0.2	2.0	I	N	L	L	L	N	L	Y	N	Y	Y	N	L	N
Powder River Basin (*WY*)	3	N	2.9	16.5	85.7	86.2	I	N	L	N	L	L	Y	Y	Y	Y	Y	N	Y	L

Population	Unit Number	Population Abundance and Estimated Quasi-extinction Risk					Management Zone	Threats												
		<200 Males/500 Birds	% Chance of <50 birds/ 20 males in 2037	% Chance of <500 birds/ 200 males in 2037	% Chance of <50 birds/ 20 males in 2107	% Chance of <500 birds/ 200 males in 2107		Isolated/Small Size	Sagebrush Elimination	Agriculture Conversion	Fire	Conifers	Weeds/Annual Grasses	Energy	Mining	Infrastructure	Grazing	Free-Roaming Equids	Recreation	Urbanization
Yellowstone Watershed (*MT*)	4	N	0	8.1	55.6	59.8	I	N	L	Y	L	L	Y	Y	N	Y	Y	N	L	N
Management Zone II: Wyoming Basin			***0.1***	***0.3***	***16.1***	***16.2***														
Eagle-South Routt (*CO*)	5	Y	ND	ND	ND	ND	II	Y	L	Y	L	L	Y	Y	N	Y	Y	N	L	Y
Middle Park (*CO*)	6	N	2.5	100	7.1	100	II	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y
Laramie (*WY, CO*)	7	N	ND	ND	ND	ND	II	Y	N	N	Y	Y	Y	Y	U	Y	Y	N	Y	Y

Population	Unit Number	Population Abundance and Estimated Quasi-extinction Risk					Management Zone	Threats												
		<200 Males/500 Birds	% Chance of <50 birds/ 20 males in 2037	% Chance of <500 birds/ 200 males in 2037	% Chance of <50 birds/ 20 males in 2107	% Chance of <500 birds/ 200 males in 2107		Isolated/Small Size	Sagebrush Elimination	Agriculture Conversion	Fire	Conifers	Weeds/Annual Grasses	Energy	Mining	Infrastructure	Grazing	Free-Roaming Equids	Recreation	Urbanization
Jackson Hole (*WY*)	8	Y	11.2	100	27.3	100	II	Y	L	N	L	L	Y	N	N	N	N	N	Y	L
Wyoming Basin (*WY portion*)	9a	N	0.0	0.0	9.9	10.7	II	N	L	N	L	L	L	Y	L	Y	Y	L	Y	L
Rich-Morgan -Summit (*WY Basin in UT*)[1]	9b	N					II	N	N	N	Y	Y	Y	Y	N	Y	N	N	Y	Y
Uintah (*WY Basin in UT*)	9c	N					II	N	N	N	Y	Y	Y	L	Y	Y	N	N	Y	Y

Population	Unit Number	Population Abundance and Estimated Quasi-extinction Risk					Management Zone	Threats												
		<200 Males/500 Birds	% Chance of <50 birds/ 20 males in 2037	% Chance of <500 birds/ 200 males in 2037	% Chance of <50 birds/ 20 males in 2107	% Chance of <500 birds/ 200 males in 2107		Isolated/Small Size	Sagebrush Elimination	Agriculture Conversion	Fire	Conifers	Weeds/Annual Grasses	Energy	Mining	Infrastructure	Grazing	Free-Roaming Equids	Recreation	Urbanization
N. Park (*WY Basin in CO*)	9d	N					II	N	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y
NWCO (*WY Basin in CO*)	9e	N					II	N	L	Y	Y	L	Y	Y	Y	Y	Y	L	Y	L
Management Zone III: Southern Great Basin[2]			***0.0***	***0.0***	***6.5***	***7.8***														
Strawberry Valley (*Part of NE Interior UT*)	10a	Y	0.8	51.8	8.8	78.6	III	Y	N	N	Y	Y	Y	Y	N	Y	N	N	Y	N
Carbon (*Part of NE interior UT*)	10b	Y					III	Y	N	N	Y	N	Y	Y	Y	Y	N	N	Y	N

Population	Unit Number	Population Abundance and Estimated Quasi-extinction Risk					Management Zone	Threats												
		<200 Males/500 Birds	% Chance of <50 birds/ 20 males in 2037	% Chance of <500 birds/ 200 males in 2037	% Chance of <50 birds/ 20 males in 2107	% Chance of <500 birds/ 200 males in 2107		Isolated/Small Size	Sagebrush Elimination	Agriculture Conversion	Fire	Conifers	Weeds/Annual Grasses	Energy	Mining	Infrastructure	Grazing	Free-Roaming Equids	Recreation	Urbanization
Sheeprock (*UT*, aka *Tooele-Juab Counties*)	11	Y	56.5	100	100	100	III	Y	N	N	Y	L	L	Y	Y	L	N	Y	L	N
Emery (*UT, aka Sanpete-Emery Counties*)	12	Y	77.7	100	99.2	100	III	Y	N	N	Y	Y	Y	Y	Y	Y	N	N	Y	N
Greater Parker Mt. (*Part of South Central UT*)	13a	N	0.0	3.2	1.1	21.0	III	N	N	N	Y	Y	Y	N	N	Y	N	N	Y	N

Population	Unit Number	Population Abundance and Estimated Quasi-extinction Risk					Management Zone	Threats												
		<200 Males/500 Birds	% Chance of <50 birds/ 20 males in 2037	% Chance of <500 birds/ 200 males in 2037	% Chance of <50 birds/ 20 males in 2107	% Chance of <500 birds/ 200 males in 2107		Isolated/Small Size	Sagebrush Elimination	Agriculture Conversion	Fire	Conifers	Weeds/Annual Grasses	Energy	Mining	Infrastructure	Grazing	Free-Roaming Equids	Recreation	Urbanization
Panguitch *(Part of South Central UT)*	13b	N					III	N	N	Y	Y	Y	Y	Y	L	Y	N	N	Y	L
Bald Hills *(Part of South Central UT)*	13c	Y					III	Y	N	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
Northwest Interior (*NV*)	14	N	ND	ND	ND	ND	III	Y	N	N	Y	N	Y	U	Y	Y	Y	Y	Y	N
Ibapah (*UT part of Southern Great Basin*)	15a	Y	0.0	2.0	4.2	78.0	III	Y	N	N	Y	Y	Y	Y	Y	Y	N	Y	Y	N

Population	Unit Number	Population Abundance and Estimated Quasi-extinction Risk					Management Zone	Threats												
		<200 Males/500 Birds	% Chance of <50 birds/ 20 males in 2037	% Chance of <500 birds/ 200 males in 2037	% Chance of <50 birds/ 20 males in 2107	% Chance of <500 birds/ 200 males in 2107		Isolated/Small Size	Sagebrush Elimination	Agriculture Conversion	Fire	Conifers	Weeds/Annual Grasses	Energy	Mining	Infrastructure	Grazing	Free-Roaming Equids	Recreation	Urbanization
Hamlin Valley (*UT part of Southern Great Basin*)	15b	Y					III	Y	N	N	Y	Y	Y	N	N	Y	N	Y	Y	N
Southern Great Basin (*NV portion*)	15c	N					III	L	L	L	Y	Y	Y	L	L	Y	Y	Y	Y	N
Quinn Canyon Range (*NV*)	16	Y	ND	ND	ND	ND	III	Y	N	N	Y	Y	Y	N	N	Y	Y	Y	Y	N
Management Zone IV: Snake River Plains			***2.3***	***10.5***	***19.4***	***39.7***														
Baker (*OR*)	17	N	61.9	100	66.8	100	IV	Y	Y	Y	Y	L	Y	L	Y	L	U	N	L	L

Population	Unit Number	Population Abundance and Estimated Quasi-extinction Risk					Management Zone	Threats												
		<200 Males/500 Birds	% Chance of <50 birds/ 20 males in 2037	% Chance of <500 birds/ 200 males in 2037	% Chance of <50 birds/ 20 males in 2107	% Chance of <500 birds/ 200 males in 2107		Isolated/Small Size	Sagebrush Elimination	Agriculture Conversion	Fire	Conifers	Weeds/Annual Grasses	Energy	Mining	Infrastructure	Grazing	Free-Roaming Equids	Recreation	Urbanization
East Central (*ID*)	18	Y	ND	ND	ND	ND	IV	Y	L	Y	L	Y	L	Y	N	Y	Y	N	L	N
Southwest Montana (*Bannack, Red Rocks, Wisdom, and Bridges*)	19-22	N	Bannack: 6.4 Red Rock: 0.1	Bannack: 70.2 Red Rock: 55.3	Bannack: 32.7 Red Rock: 2.5	Bannack: 97.7 Red Rock: 91.9	IV	N	L	N	L	L	Y	L	L	L	Y	N	L	L
Snake-Salmon-Beaverhead (*ID*)	23	N	4.2	10.2	19.3	26.8	IV	N	L	L	Y	L	Y	Y	N	L	Y	Y	L	N
Belt Mountains (*MT*)	24	Y	ND	ND	ND	ND	IV	Y	L	Y	L	L	Y	L	N	L	Y	N	L	L

Population	Unit Number	Population Abundance and Estimated Quasi-extinction Risk					Management Zone	Threats												
		<200 Males/500 Birds	% Chance of <50 birds/ 20 males in 2037	% Chance of <500 birds/ 200 males in 2037	% Chance of <50 birds/ 20 males in 2107	% Chance of <500 birds/ 200 males in 2107		Isolated/Small Size	Sagebrush Elimination	Agriculture Conversion	Fire	Conifers	Weeds/Annual Grasses	Energy	Mining	Infrastructure	Grazing	Free-Roaming Equids	Recreation	Urbanization
Weiser (*ID*)	25	N	ND	ND	ND	ND	IV	Y	L	L	L	L	Y	Y	N	L	Y	N	L	L
Northern Great Basin (*OR, ID, NV portion*)	26a	N	2.1	2.5	2.5	99.7	IV	N	L	L	Y	Y	Y	L	L	Y	Y	L	Y	Y
Box Elder (*UT portion of Northern Great Basin*)	26b	N					IV	N	N	Y	Y	Y	Y	L	Y	Y	N	N	Y	N
Sawtooth (*ID*)	27	Y	ND	ND	ND	ND	IV	Y	L	N	L	U	L	N	N	Y	Y	N	L	N

Population	Unit Number	Population Abundance and Estimated Quasi-extinction Risk					Management Zone	Threats												
		<200 Males/500 Birds	% Chance of <50 birds/ 20 males in 2037	% Chance of <500 birds/ 200 males in 2037	% Chance of <50 birds/ 20 males in 2107	% Chance of <500 birds/ 200 males in 2107		Isolated/Small Size	Sagebrush Elimination	Agriculture Conversion	Fire	Conifers	Weeds/Annual Grasses	Energy	Mining	Infrastructure	Grazing	Free-Roaming Equids	Recreation	Urbanization
Management Zone V: Northern Great Basin			*1.0*	*2.1*	*7.2*	*29*														
Central Oregon (*OR*)	28	N	4.2	15.2	74.9	91.3	V	N	L	L	Y	Y	Y	L	Y	L	Y	U	L	L
Klamath (*OR, CA*	29	Y	ND	ND	100	100	V	Y	U	U	Y	Y	Y	L	N	U	U	U	U	U
Warm Springs Valley (*NV*)	30	Y	ND	ND	ND	ND	V	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y

Population	Unit Number	Population Abundance and Estimated Quasi-extinction Risk					Management Zone	Threats												
		<200 Males/500 Birds	% Chance of <50 birds/ 20 males in 2037	% Chance of <500 birds/ 200 males in 2037	% Chance of <50 birds/ 20 males in 2107	% Chance of <500 birds/ 200 males in 2107		Isolated/Small Size	Sagebrush Elimination	Agriculture Conversion	Fire	Conifers	Weeds/Annual Grasses	Energy	Mining	Infrastructure	Grazing	Free-Roaming Equids	Recreation	Urbanization
Western Great Basin (*OR, CA, NV*)	31	N	5.5	6.4	6.4	99.1	V	N	L	L	Y	Y	Y	L	L	L	Y	Y	U	N
Management Zone VI: Columbia Basin			***12.4***	***76.2***	***62.1***	***86.3***														
Moses Coulee (*WA*)	32a	N	9.8	87.6	62.4	99.8	VI	Y	Y	Y	L	N	Y	Y	N	Y	Y	N	Y	Y
Crab Creek (*WA*)	32b	Y	ND	ND	ND	ND	VI	Y	Y	Y	Y	L	Y	Y	N	Y	Y	N	Y	L

Population	Unit Number	Population Abundance and Estimated Quasi-extinction Risk					Management Zone	Threats												
		<200 Males/500 Birds	% Chance of <50 birds/ 20 males in 2037	% Chance of <500 birds/ 200 males in 2037	% Chance of <50 birds/ 20 males in 2107	% Chance of <500 birds/ 200 males in 2107		Isolated/Small Size	Sagebrush Elimination	Agriculture Conversion	Fire	Conifers	Weeds/Annual Grasses	Energy	Mining	Infrastructure	Grazing	Free-Roaming Equids	Recreation	Urbanization
Yakama Indian Nation (*WA*)	33a	Y	ND	ND	ND	ND	VI	Y	N	N	Y	N	Y	Y	N	Y	Y	Y	Y	L
Yakima Training Center (*WA*)	33b	Y	26.1	100	50.4	100	VI	Y	N	L	Y	N	Y	N	N	Y	Y	N	Y	N
Management Zone VII: Colorado Plateau			***0.0***	***95.6***	***5.1***	***98.4***														
Parachute-Piceance-Roan Basin (CO)	34	Y	ND	ND	ND	ND	VII	Y	L	N	Y	Y	L	Y	Y	Y	Y	Y	N	N

Population	Unit Number	Population Abundance and Estimated Quasi-extinction Risk					Management Zone	Threats												
		<200 Males/500 Birds	% Chance of <50 birds/ 20 males in 2037	% Chance of <500 birds/ 200 males in 2037	% Chance of <50 birds/ 20 males in 2107	% Chance of <500 birds/ 200 males in 2107		Isolated/Small Size	Sagebrush Elimination	Agriculture Conversion	Fire	Conifers	Weeds/Annual Grasses	Energy	Mining	Infrastructure	Grazing	Free-Roaming Equids	Recreation	Urbanization
Meeker-White River (*CO*)	35	Y	ND	ND	ND	ND	VII	Y	Y	Y	Y	N	L	Y	Y	Y	Y	N	N	Y
Bi-State Distinct Population Segment																				
North Mono Lake (*CA, NV*)	36	N	15.4	100	37.9	100	III	Y	L	Y	Y	Y	Y	L	Y	Y	Y	Y	Y	Y
South Mono Lake (*CA*)	37	N	0.1	81.5	0.6	99.9	III	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y
Pine Nut (*NV*)	38	Y	ND	ND	ND	ND	III	Y	L	U	Y	Y	Y	N	L	Y	Y	Y	Y	Y

Population	Unit Number	Population Abundance and Estimated Quasi-extinction Risk					Management Zone	Threats												
		<200 Males/500 Birds	% Chance of <50 birds/ 20 males in 2037	% Chance of <500 birds/ 200 males in 2037	% Chance of <50 birds/ 20 males in 2107	% Chance of <500 birds/ 200 males in 2107		Isolated/Small Size	Sagebrush Elimination	Agriculture Conversion	Fire	Conifers	Weeds/Annual Grasses	Energy	Mining	Infrastructure	Grazing	Free-Roaming Equids	Recreation	Urbanization
White Mountains (*CA, NV*)	39	Y	ND	ND	ND	ND	III	Y	L	Y	Y	Y	Y	N	N	Y	Y	Y	U	Y

[1] This UT management area includes Summit-Morgan Counties, which is described separately by Garton *et al.* (2011) as a subpopulation in Management Zone III. Numbers for columns 4-7 for this population are 20.6, 100, 41.8, and 100, respectively (Garton *et al.* 2011).

[2] Percentages reported in this zone by Garton *et al.* (2011) include information for North and South Mono Lake, which are separately described in the Bi-State section of this table.

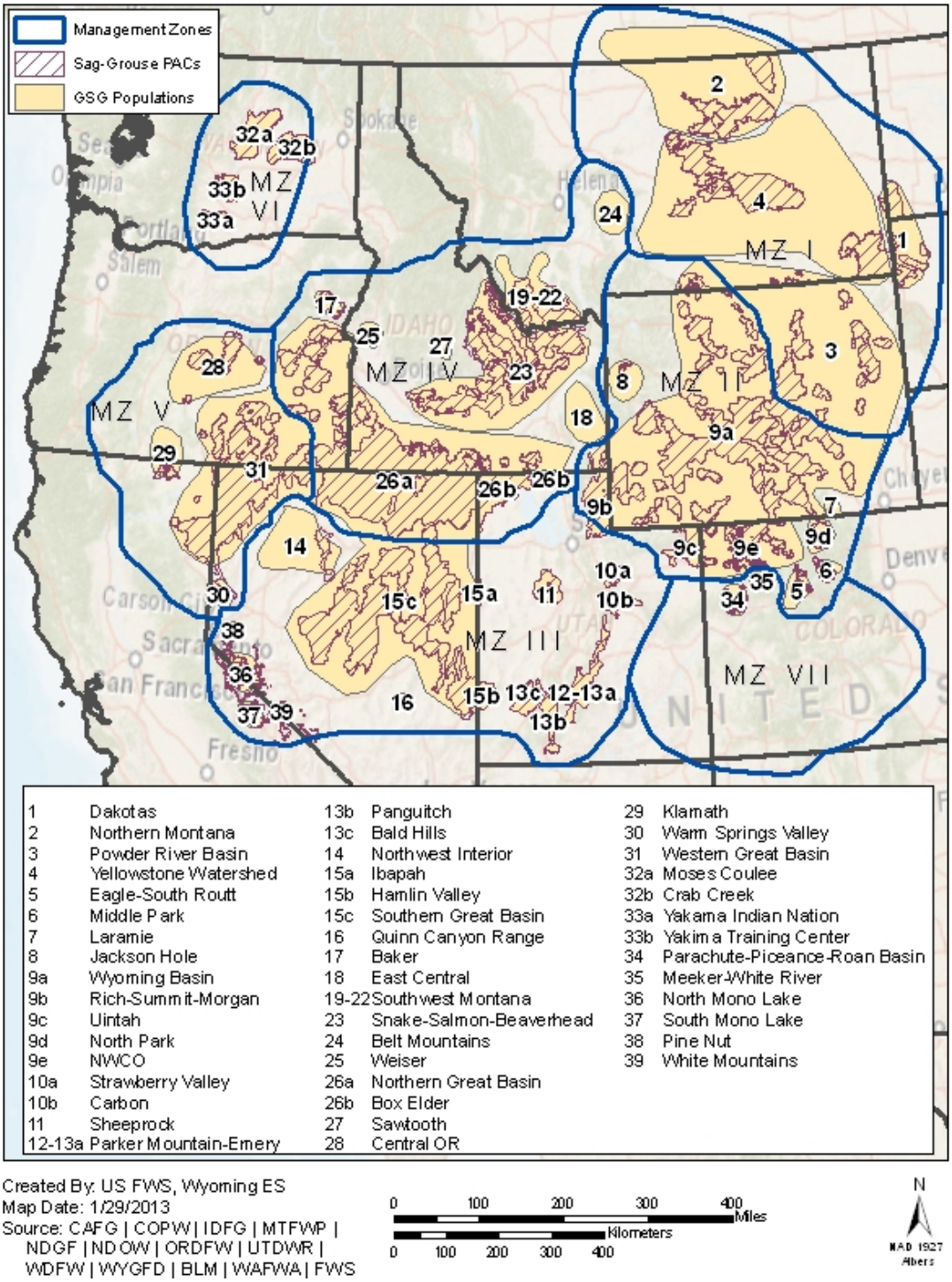

Figure 3. Sage-grouse management zones (Stiver *et al.* 2006), populations (adapted from Garton *et al.* 2011), and Priority Areas for Conservation (PACs; see Section 4.3). Threats to the populations identified here are described in Table 2.

5. CONSERVATION OBJECTIVES

The conservation objectives identified below are targeted at maintaining redundant, representative, and resilient sage-grouse habitats and populations. Due to the variability in ecological conditions and the nature of the threats across the range of the sage-grouse, developing detailed, prescriptive species or habitat actions is not possible at the range-wide scale. Specific strategies or actions necessary to achieve the following conservation objectives must be developed and implemented at the state or local level, with the involvement of all stakeholders.

In developing conservation objectives for the sage-grouse we identified the following uncertainties that limit our ability to prescribe a precise level of threat amelioration needed to conserve redundancy, representation and resilience to ensure long-term conservation of sage-grouse, especially on a range-wide level:

1. The lack of robust, range-wide genetics-based connectivity analyses;

2. The ability to successfully restore lower-elevation and weed-infested habitats is currently limited by a lack of complete understanding of underlying ecological processes, and in some areas because alteration of vegetation, nutrient cycles, topsoil, and living (cryptobiotic) soil crusts has exceeded recovery thresholds (Knick *et al*. 2003; Pyke 2011). Additionally, resources for restoration activities are often limited; and,

3. The effect of climate change on the amount and distribution of future habitat is largely unknown.

In light of these significant uncertainties, impacts to sage-grouse and their habitats should be avoided to the maximum extent possible to retain conservation options. This approach will ensure that potentially unidentified key components to long-term viability of sage-grouse are not lost, and that management flexibility and the ability to implement management changes will be retained as current information gaps are filled. Implementing an avoidance first strategy should reduce or avoid continuing declines of sage-grouse populations and habitats, as well as limit further reduction in management and restoration options. When avoidance is not possible, meaningful minimization and mitigation of the impacts should be implemented, along with a monitoring program to evaluate the efficacy of these measures. Conservation measures should be adapted to maximize effectiveness as new knowledge is obtained.

General Conservation Objectives

1. *Stop population declines and habitat loss.* There is an urgent need to "stop the bleeding" of continued population declines and habitat losses by acting immediately to eliminate or reduce the impacts contributing to population declines and range erosion. There are no

populations within the range of sage-grouse that are immune to the threat of habitat loss and fragmentation.

a) Achieving this objective requires eliminating activities known to negatively impact sage-grouse and their habitats, or re-designing these activities to achieve the same goal. As described in our 2010 warranted but precluded finding (75 FR 13910, and references therein), local sage-grouse extirpations and habitat losses have already reduced management (and therefore recovery) options in some portions of the species' range (e.g. the Columbia Basin, Washington). Further, many populations are declining (WAFWA 2008; Garton *et al*. 2011) due to past and ongoing habitat loss, degradation and fragmentation, and many face significant threats (Table 2), or are inherently challenged by current population size (as discussed in section 4, above). Implementing an avoidance first strategy should minimize continuing declines in the species and its habitats, as well as limit further reduction in management options.

b) The appropriate level of management must continue to effectively conserve all current PACs. Threats in PACs must be minimized to the extent that population trends meet the objectives of the 2006 WAFWA Conservation Strategy (Stiver *et al*. 2006; see discussion regarding specific threat amelioration objectives below). Additionally, PACs should be managed to maintain, and improve degraded habitats to provide healthy intact sagebrush shrub and native perennial grass and forb communities, appropriate to the local ecological conditions, and to conserve all essential seasonal habitat components for sage-grouse.

2. *Implement targeted habitat management and restoration*. Some sage-grouse populations warrant more than the amelioration of the impacts from stressors to maintain sage-grouse on the landscape. In these instances, and particularly with impacts resulting from wildfire, it may be critical to not only remove or reduce anthropogenic threats to these populations but additionally to improve population health through active habitat management (e.g. habitat restoration). This is particularly important for those populations that are essential to maintaining range-wide redundancy and representation.

a) Removal of all threats may not be sufficient to change the status of some populations, as some of these populations (and associated PACs) are subject to non-anthropogenic threats (e.g., lighting-caused fires) or may have already declined to a point where active management is required for their long-term viability (e.g., Clear Lake area of northern California). In these cases, proactive management of non-anthropogenic threats (e.g., strategic placement of fire-fighting resources) and restoration efforts should be implemented.

b) The effectiveness of restoration activities (ultimately determined by sage-grouse use and population trends) must be demonstrated prior to receiving any credit for mitigating losses. Restoration activities should be developed within a framework that allows for necessary adjustments.

c) Effective habitat conservation and, as appropriate, restoration activities, should be implemented immediately. The typically long response times of sagebrush ecosystems to most management activities necessitates that these activities be initiated so that their results can be considered for long-term conservation strategies. Development and Implementation of monitoring plans for these activities is an essential component of these efforts.

d) Some areas that were not included as PACs may still have great potential for providing important habitat if active habitat management is implemented. For example, removal of early-stage juniper stands may render currently unsuitable habitat into effective habitat for sage-grouse (this is also true for degraded habitats within PACs). State and federal agencies should actively pursue these opportunities. Successful habitat management efforts could increase connectivity between PACs, and will enhance management flexibility in conserving the species.

3. *Develop and implement state and federal sage-grouse conservation strategies and associated incentive-based conservation actions and regulatory mechanisms.* To conserve sage-grouse and habitat redundancy, representation, and resilience, state and federal agencies, along with interested stakeholders within range of the sage-grouse should work together to develop a plan, including any necessary regulatory or legal tools (or use an existing plan, if appropriate) that includes clear mechanisms for addressing the threats to sage-grouse within PACs. Where consistent with state conservation plans, sage-grouse habitats outside of PACs should also be addressed. We recognize that threats can be ameliorated through a variety of tools within the purview of states and federal agencies, including incentive-based conservation actions or regulatory mechanisms. Federal land management agencies should work with states in developing adequate regulatory mechanisms. Federal land management agencies should also contribute to the incentive-based conservation and habitat restoration and rehabilitation efforts.
In the development of conservation plans, entities (states, federal land management agencies, etc.) should coordinate with FWS. This will ensure that the plans address the threats contributing to the 2010 warranted but precluded determination, and that conservation strategies will meaningfully contribute to future listing analyses.

a) Successful implementation of regulatory and incentive-based mechanisms to conserve sage-grouse requires that all stakeholders participate in conservation, regardless of the size, type, ownership, or location of the threat impact. Continued losses by controllable individual activities of any size can result in significant impacts to the conservation of the species when considered cumulatively, and these losses also reduce management options.

b) Sage-grouse conservation strategies should consider using the criteria identified in the FWS/NOAA Fisheries *Policy for Evaluation of Conservation Efforts (PECE) when Making Listing Decisions* (Federal Register/Vol. 68, No. 60/Friday, March

28, 2003; Appendix B) to help evaluate its likely implementation and effectiveness.

i. Conservation plans should:
    1. Be based on the best available science;
    2. Use local data on threats and ecological conditions, including status of local sage-grouse populations and their associated habitats;
    3. Maintain the diversity of sagebrush habitats essential to provide for all sage-grouse seasonal and life history stages;
    4. Maintain genetic and physical connectivity; and,
    5. Maintain all current intact sage-grouse habitats according to the state management plans (developed in coordination with FWS as discussed above) or other conservation efforts (e.g., BLM priority areas), recognizing existing valid rights.

ii. Conservation plans should be completed no later than July 2013 for the Bi-State DPS, and September of 2014 for the rest of the species' range.

c) Regulatory mechanisms must be completed and implemented and incentive-based conservation actions negotiated as quickly as possible (no later than July 2013 for the Bi-State DPS and September 2014 for the rest of the sage-grouse range, including the Columbia Basin DPS). The effectiveness of regulatory mechanisms and incentive-based conservation activities will be assessed on whether such efforts will successfully ameliorate the specific threats associated with each population and its' associated PACs (See Table 2 in Part 5). Regulatory mechanisms and incentive-based actions should address all threats to PACs to the maximum extent practicable.

d) If adequate regulatory mechanisms cannot be implemented prior to July 2013 for the Bi-State DPS, and Sept. 2014 for the species across the rest of its range, then enforceable temporary measures should be considered in order to ensure threats will be at least temporarily ameliorated until such time that an effective regulatory mechanism can be implemented.

e) All regulatory and incentive-based mechanisms should have a monitoring plan that will provide scientifically defensible data regarding their effectiveness. New or adapted mechanisms must be developed and implemented if monitoring determines that current regulatory mechanisms are ineffective.

4. *Develop and implement proactive, voluntary conservation actions*. Proactive, incentive-based, voluntary conservation actions (e.g. Candidate Conservation Agreements with Assurances, Natural Resources Conservation Service programs) should be developed and/or implemented by interested stakeholders and closely coordinated across the range of the species to ensure they are complimentary and address sage-grouse conservation needs and threats. These efforts need to receive full funding, including funding for necessary personnel.

Many stakeholders within the sagebrush ecosystem have been working diligently to proactively minimize the impacts of their projects on the sage-grouse. Currently, proactive voluntary conservation actions for sage-grouse are being implemented in many parts of the species' range. Given the vast extent of the species' range implementation of voluntary conservation actions may not provide all actions necessary for conservation of the species range-wide. Nevertheless, the combination of voluntary efforts and active management by state and federal agencies via habitat improvements and governmental regulatory mechanisms could have a significant influence on the Service's upcoming listing determinations. These combined actions should apply to the activities which cause habitat fragmentation and loss, the primary factor identified in the FWS 2010 warranted but precluded finding. Stakeholders engaged in voluntary conservation actions should collect information on the geographic scope of these efforts, the sustained benefits to sage-grouse from their implementation, and the likelihood that they will continue to be implemented in the future. This information will be essential to informing the FWS listing decisions.

a) Funding and other necessary support for current proactive conservation efforts should be continued.

b) All proactive voluntary conservation efforts should use the best available science to develop and implement management actions. The results of these efforts should be tracked and reported annually. To monitor effectiveness, these efforts should have a monitoring plan which will provide the necessary scientifically-based information that allows for modification if necessary to achieve the conservation objective.

5. *Develop and implement monitoring plans to track the success of state and federal conservation strategies and voluntary conservation actions*. A robust range-wide monitoring program must be developed and implemented for sage-grouse conservation plans, which recognizes and incorporates individual state approaches. A monitoring program is necessary to track the success of conservation plans and proactive conservation activities. Without this information, the actual benefit of conservation activities cannot be measured and there is no capacity to adapt if current management actions are determined to be ineffective.

a) Adequate funding must be secured for development, implementation, and enforcement of regulatory and incentive-based mechanisms, other conservation strategies, and monitoring programs.

b) New or adapted management actions must be developed and implemented if the monitoring determines that current management actions are ineffective.

6. *Prioritize, fund, and implement research to address existing uncertainties*. Increased funding and support for key research projects that will address uncertainties associated with sage-grouse and sagebrush habitat management is essential. Effective amelioration

of threats can only be accomplished if the mechanisms by which those threats are imposed on the redundancy, representation, and resilience of the species and its habitats are understood.

Specific Conservation Objectives

Priority Areas for Conservation (PACs)

Delineation of key sage-grouse habitats recognizes the extensive reach of habitat threats, the existing loss and degradation of habitats, and acknowledges that preservation of every remaining area of sage-grouse habitat is improbable (Kiesecker *et al*. 2011). Priority Areas for Conservation (PACs) are key habitats identified by state sage-grouse conservation plans (for each state that has such a plan), or through other sage-grouse conservation efforts (e.g. the current BLM planning effort for greater sage-grouse). Maintenance of the integrity of PACs (i.e., maintenance of a healthy sagebrush shrub and native perennial grass and forb community appropriate to local site ecological conditions, which conserves all essential habitat components for sage-grouse) is the essential foundation for sage-grouse conservation. Threats in PACs must be minimized as part of the effort to meet the objectives of the 2006 WAFWA Conservation Strategy (Stiver *et al*. 2006). These objectives include reversing negative population trends within each Management Zone **and** achieving a positive or neutral population trend, with long-term success assessed by comparison with trend data from 1965 – 2003 for each Management Zone. Application of the following conservation objectives (as applicable to local conditions) is unlikely to result in immediate, detectable changes in sage-grouse population trends. However, incorporation of these objectives into conservation planning efforts, including rigorous monitoring plans, will help provide the assurance that the long-term population trend objectives are likely to be attained.

Sage-grouse habitats outside of PACs may also be essential, by providing connectivity between PACs (genetic and habitat linkages), habitat restoration and population expansion opportunities, and flexibility for managing habitat changes that may result from climate change. There may also be seasonal habitats outside of PACs essential to meeting the year-round needs of sage-grouse within PACs but that have not yet been identified. Therefore, maintaining habitats outside of PACs may be important (Fedy *et al.* 2012). Conservation of sage-grouse habitats outside of the PACs should be closely coordinated with each state. For those states with sage-grouse management plans, or similar documents adequately addressing the conservation of sage-grouse that have been developed in coordination with FWS, decisions on management of those areas should defer to those plans. Conservation of habitats outside of PACs should include minimization of impacts to sage-grouse and healthy native plant communities. If minimization is not possible due to valid existing rights, mitigation for impacted habitats should occur.

Loss of PACs (e.g., through wildfire) will reduce the long-term viability of the greater sage-grouse and its habitats. The precise impact of the loss of a PAC, or part of a PAC, to the long-term conservation of sage-grouse cannot be predicted, as the impact will depend on location and size of the PAC and the extent of habitat lost. Nevertheless loss of a PAC, or significant

reduction in available habitat within a PAC, will reduce redundancy and representation across the sage-grouse range, thereby increasing the risk of local extirpation, loss of population connectivity, and reducing management options. Therefore, it is imperative that no PACs are lost as a result of further infrastructure development or other anthropogenic impacts.

The following objectives are targeted at conserving PACs, but can be applied to sage-grouse habitats outside of PACs. These objectives apply to both the Bi-State DPS and sage-grouse range-wide. Achieving these objectives will conserve redundancy and representation of the species and its habitats across its range.

1. Retain sage-grouse habitats within PACs. This must be a priority. Restoration of these habitats, once lost, is difficult, expensive, and based on current knowledge, success may be limited.

2. If PACs are lost to catastrophic events, implement appropriate restoration efforts (Pyke 2011). Given that adequate restoration is often very difficult and takes many years, in addition to restoration, efforts should be made to restore the components lost within the PAC (e.g., redundancy or representation) in other areas such that there is no net loss of sage-grouse or their habitats.

3. Restore and rehabilitate degraded sage-grouse habitats in PACs. This will require sufficient funding and resources, a scientifically rigorous monitoring plan, and the ability to change management if the monitoring results so indicate.

4. Identify areas and habitats outside of PACs which may be necessary to maintain the viability of sage-grouse. If development or vegetation manipulation activities outside of PACs are proposed, the project proponent should work with federal, state or local agencies and interested stakeholders to ensure consistency with sage-grouse habitat needs.

5. Re-evaluate the status of PACs and adjacent sage-grouse habitat at least once every 5 years, or when important new information becomes available (e.g. identification of a previously unknown important winter habitat area). PAC boundaries should be adjusted based on new information regarding habitat suitability and refined mapping techniques, new genetic connectivity information, and new or updated information on seasonal range delineation. By maintaining current maps of the habitat areas necessary to provide redundancy and representation, conservation plans can be more accurately implemented, or modified if appropriate. Additionally, new restoration or rehabilitation opportunities may be identified, thereby increasing management flexibility. Basing management decisions on out-of-date data or natural resource dogma (Beck *et al*. 2012) may threaten the success of long-term conservation actions and conservation plans.

6. Actively pursue opportunities to increase occupancy and connectivity between PACs. Some areas that were not included as PACs may still have great potential for providing important habitat if active habitat management is implemented.

7. Maintain or improve existing habitat conditions in areas adjacent to burned habitat. In the late summer of 2012, several large wildfires in the Great Basin burned through sage-grouse habitats, including PACs (Figure 3). Significant sage-grouse habitat losses were sustained in PACs across California, Nevada, Idaho and Oregon, and in PACs that border those state boundaries. Acreage within fire perimeters in PACs total 265,151 acres in California, 486,293 acres in Nevada, 286,820 acres in Idaho, and 695,619 acres in Oregon. The resulting, immediate loss of habitat raises concerns for the capacity of at least some of those PACs to sustain sage-grouse populations. The unburned portions of these PACs cannot tolerate further impacts to sage-grouse without risking additional population declines. Funding for restoration activities to restore habitat and connectivity in these areas must be a priority. Minimizing or eliminating anthropogenic activities in surrounding, unburned PACs and sage-grouse habitats outside of PACs must also be a priority to enhance opportunities for re-establishment of connectivity among populations, and subsequent re-colonization of restored areas. Management actions within those surrounding PACs must strive to maintain or improve existing habitat conditions so that when a fire occurs, there is a greater chance for successful habitat recovery. Research to understand sage-grouse response to these fires should be prioritized so that any appropriate management modifications, including the modification or addition of PACs, can be implemented.

Threat Reduction

The following threat reduction objectives and measures are targeted at the habitat threats facing the greater sage-grouse, as identified in the 2010 warranted but precluded finding (75 FR 13910). Successful achievement of these objectives across the species' range will ameliorate the threats to greater sage-grouse, including the Bi-State DPS, and allow for the long-term conservation of the species. In the development of conservation plans to achieve these threat reduction objectives, entities (states, federal land management agencies, etc.) should coordinate with FWS. This will help to ensure that the conservation plans adequately address the threats contributing to the 2010 warranted but precluded finding.

The March 2010 finding determined that the greater sage-grouse was warranted for listing based on two primary factors – the present or threatened destruction, modification or curtailment of habitat or range, and the inadequacy of existing regulatory mechanisms. The following strategies addressing resilience are therefore focused on the first listing factor – habitat. In many situations adequate regulatory mechanisms are essential to addressing habitat concerns. The adequacy of regulatory mechanisms is being addressed via several other venues, including the land management planning that the FS and BLM are engaged in and the development and implementation of individual state management plans. Other factors may have local impacts on sage-grouse and state management plans developed in coordination with FWS should provide a basis for addressing these concerns. However, because those other factors did not rise to the level of warranting a listing range-wide (e.g., disease), they are not addressed in this report. Resolution of the habitat concerns discussed below will assist in addressing these other local factors and therefore, these efforts are not mutually exclusive.

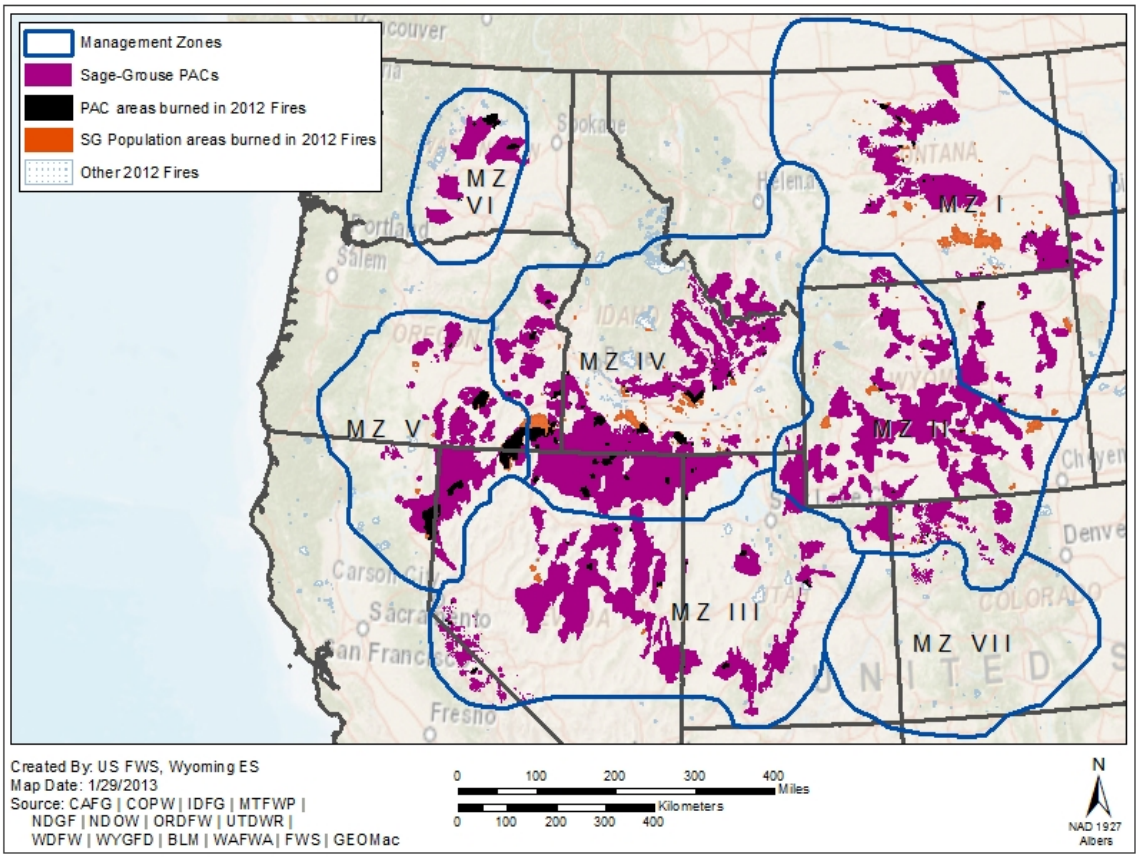

Figure 4. Sage-grouse management zones (Stiver *et al*. 2006), Priority Areas for Conservation (PACs), and 2012 fire perimeters within or near sage-grouse populations. Areas in black indicate areas of PACs that burned while areas in orange indicate areas within the range of sage-grouse, but outside of PACs that burned.

In instances where local data are available for addressing any of the objectives outlined below, they should be used. Where local data are not available information from peer-reviewed literature and rigorous scientific studies should be used to develop local management targets (e.g. amount of understory cover necessary to improve nesting success).

Brief summaries of the impacts of each habitat threat described below are provided as a general reference only. The March, 2010 listing determination (75 FR 13910) provides more detailed analyses of these threats. In addition to identifying conservation objectives associated with each threat we also provide conservation measures that are likely to help achieve that objective. For some threats, examples of options to assist in achieving the conservation objective are also provided for consideration. We did not identify objectives for addressing the potential impacts of climate change due to the uncertainties associated with modeling the resulting future condition and distribution of sage-brush habitats. However, conservation plans should consider climate change models, using local data when available, in the management of sage-grouse habitats.

The following objectives apply to PACs, but all opportunities to reduce threats within sage-grouse habitats should be considered. Where conservation actions are essential outside of PACs, it is noted in the objectives below. These objectives apply to both the Bi-State DPS, and sage-grouse range-wide.

Fire

Conservation Objective: Retain and restore healthy native sagebrush plant communities within the range of sage-grouse.

Fire (both lightning-caused and human-caused fire) in sagebrush ecosystems is one of the primary risks to the greater sage-grouse, especially as part of the positive feedback loop between exotic invasive annual grasses and fire frequency. As the replacement of native perennial bunchgrass communities by invasive annuals is a primary contributing factor to increasing fire frequencies in the sagebrush ecosystem, every effort must be made to retain and restore this native plant community, both within and outside of PACs.

Conservation Measures:

1. Restrict or contain fire within the normal range of fire activity (assuming a healthy native perennial sagebrush community), including size and frequency, as defined by the best available science.
2. Eliminate intentional fires in sagebrush habitats, including prescribed burning of breeding and winter habitats.
3. Design and implement restoration of burned sagebrush habitats to allow for natural succession to healthy native sagebrush plant communities. This will necessitate an intensive and well-funded monitoring system for this long-term endeavor. To be considered successful, restoration must also result in returning or increasing sage-grouse populations within burned areas.
4. Implement monitoring programs for restoration activities. To ensure success, monitoring must continue until restoration is complete (establishment of mature, healthy native sagebrush plant communities), with sufficient commitments to make adequate corrections to management efforts if needed.
5. Immediately suppress fire in all sagebrush habitats. Where resources are limited, these actions should first focus on PACs and any identified connectivity corridors between PACs.

Threat reduction for fire is difficult and costly. Given the intensity and wide distribution of this threat it may never be fully addressed. However implementing the suite of conservation measures listed above is likely to significantly reduce the impact of fire on the long-term viability of the sage-grouse.

Addressing fire, and subsequent successful restoration activities, in sagebrush ecosystems will require consideration of local ecological conditions, which cannot be prescribed on a range-wide level. Where state sage-grouse management plans already provide an effective strategy for fire, the COT defers to those efforts. In all other situations, the following options should be considered in developing a fire management strategy. Specific strategies for reducing the threat of fire should be drafted by July 2013 for the Bi-State population and by September 2014 for sage-grouse rangewide, and should consider the criteria outlined in the PECE policy (Appendix B).

Conservation Options:

1. Prevention of fires in sage-grouse habitats
    a. Manage for the maintenance and, where necessary, restoration of healthy perennial grass (Blank and Morgan 2012) and sagebrush vegetative communities.
    b. Manage land uses (e.g., improper livestock grazing, OHV and recreational use, roads) to minimize the spread of invasive species and or facilitate fire ignition.
    c. Address degraded sagebrush systems before fire occurs (e.g., improve grazing systems).
    d. Close rangelands that are highly susceptible to fire to OHV use during the fire season.

2. Quickly suppress fires that do occur
    a. Implement policy changes that allow access to more fire suppression resources, such as Air National Guard Mobile Airborne Firefighting Units.
    b. Re-allocate fire response resources (crews, equipment, etc.) to important sage-grouse habitats. Identify where resources are lacking and provide those resources to decrease response time to fires in sage-grouse habitats.
    c. Establish defensible fire lines in areas where: (i) effectiveness is high, (ii) fire risk is likely, and (iii) negative impacts from these efforts (e.g. fragmentation) are minimized. Avoid use of any vegetative stripping in healthy, unfragmented habitats, unless fire conditions and local ecological conditions so warrant.
    d. Carefully consider the use of backfires within PACs to minimize the potential for escape and further damage to sage-grouse and sagebrush habitats.
    e. Provide education of fire personnel on the need and value of protecting sagebrush landscapes.
    f. Remove pinyon-juniper stands which are highly flammable (stands where trees are the dominant vegetation and the primary plant influencing ecological processes (Phase 3; Miller *et al*. 2008)) in low elevation sagebrush habitats.
    g. Reduce risk of human-caused fires by limiting activities that may result in fire (e.g., fire bans for campers, limit OHV use to roads) during high risk fire seasons.
    h. Provide incentives for suppressing fires in sagebrush habitats.
    i. Federal land management agencies should consider placing additional firefighting resources and establish new Incident Attack Centers in or adjacent to PACs.
    j. Firefighters should ensure close coordination with firefighters from other management agencies and local fire departments. Additionally they should seek

local expertise to create the best possible strategies for responding to and suppressing wildfire.

3. Improve restoration support
    a. Consider re-allocation of funding from other habitat work to restoration of sage-grouse habitats affected by fire.
    b. Address shortage of locally-adapted seed and storage capabilities.
    c. Apply available seed where it is most likely to be effective and to areas of highest need.
    d. Ensure sage-grouse habitat needs are considered in restoration efforts including managing for the range of variation, as appropriate for the local area.
    e. In the case of limited resources, prioritize PACs over habitats outside of PACs for restoration efforts.

4. Renew and implement BLM Instructional Memorandum (IM) 2011-138 (Sage-grouse Conservation Related to Wildland Fire and Fuels Management; Bureau of Land Management 2011) until a decision is made on whether to incorporate the measures identified in the IM into Resource Management Plans.

Non-native, Invasive Plant Species

The increase in mean fire frequency has been facilitated by the incursion of nonnative annual grasses, primarily *Bromus tectorum* and *Taeniatherum asperum*, into sagebrush ecosystems (Billings 1994; Miller and Eddleman 2001). Exotic annual grasses and other invasive plants also alter habitat suitability for sage-grouse by reducing or eliminating native forbs and grasses essential for food and cover (75 FR 13910, and references therein). Annual grasses and noxious perennials continue to expand their range, facilitated by ground disturbances, including wildfire (Miller and Eddleman 2001), improper grazing (Young *et al*. 1972, 1976), agriculture (Benvenuti 2007), and infrastructure associated with energy development (Bergquist *et al*. 2007). Management of this threat is two-pronged: (1) control, or stopping the spread of invasive annual grasses, and (2) reduction or elimination of established invasive annual grasses. These activities should be prioritized in all sagebrush habitats, both within and outside of PACs because once established, invasive annual grasses are extremely difficult to control.

Conservation Objective: Maintain and restore healthy, native sagebrush plant communities.

Conservation Measures:

1. Retain all remaining large intact sagebrush patches, particularly at low elevations.
2. Reduce or eliminate disturbances that promote the spread of these invasive species, such as reducing fires to a “normal range” of fire activity for the local ecosystem, employing grazing management that maintains the perennial native grass and shrub community appropriate to the local site, reducing impacts from any source that allows for the

invasion by these species into undisturbed sagebrush habitats, and precluding the use of treatments intended to remove sagebrush.
3. Monitor and control invasive vegetation post-wildfire for at least three years.
4. Require best management practices for construction projects in and adjacent to sagebrush habitats to prevent invasion.
5. Restore altered ecosystems such that non-native invasive plants are reduced to levels that do not put the area at risk of conversion if a catastrophic event were to occur. This is especially important within Wyoming big sagebrush communities as these cover types are the most at risk to displacement by cheatgrass (Wisdom *et al.* 2005). While complete elimination of non-native invasive plants would be ideal, we acknowledge that this is unlikely given our current understanding of underlying ecological processes, shifts in climate, and lack of resources.

Energy Development

The increasing demand for renewable and non-renewable energy resources is resulting in continued development within the greater sage-grouse range, resulting in habitat loss, fragmentation, direct and indirect disturbance. Development results in sage-grouse population declines.

Conservation Objective: Energy development should be designed to ensure that it will not impinge upon stable or increasing sage-grouse population trends.

Addressing energy development and any subsequent successful restoration activities in sagebrush ecosystems will require consideration of local ecological conditions, which cannot be prescribed on a range-wide level. Where state sage-grouse management plans have already identified an effective strategy for energy development that meets the above objective, the strategies in those plans should be implemented. In all other situations, the following measures should be considered to avoid, reduce, or mitigate impacts from energy development.

Conservation Measures:

1. Avoid energy development in PACs (Doherty *et al*. 2010). Identify areas where leasing is not acceptable, or not acceptable without stipulations for surface occupancy that maintains sage-grouse habitats.
2. If avoidance is not possible within PACs due to pre-existing valid rights, adjacent development, or split estate issues, development should only occur in non-habitat areas, including all appurtenant structures, with an adequate buffer that is sufficient to preclude impacts to sage-grouse habitat from noise, and other human activities.
3. If development must occur in sage-grouse habitats due to existing rights and lack of reasonable alternative avoidance measures, the development should occur in the least suitable habitat for sage-grouse and be designed to ensure at a minimum that there are

no detectable declines in sage-grouse population trends (and seek increases if possible) by implementing the following:

a. Reduce and maintain the density of energy structures below which there are not impacts to the function of the sage-grouse habitats (as measured by no declines in sage-grouse use), or do not result in declines in sage-grouse populations within PACs.
b. Design development outside PACs to maintain populations within adjacent PACs and allow for connectivity among PACs.
c. Consolidate structures and infrastructure associated with energy development.
d. Reclamation of disturbance resulting from a proposed project should only be considered as mitigation for those impacts, not portrayed as minimization.
e. Design development to minimize tall structures (turbines, powerlines), or other features associated with the development (e.g., noise from drilling or ongoing operations; Blickley *et al*. 2012).

Sagebrush Removal

The intentional removal or treatment of sagebrush (using prescribed fire, or any mechanical and chemical tools to remove or alter the successional status of the sagebrush ecosystem) contributes to habitat loss and fragmentation, a primary factor in the decline of sage-grouse populations. Removal and manipulation of sagebrush may also increase the opportunities for the incursion of invasive annual grasses, particularly if the soil crust is disturbed (Beck *et al*. 2012). Although many treatments are often presented as improving sage-grouse habitats, data supporting the positive impacts of sagebrush manipulation on sage-grouse populations is limited (Beck *et al*. 2012).

Conservation Objective: Avoid sagebrush removal or manipulation in sage-grouse breeding or wintering habitats.

Exceptions to this can be considered where minor habitat losses are sustained while implementing other habitat improvement or maintenance efforts (e.g., juniper removal) and in areas used as late summer brood habitat (Connelly *et al.* 2000). Appropriate regulatory and incentive-based mechanisms must be implemented to preclude sagebrush removal and manipulation for all other purposes.

Grazing

Livestock grazing is the most widespread type of land use across the sagebrush biome (Connelly *et al.* 2004) and almost all sagebrush areas are managed for livestock grazing (Knick *et al*. 2003). Improper livestock management, as determined by local ecological conditions, may have negative impacts on sage-grouse seasonal habitats (75 FR 13910 and references therein), and

management to enhance populations of wild ungulates may also have negative impacts (e.g. removal of sagebrush overstory in an attempt to increase forage production for wild ungulates).

Conservation Objective: Conduct grazing management for all ungulates in a manner consistent with local ecological conditions that maintains or restores healthy sagebrush shrub and native perennial grass and forb communities and conserves the essential habitat components for sage-grouse (e.g. shrub cover, nesting cover). Areas which do not currently meet this standard should be managed to restore these components. Adequate monitoring of grazing strategies and their results, with necessary changes in strategies, is essential to ensuring that desired ecological conditions and sage-grouse response are achieved.

Achieving the above objective will require the development of long-term strategies that provide seasonal habitats for sage-grouse. Although grazing management should initially focus on retaining the above habitat conditions within PACs, sound grazing management should be applied across all sagebrush habitats. Grazing management strategies must consider the local ecological conditions, including soil types, precipitation zones, vegetation composition and drought conditions. Livestock and wild ungulate numbers must be managed at levels that allow native sagebrush vegetative communities to minimally achieve Proper Functioning Conditions (PFC; for riparian areas) or Rangeland Health Standards (RHS; uplands). Similar measures should be implemented on non-federal land surfaces.

There are several potentially useful tools for developing management strategies (such as Ecological Site Descriptions (ESDs) and PFC metrics. However, use of these tools must be tied to sage-grouse habitat and population parameters if they are to be considered as a sole measure for monitoring condition and, if appropriate, rehabilitation progress (Doherty *et al*. 2011). ESDs are not available across the entire range. Given the utility of ESDs in developing local management strategies, ESDs should be completed throughout the entire range of sage-grouse.

Implementation of the following options could help reduce any threats that grazing may pose to sage-grouse.

Conservation Options:

1. Ensure that allotments meet ecological potential and wildlife habitat requirements; and, ensure that the health and diversity of the native perennial grass community is consistent with the ecological site.
2. Inform and educate affected grazing permittees regarding sage-grouse habitat needs and conservation measures.
3. Incorporate sage-grouse habitat needs or habitat characteristics into relevant resource and allotment management plans, including the desired conditions with the understanding that these desired conditions may not be fully achievable: (a) due to the existing ecological condition, ecological potential or the existing vegetation; or (b) due to causal events unrelated to existing livestock grazing.
4. Conduct habitat assessments and, where necessary, determine factors causing any failure to achieve the habitat characteristics. Make adjustments as appropriate.

5. Given limited agency resources, priority should be given to PACs and then sage-grouse habitats adjacent to PACs.

Range Management Structures

Structures which support range management activities can have negative impacts on sage-grouse habitats by increasing fragmentation (e.g., fences and roads) or diminishing habitat quality (e.g., concentrating ungulates in winter habitats). Typical range management structures include fences, water developments and mineral licks. As fences can be both a positive and negative impact on sage-grouse and their habitats, depending on their location and use, they are addressed in a separate section below.

Conservation Objective: Avoid or reduce the impact of range management structures on sage-grouse.

Conservation Measures:

1. Range management structures should be designed and placed to be neutral or beneficial to sage-grouse.
2. Structures that are currently contributing to negative impacts to either sage-grouse or their habitats should be removed or modified to remove the threat.

Free-Roaming Equid Management

Free-roaming equid grazing is presented separately from ungulate grazing due to the differing impacts equids have on sagebrush ecosystems. On a per capita body mass, horses consume more forage than cattle or sheep and remove more of the plant which limits and/or delays vegetative recovery (Menard *et al*. 2002), and horses can range further between water sources than cattle, thereby making them more difficult to manage. Equid grazing results in a reduction of shrub cover and more fragmented shrub canopies, which can negatively affect sage-grouse habitat (Beever and Aldridge 2011). Additionally, sites grazed by free-roaming equids have a greater abundance of annual invasive grasses, reduced native plant diversity and reduced grass density (Beever and Aldridge 2011). Given the high mobility of free-roaming equids, the conservation measures below should be applied across all sage-grouse habitats.

Conservation Objective: Protect sage-grouse from the negative influences of grazing by free-roaming equids.

Conservation Measures

1. Develop, implement, and enforce adequate regulatory mechanisms to protect sage-grouse habitat from negative influences of grazing by free-roaming equids.

2. Manage free-roaming equids at levels that allow native sagebrush vegetative communities to minimally achieve PFC (for riparian areas) or RHS (for uplands). Similar measures should be implemented on non-federal land surfaces.

Conservation Options

1. Determine if the current appropriate management levels (AMLs) maintain suitable sage-grouse habitat parameters. Support additional research to quantitatively determine impacts of wild horses and burros on sage-grouse habitat parameters.
2. Until research on AMLs is completed, manage for AMLs within horse management areas on federal lands. Current AMLs should be adjusted for drought conditions.
3. Develop scientific procedures that can be replicated to count horses so that proper management actions can be implemented when numbers exceed AMLs.
4. Develop a sound monitoring program with prescriptive management "triggers" to make adjustments in horse and burro numbers or their distribution, as necessary.

Pinyon-juniper Expansion

Greater sage-grouse are negatively impacted by the expansion of pinyon and/or juniper in their habitats, even if the underlying sagebrush habitats remain (Freese *et al.* 2009). Sage-grouse avoid these areas of expansion (Casazza *et al*. 2010), and as the pinyon and/or juniper increases in abundance and size, the underlying habitat quality for sage-grouse diminishes.

Conservation Objective: Remove pinyon-juniper from areas of sagebrush that are most likely to support sage-grouse (post-removal) at a rate that is at least equal to the rate of pinyon-juniper incursion.

Treatments to remove pinyon and/or juniper trees in phase 1 (trees present but shrubs and herbs are the dominant vegetation that influence ecological processes) and phase 2 (tress are co-dominant with shrubs and herbs and all three vegetation layers influence ecological processes; Miller *et al.* 2008) state of incursion should match the rate of incursion (minimally 200,000 acres per year; Stiver *et al.* 2006). Removal should be prioritized by seasonal habitats, based on the habitat that is locally limiting populations. Removal techniques should not include prescribed fire in low elevation, xeric sagebrush communities.

Pinyon and/or juniper removal activities should focus initially on areas within PACs, but all opportunities to remove this threat should be considered if resources are available. Where state sage-grouse management plans provide an effective strategy for pinyon-juniper, those strategies should be implemented. In all other situations the following conservation options should be considered.

Conservation Options:

1. Prioritize the use of mechanical treatments for removing pinyon and/or juniper. These techniques allow for more selective removal of invading plants, and more importantly allows understory habitats to remain intact.
2. Use caution when planning use of prescribed fire in high elevation mountain big sage sites to prevent fire escape and any subsequent establishment of invasive annual grasses or other weeds.
3. Reduce juniper cover in sage-grouse habitats to less than 5% (Freese 2009, Cassaza *et al*. 2010), but preferably eliminate entirely.
4. Employ all necessary management actions to maintain the benefit of pinyon and/or juniper removal for sage-grouse habitats, including long-term monitoring (greater than 30 years) with appropriate management responses should the resultant habitat quality decline.

Agricultural Conversion

Agricultural conversion is typically defined as the conversion of sagebrush habitats to tilled agricultural crops or re-seeded exotic grass pastures, resulting in habitat loss and fragmentation. Agricultural conversion can also be the conversion of conservation (e.g., those enrolled in the Conservation Reserve Program (CRP) or State Acres for Wildlife Enhancement (SAFE)) when such lands are providing important habitat components for sage-grouse. This type of conversion could be detrimental to sage-grouse in areas where the birds depend on these interim successional habitats (such as in Washington).

Conservation Objective: Avoid further loss of sagebrush habitat for agricultural activities (both plant and animal production) and prioritize restoration. In areas where taking agricultural lands out of production has benefited sage-grouse, the programs supporting these actions should be targeted and continued (e.g. CRP/SAFE). Threat amelioration activities should, at a minimum, be prioritized within PACs, but should be considered in all sage-grouse habitats.

Conservation Options:

1. Revise Farm Bill policies and commodity programs that facilitate ongoing conversion of native habitats to marginal croplands (e.g., through the addition of a 'Sodsaver' provision), to support conservation of remaining sagebrush-steppe habitats.
2. Continue and expand incentive programs that encourage the maintenance of sagebrush habitats.
3. Develop criteria for set-aside programs which stop negative habitat impacts and promote the quality and quantity sage-grouse habitat.
4. If lands that provide seasonal habitats for sage-grouse are taken out of a voluntary program, such as CRP or SAFE, precautions should be taken to ensure withdrawal of the lands minimizes the risk of direct take of sage-grouse (e.g., timing to avoid

nesting season). Voluntary incentives should be implemented to increase the amount of sage-grouse habitats enrolled in these programs.

Mining

Surface mining and appurtenant facilities within sage-grouse habitats result in the direct loss of habitat, habitat fragmentation, and indirect impacts from disturbance (e.g., noise, dust). Current reclamation activities do not always consider sage-grouse habitat needs. Those that do may take decades to restore habitats and experience the same limitations as restoration activities. Surface facilities supporting underground mining activities can have similar impacts.

Conservation Objective: Maintain stable to increasing sage-grouse populations and no net loss of sage-grouse habitats in areas affected by mining.

Reclamation of mined lands within sage-grouse habitats should be focused on restoring habitats usable by sage-grouse, and the re-establishment of sage-grouse in these areas. Where state sage-grouse management plans provide effective conservation strategies for mining those strategies should be implemented. In all other situations the following conservation options should be considered.

Conservation Options:

1. Avoid new mining activities and/or any associated facilities within occupied habitats, including seasonal habitats;
2. Avoid leasing in sage-grouse habitats until other suitable habitats can be restored to habitats used by sage-grouse;
3. Reclamation plans should focus on restoring areas disturbed by mining and associated facilities to healthy sagebrush ecosystems, including evidence of use by sage-grouse.
4. Reclamation of abandoned mine lands should focus on restoring areas to healthy sagebrush ecosystems where possible.

Recreation

Recreational activities within sage-grouse habitats can result in habitat loss and fragmentation (e.g., creation of off-road trails, camping facilities) and both direct and indirect disturbance to the birds (e.g., noise, disruptive lek viewing, hunting dog trials, and dispersed camping).

Conservation Objective: In areas subjected to recreational activities, maintain healthy native sagebrush communities based on local ecological conditions and with consideration of drought conditions, and manage direct and indirect human disturbance (including noise) to avoid interruption of normal sage-grouse behavior.

Threat amelioration for recreation should be implemented in PACs, but considered in all sage-grouse habitats. Where state sage-grouse management plans provide an effective strategy for recreational activities, those strategies should be implemented. In all other situations the following conservation options should be considered.

Conservation Options:

1. Close important sage-grouse use areas to off-road vehicle use.
2. Avoid development of recreational facilities (e.g., new roads and trails, campgrounds) in sage-grouse habitats.

Ex-Urban Development

Ex-urban development (dispersed homes on small acreages) results in direct habitat loss, habitat fragmentation, and the introduction of invasive plant species. Urban and exurban activities also increase the presence of predator subsidies (e.g., trash, landfills, bird feeders) allowing for increased predators associated with humans that may have disproportionate impacts on greater sage-grouse (e.g., red fox, skunks, raccoons). Additionally, pets may have negative impacts on sage-grouse through direct predation or disturbance (e.g., chasing birds). Infrastructure associated with exurban development (e.g., powerlines, roads) also results in habitat loss and fragmentation, subsidies for avian predators such as ravens, and possible disturbance to sage-grouse. Moreover, concentration of hobby livestock on small acreages can result in habitat loss and the introduction of invasive annual grasses and weeds.

Conservation Objective: Limit urban and exurban development in sage-grouse habitats and maintain intact native sagebrush plant communities.

At a minimum, threat amelioration for ex-urban development should occur within PACs, but should also be considered in all sage-grouse habitats. Where state sage-grouse management plans provide an effective strategy for managing ex-urban development, they should be implemented. In all other situations the following conservation options should be considered.

Conservation Options:

1. Provide incentives to maintaining large tracts of private lands that provide habitat for sage-grouse. These incentives can include (but may not be limited to):
    a. Developing habitat conservation plans;
    b. Conservation easements or leases; and/or
    c. Land swaps.
2. Acquire and manage sage-grouse habitat to maintain intact ecosystems.
3. Consolidate infrastructure that supports urban and exurban development.
4. Do not allow landfills in sage-grouse habitats, or within 5 km of sage-grouse habitats.

5. Do not relinquish public lands for the purpose of urban development in sage-grouse habitat.

Infrastructure

Development of infrastructure for any purpose (e.g., roads, pipelines, powerlines, and cellular towers) results in habitat loss, fragmentation, and may cause sage-grouse habitat avoidance. Additionally, infrastructure can provide sources for the introduction of invasive plant species and predators.

Conservation Objective: Avoid development of infrastructure within PACs.

Conservation Measures:

There should be no new development of infrastructure corridors within PACs. Designated, but not yet developed infrastructure corridors should be re-located outside of PACs unless it can be demonstrated that these corridors will have no impacts on the maintenance of neutral or positive sage-grouse population trends and habitats. New infrastructure should be avoided where individual state plans have identified key connectivity corridors outside of PACs.

Where state sage-grouse management plans provide an effective strategy for infrastructure those strategies should be implemented. In all other situations the following conservation options should be considered.

Conservation Options:

1. Avoid construction of these features in sage-grouse habitat, both within and outside of PACs.
2. Power transmission corridors which cannot avoid PACs should be buried (if technically feasible) and disturbed habitat should be restored.
    a. If avoidance is not possible, consolidate new structures with existing features and/or preclude development of new structures within locally important sage-grouse habitats.
        i. Consolidation with existing features should not result in a cumulative corridor width of greater than 200m.
        ii. Habitat function lost from placement of infrastructure should be replaced.
3. Infrastructure corridors should be designed and maintained to preclude introduction of invasive plant species.
4. Restrictions limiting use of roads should be enforced.
5. Remove transmission lines and roads that are duplicative or are not functional.

6. Transmission line towers should be constructed to severely reduce or eliminate nesting and perching by avian predators, most notably ravens, thereby reducing anthropogenic subsidies to those species.
7. Avoid installation of compressor stations in PACs or other sage-grouse habitats where sage-grouse would be affected by noise and operation activities.
8. All commercial pipelines should be buried and habitat that is disturbed needs to be reclaimed with current and future emphasis placed on suppression of non-native invasive plant species.
9. Mitigate impacts to habitat from development of these features.
10. Remove (or decommission) non-designated roads within sagebrush habitats.

Fences

Fences can be deleterious to sage-grouse populations and habitats, with threats including habitat fragmentation and direct mortality through strikes (Stevens *et al.* 2012). Fences can improve habitat conditions for sage-grouse (e.g. by protecting riparian areas providing brood-rearing habitats from overgrazing). The assessment of the impact or benefit of fences must be made considering local ecological conditions and the movement of sage-grouse within local areas (Stevens *et al*. 2012).

Conservation Objective: Minimize the impact of fences on sage-grouse populations.

Conservation Options:

1. Mark fences that are in high risk areas for collision (Stevens *et al.* 2012) with permanent flagging or other suitable device to reduce sage-grouse collisions on flat to gently rolling terrain in areas of moderate to high fence densities (i.e., more than 1 km of fence per km^2) located within 2 kms of occupied leks.
2. Identify and remove unnecessary fences.
3. Placement of new fences and livestock management facilities (including corrals, loading facilities, water tanks and windmills) should consider their impact on sage-grouse and, to the extent practicable, be placed at least 1 km from occupied leks (Stevens *et al*. 2012).

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APPENDIX A—MANAGEMENT ZONE AND POPULATION RISK ASSESSMENTS

See Figure 3 for a map of management zones and populations.

MANAGEMENT ZONE I: GREAT PLAINS

This management zone consists of four sage-grouse populations as identified by Garton *et al*. (2011), including the Dakotas, Northern Montana, Powder River Basin, and Yellowstone Watershed populations. All of these populations cross state or provincial boundaries. Garton *et al.* (2011) predicted an 11.1 percent chance this Management Zone will fall below 200 males by 2037, and a 24.0 percent chance it would fall below 200 males by 2107. Privately-owned lands are a major constituent of sagebrush landscapes in the Great Plains (66 percent), followed by BLM (17 percent), and then other ownerships (Knick 2011). After Management Zones II and IV, this zone contains some of the most connected networks of sage-grouse leks in the range (Knick and Hanser 2011). On the other hand, sagebrush habitat in 37 percent of this zone is 75-100 percent similar to sagebrush habitat in areas where extirpation has occurred (Wisdom *et al.* 2011). Generally, areas in this zone that are least similar to extirpated parts of the range include the western portions of Northern Montana and Powder River populations and the southeast corner of the Yellowstone Watershed population (Wisdom *et al*. 2011, Figure 18.5).

Dakotas

The Dakotas's population occurs on the far eastern edge of the range of sage-grouse. Much of the population occurs in the Cedar Creek Anticline. Garton *et al*. (2011) reported the minimum male count for this population at 587 and predicted a 66 percent chance that this population would dip below 200 males in the next 100 years. Population counts in 2012 for North and South Dakota were approximately 300, so this population as a whole very likely still exceeds 500 birds. Priority areas for conservation (PACs) in North and South Dakota are connected by general habitat consisting of limited sagebrush habitat. Sage-grouse movements generally occur east and west between the Dakotas's population and Montana. Connectivity between the sub-populations occurs through Montana's portion of the population (Knick and Hanser 2011). This area was identified as a PAC in Montana due to historically high density of sage-grouse and for the seasonal habitat it provides for birds from North Dakota, a likely conduit for genetic connectivity. The area is heavily influenced by oil and gas development and conversion of native rangeland to cropland is a major threat to the persistence of this sage-grouse population. Over-grazing in localized areas has degraded the sagebrush habitat and can reduce nesting success. Nesting success was positively correlated to grass cover in North Dakota (Herman-Brunson 2007). Overall, this population is small and at high risk.

Northern Montana

The Northern Montana Population is predominantly in northeast Montana but extends north into southern Saskatchewan and Alberta, making up these provinces' entire sage-grouse populations. Garton *et al*. (2011) reported a minimum male count for this population at over 2,700 males and projected a very low probability (i.e., two percent) of the population dipping below 200 males in the next 100 years. The southern portion of this area, south of the Milk River, has a high abundance of sage-grouse, has been designated as a PAC, and is predominately comprised of public land. Land use in this area is livestock grazing with limited dryland farming and irrigated hay production adjacent to creeks and rivers. In general, habitat in this PAC is expansive and intact and faces few if any significant threats, particularly on public lands. Grouse in this PAC make up the majority of birds in this population. North of the Milk River, habitats comprise a relatively low density of silver sagebrush and a correspondingly low density of sage-grouse. The sage-grouse habitats in this area include more private lands and, in some portions of this area, have a long history of grain farming and low to moderate densities of natural gas production. A PAC was designated in northern Valley County where relatively intact habitats provide for resident grouse as well as a conduit for spring and fall migrating sage-grouse between Saskatchewan and southern Valley County. This PAC is adjacent to considerable farming to the east but is itself relatively stable and lacks significant threats. One or more large conservation easements are in place to protect habitat values on key private lands in northern Valley County. Given the extent and limited threats associated with this population, it is considered to be at low risk.

Powder River Basin

The Powder River Basin occurs mostly in Northeast Wyoming, but an area in southern Montana comprises the extreme northern tip of this population. A recent sagebrush cover assessment estimated average cover of sagebrush in the Powder River Basin to be 35 percent, with an average sagebrush patch size less than 300 acres (Rowland *et al*. 2005). Sagebrush patch size in the Powder River Basin has decreased by more than 63 percent in 40 years, down from 820 acre patches and an overall coverage of 41 percent in 1964. Most of the occupied sage-grouse habitat in northeast Wyoming is privately owned. Approximately 70 percent of known leks are found on private land; the remaining 30 percent are found on FS, BLM, and state lands (Northeast Wyoming Sage-grouse Working Group 2006).

Garton *et al*. (2011) reported a minimum male count for this population at 3,042 and projected a high probability (86.2 percent) of falling below 200 males by 2107. A recent viability study done for BLM (Taylor *et al*. 2012) indicates that sage-grouse viability in the Powder River Basin is being impacted by multiple stressors including West Nile virus and energy development. Their results suggest that if development continues, future viability of the already small sage-grouse populations in northeast Wyoming will be compromised. The Powder River Basin holds vast energy resources including oil, natural gas, and coal bed natural gas (Northeast Wyoming Sage-grouse Working Group 2006). The state has a core area management strategy to help

balance the priorities of retaining healthy sage-grouse population on the landscape and energy development.

Although the Montana piece of the Powder River Basin makes up a relatively small portion of the population, it may provide genetic connectivity with other Montana populations. Land use in Montana's portion of this population includes a mix of livestock grazing, coal mining, and shallow coal bed natural gas production. Montana identified relatively small but intact habitats that have limited energy development and may serve as remnant habitat for supporting small numbers of sage-grouse into the future. The expanding threat of energy development across the Powder River Basin and corresponding downward population index trend makes this overall an at-risk population.

Yellowstone Watershed

The Yellowstone Watershed Population is a large population covering an expansive area south of the Missouri River, making up the majority of sage-grouse habitats in southeast and south central Montana. Garton *et al.* (2011) reported a minimum male count of over 2,900 males. They further projected a 60 percent chance of this population dipping below 200 males in the next 100 years. Landownership is predominantly private with scattered tracts and blocks of public land. Livestock grazing and small grain farming are common in this area. Oil and gas developments are scattered across portions of this area. Extensive private lands have the potential for conversion of additional sagebrush habitats to farming and various forms of sagebrush eradication. Cropland conversion continues to take place in this area. Priority areas for conservation have been identified both in the western and southeastern portions of this population, where sage-grouse densities are greatest and habitats remain relatively intact. The western and southeastern PACs are separated by about 70 miles of a mix of habitats, including an interstate highway, the Yellowstone river corridor, and a patchwork of cropland intermingled with occupied sage-grouse habitat. Some portion of this space between PACs may be identified as a PAC in the future as movement corridors and habitats needed for population connectivity become better understood and defined. Overall this population is only potentially at-risk.

MANAGEMENT ZONE II: WYOMING BASIN

This management zone is made up of five sage-grouse populations as identified by Garton *et al.* (2011), including Jackson Hole, Laramie, Eagle-South Routt, Middle Park, and the Wyoming Basin. Colorado and Utah's portions of the Wyoming Basin are described separately as the NWCO and North Park subpopulations in Colorado, and the Rich-Summit-Morgan and Uintah Management Areas in Utah. This management zone represents the highest abundance of sage-grouse relative to other management zones across the sage-grouse's range. Garton *et al*. (2011) predicted a small, 0.3 percent chance, that this zone will fall below 200 males by 2037, and a 16.2 percent chance it would fall below 200 males by 2107. The majority of this management zone is represented by the Wyoming Basin population. Montana's portion of the zone is very small, only including the northern tip of the Wyoming Basin population in a portion of Carbon

County. BLM and privately-owned lands are major constituents of sagebrush landscapes in this zone, representing 49 percent and 35 percent of the ownership, respectively (Knick 2011). Management Zone II contains the most highly connected network of sage-grouse leks in the range (Knick and Hanser 2011). This zone is also a stronghold for sage-grouse because it contains the second largest area of habitat range-wide (and the largest in the eastern range) with low similarity to extirpated portions of the range (Wisdom *et al*. 2011).

The Colorado portion of this management zone appears to capture redundancy and representation in the PACs. Priority areas for conservation represent 61 percent of the occupied range in Colorado and 84 percent of the breeding birds in the state (CPW 2012). Being on the edge of the species' range, the Colorado populations within this management zone are somewhat isolated. Linkage zones have been mapped among the Colorado populations and subpopulations (i.e., Eagle-South Routt, Middle Park, North Park, and NWCO) (CPW 2012). It is assumed the habitat linkages will allow for movement between populations and will decrease the probability of extinction of the subpopulations by stabilizing population dynamics. Connectivity between Wyoming's and Colorado's PACs may be adequate in most areas, but there may be some areas to address in the northwest Colorado area.

Eagle-South Routt

This population occurs in north-central Colorado and is separated from nearby populations by distance and mountainous terrain (Garton *et al*. 2011). The Eagle-South Routt population adds to representation and redundancy within Management Zone II because of its location on the landscape and limited connectivity to other populations within this zone. Priority areas for conservation capture 68 percent of the occupied range in this population and include 100 percent of all known active leks. These areas also contain all habitats that were modeled "high probability of use" within four miles of leks that have been active in the last 10 years (CPW 2012). Redundancy is not captured within this population because it is a fairly isolated population that is also fairly small (the three year average number of males from 2010-2012 is 108). Populations (in terms of males only) in the late 1960s were likely in the high 200s (CGSSC 2008). The greatest threat to this population is loss of habitat from subdivision and housing development as well as the associated infrastructure and roads (CPW 2008; NWCOCP 2008). Pinyon-juniper encroachment has been, and continues to be, a significant threat to the population as well. This population is high risk because, given its smaller population size and isolation, a stochastic event could greatly negatively affect this population.

Middle Park

The Middle Park population occurs east of Eagle-South Routt in north-central Colorado and is separated from adjacent populations by distance and mountainous terrain (Garton *et al.* 2011). Representation and redundancy appear to be captured adequately in Middle Park. Priority areas for conservation capture 79 percent of the occupied range in this population and also include 95 percent of all known active leks. Furthermore, PACs contain 95 percent of all habitats that were modeled "high probability of use." Redundancy is captured reasonably well within this population because, although it currently has a three-year running average of 210 males, the

PACs include most of the known distribution of birds. Connectivity to the North Park population has been documented. Housing development is the most current and foreseeable threat. Grand County has experienced a high rate of human population growth in recent years. This high human population growth rate is projected to continue primarily due to its' proximity to major ski resorts and summer recreational activities. Although this is a relatively small sage-grouse population, Colorado Parks and Wildlife (CPW) does not believe the population has ever been very large. Since the 1970's, the population counts have been roughly between 200 and 325 males. Connectivity to the North Park population has always been somewhat naturally limited over Muddy Pass although CPW has documented birds moving over the pass. Overall this population is considered at-risk.

Laramie

This population consists of five leks located southwest of Laramie, Wyoming. Few birds are seen on these leks although one is routinely occupied by a small number of birds, despite the fact that the running average of the number of males per lek was zero from 2004 to 2007 (WAFWA 2008). None of these leks are contained in a PCA and four of these leks are threatened by proposed wind energy development. Overall this population is considered high risk.

Jackson Hole

The Jackson Hole population is a small population located near Jackson Hole, Wyoming. This population is geographically isolated due to surrounding topography and limited habitat. This population consists of 16 leks (13 active and three inactive in past 10 years), of which only one is considered large (averaging over 40 birds). Population trend information indicates that this population is decreasing slightly, declining from an average of 20.5 males per active lek in 2005 to 14.9 males per active lek in 2011. Most of the breeding habitat in this population is contained within a single PAC. However there are three small subpopulations that are isolated from the main Jackson Hole PAC: Gros Ventre (two leks); Star Valley/State Line (two leks in Idaho) and Hoback Basin (one lek). Threats to this population consist of internal habitat fragmentation resulting from wildfires, prescribed burns, herbivory of sagebrush by elk and bison winter feeding operations, urban development, and recreational activities. Grand Teton National Park and the National Elk Refuge encompass most of the PACs and protect much of the crucial habitat. This population exists in high mountain valleys with deep snowpack and the amount of available winter habitat is a limiting factor based on studies by Holloran and Anderson (2004) and Bedrosian and Craighead (2010). Yellowstone National Park is just to the north, making Jackson Hole a popular tourist destination. Skiing and snowmobiling are prime recreational activities during winter. Urban development is limited as a result of limited private lands within this population, but includes some crucial winter habitat. Recently, energy development has begun in the southern edge of this population (Hoback Basin). Population estimates, based on male lek counts, indicate that total population numbers fluctuate, with a high of approximately 500 birds. Modeled population forecasts suggest that populations will decline, and long-term persistence is unlikely (Garton *et al.* 2011). Due to low population numbers, population isolation and a high degree of threats, this population is considered high risk.

Wyoming Basin

This large population extends into Montana, Idaho, Utah, and Colorado. The population is separated from adjacent populations by distance and topography (Garton *et al*. 2011). This population is the largest population within the species' range (> 20,000 males attending leks annually), and is very robust. However, long-term population trends are slightly downward, although recent counts suggest an increase. Even so, population modeling suggests that declines will continue over the long-term (Garton *et al*. 2011). This population is described in several smaller pieces, including the Wyoming portion (including the small piece that extends into Montana) of the population, Uintah and Rich-Morgan-Summit Management Areas in Utah, and North Park and NWCO subpopulations in Colorado.

Wyoming Portion

This large population covers approximately two-thirds of the State of Wyoming. It extends into Montana, Idaho, Utah and Colorado (Utah and Colorado portions are described separately). The population is separated from adjacent populations by distance and topography (Garton *et al*. 2011). Sage-grouse habitats are expansive and relatively intact outside of areas of energy development. Despite the long-term declines in populations, implementation of the Wyoming Governor's Executive Order for sage-grouse may help alleviate these declines. The primary threats to this portion of the population are energy development and transfer, including both renewable and non-renewable resources, long-term drought, and brush eradication programs. Declines of sage-grouse near oil and gas fields in this area have been well documented (Lyon 2000; Holloran 2005; Holloran and Anderson; Kaiser 2006). Residential development has also been identified as a threat. Recent conservation actions, including the Wyoming Governor's Executive Order designating protective stipulations for core areas (PACs) and the implementation of conservation easements within these areas have reduced the threat risk to this area. Designated state core areas (PACs) adequately capture redundancy and representation for the Wyoming portion of this population. Due to the large size of this population, the presence of large, contiguous habitats, and regulatory measures providing habitat protection, this population is considered low risk.

The majority of habitat that supports the Montana portion of the Wyoming Basin population is identified as a PAC, both because of the relatively high density of sage-grouse in the area and the likely role this area plays connecting Montana's sage-grouse to Wyoming's birds. In Montana, this area is among the driest of sage-grouse habitats and has a higher prevalence of cheat-grass relative to other parts of Montana. Land use includes livestock grazing and a long history of oil limited production. This portion of the Wyoming Basin Population is relatively small but is within 20 miles of another core area in Wyoming.

Rich-Morgan-Summit

The Rich-Morgan-Summit Sage-grouse Management Area is located in Northeastern Utah, and is a part of the Wyoming Basin population, a significant population center for grouse in Utah,

Idaho, Colorado, and Wyoming. This management area also includes part of what is mapped in Garton *et al*. 2011 as Summit-Morgan Counties in Management Zone III. The area boundary was determined by consulting with adjacent states, Utah Division of Wildlife Resources, the Morgan-Summit Adaptive Resources Management Local Sage-grouse Working Group, and the Rich County Coordinated Resource Management Sage-grouse Local Working Group and follows vegetation types usable by sage-grouse. This portion of the population is regarded as stable with potential for growth. Based on a ten-year average count of males on leks, the area had an estimated 1,223 males as of 2011. Sage-grouse in this area show resiliency to known threats. Key threats to sage-grouse include invasive species, loss of agricultural operations, predation, residential development, and habitat fragmentation through recreational development. In conjunction with populations in Wyoming, the management area is considered low risk.

Uintah

The Uintah Sage-grouse Management Area is located in northeastern Utah. This management area had an estimated 452 males on leks as of 2011. Within the northern portion of this area is the Diamond Mountain and Browns Park population, a significant population center for sage-grouse in Utah, Colorado, and Wyoming. The central and southern portions of the management area contain fragmented populations with minimal connectivity and low potential for habitat improvement. The Management Area boundary was determined by consulting with Utah Division of Wildlife Resources and the Uinta Basin Adaptive Resource Management Local Working Group, and follows vegetation types usable by sage-grouse. This portion of the Wyoming Basin population is regarded as stable with a potential for growth and also has strong connectivity with other portions of the population. Sage-grouse in the Management Area show resiliency to known threats. Key threats to sage-grouse include predation, wildfire, invasive species, noxious weeds, disease, loss of agricultural operations, and habitat fragmentation (naturally occurring, but not topographical, and from existing and future anthropogenic uses). In concert with the remaining portions of this population, the management area is considered low risk.

North Park

This portion of the Wyoming Basin population is located in North Park, Jackson County, Colorado. In North Park (NP), representation and redundancy appear to be captured well. Priority areas for conservation capture 91 percent of the occupied range in this population and include 100 percent of all known active leks and 100 percent of habitat that was modeled "high probability of use" within 4 miles of a lek that has been active within the last 10 years. Historically, no significant threats were apparent to this population. However, there is renewed interest in oil development in the area. In addition, a large portion (29 percent) of public land in PACs has been leased for energy development. North Park has overlapping energy and mineral resources and thus could experience natural gas, coal bed methane, and oil extraction. Although present, the other identified threats are less than other portions of the population. The habitat within PACs is in fairly good condition, and a large portion is on public lands. This is likely Colorado's most resilient area of occupied sage-grouse habitat. Long -term data trends (since the

early 1970's) indicate this population has fluctuated roughly between 500 and 1,500 males. This subpopulation is considered low risk.

Northwest Colorado

In the northwest Colorado portion of this population, representation and redundancy appear to be captured adequately. Priority areas for conservation capture 56 percent of the occupied range and also include 95 percent of all known active leks and 95 percent of habitat that was modeled "high probability of use" within 4 miles of a lek that has been active within the last 10 years. Most of the sub-management zones within this portion of the population have some connectivity with other portions of this population. This is Colorado's largest area of sage-grouse occupancy and is considered to be at low risk of extirpation. The northern portion is likely to be more resilient than the southeastern portions of this population because of habitat condition and connectivity. There is more habitat fragmentation in the southeastern portion of this population. According to lek count data, the long-term trend appears to be stable, despite substantial fluctuations. Population peaks have occurred in 1960-70, 1978-80, and in the mid-2000s.

MANAGEMENT ZONE III: SOUTHERN GREAT BASIN

This management zone includes populations in California, Nevada, and Utah. The California populations in this Management Zone are described separately in the Bi-State DPS section (see below) and the Summit Morgan Counties population is described in Management Zone II. The populations in this management zone include Southern Great Basin, Northeast Interior, Sheeprock, Quinn Canyon Range, South Central Utah, Northeast Interior Utah, Emery, and Northwest Interior. Garton *et al*. (2011) predicted a 0.0 percent chance this Management Zone will fall below 200 males by 2037, and a 7.8 percent chance it would fall below 200 males by 2107. Landownership in this zone is predominately BLM (71 percent), followed by private (13 percent) and others (Knick 2011). This zone is part of a stronghold for sage-grouse (that includes Management Zones III, IV, and V) because the three zones contain the largest area of habitat range-wide with low similarity to extirpated portions of the range (Wisdom *et al*. 2011). Despite the fact this zone has large areas of sagebrush habitat in Nevada this area faces large risks due to wildfire. Since it is difficult to restore burned habitat (Pyke 2011), the management approach for this area should provide a cushion to deal with fire events that are expected to occur but are not predictable in their location, extent, and outcome.

Northeast Interior Utah

This population is located entirely in Utah and has been divided into the Strawberry Valley and Carbon Management Areas.

Strawberry Valley

The Strawberry Valley Sage-grouse Management Area is located in central Utah, and is a significant population center for sage-grouse in Utah. This management area had an estimated 82 males on leks as of 2011. The area boundary was determined by consulting with DWR and the Strawberry Valley Adaptive Resource Management Local Working Group, and follows vegetation types usable by sage-grouse. Significant restoration efforts have been conducted on this population and it is the most intensively managed in Utah. This population is regarded as stable with a high potential for growth. Sage-grouse in this area had suffered significant reductions in populations, but concentrated restoration efforts have resulted in significant population growth. Due to its smaller size, Strawberry Valley is considered at-risk.

Carbon

The Carbon Sage-grouse Management Area is located in the northern portion of the Colorado Plateau in central Utah. This management area had an estimated 119 males on leks as of 2011. The area is characterized by highly broken terrain, with deep canyons and mid-elevation plateaus. Telemetry studies in the area suggest that occasionally sage-grouse migrate to and from the adjoining Strawberry Valley portion of this population. The area boundary was determined by buffering active leks with topographic imagery, and adding areas of known winter use. Key threats include habitat loss and fragmentation due to a variety of factors including energy development, wildfire, invasive species, and predation. West Nile Virus has been reported in Carbon in the last 10 years. The management area is at-risk.

Emery

The Emery population in Utah is considered the Emery Sage-grouse Management Area and is also known as the Sanpete-Emery Counties population in Garton *et al*. (2011). This population had an estimated 30 males on leks as of 2011. Small, mostly isolated sage-grouse populations occupy high elevation sagebrush steppe on the eastern slope of the Wastach Plateau. Although no direct movement between these areas has been documented, this population is relatively close to the South Central Utah population (Parker Mountain portion). This population includes all currently used habitat and corridors connecting this habitat. Key threats to the population include woody species encroachment, wildfire, invasive species, predation, and habitat fragmentation. Due to its smaller size, Emery is considered at-risk.

Sheeprock

The Sheeprock population in Utah is a relatively isolated population center also known as the Sheeprock Mountains Management Area. Garton *et al*. (2011) refers to this as the Toole-Juab Counties population. This population had an estimated 102 males on leks as of 2011. The area boundary was determined by consulting with the West Desert Adaptive Resource Management local working group and Utah Division of Wildlife Resources, and follows vegetation types usable by sage-grouse. This population is regarded as stable with a potential for growth. Sage-

grouse in this area show resiliency to known threats. Key threats to sage-grouse include wildfire, invasive species (cheatgrass and knapweeds), potential loss of riparian areas due to water piping, predation, and habitat fragmentation (dispersed recreation and pinyon-juniper encroachment). The management area is considered high risk.

South Central Utah

The population is located entirely within Utah and is one of the State's largest. It has been divided into three portions for management purposes including the Greater Parker Mountain, Panguitch, and Bald Hills.

Greater Parker Mountain

The Greater Parker Mountain Sage-grouse Management Area portion of the South Central Utah population is located on the Awapa Plateau and nearby environments. The Greater Parker Mountain Local Area Working Group was established in 1996 and is the longest operational working group in Utah. The boundaries of this portion of the population were refined based on 15 years of greater sage-grouse radio telemetry studies which included research on species' vital rates, survival, and seasonal movements. Boundary refinements included coordination with the working groups and the Utah Division of Wildlife Resources. This area had an estimated 821 males on leks in 2011. Because of these long-term research studies in this area, more is known about sage-grouse population dynamics, seasonal habitat use, population threats, and abatement strategies in this area than in other areas of Utah. This portion of the population includes all connected currently used habitats and corridors connecting these habitats. Key sage-grouse threats identified include: 1) loss or degradation of habitat (primarily due to vegetation succession), 2) conversion of habitat (sagebrush to pinyon-juniper or cheatgrass at the lower elevations), 3) increased risk of predation because of expansion of, or changes in, the native predator community in response to anthropogenic factors, and 4) habitat fragmentation from loss or degradation of habitat that results in a loss of sage-grouse habitat connectivity.

Panguitch

The Panguitch portion of the South Central Utah population is referred to as the Panguitch Management Area. It incorporates more than a dozen leks, often inter-connected. This area had an estimated 304 males on leks in 2011. This portion of the population is distributed north-south in a series of linked valleys and benches, and constrained by mountains and canyons. There is a large range in the number of males in attendance among these leks. Movement of sage-grouse from one valley or bench to another among seasons is necessary to meet their seasonal habitat requirements in the highly variable annual weather conditions of this region. This area has the highest potential for increase in Utah due to habitat treatments to remove pinyon-juniper. Key threats to sage-grouse in this area are increased predator populations, vegetation management (conflicting uses or lack of), energy development, and residential/commercial development.

Bald Hills

The Bald Hills portion of the South Central Utah population is referred to as the Bald Hills Management Area. This area had an estimated 68 males on leks in 2011. Currently, sage-grouse in the area are constrained by vegetation fragmentation and human development. However, future improvements could connect this population to the Southern Great Basin population (Hamlin Valley portion) to the west. This portion of the South Central Utah population is regarded as stable with a high potential for growth. Sage-grouse in this area show resiliency to known threats. Key threats include wildfire, increased predator populations, vegetation management (conflicting uses or lack of), and energy development.

Northwest Interior

This population is largely within Pershing County, Nevada, but also incorporates a portion of western Lander County and southeastern Humboldt County. Few PACs are mapped within this population other than some habitats within the Sonoma Range in southeastern Humboldt County, the Tobin Range in eastern Pershing County, and the Fish Creek Range in western Lander County. Priority areas for conservation identified within these ranges largely cover all remaining suitable habitat for sage-grouse. There were not enough data for Garton *et al.* (2011) to conduct an analysis on population trends or persistence estimates. The largest sub-populations within this area are within the Sonoma-Tobin complex and the Fish Creek Range. Lek count information from both of these areas suggest that there is less than 500 birds in each one of these populations and the potential for connectivity appears low, but possible. Other sub-populations within this area (e.g., Eugene Mountains, East Range, Humboldt Range, Majuba Mountain, and Trinity Ranges) have extremely low populations (<50 birds) with some of these ranges having populations that are extirpated due to severe wildfire and inability of the habitat to recover. Much of these areas are now monotypic stands of cheatgrass and tansy mustard. Overall, this population is high risk.

Southern Great Basin

This population contains the largest number of sage-grouse within Management Zone 3. It is relatively expansive and divided into a Nevada portion and Ibapah and Hamlin Valley portions within Utah.

Nevada

The Nevada portion of this population contains the largest number of sage-grouse in this population delineation. Suitable habitats are somewhat uncharacteristic of sage-grouse habitats because use areas are disjunct, but connected. This is due to the “basin and range” topography that is characteristic of this region. Lower elevation valley bottoms often are dominated by playas and salt desert shrub vegetation, but transcend quickly into sagebrush dominated benches, which often comprises the breeding and winter habitat. Moving up in elevation, pinyon-juniper

woodlands dominate the mid-elevation and gives way to little sagebrush, mountain big sagebrush and mountain shrub communities used by sage-grouse as nesting and brood rearing habitat in the higher elevations (> 2,200 m).

Priority areas for conservation (PACs) adequately capture important use areas for this population as all use areas were mapped to the greatest extent practical under the time constraints given to complete a map for the BLM's interim guidance. Redundancy and representation exist within this population, largely because it covers a large geographic area. Most populations appear to be connected as indicated through recent telemetry investigations and the availability of suitable habitat between sub-populations within this region. Resiliency of the habitat is in question due to threats, either projected or realized, in the lower elevation habitats, as explained below.

Garton *et al*. (2011) determined that this population has declined by 19 percent from the period 1965-69 through 2000-2007 and that average rates of population change were <1.0 for three of the eight analysis periods from 1965-2007. In addition, Garton *et al*. (2011) determined that this population has a two percent chance of declining below 200 males within the next 30 years and a 78 percent chance of declining below 200 males within 100 years (by 2107).

Some of the historic habitat available to sage-grouse within this population has transitioned to pinyon-juniper woodlands. Miller and Tausch (2001) estimated that the area of pinyon-juniper woodlands has increased approximately 10-fold throughout the western United States since the late 1800s. Additionally, Wisdom *et al*. (2005) determined that 35 percent of the sagebrush area in the eastern Great Basin is at high risk to future displacement by pinyon-juniper woodlands and that mountain big sagebrush appeared to be most at risk, which could have meaningful impacts to sage-grouse brood rearing habitats within the upper elevations of mountain ranges within this region. In addition to this threat, much of the Great Basin is also susceptible to sagebrush displacement by cheatgrass. The most at risk vegetative community in this region is Wyoming-basin big sagebrush (Wisdom *et al.* 2005) located predominately within the lower elevation benches of mountain ranges. In some areas, this condition has already been realized and the future risk for existing sagebrush habitats is moderate to high. This threatens both breeding and winter habitats for sage-grouse. For example, in a study conducted within this region (in Eureka County, NV), Blomberg *et al.* (2012) determined that sage-grouse leks that were not impacted by exotic grasslands experienced recruitment levels that were six times greater than those impacted by exotic grasslands. Additionally, this study found that drought is a major contributor to reduced recruitment and low population growth within the Southern Great Basin. Other threats such as mining and infrastructure have the potential to affect this sage-grouse population due to mine expansions, as well as new mines and the infrastructure associated with them. Existing mining claims are virtually ubiquitous throughout the Southern Great Basin PAC. Overall, sage-grouse in the Southern Great Basin in Nevada are potentially at-risk.

Ibapah

The Ibapah portion of the Southern Great Basin population is also referred to as the Ibapah Management Area and is located in northwestern Utah. This area had an estimated 39 males on leks as of 2011, primarily on Goshute Tribal lands. The area boundary was determined by

consulting with Nevada, the West Desert Adaptive Resource Management Local Area Working Group, and the Utah Division of Wildlife Resources and follows vegetation types used by sage-grouse. Sage-grouse in this area show resiliency to known threats. Key threats to sage-grouse are fire, invasive species (cheatgrass and knapweeds), potential loss of riparian areas due to water piping, predation, and habitat fragmentation (from dispersed recreation and pinyon-juniper encroachment).

Hamlin Valley

The Hamlin Valley portion of the Southern Great Basin population is also referred to as the Hamlin Valley Management Area. It is located in southwestern Utah, on the border of Utah and Nevada and is important due to its connectivity with other portions of the population. Although currently isolated from other habitat areas in Utah, habitat restoration could link this population to the South Central Utah population. This area consists of a relatively small number of birds (i.e., 89 males in 2011) that use less than 10 leks throughout the habitat area. This portion of the population is regarded as moderately stable with a high potential for growth. Key threats include wildfire, increased predator populations, vegetation management, wild horse management, and habitat fragmentation.

Quinn Canyon Range

This is a very small and isolated population located in southeastern Nevada. There were not enough data for Garton *et al*. (2011) to conduct an analysis on population trends or persistence. Two to three leks have been identified in this area, but there is very little information associated with these sites and most of this information is anecdotal. Habitat within this area has been compromised by pinyon-juniper encroachment. No PACs were identified for this population largely because the majority of vegetative associations are either salt desert shrub communities or pinyon-juniper stands. Very little sagebrush exists within this population. Overall this is a high risk population.

MANAGEMENT ZONE IV: SNAKE RIVER PLAIN

This zone represents one of the largest areas of connected sage-grouse habitat, as demonstrated by Knick *et al*. (2011), and supports the largest population of sage-grouse outside of the Wyoming Basin (Garton *et al*. 2011). The Snake River Plain management zone includes sage-grouse populations in Oregon, Idaho, Nevada, Utah and Montana. Garton *et al*. (2011) predicted a 10.5 percent chance this Management Zone will fall below 200 males by 2037, and a 39.7 percent chance it would fall below 200 males by 2107.

Baker

The Baker population has approximately the same distribution as the area covered by the Baker administrative unit identified in Oregon's Sage-grouse Conservation Strategy (Hagen 2011b). The Baker spring population was estimated to be 872 -1,650 birds in 2010, the smallest extant

population of sage-grouse that is exclusively in Oregon. Garton *et al.* (2011) based their Baker population assessment on minimum estimate of 137 birds in 2007 and estimated a 61.9% chance there will be fewer than 50 birds in the population by the year 2037, similarly, there is 66.8% chance of fewer than 50 birds by 2137. The Oregon Department of Fish and Wildlife lek counts indicated more than 300 males in Baker County in 2011. Since systematic counts began in 1989, the number of counted males/lek has remained relatively stable (Hagen 2011b). Due to habitat and topography it has been assumed the Baker population has little connectivity with other sage-grouse populations. Recent telemetry information suggests that at least some birds move between the Weiser population in Idaho and the Baker population.

The Baker population is more at risk and likely less resilient, since connectivity to other populations appears limited (future genetics work will help clarify this). There is no redundancy in this population as all birds are believed to be in one general area. For the entire population, the environmental similarity to extirpated populations is high (Wisdom *et al*. 2011). Most (68%) of the sage-grouse habitat for the Baker population is in private ownership and 31% is administered by BLM (Hagen 2011b). This is the largest proportion of privately managed sage-grouse habitat for any population in Oregon. Consequently, there are limited regulatory mechanisms in place, making it uncertain as to whether state-recommended conservation measures and practices will be applied on the majority of lands within this population.

More than 80% of the historical sagebrush habitat for the Baker Population remains available today but steeper habitat and rugged topography reduces the suitability for sage-grouse. Nearly 300,000 acres in this region were identified as priority areas for conservation, and includes much of the current range of the Baker population. Invasive weeds and juniper encroachment are considered to be the primary threats to this population (Hagen 2011b), but other threats to this population include renewable energy development (primarily wind), energy transmission, and OHV recreation. Recently, thousands of acres of juniper have been treated in this region to benefit sage-grouse and other sagebrush obligates. Most of the area used by this population has been mapped as priority habitat.

East-Central Idaho

Areas within the East Idaho Uplands in the Blackfoot River drainage downstream from Blackfoot Reservoir have historically provided popular sites for greater sage-grouse hunters. The area is generally characterized by a high proportion of private and state land and a local working group has been actively pursuing conservation measures. Nevertheless little information is available on sage-grouse populations other than some limited location and attendance data on a few leks. No lek routes have been established within this area that would allow consistent monitoring of sage-grouse populations. This lack of data is largely due to very difficult access in most years during winter and spring. Analysis of limited data by Garton *et al.* (2011) suggests that this population has a low probability of persistence. Although causal observation and some historic data suggest the study area provides adequate breeding and nesting habitat, sage-grouse numbers appear to be very low. Initial summer surveys in 2011 suggested sage-grouse were reasonably widespread throughout the area. However, given the apparent overall quality of the habitat, sage-grouse numbers seem surprisingly low and difficult

to explain. Factors that could act to reduce sage-grouse populations in this area include sagebrush treatments in breeding habitat, West Nile virus, and loss or fragmentation of winter range. Overall this population is considered high risk.

Southwest Montana

The Southwest Montana Population occurs in Beaverhead and Madison Counties, within a 60 mile radius of Dillon, MT. Segments of this population also make seasonal migrations into Idaho. Garton *et al*. (2011) analyzed the Southwest Montana population as 4 separate smaller populations (i.e., Bannack, Wisdom, Red Rock, and Bridges), but did not provide an analysis of the overall population. Telemetry data, however, has demonstrated considerable intermingling between each of these lek complexes, clarifying that these birds represent a single population (and could be more accurately described as four sub-populations). Priority areas for conservation encompass about 80 percent of the habitat associated with the Southwest Montana Population. These PACs were identified because of the relatively high density of sage-grouse and the genetic conduit this area provides with Idaho's birds. Habitat threats are generally limited to improper grazing management, isolated sagebrush control efforts, and expansion of conifers into sage-grouse habitat in localized instances. Habitat conversion on the Idaho side of this Management Zone may also affect this population to some extent. Both the Centennial and Big Hole valleys are focus areas for native habitat conservation for grayling, sage-grouse and other wildlife, resulting in considerable acreage enrolled in long-term and perpetual conservation agreements with private landowners. Given this population's size, limited habitat threats, and ties to Idaho's birds, the Southwest Montana population is characterized as being at a low level of risk.

Snake-Salmon-Beaverhead

Recent data indicates this large population extends into southwestern Montana. This area contains a large amount of publicly managed land (largely BLM and USFS). Within the southern portion of this population, wildfires and invasive species have continued to reduce the quality of habitat. The mountain Valley portions of this population appear to have relatively stable habitats. Thus far, energy development is very limited and there are few wild horses. A recent rate of change analysis indicates this population has been stable to increasing from 2007 to 2010. Garton *et al.* (2011) indicated that this population had virtually no chance of declining below 500 in the next 100 years. Population analysis indicates that sage-grouse have fluctuated around 5,000 males since 1992. Because of relatively large numbers of birds and stable to increasing populations, this population is considered low risk.

Belt Mountains

This population occurs within a broad intermountain valley that extends roughly from White Sulfur Springs south toward Livingston, within Meagher and Park Counties. This population experienced considerable habitat conversion to small grain cropping in the late 1960s through the 1980s, involving at least one key sage-grouse wintering area (Swenson *et al.* 1987). Ironically, some of these croplands have since been enrolled into the Conservation Reserve Program (CRP)

but natural sagebrush recovery appears minimal. Garton *et al.* (2011) were unable to develop any population predictions due to a lack of sufficient data. This population is at least 50 miles distant from the nearest adjacent population. Timbered and mountainous terrain and expansive non-habitat barriers further isolate this population in nearly every direction. Sagebrush control projects, primarily using herbicides, and conversion to cropland and domestic seeded pastures have continued to affect portions of the remaining habitat during the past 20 years. More recently, isolated housing developments and limited drilling for oil and/or gas resources have impacted a relatively small portion of remaining sagebrush grassland habitats in this area. The small population size, isolation from other populations, and a history of significant habitat perturbations, some of which continue but perhaps at a slower rate, places this population as high risk.

Weiser

This small population in western Idaho did not have sufficient data to allow analysis by Garton *et al.* (2011). However, 2010 data indicated the area had 14 occupied leks. Recently some connection with the Baker, Oregon population has been documented. The area is generally characterized by a high proportion of private land and a local working group has been actively pursuing conservation measures. Because of relatively few birds, fragmented habitat and a large portion of existing habitat on private lands, this population is considered at risk.

Northern Great Basin

The Northern Great Basin population is a large population in Oregon, Idaho, Nevada, and Utah. It has been divided into the large portion in Oregon, Idaho, and Nevada and a smaller portion in northwestern Utah called the Box Elder area. This area contains a large amount of publicly managed land (largely BLM). The area also includes among the least fragmented and largest sagebrush dominated landscapes within the extant range of sage-grouse (Knick and Hanser 2011). However, the northern and eastern portions of the population are more environmentally similar to areas where sage-grouse have been extirpated (Wisdom *et al.* 2011).

Despite efforts to manage wildfire risks, wildfires and invasive species have continued to reduce the quality of habitat in portions of this area. Idaho's Murphy Fire Complex recently affected roughly 600,000 acres of habitat for this population. The 2012 Long Draw fire in Oregon affected 582,000 acres; 455,000 acres were considered either Core or Low Density sage-grouse habitat under Oregon's conservation strategy, of which 213,000 acres in a PAC.

A recent rate of change analysis indicated that at least part of this large population has been stable to increasing from 2007-2010. Garton *et al.* (2011) indicated that this population had virtually no chance of declining below 50 in 30 or 100 years. Population analysis indicated that sage-grouse will fluctuate around a carrying capacity that will decline from an estimated 6,770 males in 2007 to 1787 males in 2037 if current trends continue (Garton *et al.* 2011).

Redundancy and representation appear to be captured adequately in the PACs. In Oregon, PACs capture 95 percent of all known breeding locations, 98 percent of known wintering locations (which was expected since this was based on telemetry data), and 89 percent of known summer locations. Priority areas for conservation and low density (non-priority but managed) habitat combined capture all but three percent of known summer, one percent of known breeding, and one percent of known wintering habitat. Oregon PACs also considered the need to maintain a network of connected habitats.

The Nevada portion of the Northern Great Basin population represents the largest, most contiguous concentration of sage-grouse in Nevada and includes the Santa Rosa, Desert, Tuscarora, North Fork, O'Neil Basin, Islands, Snake and Gollaher Population Management Units. Portions of this area are well connected with Oregon, Idaho and Utah. Fire and invasive annual grasses are the major threats to the Nevada portion of this population. Since 2000, over 800,000 acres of sagebrush habitats have burned in this region. Rehabilitation efforts and the higher elevation/higher precipitation zones for some recent wildfires have led to expedited habitat recovery that is once again being utilized by sage-grouse demonstrating at least some resiliency for this portion of the population.. Winter habitat in some areas has been compromised although recent winter snowpack has been below average, allowing birds to utilize an expanded area. The Gollaher and Tuscarora population management units have been prone to wildfire and are more susceptible to invasive species such as cheatgrass. Mining and infrastructure have potential to pose additional threats to sage-grouse habitat as gold prices have increased 112% over the last 5 years and mining claims are numerous within the Nevada portion of the Northern Great Basin.

Oregon represents the western part of this large population which is shared with southern Idaho, NE Nevada, and NW Utah. Within Oregon, this represents one of the largest populations. The delineation of the Northern Great Basin population doesn't correspond well to any existing assessment for Oregon, but does include almost all of the Vale administrative unit, as well as portions of the Burns administrative unit. In Oregon alone, the spring population in the Northern Great Basin is likely several thousand birds, with 2011 spring lek counts approaching 3,000 males (in the Beulah, Malheur River, Owyhee, and eastern portion of Whitehorse Wildlife Management Units). Garton *et al*. (2011) estimated for the Northern Great Basin a minimum population estimate of 9,114 males in 2007 (includes S. ID, NE NV, NW UT). Modeling suggested there is a 2.5% chance birds will drop below 500 by the year 2037, but a 99.7% chance the population will be below 500 by 2137 (Garton *et al*. 2011). Loss of sagebrush habitat has been and continues to be threat to the population in Oregon. Between 1963 and 1974, 500,000 acres of sagebrush habitat was seeded to crested wheatgrass or sprayed with herbicide, and 1,600 water developments and 463 miles of pipeline were installed in the Vale District BLM's area for the Vale project. More recently, wildfire is the most significant threat to landscape scale losses of sagebrush habitat as indicated by the previously mentioned 582,000 acre Long Draw fire of 2012. In conjunction with fire, invasive weeds are also one of the greatest risks the 4+ million acres of sagebrush habitat for this population in Oregon. More than

580,000 acres is already dominated by invasive species (Hagen 2011b). In many instances, these areas were historically dominated by Wyoming big sagebrush habitat. Other threats in this region include mining development, renewable energy development, transmission, and juniper encroachment at higher elevations. West Nile virus has also been consistently detected in mosquitoes in this region (http://public.health.oregon.gov/) and the population was subjected to the largest known West Nile virus mortality event involving sage-grouse in Oregon (2006). Despite efforts to manage wildfire risks, wildfires and invasive species have continued to reduce the quality of habitat in portions of this area. Largely due to the landscape altering potential of very large wildfires, with recent years as evidence, overall this part of the population is potentially at risk.

Box Elder

The Box Elder portion of the Northern Great Basin population is located in northwestern Utah. This area is referred to as the Box Elder Management Area. It had an estimated 755 males on leks as of 2011. This population is regarded as stable with a potential for growth. Key threats include wildfire, invasive species, loss of agricultural operations, and habitat fragmentation. The area can likely sustain increases in sage-grouse populations with continued reclamation and restoration. As a result, this area should be a high priority for funding of habitat enhancement. Because this area is a portion of the large Northern Great Basin population, it is potentially at risk.

Sawtooth

This small population in central Idaho did not have sufficient data to allow analysis by Garton *et al*. (2011). No occupied leks are known to exist at this time. This area is largely encompassed by the Sawtooth National Recreation Area and includes a high proportion of public land. This population declined to one male on one lek in 1986 and was subsequently increased by translocation during the mid-1980s. Overall this population is at high risk.

MANAGEMENT ZONE V: NORTHERN GREAT BASIN

There are four sage-grouse populations identified in this management zone, including Central Oregon, Klamath, Warm Springs Valley, and the Western Great Basin. Garton *et al.* (2011) predicted a 2.1 percent chance this Management Zone will fall below 200 males by 2037, and a 29.0 percent chance it would fall below 200 males by 2107. Only two of the populations (Central Oregon and Western Great Basin) had sufficient information for a population assessment by Garton *et al.* (2011). BLM lands are a major constituent of sagebrush landscapes in the Northern Great Basin (62 percent), followed by private (21 percent), Forest Service (10 percent), state (8 percent), and then other ownerships (Knick 2011). This zone is part of a stronghold for sage-grouse (that includes Management Zones III, IV, and V) because the three zones contain the largest area of habitat range-wide with low similarity to extirpated portions of the range (Wisdom *et al.* 2011).

Central Oregon

The Central Oregon population has approximately the same distribution as the area covered by the Prineville administrative unit identified in Oregon's Sage-grouse Conservation Strategy. Approximately 700,000 acres of habitat for the Central Oregon population has been identified as priority areas for conservation. This is a relatively large population, with the minimum spring population estimated at 1,775-2,084 birds in 2010 (Hagen 2011b). The population has declined steadily since 1980 (average, -0.004 percent/yr [Hagen 2011b]). There is a 15.2 percent chance the population will decline below 500 by 2037, and a 91.3 percent chance that fewer than 500 birds will be in the population by 2137 (Garton *et al*. 2011).

This population is estimated to have only 53 percent of historic sagebrush habitat, having lost more historic habitat than any other sage-grouse administrative unit in Oregon. The area also has more privately owned sage-grouse habitat (48 percent) than most other sage-grouse management zone populations in Oregon. This population faces a wide suite of threats, including juniper encroachment, (Freese 2009) which threatens over 900,000 acres of the 1.8 million acres of sagebrush habitat in in this area (Hagen 2011b). Additional threats include invasive weeds, renewable energy development (both wind and geothermal), transmission, roads, OHV recreation, and residential development. Projections based on historic trends suggest this population is at risk, but in the last 2 years there have been a number of positive developments including thousands of acres of habitat improvement under the NRCS's Sage-grouse Initiative and increasing local interest sage-grouse conservation. Juniper encroachment does threaten connectivity with other Oregon populations to the south and east (Hagen 2011b).
Based on Garton *et al*. (2011), this population appears fairly resilient in 30 years, but not in 100 years. Redundancy and representation appear to be captured adequately. PACs capture 95 percent of all known sage-grouse breeding locations, 98 percent of known wintering locations, and 89 percent of known summer locations. Priority areas for conservation and low density (non-priority but managed) habitat combined capture all but three percent of known summer, one percent of known breeding, and one percent of known wintering habitat. Since this population's habitat/landscape appears more similar to landscapes in extirpated populations than extant populations, particularly in the northwest extant of range (Wisdom *et al.* 2011), we suggest retaining all priority habitats for this populations. Most of the sites within this population (with the possible exception of the southwestern site) probably have some connectivity with other sites in this population, though verification from genetics is lacking. Although much of the known habitat is mapped, we suggest retaining all PACs in Central Oregon.

Klamath

The Klamath population is all that remains of a population that once extended from northern California through southern Oregon. The California portion includes the Devil's Garden Area of Modoc County, which had at least 46 known leks as recently as the 1970s, and was well connected to populations in Oregon and the Western Great Basin. By the early 2000s, only one known lek remained on the Clear Lake National Wildlife Refuge in California, with less than 10 males. Since 2005, birds have been translocated from Oregon and Nevada to the refuge to prevent extirpation. A small amount of priority habitat is mapped for the area where birds

currently exist, but not connected to the Western Great Basin or Central Oregon populations. Redundancy is not adequate and resistance is poor. This population is at immediate risk of extinction without continued augmentation. There is no priority habitat mapped in this population for Oregon because we have not documented birds there recently.
There are no priority areas for conservation mapped for this population in Oregon because sage-grouse in the Oregon part of the Klamath population are thought to be extirpated. As recently as the early 1990's, a few birds attended leks in Oregon, but there have been no confirmed sightings since 1993, despite periodic survey efforts. The Klamath population was likely an extension of the population in northeast California and likely had limited connectivity with sage-grouse populations in eastern Oregon due to barriers of unsuitable habitat. Habitat in both California and Oregon is severely compromised by juniper encroachment, wildfire, and invasive grasses. Significant juniper treatments have taken place in and around the area currently occupied by sage-grouse and in the former Oregon range. There is potential for limited range expansion for sage-grouse in the future.

Warm Springs Valley

This is a small population that exists in southern Washoe County within the Virginia Population Management Unit. Only two confirmed active leks comprise this population; however, lek size is relatively large (average of over 40). The identified PACs encompass the majority of use areas. Extensive research has been conducted within this particular Population Management Unit. Some individuals have dispersed to the southern portion of the western Great Basin population during the winter, so there is the possibility of genetic interchange. There is an indication of this from work conducted by Oyler-McCance *et al*. (2005) suggesting a relationship with the Lassen population in California. Representation and redundancy are limited within this population due to its small size, proximity to urbanized setting and threats from invasive species.

The Warm Springs population in southern Washoe County may be close to a threshold if additional threats occur. This population is very close to urban areas, has experienced large wildfire and energy development in the form of a utility scale transmission line (345kV Alturas line) and water transfer pipeline (Vidler Water), and is experiencing some pinyon-juniper encroachment. However, the primary area used by sage-grouse in the population (Spanish Flat) remains intact and benefits from higher elevation precipitation regimes. Overall, this is population is at risk.

Western Great Basin

The Western Great Basin population is shared among southeastern Oregon, northeastern California and northwestern Nevada. Range-wide for sage-grouse, this area contains one of four remaining large intact expanses of sagebrush habitat and connects south-central Oregon with northwest Nevada, with most of the sagebrush dominated landscape in Oregon (Knick and Hanser 2011). Habitat fragmentation increases to the south and west in the population, with northeast California having a high similarity with portions of extirpated range (Wisdom *et al.* 2011). Garton *et al.* (2011) estimated for the Western Great Basin a minimum population estimate of 5,904 males in 2007 (includes NE CA, NW NV). Over 8 analysis periods conducted

by Garton *et al*. (2011), average rates of change were <1.0 in 3 of those periods and the minimum population estimate was determined to be 5,904 males in 2007 based on counts at 393 leks. Modeling suggested there is a 6.4 percent chance birds will drop below 500 by the year 2037, but a 99.1 percent chance the population will be below 500 by 2137 (Garton *et al*. 2011). The Western Great Basin is the most resilient population in Management Zone 5, but reducing threats alone is not likely to ensure long-term persistence in some areas. Resiliency needs to be improved in the California and Nevada portions of the Western Great Basin with increased habitat suitability in terms of shrub densities and native grasses and forbs.

Oregon's portion of the population has some of the best habitat and highest sage-grouse densities in the state, including Hart Mountain National Antelope Refuge and Trout Creek Mountains, though habitat in the Trout Creeks was likely compromised by 2012 fires. The delineation of the Western Great Basin population doesn't correspond well to any existing assessment for Oregon, but does include almost all of the Lakeview administrative unit, as well as portions of the Burns and Vale administrative units. In just Oregon, the spring population in the Western Great Basin likely exceeded 10,000 birds in 2010 (interpolation from Hagen 2011b). In the Oregon, >80 percent of the historical sage-grouse habitat remains intact, and most of the habitat is in public ownership (Hagen 2011b). In the Lakeview administration unit, which comprises most of the Western Great Basin population in Oregon, about 78 percent of the region is administered by the BLM and the FWS manages more than 278,000 acres. Invasive weeds, fire, and juniper encroachment (particularly on the western edge) represent the greatest risks to this population. Renewable energy development (wind and geothermal) and wild horses have been identified as a threat to sage-grouse habitat in portions of Oregon's (e.g., Steens, Dry Valley/Jack Mountain Action Areas) Western Great Basin population. Given the majority of this population occupies federal land, proper and proactive habitat management could ensure the persistence of this sage-grouse population well into the future. Redundancy and representation appear to be captured adequately in the Oregon portion of this population given that priority habitats include most of the known distribution of birds (see rationale in Central above).

The California portion of the Western Great Basin includes the majority of the Buffalo-Skedaddle Population Management Unit. Priority habitat in California includes 100 percent of known sage-grouse distribution. This population was part of a much larger population that was connected to the Klamath population into the 1970's. Habitat degradation, including juniper expansion and spread of exotic grasses has been extraordinary in this region, resulting in range contraction over the past few decades. In August, 2012, the Rush Fire burned more than 265,000 acres of PACs in California and more than 313,000 acres including Nevada. Most of the largest leks and important nesting habitats were within the fire perimeter. Furthermore, the fire was focused on the East Lassen area to the east of Highway 395, which connects to the Western Great Basin Population in Nevada. The remaining area occupied by grouse in Central Lassen on the western periphery of the range may be further isolated by this fire. The extant population was considered well connected prior to the fire, but connectivity post-fire is unclear. The California portion of the Western Great Basin had experienced recent positive population trends, demonstrating that the population could exhibit positive growth rates during years of favorable environmental conditions. However, habitat suitability pre-fire was considered low (Davis 2012) and was in need of improvement to increase resistance of this population. The full effects of this

large-scale wildfire are unclear at this time. The Nevada portion of this population includes the Buffalo/Skedaddle, Massacre, Vya, Sheldon, Black Rock, Pine Forest and Lone Willow Population Management Units. Currently identified priority habitat encompasses an area greater than the 85 percent core breeding density as reconstructed by the Nevada Department of Wildlife using methods described by Doherty *et al.* (2010), but utilizing the 10-year average for lek attendance rather than the most recent peak. Redundancy and representation are adequately captured both within the Nevada portion of this population and certainly within the Western Great Basin population as identified by Garton *et al*. (2011).

The Lone Willow portion of the Western Great Basin population (connected with Oregon) was affected by a very large wildfire in 2012. The Holloway Fire burned approximately 214,000 acres in Nevada and 245,000 acres in Oregon of which about 140,000 acres in Nevada and 221,000 acres in Oregon were considered important or essential sage-grouse habitat. The Miller Homestead fire in Oregon included an additional 162,000 acres of sagebrush habitat within its perimeter, 149,000 acres of which was identified as a PAC for the Western Great Basin population. Fire and annual grasses should be characterized as substantial and imminent threats within this portion of the population. Additionally, this area faces threats from lithium and uranium exploration and extraction. Along with infrastructure that may come with this potential development, it may be appropriate to characterize mining and infrastructure as substantial, non-imminent threats to this portion of the population.

Both the Massacre and Buffalo/Skedaddle Population Management Units face high risk due to invasive species being pervasive within the understory of lower elevation sagebrush communities. Improper livestock grazing practices and wild horse utilization have caused severe habitat degradation in some instances, especially with respect to meadow, spring and riparian habitats. Within the Massacre PMU, important information relative to habitat condition is contained within the BLM's Environmental Assessment for a Wild Horse Population Management Plan within the High Rock Complex (DOI-BLM-CA-N070-2011-04-EA). Appendix F of this document provided the results of Rangeland Health Assessments (RHAs) across five Herd Management Areas (HMAs). Within the "Standards for Biodiversity" sections of these RHAs, of the 28 sites assessed, 50% of them were not meeting biodiversity standards. This was mainly due to a lack of an adequate quantity of key deep-rooted perennial grasses such as Thurber's needlegrass, bluebunch wheatgrass and Idaho fescue, but also due to poor riparian condition as well. Whether or not this condition is the result of historic or current livestock grazing practices and/or wild horse utilization is debatable, but the fact that it continues to exist requires more appropriate management actions to improve the condition of the habitat. Since much of this region is susceptible to annual grass establishment, it is important that the perennial grass understory is maintained and perpetuated to help curtail the invasion of species like cheatgrass. This is supported by the findings of Blank and Morgan (2012) where, relative to controls, established perennial grasses significantly hindered the growth of cheatgrass. In addition to less than adequate upland conditions, this EA also found that riparian areas, spring and meadow complexes were damaged as well. The EA reports: "Riparian functional assessments completed in 2010 have determined that most riparian sites within the High Rock Complex are "Functional at Risk" (66%), and several other sites (17%) are rated as "Nonfunctional". This means that the majority of sites (83%) are in an obvious degraded

condition. Sites rated as FAR are in danger of becoming "Nonfunctional" if the stresses and disturbances causing these conditions are allowed to continue. The dominant causal factors for riparian and wetland sites not being rated as PFC is grazing and trampling from livestock and wild horses. Many sites have recorded causal factors for not achieving PFC as continuous, year round use by wild horses.

Within the Sheldon National Wildlife Refuge, wild horses were rated as the highest risk to sage-grouse habitat quality by the Washoe-Lassen-Modoc local working group. This assessment was further justified within the Sheldon National Wildlife Refuge Comprehensive Conservation Plan (CCP) which identified management of feral horses and burros as the most important issue affecting the ability of the Service to fulfill the purposes for Sheldon Refuge (USFWS 2012). Additionally, an Environmental Assessment prepared by the USFWS (USFWS 2008) determined that wild horses and burros had direct adverse impacts to biological integrity, diversity and environmental health within Sheldon Refuge.

The Western Great Basin is most resilient in MZ5, but reducing threats alone is not likely to ensure long-term persistence in some areas. Resiliency needs to be improved in the California portion of the Western Great Basin with increased habitat suitability in terms of shrub densities and native grasses and forbs. Additionally, for this population to retain its resiliency, significant efforts are needed to ensure post-fire habitat recovery and prevent dominance of non-native vegetation. Overall this population is considered potentially at risk.

MANAGEMENT ZONE VI: COLUMBIA BASIN

There are four identified populations in Management Zone VI, which exists mostly in Washington State. Two of these populations, Moses Coulee and Yakima Training Center, are extant populations that were identified and assessed by Garton *et al.* 2011. The additional populations are Crab Creek and Yakama Nation, both of which were addressed with the aid of translocated individuals. Based on information collected at Moses Coulee and Yakima Training Center, Garton *et al*. (2011) predicted a 76.2 percent chance that this population would dip below 200 males in the next 30 years and 86.3 percent chance it would dip below 200 by 2107. Along with the Colorado Plateau, leks in this management zone are the least connected (Knick and Hanser 2011). The PACs likely are large enough to support the current populations and the recovery areas encourage the expansion needed to improve the overall viability. The small size of existing populations and lack of current viability in this management zone means that current management direction (target toward recovery rather than maintenance) is different than in other management zones.

The PACs within this management zone capture redundancy and representation within the management zone, assuming that the protections and management prescriptions area adequate within these areas and they are followed. The PACs were specifically chosen to protect the identified populations. However, because the populations in this management zone are not believed to be viable at this time, the area of protection is larger and designed to include recovery

areas which are needed to support a larger, more connected, and hopefully viable population in the future. Based on population viability, it is unlikely that any of the populations in this zone are resilient to threats or disturbances. The order of descending risk is Yakama Nation, Crab Creek, Yakima Training Center, and Moses Coulee.

Moses Coulee

The Moses Coulee population has been maintaining its number for the last 30 years, largely due to the support of farm programs. However, the lower risk of Moses Coulee does not mean that the population is at no risk. This population is at risk. In 2007, 230 males were counted in this population (Garton *et al*. 2011); they estimated an 88 percent probability that the population would dip below 200 males by the year 2037 or close to a 100 percent probability that the population would dip below 200 males by the year 2107. The estimated a 62 percent probability that the population would dip below 20 males by 2107. Despite these dire concerns, the Moses Coulee population of males was estimated to be about 350 in 2012 (Schroeder *et al*. 2012).

Major issues in Moses Coulee are the lack of habitat stability due to the abundant private land, habitat fragmentation, and dependence on farm programs. There is public land managed by the Washington Department of Fish and Wildlife, BLM, Washington and Department of Natural Resources, but the public land is relatively sparse compared to the quantity of private land (Stinson *et al*. 2004). The abundance of private land adds to the management uncertainty. Because of relatively large amounts of enrollment in CRP and State Acres for Wildlife Enhancement (SAFE) programs, there is a great deal of support for sage-grouse in the Moses Coulee area at least for the next decade. Even so, the high degree of fragmentation and 'subsidized' predators (subsidized with road kill, orchards, and nesting and perching structures) increases the overall predation rate.

Yakama Nation

The Yakama Nation population is extremely small with extremely low viability, if any. The area was historically occupied, but the extinction of the endemic population was not precisely documented (Schroeder *et al*. 2000). During 2006-2008 sage-grouse were translocated to the Yakama Nation in an attempt to re-establish a population. Although it is still too early to evaluate success, the results are not promising at this time. The Yakama Nation faces many threats to their sage-grouse population including poor habitat quality, small population size, and lack of connectivity with existing populations, and wild horses. The wild horse population is severe in portions of the Yakama Nation. It is not clear if the Yakama will be able to aggressively deal with the horse issue. On the positive side, the land is owned by the Yakama Nation and the strictly control access. Consequently, they have a great deal of management control as well as interested in recovering a population of sage-grouse on their land. This population is considered high risk.

Crab Creek

The Crab Creek was occupied by sage-grouse until the mid-1980s (Schroeder *et al*. 2000). By the mid-1990s the Washington Department of Wildlife and the BLM had acquired and/or consolidated approximately 50,000 acres in the Crab Creek area. Because sage-grouse were a priority for management on many of these acres and management direction was altered in favor of sage-grouse, it was believed that this area could once again support sage-grouse. Translocations were initiated in 2008 (Schroeder *et al*. 2012). In 2012, the number of males counted on a single lek was 13. Based on survival and productivity, the potential for this population appears promising. However, it is still too early to determine if the re-establishment effort was successful. The primary risk factors for this population include its small size, habitat fragmentation, and the risk of losing acres formerly enrolled in farm programs (CRP and SAFE). This population is considered high risk.

Yakima Training Center

The second most resilient population in this zone is the Yakima Training Center population which is much smaller than Moses Coulee, but is almost entirely public land. Long-term viability is anything but certain. In 2007, 85 males were counted in this population (Garton *et al*. 2012); they estimated a 26 percent probability that the population would dip below 20 males by the year 2037 or 50 percent probability that the population would dip below 20 males by 2107. The number of males counted in 2011 was 72 (Schroeder *et al.* 2012). The use of the Yakima Training Center for military training activities and the risk of fire have reduced the overall suitability of the habitat supporting this population. A substantial amount of the sage-grouse habitat on the area has been harmed directly and indirectly military training activities, particularly due to wildfires. Despite efforts to manage wildfire risks, wildfires have continued to reduce the quality of habitat in the population. Other key factors in this population are two interstate highways (I 82 and I 90) which border the population on north and west side, powerlines which border the population on the north, west, and south sides, the Columbia River Valley which is natural but reduces movement on the east side, and wind development on the north side. The cumulative effect of these factors is that the population is constricted with little opportunity for expansion. On the positive side, the population occupies and area dominated by public land. This population is considered high risk.

MANAGEMENT ZONE VII: COLORADO PLATEAU

This management zone contains two populations; Parachute-Piceance Basin and Meeker-White River Colorado. The designated priority areas for conservation appear to capture redundancy and representation. Priority habitats are well mapped and include all high use habitat (which includes breeding, summer, and winter habitat within 4 miles of all known leks) and linkage zones to Management Zone 2 to the north. There is no known connectivity with Utah

(Management Zone 3 to the west) due to natural habitat fragmentation and large areas of non-habitat.

Parachute-Piceance-Roan

The Parachute-Piceance-Roan Basin population appears to be captured within priority areas for conservation, and representation appears to be captured adequately. Priority areas for conservation capture 60 percent of the occupied range in this population and also include 100 percent of all known active leks and all habitats that were modeled "high probability of use" within four miles of a lek that has been active in the last 10 years. Redundancy is not captured within this population because it is a relatively small (three year running average number of males is 93) and somewhat isolated. This population is on the very southern edge of the species range. There is some potential for connectivity to the north to the Wyoming Basin population in Management Zone 2. Linkage habitats have been included in mapping efforts. Representation and redundancy are at risk within this population due to its small size, energy development and the associated infrastructure, especially road development. Pinyon-juniper encroachment is also an issue. The Parachute-Piceance-Roan population appears to have some resiliency. The population has been monitored since 2005 and appears to be fluctuating similar to other larger populations in the state. A large majority of PACs are privately owned, mostly by energy companies. Energy and mineral development is the highest ranked threat to sage-grouse in this area. Advances in drilling technology and rapid natural gas demand and subsequent rising prices have led to a significant increase in natural gas drilling activity. Road and infrastructure are also ranked high as they are closely related to energy production. Historic habitat has been lost and fragmented also by pinyon-juniper encroachment. This population is considered to be at high risk.

Meeker-White River Colorado

This population is located just northeast of Parachute-Piceance-Roan Basin. There is no redundancy and little representation in the Meeker-White River population (three-year running average high male count is six birds). Priority areas for conservation capture 27 percent of the occupied range in this population and include the only known active lek. All habitats modeled "high probability of use" and within four miles of any lek (active in the last 10 years) are within priority habitat. Representation and redundancy are at risk within this population due to its small size, proximity to an urbanized setting and, thus, housing development and associated infrastructure and agriculture conversion. This is a very small population located near the town of Meeker and consists of only one active lek that was discovered in 2004, and strutting male counts have been on a steady decline since (e.g., from a high of 30 males in 2004 to six males in 2012). Most of the occupied habitat is privately owned (90 percent) and is in two disconnected patches of habitat, separated by the White River. One of the patches remains unfragmented. The other patch is located where housing development will primarily occur. Meeker-White River has lost resiliency. The population has been monitored since 2004 and the population has been in a steady decline from 30 males to the current six males. Housing development is increasing mainly due to energy development in nearby counties. A large part of the habitat was converted to agriculture in the 1960's, which is likely a primary reason why the population went into

decline. A current issue is that some of the lands in pasture and CRP land may now be converted back to crop lands. This population is considered to be at high risk.

BI-STATE DPS

The Bi-State Distinct Population Segment (Bi-State DPS) is geographically and genetically isolated from other populations of greater sage-grouse (Oyler McCance *et al.* 2005, Benedict *et al.* 2003). Four populations are identified in the Bi-State DPS, including: Pine Nut, North of Mono Lake, South of Mono Lake, and the White Mountains. These populations are delineated based on a fair degree of geographic and genetic isolation within the overall Bi-State DPS. Within the Bi-State, all occupied habitat is considered PAC. Two core populations exist to the north and south of Mono Lake, with small peripheral populations in the Pine Nut Range to the north and White Mountains to the south. Garton *et al.* (2011) indicate that long-term persistence is questionable for both core populations with a high probability of dropping below effective population sizes of 50 birds in the next 100 years (100 percent for North Mono and 81.5 percent for South Mono). However, probability of dropping below effective population sizes of 50 birds is low in the next 30 years (15.4 percent for North Mono and 0.1 percent for South Mono. The Bi-State DPS has grown consistently each year from 2008–2012 to the highest population size on record, presumably in response to a trend in higher precipitation and favorable range conditions. Relatively large population increases have been seen in the core populations to the north and south of Mono Lake that have multiple well-connected leks, while peripheral populations have not seen these population increases. The Bi-State DPS is still represented in most of the known historic distribution, but threatened by small and isolated populations on the periphery of the range. Genetic diversity remains high in most of the Bi-State DPS, with emerging evidence that representation has been lost in some areas by population reduction and some loss of genetic diversity.

North Mono Lake

The population to the north of Mono Lake consists of a central stronghold located in the Bodie Hills, CA, and several additional peripheral populations in CA and NV that vary in size and degree of isolation. The Bodie Hills population has grown in recent years to be the largest and most connected population in the Bi-State, with more than 500 males counted on leks in 2012. The Bodie Hills breeding complex has about 9 to 11 core leks, ranging from about 100-500 males counted over the past 20 years. The Bodie Hills breeding complex appears to be best connected with the Aurora, Rough Creek and Nine Mile Flat area within the Mount Grant PMU in Nevada. This area, plus Mount Grant proper in the Wassuk Range contains eight active leks. The Fales area in California, consisting of two known leks at Wheeler Flat and Burcham Flat on the northwestern edge of this population, is largely isolated from Bodie, but probably has some connectivity to another small population at Jackass Spring along the border and Desert Creek/Sweetwater Flat in NV. The Fales population was much larger prior to the early 1980's and has experienced the greatest population declines in California, with less than 100 males counted on leks in 2012. The core population to the north of Mono Lake in total appears to be

fairly resistant but individual subpopulations much less so. While the population remains relatively stable, the size and geographical extent is moderately small and the degree of historic impacts has not been severe. Although there is good resistance in the core of this population, additional threats should be avoided in both the core and peripheral areas. The North Mono Lake population is the largest population in the Bi-State and least isolated, and is potentially at risk because of periodic fluctuations in population size, and multiple threats to the population.

South Mono Lake

The population to the south of Mono Lake consists of a central stronghold located in Long Valley, CA. The Long Valley and Bodie Hills populations are considered the two main core populations in the Bi-State DPS. Similar to Bodie, the Long Valley population has grown in recent years, with more than 400 males counted on leks in 2012. Similar to the Bodie Hills, the Long Valley breeding complex contains about 9-11 core leks, with about 150-400 males counted over the past 20 years. One additional breeding population located at Parker Creek in CA is considered isolated from Long Valley and only known to contain one lek. The Long Valley breeding complex remains relatively stable and resistance to ongoing impacts is generally good. As with the North Mono population, however, this breeding complex is not overly large. The Long Valley population is probably more vulnerable than Bodie because it is considered isolated from other Bi-State populations and seasonal habitats are limited to a relatively small area. Therefore, this population could be severely impacted by catastrophic events, and further cumulative threats should be avoided. The Parker population is probably fewer than 100 estimated birds total and lacks resistance. The South Mono Lake is currently relatively large population, but is potentially at risk because of isolation, periodic fluctuations in population size, and multiple threats to the population.

Pine Nut

The Pine Nut population is the smallest and most threatened population in the Bi-State DPS. The population consists of one consistently active lek, although there is indication that additional sites may be present and there is some connectivity to the population to the north of Mono Lake. The long-term average male attendance is approximately 14 males over the past 11 years. The population appears predisposed to environmental vagaries in the form of wildfire and drought as well as additional anthropogenic stressors that have and continue to influence the population. These conditions have resulted in a population that is largely nonresistant to additional impacts. The Pine Nut population is classified as high risk because of very low population size and relatively high level of threats.

White Mountains

The population in the White Mountains is not well understood because of difficulty in accessing the area to conduct lek surveys. However, at least one lek is known to exist at Chiatovich Flat in California and 2 recently discovered leks are known to exist in NV. As with the other Bi-State breeding populations, sage-grouse in the White Mountains are probably mostly threatened by small population size and are therefore vulnerable to catastrophic events. However, this

population, located in high elevation habitats on the extreme southwest of the species range, has probably always been small and faces the fewest threats in the Bi-State DPS. The White Mountains are classified as potential risk because of the aforementioned uncertainty regarding population size, but has the least land use threats in the Bi-State DPS.

APPENDIX B—POLICY FOR THE EVALUATION OF CONSERVATION EFFORTS WHEN MAKING LISTING DECISIONS

preferred the rulemaking petition. The coordinates for Channel 287C3 at Alamo are 32–19–29 North Latitude and 82–43–23 West Longitude. This allotment has a site restriction of 20.4 kilometers (12.7 miles) north of Alamo.

DATES: Effective April 28, 2003.

FOR FURTHER INFORMATION CONTACT: R. Barthen Gorman, Media Bureau, (202) 418–2180.

SUPPLEMENTARY INFORMATION: This is a synopsis of the Commission's Report and Order, MM Docket No. 01–111, adopted March 12, 2003, and released March 14, 2003. The full text of this Commission decision is available for inspection and copying during normal business hours in the FCC's Reference Information Center at Portals II, 445 12th Street, SW., Room CY–A257, Washington, DC, 20554. The document may also be purchased from the Commission's duplicating contractor, Qualex International, Portals II, 445 12th Street, SW., Room CY–B402, Washington, DC, 20554, telephone 202 863–2893. facsimile 202 863–2898, or via e-mail *qualexint@aol.com.*

List of Subjects in 47 CFR Part 73

Radio, Radio broadcasting.

■ Part 73 of Title 47 of the Code of Federal Regulations is amended as follows:

PART 73—RADIO BROADCAST SERVICES

■ 1. The authority citation for Part 73 reads as follows:

Authority: 47 U.S.C. 154, 303, 334 and 336.

§ 73.202 [Amended]

■ 2. Section 73.202(b), the Table of FM Allotments under Georgia, is amended by adding Alamo, Channel 287C3.

Federal Communications Commission.

John A. Karousos,

Assistant Chief, Audio Division Media Bureau.

[FR Doc. 03–7470 Filed 3–27–03; 8:45 am]

BILLING CODE 6712–01–P

FEDERAL COMMUNICATIONS COMMISSION

47 CFR Part 73

[DA 03–629; MB Docket No. 02–120; RM–10442]

Radio Broadcasting Services; Owen, Wisconsin

AGENCY: Federal Communications Commission.

ACTION: Final rule.

SUMMARY: The Audio Division, at the request of Starboard Broadcasting, Inc., allots Channel 242C3 at Owen, Wisconsin, as the community's first local FM service. Channel 242C3 can be allotted to Owen, Wisconsin, in compliance with the Commission's minimum distance separation requirements with a site restriction of 12.9 km (8.0 miles) northeast of Owen. The coordinates for Channel 242C3 at Owen, Wisconsin, are 45–03–08 North Latitude and 90–29–21 West Longitude. A filing window for Channel 242C3 at Owen, WI, will not be opened at this time. Instead, the issue of opening this allotment for auction will be addressed by the Commission in a subsequent Order.

DATES: Effective April 28, 2003.

FOR FURTHER INFORMATION CONTACT: Deborah Dupont, Media Bureau, (202) 418–2180.

SUPPLEMENTARY INFORMATION: This is a synopsis of the Commission's Report and Order, MB Docket No. 02–120, adopted March 12, 2003, and released March 14, 2003. The full text of this Commission decision is available for inspection and copying during normal business hours in the FCC Information Center, Portals II, 445 12th Street, SW., Room CY–A257, Washington, DC 20554. The complete text of this decision may also be purchased from the Commission's duplicating contractor, Qualex International, Portals II, 445 12th Street, SW., Room CY–B402, Washington, DC, 20554, (202) 863–2893, facsimile (202) 863–2898, or via e-mail *qualexint@aol.com.*

List of Subjects in 47 CFR Part 73

Radio, Radio broadcasting.

■ Part 73 of title 47 of the Code of Federal Regulations is amended as follows:

PART 73—RADIO BROADCAST SERVICES

■ 1. The authority citation for part 73 continues to read as follows:

Authority: 47 U.S.C. 154, 303, 334 and 336.

§ 73.202 [Amended]

■ 2. Section 73.202(b), the Table of FM Allotments under Wisconsin, is amended by adding Owen, Channel 242C3.

Federal Communications Commission.

John A. Karousos,

Assistant Chief, Audio Division, Media Bureau.

[FR Doc. 03–7472 Filed 3–27–03; 8:45 am]

BILLING CODE 6712–01–P

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

50 CFR Chapter IV

[Docket No. 000214043–2227–02; I.D. 011603A]

RIN 1018–AF55, 0648–XA48

Policy for Evaluation of Conservation Efforts When Making Listing Decisions

AGENCIES: Fish and Wildlife Service, Interior; National Marine Fisheries Service, NOAA, Commerce.

ACTION: Announcement of final policy.

SUMMARY: We, the Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) (the Services), announce a final policy for the evaluation of conservation efforts when making listing decisions (PECE) under the Endangered Species Act of 1973, as amended (Act). While the Act requires us to take into account all conservation efforts being made to protect a species, the policy identifies criteria we will use in determining whether formalized conservation efforts that have yet to be implemented or to show effectiveness contribute to making listing a species as threatened or endangered unnecessary. The policy applies to conservation efforts identified in conservation agreements, conservation plans, management plans, or similar documents developed by Federal agencies, State and local governments, Tribal governments, businesses, organizations, and individuals.

DATES: This policy is effective April 28, 2003.

ADDRESSES: Chief, Division of Conservation and Classification, U.S. Fish and Wildlife Service, 4401 North Fairfax Drive, Arlington, VA 22203 (Telephone 703/358–2171, Facsimile 703/358–1735); or Chief, Endangered Species Division, National Marine Fisheries Service, Office of Protected Resources, 1315 East-West Highway, Silver Spring, MD 20910 (Telephone 301/713–1401, Facsimile 301/713–0376).

FOR FURTHER INFORMATION CONTACT: Chris Nolin, Chief, Division of Conservation and Classification, U.S. Fish and Wildlife Service at the above address, telephone 703/358–2171 or facsimile 703/358–1735, or Margaret Lorenz, Endangered Species Division, National Marine Fisheries Service at the

above address, telephone 301/713–1401 or facsimile 301/713–0376.

SUPPLEMENTARY INFORMATION:

Background

This policy provides direction to Service personnel in determining how to consider a conservation agreement when making a decision on whether a species warrants listing under the Act. It also provides information to the groups interested in developing agreements or plans that would contribute to making it unnecessary for the Services to list a species under the Act.

On June 13, 2000, we published in the **Federal Register** (65 FR 37102) a draft policy for evaluating conservation efforts that have not yet been implemented or have not yet demonstrated effectiveness when making listing decisions under the Act. The policy establishes two basic criteria: (1) The certainty that the conservation efforts will be implemented and (2) the certainty that the efforts will be effective. The policy provides specific factors under these two basic criteria that we will use to direct our analysis of the conservation effort. At the time of making listing determinations, we will evaluate formalized conservation efforts (i.e., conservation efforts identified in a conservation agreement, conservation plan, management plan, or similar document) to determine if the conservation effort provides certainty of implementation and effectiveness and, thereby, improves the status, as defined by the Act, of the species such that it does not meet the Act's definition of a threatened or endangered species.

When we evaluate the certainty of whether the formalized conservation effort will be implemented, we will consider the following: Do we have a high level of certainty that the resources necessary to carry out the conservation effort are available? Do the parties to the conservation effort have the authority to carry it out? Are the regulatory or procedural mechanisms in place to carry out the efforts? And is there a schedule for completing and evaluating the efforts? If the conservation effort relies on voluntary participation, we will evaluate whether the incentives that are included in the conservation effort will ensure the level of participation necessary to carry out the conservation effort. We will also evaluate the certainty that the conservation effort will be effective. In making this evaluation, we will consider the following: Does the effort describe the nature and extent of the threats to the species to be addressed and how these threats are reduced by the conservation effort? Does the effort establish specific conservation objectives? Does the effort identify the appropriate steps to reduce threats to the species? And does the effort include quantifiable performance measures to monitor for both compliance and effectiveness? Overall, we need to be certain that the formalized conservation effort improves the status of the species at the time we make a listing determination.

This policy is important because it gives us a consistent set of criteria to evaluate formalized conservation efforts. For states and other entities that are developing agreements or plans, this policy informs them of the criteria we will use in evaluating formalized conservation efforts when making listing decisions, and thereby guides States and other entities that wish to develop formalized conservation efforts that may contribute to making listing unnecessary.

In the notice of the draft policy, we specifically requested comments on the criteria that we would use to evaluate the certainty that a formalized conservation effort will be implemented. Also, we requested comments on the timing of the development of conservation agreements or plans. We have learned that timing is the most critical element when developing a successful conservation agreement or plan. Encouraging and facilitating early development of conservation agreements or plans is an important objective of this policy. Last-minute agreements (i.e., those that are developed just before or after a species is proposed for listing) often have little chance of affecting the outcome of a listing decision. Once a species is proposed for listing under the Act, we may have insufficient time to include consideration of a newly developed conservation plan in the public notice and comment process and still meet our statutory deadlines. Last-minute efforts are also less likely to be able to demonstrate that they will be implemented and effective in reducing or removing threats to the species. In addition, there are circumstances in which the threats to a species are so imminent and/or complex that it will be almost impossible to develop an agreement or plan that includes conservation efforts that will result in making the listing unnecessary. Accordingly, we encourage the early development of formalized conservation efforts before the threats become too extreme and imminent and when there is greater flexibility in sufficiently improving a species' status to the point where listing the species as threatened or endangered is unnecessary.

Summary of Comments and Recommendations

In response to our request for comments on the draft policy, we received letters from 44 entities. Thirty-five were in support of the policy and nine were against. We reviewed all comments received and have incorporated accepted suggestions or clarifications into the final policy text. Because most of these letters included similar comments (several were form letters) we grouped the comments according to issues. The following is a summary of the relevant comments and our responses. We also received comments that were not relevant to the policy and, therefore, outside the policy's scope. We responded to some of these comments where doing so would clarify the process for determining whether a species is endangered or threatened (the listing process) or clarify the nature of conservation plans, agreements, and efforts.

Policy Scope Issues

Issue 1: Many commenters felt that this policy should also apply to downlisting species from endangered to threatened status and delisting actions, or else parties to an agreement where the final decision is to list the species would not have any incentives to take action on a listed species until a recovery plan is developed. In addition, one commenter suggested that the policy scope should be expanded to include the process of designating critical habitat.

Response 1: We believe that the immediate need is to develop criteria that will guide consistent and predictable evaluation of conservation efforts at the time of a listing determination. We may consider such a policy for downlisting or delisting actions in the future. However, we note that a recovery plan is the appropriate vehicle to provide guidance on actions necessary to delist a species. Also, we may consider developing a similar policy for critical habitat designations.

Issue 2: Two commenters stated that our estimates of time needed to develop, implement, monitor, and report on conservation efforts are underestimated.

Response 2: We agree that our original estimates were too low. We have increased our estimate to an average of 2,500 person-hours to complete a conservation agreement (with a range of 1,000 to 4,000 person-hours). We also increased our estimate of the average number of person-hours to conduct monitoring and to prepare a report to

320 and 80 hours, respectively. We expect the amount of time will vary depending on several factors including, but not limited to, the number of species addressed, amount of biological information available on the species, and the complexity of the threats. Therefore, we have provided an average to assist interested parties in their planning efforts.

Issue 3: One commenter questioned whether we would evaluate proposed agreements or plans using the stated criteria automatically or only upon request. The commenter also questioned whether we will consider agreements or plans that we previously determined were not sufficient to prevent the need for listing in combination with ''new'' proposed agreements or plans when we evaluate whether to list a species.

Response 3: If a listing proposal is under review, we will consider any conservation effort. We will evaluate the status of the species in the context of all factors that affect the species' risk of extinction, including all known conservation efforts whether planned, under way, or fully implemented. However, for formalized conservation efforts not fully implemented, or where the results have not been demonstrated, we will consider the PECE criteria in our evaluation of whether, and to what extent, the formalized conservation efforts affect the species' status under the Act.

Issue 4: One commenter asked the length of time for which a plan is approved.

Response 4: The PECE is not a plan-approval process, nor does it establish an alternative to listing. PECE outlines the criteria we will consider when evaluating formalized conservation efforts that have not yet been fully implemented or do not yet have a record of effectiveness at the time we make a listing decision. Should the status of a species decline after we make a decision not to list this species, we would need to reassess our listing decision. For example, there may be situations where the parties to a plan or agreement meet their commitments, but unexpected and/or increased threats (e.g., disease) may occur that threaten the species' status and make it necessary to list the species.

Issue 5: One commenter asked if the ''new information'' reopener is operative at any time.

Response 5: Yes, because section 4(b)(1) of the Act requires us to use the best available scientific and commercial data whenever making decisions during the listing process. In making a decision whether to list a species, we will take into account all available information, including new information regarding formalized conservation efforts. If we receive new information on a formalized conservation effort that has not yet been implemented or not yet demonstrated effectiveness prior to making a listing decision, we will evaluate the conservation effort in the context of the PECE criteria. If we receive new information on such an effort after we have decided to list a species, then we will consider this new information along with other measures that reduce threats to the species and may use this information in downlisting the species from endangered to threatened status or delisting. However, PECE will not control our analysis of the downlisting of the species.

Issue 6: One commenter stated that it is unrealistic and unreasonable to expect agreements to be in place at the time the conservation effort is evaluated. In addition, the commenter stated that it is particularly unrealistic and unreasonable to expect that conservation agreements or plans be submitted within 60 days of publication of a proposed rule.

Response 6: We strongly encourage parties to initiate formalized conservation efforts prior to publication of a proposal to list a species under the Act. If a formalized conservation effort is submitted during the public comment period for a proposed rule, and may be significant to the listing decision, then we may extend or reopen the comment period to allow time for comment on the new conservation effort. However, we can extend the public comment period only if doing so does not prevent us from completing the final listing action within the statutory timeframe.

Issue 7: One commenter stated that most existing conservation agreements are ineffective, and furthermore that we are unable to determine their effectiveness for several years.

Response 7: We agree that it could take several years for some conservation efforts to demonstrate results. However, the PECE criteria provide the framework for us to evaluate the likely effectiveness of such formalized conservation efforts. Some existing conservation efforts have proven to be very effective and have justifiably influenced our listing decisions.

Issue 8: Several commenters stated that funds are better spent to list species, designate critical habitat, and implement recovery efforts rather than to develop conservation agreements.

Response 8: Conservation agreements can be seen as early recovery efforts. Early conservation efforts to improve the status of a species before listing is necessary may cost less than if the species' status has already been reduced to the point where it needs to be listed. Early conservation of candidate species can reduce threats and stabilize or increase populations sufficiently to allow us to use our resources for species in greater need of the Act's protective measures.

Issue 9: Some commenters questioned the 14 conservation agreements that we cited which contributed to making listing the covered species as threatened or endangered unnecessary. Commenters requested information on each plan to better allow the public to evaluate the adequacy of the agreements.

Response 9: We referenced the 14 conservation agreements in the Paperwork Reduction Act section of the draft policy and used them solely to estimate the information collection and recordkeeping burden that would result from our draft policy if it were made final. Therefore, we do not recommend using these to comment on the new policy.

Biological Issues

Issue 10: One commenter questioned our method for evaluating a conservation plan that addresses only a portion of a species' range.

Response 10: Using the PECE criteria, we will evaluate all formalized conservation efforts that have yet to be implemented or have yet to demonstrate results at the time we make our listing decision. This is true for efforts that are applicable to all or only a portion of the species' range. The PECE does not set standards for how much conservation is needed to make listing unnecessary. The significance of plans that address only a portion of a species' range will be evaluated in the context of the species' overall status. While a formalized conservation effort may be effective in reducing or removing threats in a portion of the species' range, that may or may not be sufficient to remove the need to list the species as threatened or endangered. In some cases, the conservation effort may lead to a determination that a species warrants threatened status rather than endangered.

In addition, parties may have entered into agreements to obtain assurances that no additional commitments or restrictions will be required if the species is listed. A landowner or other non-Federal entity can enter into a Candidate Conservation Agreement with Assurances (CCAA) (64 FR 32726, June 17, 1999), which are formal agreements between us and one or more non-Federal parties that address the conservation needs of proposed or

candidate species, or species likely to become candidates. These agreements provide assurances to non-Federal property owners who voluntarily agree to manage their lands or waters to remove threats to candidate or proposed species, or to species likely to become candidates. The assurances are authorized under the CCAA regulations (50 CFR 17. 22(d)(5) and 17.32(d)(5)) and provide non-Federal property owners assurances that their conservation efforts will not result in future regulatory obligations in excess of those they agree to at the time they enter into the Agreement. Should the species eventually be listed under the Act, landowners will not be subjected to increased property use restrictions as long as they conform to the terms of the agreement. While one of these agreements may not remove the need to list, several such agreements, covering a large portion of the species' range, may.

Issue 11: Several commenters suggested that the Services should consider conservation efforts developed for species other than the species for which a listing decision is being made when the species have similar biological requirements and the conservation effort addresses protection of habitat of the species for which a listing decision is being made.

Response 11: We agree. When a decision whether or not to list a species is being made, we will consider all conservation efforts that reduce or remove threats to the species under review, including conservation efforts developed for other species. However, for all formalized conservation efforts that have not yet been implemented or have yet to demonstrate results, we will use the PECE criteria to evaluate the conservation effort for certainty of implementation and effectiveness for the species subject to the listing decision.

Issue 12: One commenter stated the ''biology/natural history'' of the species should be adequately known and explained in order to evaluate the effectiveness of the effort.

Response 12: When we consider the elements under the effectiveness criterion, we will evaluate whether the formalized conservation effort incorporates the best available information on the species' biology and natural history. However, due to variation in the amount of information available about different species and the threats to their existence, the level of information necessary to provide a high level of certainty that the effort will be effective will vary.

We believe it is important, however, to start conservation efforts as early as possible even if complete biological information is lacking. Regardless of the extent of biological information we have about a species, there will almost always be some uncertainty about threats and the most effective mechanisms for improving the status of a species. We will include the extent of gaps in the available information in our evaluation of the level of certainty that the formalized conservation effort will be effective. One method of addressing uncertainty and accommodating new information is the use of monitoring and the application of adaptive management principles. The PECE criteria note that describing the threats and how those threats will be removed, including the use of monitoring and adaptive management principles, as appropriate, is critical to determining that a conservation effort that has yet to demonstrate results has reduced or removed a particular threat to a species.

Issue 13: Several commenters suggested that affected party(ies) should work with the Services to identify species that will be proposed for listing in the near future to help concentrate and direct efforts to those species that most warrant the protection, and help make the party(ies) aware of when and what actions should be taken to help conserve species in need.

Response 13: We do identify species in need of protection. The FWS publishes a Candidate Notice of Review (CNOR) in which the FWS identifies those species of plants and animals for which they have sufficient information on the species' biological status and threats to propose them as endangered or threatened under the Act, but for which development of a proposed listing regulation is precluded by other higher priority listing activities. NMFS, which has jurisdiction over marine species and some anadromous species, defines candidate species more broadly to include species whose status is of concern but more information is needed before they can be proposed for listing. NMFS candidate species can be found on their web site at *http://www.nmfs.noaa.gov*. The FWS's CNOR is published in the **Federal Register** and can also be found on their web site at *http://endangered.fws.gov.*

We agree that it is important to start developing and implementing conservation efforts and coordinating those efforts with us as early as possible. Early conservation helps preserve management options, minimizes the cost of reducing threats to a species, and reduces the potential for land use restrictions in the future. Addressing the needs of species before the regulatory protections associated with listing under the Act come into play often allows greater management flexibility in the actions necessary to stabilize or restore these species and their habitats. Early implementation of conservation efforts may reduce the risk of extinction for some species, thus eliminating the need for them to be listed as threatened or endangered.

Issue 14: One commenter stated that requiring an implementation schedule/timeline for conservation objectives is not feasible when baseline data on a species is poorly understood. The policy should recognize that variation in patterns of species distribution and land ownership will cause variation in the difficulty of developing conservation efforts. Thus, some conservation efforts should be allotted more time for their completion.

Response 14: Biological uncertainty is a common feature of any conservation effort. Nevertheless, some conservation actions can proceed even when information on the species is incomplete. Implementation schedules are an important element of all formalized conservation planning efforts (e.g., recovery plans). The implementation schedule identified in PECE criterion A.8. establishes a timeframe with incremental completion dates for specific tasks. In light of the information gaps that may exist for some species or actions, schedules for completing certain tasks may require revision in response to new information, changing circumstances, and the application of adaptive management principles. Including an implementation schedule in a formalized conservation effort is critical to determining that the effort will be implemented and effective and has improved the status of the species under the Act at the time we make our listing determination.

We acknowledge that the amount of time required to develop and implement formalized conservation efforts will vary. Therefore, we encourage early development and implementation of conservation efforts for species that have not yet become candidates for listing and for those species that are already candidates. This policy does not dictate timeframes for completing conservation efforts. However, the Act mandates specific timeframes for many listing decisions, and we cannot delay final listing actions to allow for the development and signing of a conservation agreement or plan. We and participants must also acknowledge that, for species that are poorly known, or whose threats are not well understood, it is unlikely that conservation efforts that have not been implemented or that have yet to yield

results will have improved the status of the species sufficiently to play a significant role in the listing decision.

Issue 15: One commenter stated that the Services, when evaluating the certainty of conservation efforts while making listing decisions, should factor into the analysis the Services' ability to open or reopen the listing process at any time, and to list the species on an emergency basis if necessary.

Response 15: We will initiate or revisit a listing decision if information indicates that doing so is warranted, and on an emergency basis if there is an imminent threat to the species' well-being. However, we do not make any listing determinations based on our ability to change our decisions. We base our listing decisions on the status of the species at that time, not on some time in the future.

Criteria Issues

Issue 16: Several commenters requested that we further explain the criteria for both implementation and effectiveness. The commenters claim that our criteria are too vague and are subject to interpretation by the Services. One commenter said that, by stating ''this list should not be considered comprehensive evaluation criteria,'' the policy allows the Services to consider criteria not addressed in the agreement, and allows for too much leeway for the Services to reject conservation efforts of an agreement, even if all criteria listed in the draft policy are satisfied.

Response 16: PECE establishes a set of criteria for us to consider when evaluating formalized conservation efforts that have not yet been implemented or have not yet demonstrated effectiveness to determine if the efforts have improved the status of the species. At the time of the listing decision, we must find, with minimal uncertainty, that a particular formalized conservation effort will be implemented and will be effective, in order to find that the effort has positively affected the conservation status of a species. Meeting these criteria does not create an approval process. Some conservation efforts will address these criteria more thoroughly than others. Because, in part, circumstances vary greatly among species, we must evaluate all conservation efforts on a case-by-case basis at the time of listing, taking into account any and all factors relevant to whether the conservation effort will be implemented and effective.

Similarly, the list of criteria is not comprehensive because the conservation needs of species will vary greatly and depend on species-specific, habitat-specific, location-specific, and action-specific factors. Because conservation needs vary, it is not possible to state all of the factors that might determine the ultimate effectiveness of formalized conservation efforts. The species-specific circumstances will also determine the amount of information necessary to satisfy these criteria. Evaluating the certainty of the effectiveness of a formalized conservation effort necessarily includes an evaluation of the technical adequacy of the effort. For example, the effectiveness of creating a wetland for species conservation will depend on soil texture, hydrology, water chemistry, and other factors. Listing all of the factors that we would appropriately consider in evaluations of technical adequacy is not possible.

Issue 17: One commenter suggested that we consider conservation plans in the development stage rather than waiting until finalized due to the possible benefits that may result from initial efforts.

Response 17: Plans that have not been finalized and, therefore, do not conform to the PECE criteria, may have some conservation value for the species. For example, in the process of developing a plan, participants and the public may become more informed about the species and its conservation needs. We will consider any benefits to a species that have accrued prior to the completion of an agreement or plan in our listing decision, under section 4(b)(1)(A) of the Act. However, the mere existence of a planning process does not provide sufficient certainty to actually improve the status of a species. The criteria of PECE set a rigorous standard for analysis and assure a high level of certainty associated with formalized conservation efforts that have not been implemented, or have yet to yield results, in order to determine that the status of the species has improved.

We encourage parties to involve the appropriate Service during the development stage of all conservation plans, whether or not they are finalized prior to a listing decision. Sharing of the best available information can lead to developing better agreements. In the event that the focus species is listed, these planning efforts can be utilized as the basis for development of Safe Harbor Agreements or Habitat Conservation Plans, through which we can permit incidental take under Section 10(a) of the Act, or provide a basis for a recovery plan.

Issue 18: Several commenters stated that the policy should provide more sufficient, clear criteria by which the implementation and effectiveness of conservation efforts is monitored and assessed. One commenter also suggested that we require a specific reporting format to help show effectiveness of conservation efforts.

Response 18: When evaluating formalized conservation efforts under PECE, we will consider whether the effort contains provisions for monitoring and reporting implementation and effectiveness results (see criterion B.5).

Regarding a standard reporting format, the nature of the formalized conservation efforts we evaluate will probably vary a great deal. Efforts may range from complex to single-threat approaches. Therefore, for us to adopt a one-size-fits-all approach to report on monitoring efforts and results would be inappropriate.

Issue 19: One commenter stated that PECE is too demanding with respect to identification and commitment of resources ''up-front,'' and that these strict requirements and commitments on conservation efforts harm the voluntary nature of agreements.

Response 19: Addressing the resources necessary to carry out a conservation effort is central to establishing certainty of plan implementation and effectiveness. Accordingly, we believe that PECE must establish a minimum standard to assure certainty of implementation and effectiveness. This certainty is necessary in determining whether the conservation effort has improved the status of species.

It is our intention and belief that the PECE criteria will actually increase the voluntary participation in conservation agreements by increasing the likelihood that parties' voluntary efforts and commitments that have yet to be implemented or have yet to demonstrate results will play a role in a listing decision.

Issues Related to Specific Changes

Several commenters recommended specific changes to the evaluation criteria. The recommended additions in language to the criteria are italicized and deletions are shown in strikeout to help the reader identify the proposed changes.

Issue 20: Commenters stated that there is potential confusion between evaluation criteria A.2. (authority) and A.3.(authorization) as they believed some Service staff may have difficulty distinguishing between an ''authority,'' and an ''authorization.'' To help eliminate this potential confusion, commenters requested that criterion A.2. be changed to read: ''the legal authority of the party(ies) to the agreement or plan to implement the conservation effort and the legal

procedural requirements necessary to implement the effort are described.'' They also requested that we change criterion A.3. to read: The legal requirements (e.g. permits, environmental review documents) necessary to implement the conservation effort are identified, and an explanation of how the party(ies) to the agreement or plan that will implement the effort will fulfill these requirements is provided.''

Response 20: We agree with adding the word ''legal'' and also have incorporated additional language and separated this criterion (former criterion A.2) into two criteria (A.2. and A.3.). Evaluation Criterion A.2. now reads, ''The legal authority of the party(ies) to the agreement or plan to implement the formalized conservation effort, and the commitment to proceed with the conservation effort are described.'' New evaluation Criterion A.3. reads, ''The legal procedural requirements necessary to implement the effort are described, and information is provided indicating that fulfillment of these requirements does not preclude commitment to the effort.'' In making these changes, we recognize that there may be overlap between new criterion A.3. and the criterion on authorizations (now A.4.), but our intent is to separate a criterion on procedural requirements from substantive authorizations (e.g. permits). We believe that we need to specifically determine that the parties to the agreement will obtain the necessary authorizations. We also recognize that parties may not be able to commit to some conservation efforts until they have fulfilled procedural requirements (e.g. under the National Environmental Policy Act) since some laws preclude commitment to a specific action until certain procedures are completed. Additionally, in creating a new criterion A.3., we find it unnecessary to incorporate the suggested changes to old A.3. (now A.4.).

Issue 21: Commenters requested the following change to Criterion A.4. (now Criterion A.5.): ''The level of voluntary participation (e.g., permission to enter private land or other contributions by private landowners) necessary to implement the conservation effort is identified, and an explanation of how the party(ies) to the agreement or plan that will implement the conservation effort will obtain that level of voluntary participation is provided (e.g., an explanation of why incentives to be provided are expected to result in the necessary level of voluntary participation)''.

Response 21: We do not believe that including ''an explanation of how the party(ies) * * * will obtain that level of voluntary participation * * *'' will provide us with enough information in order to determine that necessary voluntary participation will, in fact, be obtained. Evaluation Criterion A.5. (formerly A.4.) now reads: ''The type and level of voluntary participation (e.g., number of landowners allowing entry to their land, or number of participants agreeing to change timber management practices and acreage involved) necessary to implement the conservation effort is identified, and a high level of certainty is provided that the party(ies) to the agreement or plan that will implement the conservation effort will obtain that level of voluntary participation (e.g., an explanation of how incentives to be provided will result in the necessary level of voluntary participation).''

Issue 22: Commenters suggested that Evaluation Criterion A.5. (now criterion A.6.) be changed to read as ''Any statutory or regulatory deficiency or barrier to implementation of the conservation effort is identified and an explanation of how the party(ies) to the agreement or plan that will implement the effort will resolve the deficiency or barriers is provided.''

Response 22: We do not agree with the suggested language change. We believe that all regulatory mechanisms, including statutory authorities, must be in place to ensure a high level of certainty that the conservation effort will be implemented.

Issue 23: The suggested change to Evaluation Criterion A.6. (now A.7.) is ''A fiscal schedule and plan is provided for the conservation effort, including a description of the obligations of party(ies) to the agreement or plan that will implement the conservation effort, and an explanation of how they will obtain the necessary funding is provided.''

Response 23: We do not agree with the suggested language change since we believe that there must be a high level of certainty that the party(ies) will obtain the necessary funding to implement the effort. While we agree that including a fiscal schedule, a description of the obligations of the party(ies), and an explanation of how they will obtain the funding is important, this information, by itself, does not provide enough certainty for us to consider a formalized conservation effort that has not yet been implemented as contributing to a listing decision. Also see our response to Issue 41.

Issue 24: One commenter suggested that the Services should consider an incremental approach to evaluating implementation dates for the conservation effort.

Response 24: We agree with the commenter's suggested change. Evaluation Criterion A.8. (formerly A.7.) now reads as: ''An implementation schedule (including incremental completion dates) for the conservation effort is provided.''

Issue 25: Commenters suggested that Criterion A.8. (now A.9.) be revised to read: ''The conservation agreement or plan that includes the conservation effort include a commitment by the party(ies) to apply their legal authorities and available resources as provided in the agreement or plan.''

Response 25: The participation of the parties through a written agreement or plan establishes each party's commitment to apply their authorities and resources to implementation of each conservation effort. Therefore, it is unnecessary to include the suggested language; criterion A.9. (formerly A.8.) remains unchanged.

Issue 26: A commenter also suggested adding a criterion: ''Evidence that other conservation efforts have been implemented for sympatric species within the same ecosystem that may provide benefits to the subject species is provided.''

Response 26: We do not think it is necessary to add such a criterion. At the time of listing, we will take into consideration all relevant information, including the effect of other conservation efforts for sympatric species on the status of the species we are considering for listing.

Issue 27: Several commenters recommended that we make specific changes to the Criterion B.1. language to read as: ''The nature and extent of threats being addressed by the conservation effort are described, and how the conservation effort will reduce the threats are defined.'' In addition, commenters suggested we change Criterion B.2. to read as: ''Explicit incremental objectives for the conservation effort and dates for achieving them should be stated.''

Response 27: We agree that, in addition to identifying threats, the plan should explain how formalized conservation efforts reduce threats to the species. Therefore, Evaluation Criterion B.1. now reads as: ''The nature and extent of threats being addressed by the conservation effort are described, and how the conservation effort reduces the threats is described.'' We agree that conservation efforts should include incremental objectives. This allows the parties to evaluate progress toward the overall goal of a conservation effort, which is essential for adaptive

management. In addition, setting and achieving interim objectives is helpful in maintaining support for the effort. Therefore, Evaluation Criterion B.2. now reads as: ''Explicit incremental objectives for the conservation effort and dates for achieving them are stated.''

Issue 28: Some commenters recommended that the party's (ies') prior record with respect to development and implementation of conservation efforts be recognized towards their credibility and reliability to implement future conservation efforts. A commenter also suggested adding a criterion to read as: ''Demonstrated ability of the party(ies) to develop and implement effective conservation efforts for this or other species and habitats.'' Another comment suggested that the history and momentum of a program should be taken into account (e.g., watershed council programs) when considering the certainty of effectiveness and implementation. These considerations would help ensure a high level of certainty that regulatory mechanisms, funding authorizations, and voluntary participation will be adopted by a specified date adequate to provide certainty of implementation.

Response 28: Although it would be beneficial for the party(ies) to demonstrate their past abilities to implement effective formalized conservation efforts for the focus species or other species and habitats, we do not believe that this is necessary to demonstrate a high level of certainty that the conservation effort will be implemented. In addition, a criterion that emphasizes previous experience in implementing conservation efforts may limit formalized conservation efforts to only those party(ies) that have a track record and would unjustifiably constrain consideration of efforts by those who do not satisfy this criterion. Such parties can provide certainty in other ways. We agree that a party's (ies') prior record and history with respect to implementation of conservation efforts should be recognized towards their credibility and reliability. Information concerning a party's experience in implementing conservation efforts may be useful in evaluating how their conservation effort satisfies the PECE criteria. The momentum of a project is a good indication of the progress that is being made towards a party's (ies') conservation efforts, but momentum can decrease, and thus cannot be solely relied upon to determine the certainty that a formalized conservation effort will be implemented or effective.

Issue 29: One commenter stated that our use of ''must'' in meeting the criteria is inappropriate in the context of a policy, and the policy should rather be treated as guidance.

Response 29: The only mandatory statements in the policy refer to findings that we must make. In order for us to find that a particular formalized conservation effort has improved the status of the species, we must be certain that the formalized conservation effort will be implemented and will be effective. No party is required to take any action under this policy. Rather the policy provides us guidance on how we will evaluate formalized conservation efforts that have yet to be implemented or have yet to demonstrate effectiveness at the time of our listing decision.

Legal Issues

Issue 30: Many commenters mentioned past litigation (i.e., decisions on coho salmon and Barton Springs salamander) in which the courts have ruled against the Services in cases that have involved Candidate Conservation Agreements or other conservation efforts, and question how the PECE policy addresses this issue. Commenters question how this policy will keep the Services from relying on speculative conservation efforts.

Response 30: We referenced past adverse decisions when we published the draft policy. The purpose of PECE, in part, is to address situations similar to those in which some courts found past conservation efforts insufficient. We developed the PECE to establish a set of consistent standards for evaluating certain formalized conservation efforts at the time of a listing decision and to ensure with a high level of certainty that formalized conservation efforts will be implemented and effective. We agree that we may not rely on speculative promises of future action when making listing decisions.

Issue 31: Several commenters questioned the legality of considering private party's (ies') input when section 4(b)(1)(A) of the Act states ''* * * and after taking into account those efforts, if any, being made by any State or foreign nation, or any political subdivision of a State or foreign nation, to protect such species * * *'' In addition, commenters stated that the PECE policy is inconsistent with the plain language and the congressional intent of the Act by allowing agencies to evaluate any private measures. They also stated that this was inconsistent with considering section 4(a)(1)(D), which only permits agencies to evaluate ''existing regulatory mechanisms.'' They also stated that the Services incorrectly conclude that section 4(a)(1)(E), ''other natural or manmade factors affecting [the species'] continued existence,'' allows the Services to consider actions of ''any other entity'' in making listing determinations. One commenter stated that there are no provisions to authorize the Services to consider voluntary conservation agreements by other Federal agencies. In 1982, the Act omitted 1973 language for listing determinations made with ''other interested Federal agencies.'' In addition, the commenters stated that the Act imposes conservation duties on all Federal agencies only after the Services have taken the initial step in listing the species.

Response 31: Please refer to the Policy Scope section for an explanation of our authority under section 4 of the Act to assess all threats affecting the species status as well as all efforts that reduce threats to the species.

Issue 32: One commenter suggested that we formalize this policy by codifying it in the Code of Federal Regulations. They suggest that by adopting this policy as agency regulation, we can make the policy more binding, provide a basis for judicial deference, and thus hopefully reduce the amount of litigation.

Response 32: We believe that codifying PECE in the Code of Federal Regulations is not necessary because it is intended as a policy to guide how we will evaluate formalized conservation efforts when making listing decisions.

Issue 33: Some commenters believe that all regulatory mechanisms must be in place prior to finalizing a conservation plan, while other commenters feel that this requirement may dissuade voluntary conservation efforts of private landowners. One commenter stated that, based on the amount of time usually needed to enact most regulatory mechanisms, it seems appropriate to set this minimum standard for evaluating formalized conservation efforts. This criterion should prompt more serious political consideration of adopting a regulatory mechanism sooner rather than later. Another commenter suggested that, instead of requiring regulations, we should require cooperators to identify and address any regulatory deficiencies affecting the species.

Response 33: In order for us to determine with a high level of certainty that a formalized conservation effort will be implemented, among other things, all regulatory mechanisms necessary to implement the effort must be in place at the time we make our listing decision. However, there may be

situations where regulatory mechanisms are not necessary for implementing the conservation effort due to the nature of the action that removes threats, or there may be situations where necessary regulatory mechanisms are already in place.

Issue 34: One commenter stated that only when an alternative regulatory mechanism provides the same or higher protections than listing can the threat factors be said to be alleviated. A high level of certainty over future funding or voluntary participation might be acceptable if alternative regulatory mechanisms to prevent take in the interim are in place.

Response 34: Determinations to list species under the Act are based solely on whether or not they meet the definitions of threatened or endangered as specified by the Act. Through PECE, we will evaluate, at the time of our listing decision, whether a formalized conservation effort adequately reduces threats and improves the status of the species to make listing unnecessary. Additional alternative regulatory mechanisms to prevent take are not necessary if the threats to the species are reduced to the point that the species does not meet the definitions of threatened or endangered.

Issue 35: One commenter stated concern that the Services would not be able to provide assurances to private landowners because no specific provisions in the Act authorize conservation agreements in lieu of listing, and that third party lawsuits also undermine the Services' assurances. One commenter asked what future protection of their ongoing actions participants would receive.

Response 35: Satisfying the PECE criteria does not provide assurances that we will not decide to list a species. Also, because of the individual nature of species and the circumstances of their status, PECE does not address how much conservation is required to make listing unnecessary. Because of the numerous factors that affect a species' status, we may list a species despite the fact that one or more formalized conservation efforts have satisfied PECE. However, assurances can be provided to non-Federal entities through an approved Candidate Conservation Agreement with Assurances (CCAA) and in an associated enhancement of survival permit issued under section 10(a)(1)(A) of the Act. Many property owners desire certainty with regard to future regulatory restrictions to guarantee continuation of existing land or water uses or to assure allowance for future changes in land use. By facilitating this kind of individual land use planning, assurances provided under the CCAA policy can substantially benefit many property owners. These agreements can have significance in our listing decisions, and we may also evaluate them according to the criteria in the PECE if they are not yet implemented or have not demonstrated results. However, we will make the determination of whether these CCAAs preclude or remove any need to list the covered species on a case-by-case basis in accordance with the listing criteria and procedures under section 4 of the Act.

Issue 36: Several commenters stated that the PECE does not always provide incentives to conserve species and is, therefore, not supported by the Congressional finding of section 2(a)(5) of the Act. The commenters stated that the parties lack incentives to develop conservation programs until after the species is listed (e.g., *Building Industry Association of Southern California* v. *Babbitt*, where listing the coastal California gnatcatcher encouraged enrollment in conservation programs.) In addition, they stated that PECE provides a means for the listing process to be avoided entirely, and, therefore, may often fail to provide incentives that Congress referred to in its findings in section 2(a)(5). They stated that the ''system'' of incentives to which that Congressional finding refers is already found in incidental take provisions in section 10 of the Act, which will better ensure development and implementation of successful conservation programs.

Response 36: PECE is not ''a way to avoid listing'' or an ''in lieu of listing'' policy. This policy outlines guidance on the criteria we will use to evaluate formalized conservation efforts in determining whether to list a species. Knowing how we will evaluate any unimplemented or unmeasured formalized conservation efforts may help parties draft more effective agreements. However, there is a conservation incentive because, if a species becomes listed, these efforts can contribute to recovery and eventual delisting or downlisting of the species. Also, see our response to Issue 35.

Issue 37: Several commenters stated that relying on unimplemented future conservation measures is inconsistent with the definitions of ''threatened species'' and ''endangered species'' as provided in section 3 of the Act, and that PECE's evaluation of future, unimplemented conservation efforts in listing determinations is inconsistent with both the plain language of the Act and Congressional intent. Also, the commenters stated that the PECE erroneously claims that the definitions of ''threatened species'' and ''endangered species'' connote future status, not present status.

Response 37: We agree that, when we make a listing decision, we must determine the species' present status which includes, in part, an evaluation of current threats. However, deciding or determining whether a species meets the definition of threatened or endangered also requires us to make a prediction about the future persistence of a species. Central to this concept is a prediction of future conditions, including consideration of future negative effects of anticipated human actions. The language of the Act supports this approach. The definitions for both ''endangered species'' and ''threatened species'' connote future condition, which indicates that consideration of whether a species should be listed depends in part on identification and evaluation of future actions that will reduce or remove, as well as create or exacerbate, threats to the species. We cannot protect species without taking into account future threats to a species. The Act does not require that, and species conservation would be compromised if, we wait until a threat is actually impacting populations before we list the species as threatened or endangered. Similarly, the magnitude and/or imminence of a threat may be reduced as a result of future positive human actions. Common to the consideration of both the negative and positive effects of future human actions is a determination of the likelihood that the actions will occur and that their effects on the species will be realized. Therefore, we consider both future negative and future positive impacts when assessing the listing status of the species. The first factor in section 4(a)(1)—''the present or threatened destruction, modification, or curtailment of [the species'] habitat or range''—identifies how analysis of both current actions affecting a species' habitat or range and those actions that are sufficiently certain to occur in the future and affect a species' habitat or range are necessary to assess a species' status. However, future Federal, state, local, or private actions that affect a species are not limited to actions that will affect a species' habitat or range. Congress did not intend for us to consider future actions affecting a species' habitat or range, yet ignore future actions that will influence overutilization, disease, predation, regulatory mechanisms, or other natural or manmade factors. Therefore, we construe Congress' intent, as reflected

by the language of the Act, to require us to consider both current actions that affect a species' status and sufficiently certain future actions—either positive or negative—that affect a species' status.

Issue 38: Several commenters stated that PECE's ''sufficient certainty'' standard is inconsistent with the Act's ''best available science'' standard. They stated that courts have ruled that any standard other than ''best available science'' violates the plain language and the Congressional intent of the Act. The commenters also stated that the ''sufficient certainty'' standard violates Congressional intent because it weakens the standard required by the Act to list species and can result in unnecessary, and potentially harmful, postponement of affirmative listing.

Response 38: We agree that our listing decisions must be based on the best available science. PECE does not address or change the listing criteria and procedures established under section 4 of the Act. Listing analyses include the evaluation of conservation efforts for the species under consideration. PECE is designed to help ensure a consistent and rigorous review of formalized conservation efforts that have yet to be implemented or efforts that have been implemented but have not yet shown effectiveness by establishing a set of standards to evaluate the certainty of implementation and effectiveness of these efforts.

Issue 39: Several commenters stated that PECE reduces or eliminates public comment on proposed rules to list species and is in violation of the Administrative Procedure Act (APA). Further, they stated that PECE violates the APA by allowing submission of formalized conservation measures after the proposed rule is issued to list species as threatened or endangered. Receiving ''conservation agreements or plans before the end of the comment period in order to be considered in final listing decision'' encourages landowners to submit conservation agreements at the last minute to avoid public scrutiny, and the PECE process could be a potential delay tactic used by landowners to postpone the listing of species. They stated that the Courts agree that failure of the Services to make available to the public conservation agreements on which listing decisions are based violates the public comment provision of the APA.

Response 39: All listing decisions, including those involving formalized conservation agreements, will comply with the requirements of the APA and ESA. If we receive a formalized conservation agreement or plan during an open comment period and it presents significant new information relevant to the listing decision, we would either extend or reopen the public comment period to solicit public comments specifically addressing that plan or agreement. We recognize, however, that there may be situations where APA requirements must be reconciled with the ESA's statutory deadlines.

Issue 40: Several commenters expressed their concern that conservation efforts do not have binding obligations.

Response 40: While PECE does not require participants to have binding obligations, the policy does require a high level of certainty that a conservation effort will be implemented and effective at the time we make our listing decision. Furthermore, any subsequent failure to satisfy one or more PECE criteria would constitute new information and, depending on the significance of the formalized conservation effort to the species' status, may require a reevaluation of whether there is an increased risk of extinction, and whether that increased risk indicates that the species' status is threatened or endangered.

Funding Issues

Issue 41: Several commenters requested that we further specify our criteria stating that ''a high level of certainty that the party(ies) to the agreement or plan that will implement the conservation effort will obtain the necessary funding is provided.'' In addition, one commenter questioned whether ''a high level of certainty'' for authorizations or funding was really an improvement over the status quo and suggested that we either list the required elements we will use to evaluate completeness of the conservation efforts or quantitatively define an evaluation standard.

Response 41: A high level of certainty of funding does not mean that funding must be in place now for implementation of the entire plan, but rather, it means that we must have convincing information that funding will be provided each year to implement relevant conservation efforts. We believe that at least 1 year of funding should be assured, and we should have documentation that demonstrates a commitment to obtain future funding, e.g., documentation showing funding for the first year is in place and a written commitment from the senior official of a state agency or organization to request or provide necessary funding in subsequent budget cycles, or documentation showing that funds are available through appropriations to existing programs and the implementation of this plan is a priority for these programs. A fiscal schedule or plan showing clear links to the implementation schedule should be provided, as well as an explanation of how the party(ies) will obtain future necessary funding. It is also beneficial for entities to demonstrate that similar funding was requested and obtained in the past since this funding history can show the likelihood that future funding will be obtained.

Issue 42: One commenter suggested that the PECE policy holds qualifying conservation efforts to a higher standard than recovery plans. The commenter quoted several existing recovery plans that included disclaimers about budget commitments associated with specific tasks. Therefore, the commenter concluded that it is unrealistic and unreasonable to mandate that funding be in place when a conservation effort is evaluated.

Response 42: The Act does not require that certainty of implementation be provided for recovery management actions for listed species or conservation efforts for nonlisted species. Likewise, the PECE does not require that certainty of implementation be provided for during development of conservation efforts for nonlisted species. It is inappropriate to consider the PECE as holding conservation plans or agreements to a higher standard than the standard that exists for recovery plans because the PECE does not mandate a standard for conservation plans or agreements at the time of plan development. Rather, the PECE provides us guidance for the evaluation of conservation efforts when making a listing decision for a nonlisted species.

Recovery plans for listed species and conservation plans or agreements for nonlisted species identify needed conservation actions but may or may not provide certainty that the actions will be implemented or effective. However, when making a listing decision for nonlisted species, we must consider the certainty that a conservation effort will be implemented and effective. The PECE establishes criteria for us to use in evaluating conservation efforts when making listing decisions.

It is possible that we would evaluate a management action identified in a recovery plan for a listed species using the PECE. If, for example, a yet-to-be-implemented task identified in a recovery plan for a listed species would also benefit a nonlisted species, we, in making a listing decision for the nonlisted species, would apply the PECE criteria to that task to determine whether it could be considered as contributing to a decision not to list the

species or to list the species as threatened rather than endangered. In this situation, we would evaluate the management task identified in a recovery plan using the PECE criteria in the same way as other conservation efforts for the nonlisted species. That is, the recovery plan task would be held to the same evaluation standard in the listing decision as other conservation efforts.

Foreign Species Issues

Issue 43: One commenter asked why the proposed policy excluded conservation efforts by foreign governments, even though section 4(b)(1)(A) of the Act requires the Services to take such efforts into account. This commenter also stated that the proposed policy is contrary to ''The Foreign Relations Law of the United States,'' which he argues requires the United States to defer to other nations when they have a ''clearly greater interest'' regarding policies or regulations being considered by the United States that could negatively affect their nations.

Response 43: As required by the Act, we have taken and will continue to take into account conservation efforts by foreign countries when considering listing of foreign species (sections 4(b) and 8 of the Act). Furthermore, whenever a species whose range occurs at least in part outside of the United States is proposed for a listing action (listing, change in status, or delisting), we communicate with and solicit the input of the countries within the range of the species. At that time, countries are provided the opportunity to share information on the status of the species, management of the species, and on conservation efforts within the foreign country. We will take those comments and information provided into consideration when evaluating the listing action, which by law must follow the analysis outlined in sections 4(a) and 4(b) of the Act. Thus, all listing decisions for foreign species will continue to comply with the provisions of the Act.

Issues Outside Scope of Policy

We received several comments that were outside of the scope of PECE. Below, we have briefly addressed these comments.

Issue 44: A comment was made that the Services should not list foreign species under the Act when such listing is in conflict with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Response 44: Considerations regarding CITES are outside the scope of the PECE. However, we do not believe there is a conflict with CITES and listing of a foreign species under the Act. When evaluating the status of foreign species under the Act, we take into consideration whether the species is listed under CITES (and if listed, at what level) and all available information regarding the listing. If you have questions regarding CITES, please contact the FWS Division of Scientific Authority at 4401 N. Fairfax Drive, Room 750, Arlington, VA 22203 or by telephone at 703–358–1708.

Issue 45: One commenter stated that all conservation agreements/plans should be subject to independent scientific peer review. This commenter also argued that any conservation agreement or plan for a candidate species should remove all known major threats for the species and convey a reasonably high certainty that the agreement or plan will result in full conservation of the species.

Response 45: We believe that scientific review can help ensure that formalized conservation efforts are comprehensive and effective, and we expect that most or all participants will seek scientific review, but we will not require a formal independent peer review of conservation plans at the time of development. If a formalized conservation plan is presented for a species that has been proposed for listing, all relevant information, including formalized conservation efforts, will be subject to independent scientific review consistent with our policy on peer review (59 FR 34270). We will also solicit public comments on our listing proposals.

The amount or level of conservation proposed in a conservation plan (e.g., removal of all versus some of the major threats) is outside the scope of PECE. Assuming that all of the PECE criteria have been satisfied for the efforts to which they apply, it stands to reason that plans that comprehensively address threats are likely to be more influential in listing decisions than plans that do not thoroughly address the conservation of the species. We believe that by establishing the PECE criteria for certainty of implementation and effectiveness, we are promoting the development of plans that improve the status of species. We expect that in some cases this improvement will reduce the risk of extinction sufficiently to make listing under the Act unnecessary, to result in listing a species as threatened rather than endangered, or to make classifying a species as a candidate for listing unnecessary.

Issue 46: Several commenters questioned the extent of state involvement in the development of conservation efforts. One commenter said that the policy should mandate that States be involved with plan development, and that states approve all conservation efforts.

Response 46: It is outside the scope of PECE to establish standards to determine who participates in the development of conservation efforts and at what level. In many cases, states play a crucial role in the conservation of species. For formalized conservation efforts to be effective, it is logical for the states to play an integral role. To that end, we highly encourage state participation to help ensure the conservation of the species, but we do not believe that states should be mandated to participate in the development of all conservation plans. In some cases, states may not have the resources to participate in these plans, and in other situations, individuals or non-state entities may have the ability to develop an effective and well-implemented plan that does not require state participation, but that contributes to the conservation of a species. Through our listing process, we will work with state conservation agencies, and, if the listing decision involves a public comment period, states have a formal opportunity to comment on any conservation efforts being considered in the listing decision.

Issue 47: Several comments were made regarding the feedback mechanisms to correct a party's (ies') inadequate or ineffective implementation of a conservation effort. It was suggested that the Services specify clearly, and based on scientific information, those factors which the Services believe indicate that a conservation effort is either not being implemented or not being effective. Comments also suggested that party(ies) be given reasonable time (e.g., 90–120 days) to respond to the Service's findings by either implementing actions, achieving objectives, or providing information to respond to the Services.

Response 47: PECE is not a regulatory approval process, and establishing a formal feedback mechanism between the Services and participants is not within the scope of PECE. The final determination whether to list a species under the Act will rest solely upon whether or not the species under consideration meets the definition of threatened or endangered as specified by the Act, which will include consideration of whether formalized

conservation efforts that meet PECE criteria have enhanced the status of the species. We will provide guidance to improve conservation efforts when possible, but we cannot delay listing decisions in order to participate in a corrective review process when the best scientific and commercial data indicate that a species meets the definition of threatened or endangered.

Issue 48: One commenter requested that we clarify how significant the conservation agreement must be to the species, and describe the anticipated overall impact/importance to the species and the estimated extent of the species' overall range that the habitat conservation agreement might cover.

Response 48: PECE does not establish standards for how much or what kind of conservation is required to make listing a species under the Act unnecessary. We believe that high-quality formalized conservation efforts should explain in detail the impact and significance of the effort on the target species. However, at the time of our listing decision, we will evaluate formalized conservation efforts using PECE to determine whether the effort provides certainty of implementation and effectiveness and improves the status of the species. Through our listing process, we will determine whether or not a species meets the definition of threatened or endangered.

Issue 49: Several commenters wrote that states do not have additional resources to be pro-active on candidate conservation efforts, and suggested that funding for conservation plans or efforts should be provided by the Federal Government.

Response 49: This comment is outside the scope of the PECE. This policy establishes a set of standards for evaluating formalized conservation efforts in our listing decisions and does not address funding sources to develop and implement these efforts.

Summary of Changes From the Proposed Policy

We have slightly revised some of the evaluation criteria as written in the proposed policy. We made the following changes to reflect comments that we received during the public comment period. We added the word ''legal'' to criterion A.2., incorporated additional language (''the commitment to proceed with the conservation effort is described.''), and separated this criterion into two criteria (A.2. and A.3.). We revised criterion A.3. (formerly part of A.2.) to recognize that parties cannot commit to completing some legal procedural requirements (e.g. National Environmental Policy Act) since some procedural requirements preclude commitment to a proposed action before the procedures are actually completed. We changed criterion A.5. (formerly A.4.) by adding ''type'' and ''(e.g., number of landowners allowing entry to their land, or number of participants agreeing to change timber management practices and acreage involved)'' and by replacing ''why'' with ''how'' and ''are expected to'' with ''will.'' We deleted the word ''all'' at the beginning of criterion A.6. as we felt it was redundant. We added ''(including incremental completion dates)'' to criterion A.8. (formerly A.7.). To criterion B.1. we added ''and how the conservation effort reduces the threats is described.''

Also in the proposed policy we stated that if we make a decision not to list a species, or to list the species as threatened rather than endangered, based in part on the contributions of a formalized conservation effort, we will monitor the status of the species. We have clarified this in the final policy to state that we will monitor the status of the effort, including the progress of implementation of the formalized conservation effort.

Required Determinations

Regulatory Planning and Review

In accordance with Executive Order 12866, this document is a significant policy and was reviewed by the Office of Management and Budget (OMB) in accordance with the four criteria discussed below.

(a) This policy will not have an annual economic effect of $100 million or more or adversely affect an economic sector, productivity, jobs, the environment, or other units of government. The policy for the evaluation of conservation efforts when making listing decisions does not pertain to commercial products or activities or anything traded in the marketplace.

(b) This policy is not expected to create inconsistencies with other agencies' actions. FWS and NMFS are responsible for carrying out the Act.

(c) This policy is not expected to significantly affect entitlements, grants, user fees, loan programs, or the rights and obligations of their recipients.

(d) OMB has determined that this policy may raise novel legal or policy issues and, as a result, this action has undergone OMB review.

Regulatory Flexibility Act (5 U.S.C. 601 et seq.)

Under the Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*, as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996), whenever an agency is required to publish a notice of rulemaking for any proposed or final rule, it must prepare and make available for public comment a regulatory flexibility analysis that describes the effect of the rule on small entities (i.e., small businesses, small organizations, and small government jurisdictions), unless the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities.

SBREFA amended the Regulatory Flexibility Act to require Federal agencies to provide the statement of the factual basis for certifying that a rule will not have a significant economic impact on a substantial number of small entities. The following discussion explains our determination.

We have examined this policy's potential effects on small entities as required by the Regulatory Flexibility Act and have determined that this action will not have a significant economic impact on a substantial number of small entities since the policy will not result in any significant additional expenditures by entities that develop formalized conservation efforts. The criteria in this policy describe how we will evaluate elements that are already included in conservation efforts and do not establish any new implementation burdens. Therefore, we believe that no economic effects on States and other entities will result from compliance with the criteria in this policy.

Pursuant to the Regulatory Flexibility Act, at the proposed policy stage, we certified to the Small Business Administration that this policy would not have a significant economic impact on a substantial number of small entities, since we expect that this policy will not result in any significant additional expenditures by entities that develop formalized conservation efforts. We received no comments regarding the economic impacts of this policy on small entities. Thus, we certify that this final policy will not have a significant adverse impact on a substantial number of small entities and conclude that a regulatory flexibility analysis is not necessary.

We have determined that this policy will not cause (a) any effect on the economy of $100 million or more, (b) any increases in costs or prices for consumers; individual industries; Federal, State, or local government agencies; or geographical regions, or (c) any significant adverse effects on competition, employment, investment, productivity, innovation, or the ability

of U.S.-based enterprises to compete with foreign-based enterprises (see Economic Analysis below).

Executive Order 13211

On May 18, 2001, the President issued an Executive Order (E.O. 13211) on regulations that significantly affect energy supply, distribution, and use. Executive Order 13211 requires agencies to prepare Statements of Energy Effects when undertaking certain actions. Although this policy is a significant action under Executive Order 12866, it is not expected to significantly affect energy supplies, distribution, or use. Therefore, this action is not a significant energy action and no Statement of Energy Effects is required.

Unfunded Mandates Reform Act (2 U.S.C. 1501 et seq.)

In accordance with the Unfunded Mandates Reform Act (2 U.S.C. 1501 *et seq.*):

(a) This policy will not ''significantly or uniquely'' affect small governments. A Small Government Agency Plan is not required. We expect that this policy will not result in any significant additional expenditures by entities that develop formalized conservation efforts.

(b) This policy will not produce a Federal mandate on state, local, or tribal governments or the private sector of $100 million or greater in any year; that is, it is not a ''significant regulatory action'' under the Unfunded Mandates Reform Act. This policy imposes no obligations on state, local, or tribal governments (see Economic Analysis below).

Takings

In accordance with Executive Order 12630, this policy does not have significant takings implications. While state, local or Tribal governments, or private entities may choose to directly or indirectly implement actions that may have property implications, they would do so as a result of their own decisions, not as a result of this policy. This policy has no provision that would take private property.

Federalism

In accordance with Executive Order 13132, this policy does not have significant Federalism effects. A Federalism assessment is not required. In keeping with Department of the Interior and Commerce policy, we requested information from and coordinated development of this policy with appropriate resource agencies throughout the United States.

Civil Justice Reform

In accordance with Executive Order 12988, this policy does not unduly burden the judicial system and meets the requirements of sections 3(a) and 3(b)(2) of the Order. With the guidance provided in the policy, requirements under section 4 of the Endangered Species Act will be clarified to entities that voluntarily develop formalized conservation efforts.

Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et seq.)

This policy contains collection-of-information requirements subject to the Paperwork Reduction Act (PRA) and which have been approved by Office of Management and Budget (OMB). The FWS has OMB approval for the collection under OMB Control Number 1018–0119, which expires on December 31, 2005. The NMFS has OMB approval for the collection under OMB Control Number 0648–0466, which expires on December 31, 2005. We may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. Public reporting burden for FWS collections of information is estimated to average 2,500 hours for developing one agreement with the intent to preclude a listing, 320 hours for annual monitoring under one agreement, and 80 hours for one annual report. The FWS expects that six agreements with the intent of making listing unnecessary will be developed in one year and that four of these will be successful in making listing unnecessary, and therefore, the entities who develop these four agreements will carry through with their monitoring and reporting commitments. Public reporting burden for NMFS collections of information is estimated to average 2,500 hours for developing one agreement with the intent to preclude a listing, 320 hours for annual monitoring under one agreement, and 80 hours for one annual report. The NMFS expects that two agreements with the intent of making listing unnecessary will be developed in one year and that one of these will be successful in making listing unnecessary, and therefore, the entities who develop this agreement will carry through with their monitoring and reporting commitments. These estimates include the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate, or any other aspect of this data collection, including suggestions for reducing the burden, to the FWS and NMFS (see **ADDRESSES** section of this policy).

National Environmental Policy Act

We have analyzed this policy in accordance with the criteria of the National Environmental Policy Act (NEPA), the Department of the Interior Manual (318 DM 2.2(g) and 6.3(D)), and National Oceanic and Atmospheric Administration (NOAA) Administrative Order 216–6. This policy does not constitute a major Federal action significantly affecting the quality of the human environment. The FWS has determined that the issuance of the policy is categorically excluded under the Department of the Interior's NEPA procedures in 516 DM 2, Appendix 1 (1.10) and 516 DM 6, Appendix 1. NOAA has determined that the issuance of this policy qualifies for a categorical exclusion as defined by NOAA Administrative Order 216–6, Environmental Review Procedure.

ESA Section 7 Consultation

We have determined that issuance of this policy will not affect species listed as threatened or endangered under the Endangered Species Act, and, therefore, a section 7 consultation on this policy is not required.

Government-to-Government Relationship With Tribes

In accordance with the President's memorandum of April 29, 1994, ''Government-to-Government Relations with Native American Tribal Governments'' (59 FR 22951), E.O. 13175, and the Department of Interior's 512 DM 2, this policy does not directly affect Tribal resources. The policy may have an indirect effect on Native American Tribes as the policy may influence the type and content of conservation plans and efforts implemented by Tribes, or other entities. The extent of this indirect effect will be determined on a case-by-case basis during our evaluation of individual formalized conservation efforts when we make a listing decision. Under Secretarial Order 3206, we will, at a minimum, share with the entity that developed the formalized conservation effort any information provided by the Tribes, through the public comment period for the listing decision or formal submissions. During the development of conservation plans, we can encourage the incorporation of conservation efforts that will restore or enhance Tribal trust resources. After consultation with the Tribes and the entity that developed the formalized conservation effort and after

careful consideration of the Tribe's concerns, we must clearly state the rationale for the recommended final listing decision and explain how the decision relates to our trust responsibility. Accordingly:

(a) We have not yet consulted with the affected Tribe(s). We will address this requirement when we evaluate formalized conservation efforts that have yet to be implemented or have recently been implemented and have yet to show effectiveness at the time we make a listing decision.

(b) We have not yet worked with Tribes on a government-to-government basis. We will address this requirement when we evaluate formalized conservation efforts that have yet to be implemented or have recently been implemented but have yet to show effectiveness at the time we make a listing decision.

(c) We will consider Tribal views in individual evaluations of formalized conservation efforts.

(d) We have not yet consulted with the appropriate bureaus and offices of the Department about the identified effects of this policy on Tribes. This requirement will be addressed with individual evaluations of formalized conservation efforts.

Information Quality

In Accordance with section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001 (Public Law 106–554), OMB directed Federal agencies to issue and implement guidelines to ensure and maximize the quality, objectivity, utility, and integrity of Government information disseminated to the public (67 FR 8452). Under our Information Quality guidelines, if we use a conservation plan or agreement as part of our decision to either list or not list a species under the Act, the plan or agreement is considered to be disseminated by us and these guidelines apply to the plan or agreement. The criteria outlined in this policy are consistent with OMB, Department of Commerce, NOAA, and Department of the Interior. FWS information quality guidelines. The Department of the Interior's guidelines can be found at *http://www.doi.gov/ocio/guidelines/515Guides.pdf*, and the FWS's guidelines can be found at *http://irm.fws.gov/infoguidelines/.* The Department of Commerce's guidelines can be found at *http://www.osec.doc.gov/cio/oipr/iqg.html*, and the NOAA/NMFS's guidelines can be found at *http://www.noaanews.noaa.gov/stories/iq.htm*. Under these guidelines, any affected person or organization may request from FWS or NMFS, a correction of information they believe to be incorrect in the plan or agreement. ''Affected persons or organizations'' are those who may use, be benefitted by, or be harmed by the disseminated information (i.e., the conservation plan or agreement). The process for submitting a request for correction of information is found in the respective FWS and NOAA guidelines.

Economic Analysis

This policy identifies criteria that a formalized conservation effort must satisfy to ensure certainty of implementation and effectiveness and for us to determine that the conservation effort contributes to making listing a species unnecessary or contributes to forming a basis for listing a species as threatened rather than endangered. We developed this policy to ensure consistent and adequate evaluation of agreements and plans when making listing decisions. The policy will also provide guidance to States and other entities on how we will evaluate certain formalized conservation efforts during the listing process.

The criteria in this policy primarily describe elements that are already included in conservation efforts and that constitute sound conservation planning. For example, the criteria requiring identification of responsible parties, obtaining required authorizations, establishment of objectives, and inclusion of an implementation schedule and monitoring provisions are essential for directing the implementation and affirming the effectiveness of conservation efforts. These kinds of ''planning'' requirements are generally already included in conservation efforts and do not establish any new implementation burdens. Rather, these requirements will help to ensure that conservation efforts are well planned and, therefore, increase the likelihood that conservation efforts will ultimately be successful in making listing species unnecessary.

The development of an agreement or plan by a state or other entity is completely voluntary. However, when a state or other entity voluntarily decides to develop an agreement or plan with the specific intent of making listing a species unnecessary, the criteria identified in this policy can be construed as requirements placed on the development of such agreements or plans. The state or other entity must satisfy these criteria in order to obtain and retain the benefit they are seeking, which is making listing of a species as threatened or endangered unnecessary.

The criteria in the policy require demonstrating certainty of implementation and effectiveness of formalized conservation efforts. We have always considered the certainty of implementation and effectiveness of conservation efforts when making listing decisions. Therefore, we believe that no economic effects on states and other entities will result from using the criteria in this policy as guidance.

Furthermore, publication of this policy will have positive effects by informing States and other entities of the criteria we will use in evaluating formalized conservation efforts when making listing decisions, and thereby guide states and other entities in developing voluntary formalized conservation efforts that will be successful in making listing unnecessary. Therefore, we believe that informational benefits will result from issuing this policy. We believe these benefits, although important, will be insignificant economically.

Authority

The authority for this action is the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*).

Policy for Evaluation of Conservation Efforts When Making Listing Decisions

Policy Purpose

The Fish and Wildlife Service and National Marine Fisheries Service developed this policy to ensure consistent and adequate evaluation of formalized conservation efforts (conservation efforts identified in conservation agreements, conservation plans, management plans, and similar documents) when making listing decisions under the Act. This policy may also guide the development of conservation efforts that sufficiently improve a species' status so as to make listing the species as threatened or endangered unnecessary.

Definitions

''Adaptive management'' is a method for examining alternative strategies for meeting measurable biological goals and objectives, and then, if necessary, adjusting future conservation management actions according to what is learned.

''Agreements and plans'' include conservation agreements, conservation plans, management plans, or similar documents approved by Federal agencies, State and local governments, Tribal governments, businesses, organizations, or individuals.

''Candidate species,'' as defined by regulations at 50 CFR 424.02(b), means

any species being considered for listing as an endangered or a threatened species, but not yet the subject of a proposed rule. However, the FWS includes as candidate species those species for which the FWS has sufficient information on file relative to status and threats to support issuance of proposed listing rules. The NMFS includes as candidate species those species for which it has information indicating that listing may be warranted, but for which sufficient information to support actual proposed listing rules may be lacking. The term ''candidate species'' used in this policy refers to those species designated as candidates by either of the Services.

''Conservation efforts,'' for the purpose of this policy, are specific actions, activities, or programs designed to eliminate or reduce threats or otherwise improve the status of a species. Conservation efforts may involve restoration, enhancement, maintenance, or protection of habitat; reduction of mortality or injury; or other beneficial actions.

''Formalized conservation efforts'' are conservation efforts identified in a conservation agreement, conservation plan, management plan, or similar document. An agreement or plan may contain numerous conservation efforts.

Policy Scope

When making listing decisions, the Services will evaluate whether formalized conservation efforts contribute to making it unnecessary to list a species, or to list a species as threatened rather than endangered. This policy applies to those formalized conservation efforts that have not yet been implemented or have been implemented, but have not yet demonstrated whether they are effective at the time of a listing decision. We will make this evaluation based on the certainty of implementing the conservation effort and the certainty that the effort will be effective. This policy identifies the criteria we will use to help determine the certainty of implementation and effectiveness. Listing decisions covered by the policy include findings on petitions to list species, and decisions on whether to assign candidate status, remove candidate status, issue proposed listing rules, and finalize or withdraw proposed listing rules. This policy applies to formalized conservation efforts developed with or without a specific intent to influence a listing decision and with or without the involvement of the Services.

Section 4(a)(1) of the Endangered Species Act of 1973, as amended (16 U.S.C. 1533(a)(1)), states that we must determine whether a species is threatened or endangered because of any of the following five factors:(A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or manmade factors affecting its continued existence.

Although this language focuses on impacts negatively affecting a species, section 4(b)(1)(A) requires us also to ''tak[e] into account those efforts, if any, being made by any State or foreign nation, or any political subdivision of a State or foreign nation, to protect such species, whether by predator control, protection of habitat and food supply, or other conservation practices, within any area under its jurisdiction, or on the high seas.'' Read together, sections 4(a)(1) and 4(b)(1)(A), as reflected in our regulations at 50 CFR 424.11(f), require us to take into account any State or local laws, regulations, ordinances, programs, or other specific conservation measures that either positively or negatively affect a species' status (i.e., measures that create, exacerbate, reduce, or remove threats identified through the section 4(a)(1) analysis). The manner in which the section 4(a)(1) factors are framed supports this conclusion. Factor (D) for example—ldquo;the inadequacy of existing regulatory mechanisms''—indicates that overall we might find existing regulatory mechanisms adequate to justify a determination not to list a species.

Factor (E) in section 4(a)(1) (any ''manmade factors affecting [the species'] continued existence'') requires us to consider the pertinent laws, regulations, programs, and other specific actions of any entity that either positively or negatively affect the species. Thus, the analysis outlined in section 4 of the Act requires us to consider the conservation efforts of not only State and foreign governments but also of Federal agencies, Tribal governments, businesses, organizations, or individuals that positively affect the species' status.

While conservation efforts are often informal, such as when a property owner implements conservation measures for a species simply because of concern for the species or interest in protecting its habitat, and without any specific intent to affect a listing decision, conservation efforts are often formalized in conservation agreements, conservation plans, management plans, or similar documents. The development and implementation of such agreements and plans has been an effective mechanism for conserving declining species and has, in some instances, made listing unnecessary. These efforts are consistent with the Act's finding that ''encouraging the States and other interested parties * * * to develop and maintain conservation programs * * * is a key * * * to better safeguarding, for the benefit of all citizens, the Nation's heritage in fish, wildlife, and plants'' (16 U.S.C. 1531 (a)(5)).

In some situations, a listing decision must be made before all formalized conservation efforts have been implemented or before an effort has demonstrated effectiveness. We may determine that a formalized conservation effort that has not yet been implemented has reduced or removed a threat to a species when we have sufficient certainty that the effort will be implemented and will be effective.

Determining whether a species meets the definition of threatened or endangered requires us to analyze a species' risk of extinction. Central to this risk analysis is an assessment of the status of the species (i.e., is it in decline or at risk of decline and at what rate is the decline or risk of decline) and consideration of the likelihood that current or future conditions or actions will promote (see section 4(b)(1)(A)) or threaten a species' persistence. This determination requires us to make a prediction about the future persistence of a species, including consideration of both future negative and positive effects of anticipated human actions. The language of the Act supports this approach. The definitions for both ''endangered species'' and ''threatened species'' connote future condition, which indicates that consideration of whether a species should be listed depends in part on identification and evaluation of future actions that will reduce or remove, as well as create or exacerbate, threats to the species. The first factor in section 4(a)(1)—''the present or *threatened* destruction, modification, or curtailment of [the species'] habitat or range''—identifies how analysis of both current actions affecting a species' habitat or range and those actions that are sufficiently certain to occur in the future and affect a species' habitat or range are necessary to assess a species' status. However, future Federal, State, local, or private actions that affect a species are not limited to actions that will affect a species' habitat or range. Congress did not intend for us to consider future actions affecting a species' habitat or range, yet ignore future actions that will influence overutilization, disease, predation,

regulatory mechanisms, or other natural or manmade factors. Therefore, we construe Congress' intent, as reflected by the language of the Act, to require us to consider both current actions that affect a species' status and sufficiently certain future actions—either positive or negative—that affect a species' status. As part of our assessment of future conditions, we will determine whether a formalized conservation effort that has yet to be implemented or has recently been implemented but has yet to show effectiveness provides a high level of certainty that the effort will be implemented and/or effective and results in the elimination or adequate reduction of the threats.

For example, if a state recently designed and approved a program to eliminate collection of a reptile being considered for listing, we must assess how this program affects the status of the species. Since the program was just designed, an implementation and effectiveness record may not yet exist. Therefore, we must evaluate the likelihood, or certainty, that it will be implemented and effective, using evidence such as the State's ability to enforce new regulations, educate the public, monitor compliance, and monitor the effects of the program on the species. Consequently, we would determine that the program reduces the threat of overutilization of the species through collecting if we found sufficient certainty that the program would be implemented and effective.

In another example, a state could have a voluntary incentive program for protection and restoration of riparian habitat that includes providing technical and financial assistance for fencing to exclude livestock. Since the state has already implemented the program, the state does not need to provide certainty that it will be implemented. If the program was only recently implemented and no record of the effects of the program on the species' status existed, we would evaluate the effectiveness of this voluntary program at the time of our listing decision. To assess the effectiveness, we would evaluate the level of participation (e.g., number of participating landowners or number of stream-miles fenced), the length of time of the commitment by landowners, and whether the program reduces the threats on the species. We would determine that the program reduces the threat of habitat loss and degradation if we find sufficient certainty that the program is effective.

In addition, we will consider the estimated length of time that it will take for a formalized conservation effort to produce a positive effect on the species. In some cases, the nature, severity, and/or imminence of threats to a species may be such that a formalized conservation effort cannot be expected to produce results quickly enough to make listing unnecessary since we must determine at the time of the listing decision that the conservation effort has improved the status of the species.

Federal agencies, Tribal governments, state and local governments, businesses, organizations, or individuals contemplating development of an agreement or plan should be aware that, because the Act mandates specific timeframes for making listing decisions, we cannot delay the listing process to allow additional time to complete the development of an agreement or plan. Nevertheless, we encourage the development of agreements and plans even if they will not be completed prior to a final listing decision. Such an agreement or plan could serve as the foundation for a special rule under section 4(d) of the Act, which would establish only those prohibitions necessary and advisable for the conservation of a threatened species, or for a recovery plan, and could lead to earlier recovery and delisting.

This policy provides us guidance for evaluating the certainty of implementation and effectiveness of formalized conservation efforts. This policy is not intended to provide guidance for determining the specific level of conservation (e.g., number of populations or individuals) or the types of conservation efforts (e.g., habitat restoration, local regulatory mechanisms) specifically needed to make listing particular species unnecessary and does not provide guidance for determining when parties should enter into agreements. We do encourage early coordination in conservation measures to prevent the species from meeting the definition of endangered or threatened.

If we make a decision not to list a species or to list the species as threatened rather than endangered based in part on the contributions of a formalized conservation effort, we will track the status of the effort including the progress of implementation and effectiveness of the conservation effort. If any of the following occurs: (1) a failure to implement the conservation effort in accordance with the implementation schedule; (2) a failure to achieve objectives; (3) a failure to modify the conservation effort to adequately address an increase in the severity of a threat or to address other new information on threats; or (4) we receive any other new information indicating a possible change in the status of the species, then we will reevaluate the status of the species and consider whether initiating the listing process is necessary. Initiating the listing process may consist of designating the species as a candidate species and assigning a listing priority, issuing a proposed rule to list, issuing a proposed rule to reclassify, or issuing an emergency listing rule. In some cases, even if the parties fully implement all of the conservation efforts outlined in a particular agreement or plan, we may still need to list the species. For example, this may occur if conservation efforts only cover a portion of a species' range where the species needed to be conserved, or a particular threat to a species was not anticipated or addressed at all, or not adequately addressed, in the agreement or plan.

Evaluation Criteria

Conservation agreements, conservation plans, management plans, and similar documents generally identify numerous conservation efforts (i.e., actions, activities, or programs) to benefit the species. In determining whether a formalized conservation effort contributes to forming a basis for not listing a species, or for listing a species as threatened rather than endangered, we must evaluate whether the conservation effort improves the status of the species under the Act. Two factors are key in that evaluation: (1) for those efforts yet to be implemented, the certainty that the conservation effort will be implemented and (2) for those efforts that have not yet demonstrated effectiveness, the certainty that the conservation effort will be effective. Because the certainty of implementation and effectiveness of formalized conservation efforts may vary, we will evaluate each effort individually and use the following criteria to direct our analysis.

A. The certainty that the conservation effort will be implemented:

1. The conservation effort, the party(ies) to the agreement or plan that will implement the effort, and the staffing, funding level, funding source, and other resources necessary to implement the effort are identified. 2. The legal authority of the party(ies) to the agreement or plan to implement the formalized conservation effort, and the commitment to proceed with the conservation effort are described.3. The legal procedural requirements (e.g. environmental review) necessary to implement the effort are described, and information is provided indicating that fulfillment of these requirements does

not preclude commitment to the effort. 4. Authorizations (e.g., permits, landowner permission) necessary to implement the conservation effort are identified, and a high level of certainty is provided that the party(ies) to the agreement or plan that will implement the effort will obtain these authorizations. 5. The type and level of voluntary participation (e.g., number of landowners allowing entry to their land, or number of participants agreeing to change timber management practices and acreage involved) necessary to implement the conservation effort is identified, and a high level of certainty is provided that the party(ies) to the agreement or plan that will implement the conservation effort will obtain that level of voluntary participation (e.g., an explanation of how incentives to be provided will result in the necessary level of voluntary participation). 6. Regulatory mechanisms (e.g., laws, regulations, ordinances) necessary to implement the conservation effort are in place. 7. A high level of certainty is provided that the party(ies) to the agreement or plan that will implement the conservation effort will obtain the necessary funding. 8. An implementation schedule (including incremental completion dates) for the conservation effort is provided. 9. The conservation agreement or plan that includes the conservation effort is approved by all parties to the agreement or plan.

B. The certainty that the conservation effort will be effective:

1. The nature and extent of threats being addressed by the conservation effort are described, and how the conservation effort reduces the threats is described. 2. Explicit incremental objectives for the conservation effort and dates for achieving them are stated. 3. The steps necessary to implement the conservation effort are identified in detail. 4. Quantifiable, scientifically valid parameters that will demonstrate achievement of objectives, and standards for these parameters by which progress will be measured, are identified. 5. Provisions for monitoring and reporting progress on implementation (based on compliance with the implementation schedule) and effectiveness (based on evaluation of quantifiable parameters) of the conservation effort are provided.6. Principles of adaptive management are incorporated.

These criteria should not be considered comprehensive evaluation criteria. The certainty of implementation and effectiveness of a formalized conservation effort may also depend on species-specific, habitat-specific, location-specific, and effort-specific factors. We will consider all appropriate factors in evaluating formalized conservation efforts. The specific circumstances will also determine the amount of information necessary to satisfy these criteria.

To consider that a formalized conservation effort(s) contributes to forming a basis for not listing a species or listing a species as threatened rather than endangered, we must find that the conservation effort is sufficiently certain to be implemented and effective so as to have contributed to the elimination or adequate reduction of one or more threats to the species identified through the section 4(a)(1) analysis. The elimination or adequate reduction of section 4(a)(1) threats may lead to a determination that the species does not meet the definition of threatened or endangered, or is threatened rather than endangered. An agreement or plan may contain numerous conservation efforts, not all of which are sufficiently certain to be implemented and effective. Those conservation efforts that are not sufficiently certain to be implemented and effective cannot contribute to a determination that listing is unnecessary or a determination to list as threatened rather than endangered. Regardless of the adoption of a conservation agreement or plan, however, if the best available scientific and commercial data indicate that the species meets the definition of ''endangered species'' or ''threatened species'' on the day of the listing decision, then we must proceed with appropriate rule-making activity under section 4 of the Act.

Dated: September 16, 2002.

Steve Williams,

Director, Fish and Wildlife Service.

December 23, 2002.

William T. Hogarth,

Assistant Administrator for Fisheries, National Marine Fisheries Services.

[FR Doc. 03–7364 Filed 3–27–03; 8:45 am]

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DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

50 CFR Part 679

[Docket No. 021212306–2306–01; I.D. 032403A]

Fisheries of the Exclusive Economic Zone Off Alaska; Pollock in Statistical Area 610 of the Gulf of Alaska

AGENCY: National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: Modification of a closure.

SUMMARY: NMFS is reopening directed fishing for pollock in Statistical Area 610 of the Gulf of Alaska (GOA) for 24 hours. This action is necessary to fully use the B season allowance of the total allowable catch (TAC) of pollock specified for Statistical Area 610.

DATES: Effective 1200 hrs, Alaska local time (A.l.t.), March 26, 2003, through 1200 hrs, A.l.t., March 27, 2003.

FOR FURTHER INFORMATION CONTACT: Mary Furuness, 907–586–7228.

SUPPLEMENTARY INFORMATION: NMFS manages the groundfish fishery in the GOA exclusive economic zone according to the Fishery Management Plan for Groundfish of the Gulf of Alaska (FMP) prepared by the North Pacific Fishery Management Council under authority of the Magnuson-Stevens Fishery Conservation and Management Act. Regulations governing fishing by U.S. vessels in accordance with the FMP appear at subpart H of 50 CFR part 600 and 50 CFR part 679.

NMFS closed the B season directed fishery for pollock in Statistical Area 610 of the GOA under § 679.20(d)(1)(iii) on March 19, 2003 (68 FR 13857, March 21, 2003).

NMFS has determined that, approximately 986 mt of pollock remain in the B season directed fishing allowance. Therefore, in accordance with 679.25(a)(2)(i)(C) and (a)(2)(iii)(D), and to fully utilize the B season allowance of pollock TAC specified for Statistical Area 610, NMFS is terminating the previous closure and is reopening directed fishing for pollock in Statistical Area 610 of the GOA. In accordance with § 679.20(d)(1)(iii), the Regional Administrator finds that this directed fishing allowance will be reached after 24 hours. Consequently, NMFS is prohibiting directed fishing for pollock in Statistical Area 610 of the GOA effective 1200 hrs, A.l.t., March 27, 2003.

U.S. Fish & Wildlife Service

News Release

April 9, 2008

U.S. Fish and Wildlife Service Releases Revised Plan for Horse and Burro Management at Sheldon National Wildlife Refuge

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Final assessment finds no significant impact on people or natural or cultural resources

The U.S. Fish and Wildlife Service today released its revised plan for managing feral horses and burros at Sheldon National Wildlife Refuge in northwestern Nevada.

The revised final Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) documenting the refuge's Horse and Burro Management Program will guide activities until the refuge completes its Comprehensive Conservation Plan (CCP).

"After two years of planning and multiple opportunities for public review and comment, we believe our program will humanely maintain horse and burro populations at levels that will not allow their impact on habitat, wildlife and cultural resources to increase, and will lower the risk these animals pose to public safety," said Ren Lohoefener, Director of the Service's Pacific Region. "We've also built in additional safeguards to help ensure we find good homes for adopted animals."

An estimated 900 horses and burros currently wander freely year-round across Sheldon Refuge, which was established in the 1930s to conserve American pronghorn antelope and other native wildlife. The combined horse and burro population, which totaled less than 400 in the early 1990s, is growing at an estimated annual rate of between 17 and 23 percent. The horses and burros consume forage and water, trample vegetation, compact soils and otherwise directly and indirectly harm native fish, wildlife, plants and their habitats. Horses and burros also pose a public safety hazard to travelers along Highway 140.

In Sheldon's high-elevation, semi-arid environments, conflicts among non-native horses and burros and native species are most severe during late summer and mid-winter and are prominent at Sheldon's limited water resources and adjacent meadows, wetlands and riparian zones. Monitoring information from 2002 concluded that 44 percent of all streams and 80 percent of the springs on the refuge were severely degraded by feral horses and burros.

Although the Service has conducted periodic gathering of horses and burros on the refuge since the 1940s, recent efforts have not kept pace with growth in the populations, exacerbating habitat damage, particularly to riparian areas.

Sheldon's Horse and Burro Management Program seeks to maintain relatively stable horse and burro population numbers at the 2007 population levels of approximately 800 horses and 90 burros until completion of the CCP, scheduled for 2010. This will be accomplished by periodic roundups and an adoption program that would move horses and burros off refuge lands in a humane manner. Based on current population and recruitment estimates, the annual removal would roughly equal 140 to 180 horses and 15 to 20 burros.

The Service plans to modify the refuge's corral system by reconfiguring large pens into smaller, safer pens, improve the water delivery system, test the use of contraceptives to reduce the rate of horse population growth, and explore techniques for marking animals. The pen modifications are expected to increase the efficiency of holding and sorting horses and reduce risks of injury to animals and personnel.

Horse gathers would occur outside the main foaling season (February through May) and would be conducted using helicopters assisted by horseback wranglers and through use of horseback wranglers alone. Burros would be gathered by baiting them into corrals with hay or other forage. Gathers would target removal and either public adoption or relocation of animals away from refuge areas of greatest concern, such as areas near Highway 140, areas with degraded riparian habitats and areas that had experienced recent wildfires. The next gather would likely occur during late summer 2008.

All animals in the gather would be processed with expert staff and a veterinarian. Horses and burros would be placed in good homes through adoption agents, who would undergo background checks before being selected. Among other things, the agents would be responsible for carefully screening potential adopters and requiring them to sign agreements, further helping to ensure that adopted animals are properly cared for and do not end up in a slaughter facility.

The Service expects to begin additional monitoring efforts to statistically quantify horse and burro population estimates on Sheldon Refuge, examine movements of animals across the landscape, and assess the ecosystem response once horses are excluded from specific areas.

The Service is working cooperatively with the U.S. Bureau of Land Management, private landowners, the Nevada Department of Wildlife and others with management expertise in addressing similar natural resource

management challenges, including horse and burro management on adjacent lands.

The Service expects to initiate implementation of the Horse and Burro Management Program no sooner than 30 days from now. A copy of the revised Final Environmental Assessment and Finding of No Significant Impact can be obtained on the Service's website: http://www.fws.gov/sheldonhartmtn/sheldon/horseburro.html. Questions can be e-mailed to sheldon-hart@fws.gov.

The mission of the U.S. Fish and Wildlife Service is working with others to conserve, protect and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American people. We are both a leader and trusted partner in fish and wildlife conservation, known for our scientific excellence, stewardship of lands and natural resources, dedicated professionals and commitment to public service. For more information on our work and the people who make it happen, visit www.fws.gov.

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Quaternary Extinctions

A PREHISTORIC REVOLUTION

PAUL S. MARTIN
RICHARD G. KLEIN
EDITORS

The University of Arizona Press
Tucson

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About the Editors

PAUL S. MARTIN has contemplated Pleistocene events of arid regions from his desert laboratory on Tumamoc Hill west of Tucson, Arizona, for more than twenty-five years. He has studied the herpetofauna of eastern Mexico, the Pleistocene fossil pollen record of Arizona, and the potential for fossil packrat middens in studies of climatic changes as well as the causes of late Pleistocene extinctions. His interest in the extinction of late Pleistocene large animals has taken him to fossil sites in the four corners of the world. A geosciences professor, he has been on the faculty of the University of Arizona in Tucson since 1957.

RICHARD G. KLEIN has done research on Early Man in the Soviet Union, Spain, and especially South Africa, where he has analyzed fossil assemblages ranging from early Pliocene to historic in age and including archaeological and "natural" occurrences. His primary interest is in animal bones as indicators of environmental change and of collector behavior. He taught at the University of Wisconsin-Milwaukee, Northwestern University, and the University of Washington before joining the University of Chicago as a professor of anthropology.

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Ten Million Years of Mammal Extinctions in North America

S. DAVID WEBB

THE UNAIDED EYE, THE LIGHT MICROSCOPE, and the electron microscope "see" remarkably different images of the same object. One's view is governed greatly by the scale of one's perceptions. The human mind, however, knowing that these images must be reconciled, is up to the task. Similarly, different time scales will feature different aspects of the same chapter of earth history. In this essay I present land mammal extinctions in the perspective of the last ten million years, two orders of magnitude greater than is usual in Pleistocene extinction studies. It is not surprising that this longer scale renders different features. Understandably, this longer view must be reconciled with views based on a shorter scale.

In the past 300 million years, a succession of large tetrapod groups have reigned over the earth and then vanished with apparent abruptness. Bakker (1977), for example, recognized eight dynasties of this sort and dealt in some detail with the demise of the dinosaurs in the late Cretaceous. Each decline spanned several million years. I view the decline of the large-mammal dynasty during the late Cenozoic on about the same scale as these older extinction events.

In the early Miocene, mammals had reached a peak of ordinal and familial diversity in the world (Lillegraven 1972). The proportion of large mammals (those with body weights greater than 5 kg) was on the increase. Bourliére (1975) explains "the bimodal distribution of body weights among terrestrial mammals" and recognizes as large mammals those with average adult body weight of more than 5 kg. In North America during the middle Miocene (12 to 15 million years ago), major radiations were in progress among native ungulates like the horses, camels, and pronghorn. Presumably the burgeoning of such ungulate groups was an evolutionary response to the expansion of savanna and steppe in North America at the expense of forest habitats (Gregory 1971; Webb 1977 and 1983a).

In the late Miocene, however, a series of declines began that continued through the late Pleistocene extinctions. The first sharp decrease in the number of large-mammal genera in North America came at the end of the Clarendonian about nine million years ago (mya). On a long time scale these late Cenozoic extinctions appear to form a string of related events culminating in the best-documented one about ten thousand

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This postulated relationship between the late Pleistocene extinctions and the broader late Cenozoic decline can be illustrated by the extinction of the horses (Equidae) in North America. It is sometimes stated that this family became extinct on this continent at the end of the Pleistocene. In fact only one genus with a few species was extirpated in the late Pleistocene of North America (Kurtén and Anderson 1980). Another genus, *Nannipus*, and about four other equid species became extinct about two million years earlier in the latest Pliocene (late Blancan). Before that, however, three even greater apparent extinction events occurred in the long history of this native North American family. The first decline occurred in the late Clarendonian (nine mya) when two browsing genera and one grazing genus were lost. Two other equal declines occurred in the medial Hemphillian (about seven mya) and again in the late Hemphillian (about five mya). The stair-stepped late Cenozoic decline of the Equidae is summarized in Figure 9.1. It is true that the final demise of the family came with the late Rancholabrean extinctions, but this was merely the last, and by no means the worst, episode in the late Cenozoic decline of the Equidae.

My primary purpose here is to summarize the patterns of late Cenozoic extinctions in North American land mammals. A further purpose is to consider the possible mechanisms of these extinctions. In the framework of this long time scale, secular climatic deteriorations appear to be the only persistent cause sufficient to explain the late Cenozoic decline of land mammals.

Figure 9.2 represents the fossil record of late Cenozoic land mammal extinctions in North America, using nine biochronologic divisions. This figure summarizes the known stratigraphic ranges of all North American land mammal genera from Table 9.1. The greatest extinction episode, the late Hemphillian (about five mya), involved sixty-two genera, thirty-five of which were large mammals. The Rancholabrean episode did not devastate as many *land mammal genera*, but it did affect thirty-nine *large land mammal genera*, four more than in the late Hemphillian episode. Next, in descending order of their effects on number of mammal genera, were the Clarendonian, the late Blancan, and the early Hemphillian extinctions. These three intervals also had a major impact on large land mammals, with twenty to twenty-four genera making their last appearances in each interval. The least important was the late Irvingtonian. The six late Cenozoic extinctions appear separated by roughly two-million-year intervals of relatively stable existence for land mammal genera.

A major problem in comparing extinction sets of different ages concerns the varying scale of the stratigraphic record. As Figure 9.2 indicates, the older intervals are longer (more crudely defined) than the younger intervals. With increasing antiquity our capability at radiometric dating of short-term events, those occurring within a few millenia of each other, vanishes. In addition, the sedimentary record becomes exponentially less complete (Sadler, 1981). There are two opposite interpretations of the relationship between apparent extinctions and the stratigraphic record from which they are deduced. One interpretation assumes that all the extinctions in one stratigraphic interval occurred at one "instant" (e.g. "the dinosaurs died at the end of the Cretaceous"). The opposite assumes a uniform rate of extinction and prorates them over the entire interval. If extinctions occurred episodically, this second approach would dilute their impact in longer stratigraphic intervals. This dilemma can be resolved only by continuing efforts

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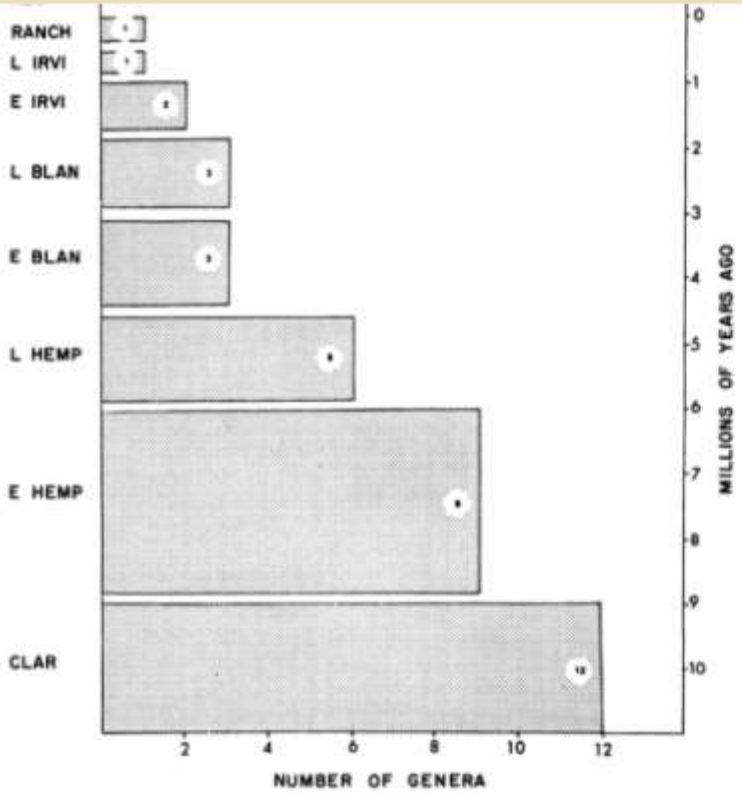

Figure 9.1. The decline of horses in North America. From twelve genera in the Clarendonian, three extinction episodes of the late Miocene reduced the number to three. The late Pleistocene saw the final extermination of *Equus* from North America. The North American land mammal ages on the left are in ascending order: Clarendonian (CLAR); early and late Hemphillian (E HEMP and L HEMP); early and late Blancan (E BLAN and L BLAN); early and late Irvingtonian (E IRVI and L IRVI); Rancholabrean (RANCH); and Recent (REC). The height of each block represents approximate duration of each age. See Tedford (1970) for a thorough analysis of these ages and their usage.

near the end of that interval within a few thousand years, in which case it was at least as great an extinction episode as the Rancholabrean. But, if the extinctions are prorated through their stratigraphic interval, late Hemphillian extinctions span 1.5 my and occur at only one-third the rate of the Rancholabrean. One wonders whether the more ancient extinction episodes were as strongly pulsed as the Rancholabrean episode.

Extinction and Climate

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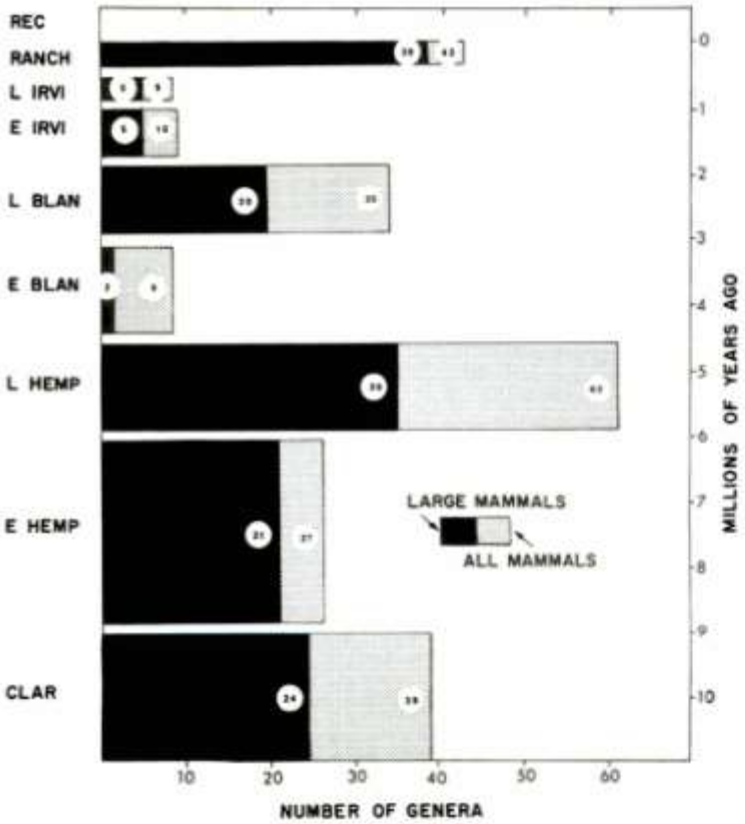

Figure 9.2. Late Cenozoic extinction episodes in North American land mammals. The effect on small mammals (less than 5 kg body weight) was much greater in the late Hemphillian episode than in the late Rancholabrean. (For abbreviations see Figure 9.1 legend.)

of its widespread efficacy (across diverse habitats and various climatic regimes), and because of its resemblance to the dire effects that Recent human cultures are inflicting on many surviving species of large mammals.

In the broader scale of the late Cenozoic, however, man appears too late to be the major cause. The genus *Homo* evolved midway in the late Cenozoic glacial ages but arrived in the New World only for the last in a long string of extinctions. Hunting

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Table 9.1. Stratigraphic Ranges of Late Cenozoic Mammals in North America
("over 5 kg adult body weight; s.l. = sensu lato)

Taxon	Clar	E Hemp	L Hemp	E Blan	L Blan	E Irvi	L Irvi	Ranch	Rec
Didelphidae									
Didelphis									
Erinaceidae									
Metechinus									
Lanthanotherium									
Soricidae									
Meterix									
Limnoecus									
Parydrosorex									
Alluvisorex									
Hesperosorex									
Sorex									
Planisorex									
Microsorex									
Blarina									
Notiosorex									
Cryptotis									
Paracryptotis									
Ancuroneomys									
Talpidae									
Achyloscaptor									
Mystipterus									
Domninoides									
Gaillardia									
Lemoynes									
Condylura									
Scalopus									
Scaparus									
Parascalops									
Neurotrichus									
Dasypodidae									
**Kraglievichia*									
**Holmesina*									
**Dasypus*									
Glyptodontidae									
**Glyptotherium*									
Megalonychidae									
**Pliometanastes*									
**Megalonyx*									
Megatheriidae									
**Nothrotheriops*									
**Eremotherium*									
Mylodontidae									
**Thinobadistes*									
**Glossotherium*									
Ochotonidae									
Hesperolagomys									
Ochotona									

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Table 9.1. Stratigraphic Ranges of Late Cenozoic Mammals in North America

(*over 5 kg adult body weight; s.l. = sensu lato)

(continued)

Taxon	Clar	E Hemp	L Hemp	E Blan	L Blan	E Irvi	L Irvi	Ranch	Rec
Leporidae									
Hypolagus									
Notolagus									
Alilepus									
Pratilepus									
Nekrolagus									
Brachylagus									
Aurolagus									
Sylvilagus									
Lepus									
Romerolagus									
Aplodontidae									
Liodontia									
Aplodontia									
Mylagaulidae									
**Mylagaulus*									
**Epigaulus*									
Sciuridae									
Sciurus									
Tamias									
Eutamias									
Tamiasciurus									
Spermophilus									
Ammospermophilus									
Cynomys									
Marmota									
**Paenemarmota*									
Glaucomys									
Sciuroptenus									
Cryptopterus									
Microsciurus									
Syntheosciurus									
Castoridae									
Hystricops									
Eucastor									
Dipoides									
Procastoroides									
**Castoroides*									
**Paradipoides*									
**Castor*									
Eomyidae									
Ronquillomys									
Kansasimys									
Leptodontomys									
Heteromyidae									
Perognathoides									
Perognathus									
Dipronomys									
Cupidinimus									
Liomys									

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Table 9.1. Stratigraphic Ranges of Late Cenozoic Mammals in North America
("over 5 kg adult body weight; s.l. = sensu lato)
(continued)

Taxon	Clar	E Hemp	L Hemp	E Blan	L Blan	E Irvi	L Irvi	Ranch	Rec
Heteromyidae *(cont.)*									
Prodipodomys									
Dipodomys									
Microdipodops									
Heteromys									
Geomydidae									
Parapliosaccomys									
Pliosaccomys									
Pliogeomys									
Geomys									
Thomomys									
Nerterogeomys									
Cratogeomys									
Heterogeomys									
Zygogeomys									
Pappogeomys									
Orthogeomys									
Macrogeomys									
Zapodidae									
Macrognathomys									
Pliozapus									
Zapus									
Napaeozapus									
Cricetidae									
Copemys									
Peromyscus									
Ochrotomys									
Calomys									
Neotoma									
Paraneotoma									
Oryzomys									
Baiomys									
Prosigmodon									
Sigmodon									
(new genus)									
Paronychomys									
Onychomys									
Galushamys									
Gnomomys									
Tregomys									
Reithrodontomys									
Symmetrodontomys									
Pliotomodon									
Repomys									
Nelsonia									
Neotomodon									
(13 recent genera)									
Arvicolidae									
Microtoscoptes									
Gonidontomys									

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Table 9.1. Stratigraphic Ranges of Late Cenozoic Mammals in North America
(*over 5 kg adult body weight; s.l. = sensu lato)
(continued)

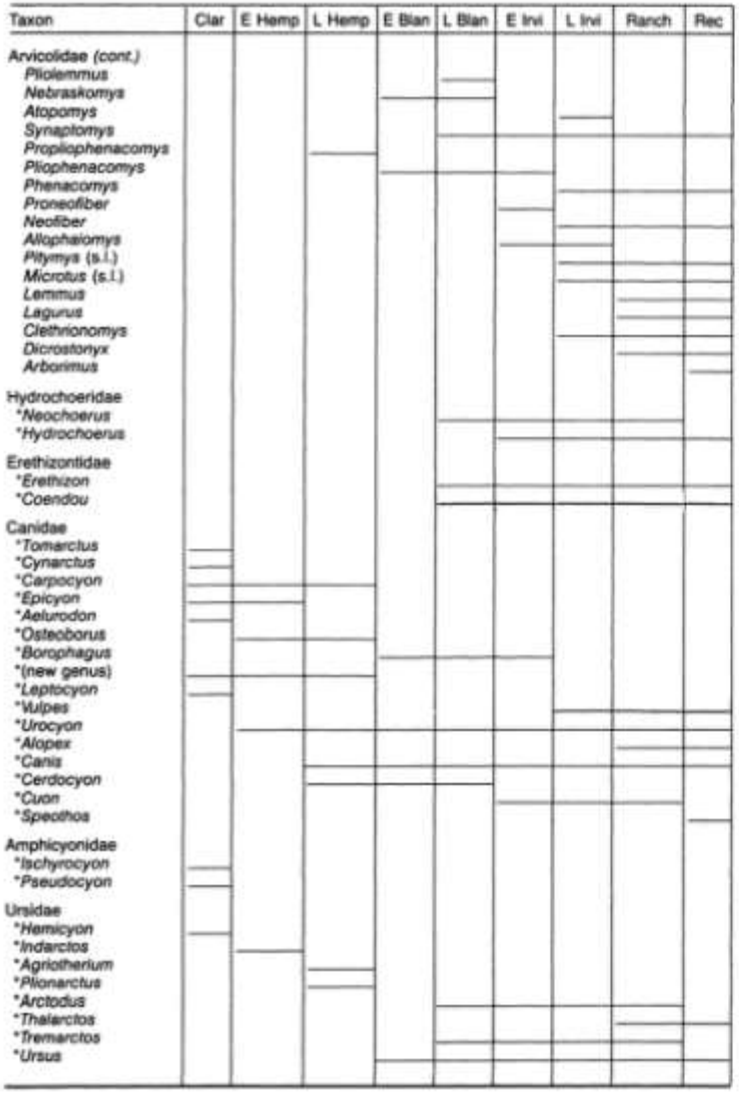

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Table 9.1. Stratigraphic Ranges of Late Cenozoic Mammals in North America
(*over 5 kg adult body weight; s.l. = sensu lato)
(continued)

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Table 9.1. Stratigraphic Ranges of Late Cenozoic Mammals in North America
(*over 5 kg adult body weight; s.l. = sensu lato)
(continued)

Taxon	Clar	E Hemp	L Hemp	E Blan	L Blan	E Irvi	L Irvi	Ranch	Rec
Felidae *(cont.)*									
**Lynx*									
**Felis*									
**Panthera*									
**Acinonyx*									
Hyaenidae									
**Chasmaporthetes*									
Mammutidae									
**Pliomastodon*									
**Mammut*									
Gomphotheriidae									
**Gomphotherium*									
**Amebelodon*									
**Platybelodon*									
**Rhynchotherium*									
**Stegomastodon*									
**Cuvieronius*									
Elephantidae									
**Mammuthus*									
Tapiridae									
**Tapiravus*									
**Tapirus*									
Rhinocerotidae									
**Peraceras*									
**Aphelops*									
**Teleoceras*									
Equidae									
**Archaeohippus*									
**Hypohippus*									
**Megahippus*									
**Merychippus*									
**Protohippus*									
**Pseudhipparion*									
**Neohipparion*									
**Cormohipparion*									
**Hippárion*									
**Nannippus*									
**Calippus*									
**Pliohippus*									
**Astrohippus*									
**Dinohippus*									
**Dolichihippus*									
**Equus* (s.l.)									
Toxodontidae									
**Mixotoxodon*									

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Table 9.1. Stratigraphic Ranges of Late Cenozoic Mammals in North America
(*over 5 kg adult body weight; s.l. = sensu lato)
(continued)

Taxon	Clar	E Hemp	L Hemp	E Blan	L Blan	E Irvi	L Irvi	Ranch	Rec
Felidae *(cont.)*									
**Lynx*									
**Felis*									
**Panthera*									
**Acinonyx*									
Hyaenidae									
**Chasmaporthetes*									
Mammutidae									
**Pliomastodon*									
**Mammut*									
Gomphotheriidae									
**Gomphotherium*									
**Amebelodon*									
**Platybelodon*									
**Rhynchotherium*									
**Stegomastodon*									
**Cuvieronius*									
Elephantidae									
**Mammuthus*									
Tapiridae									
**Tapiravus*									
**Tapirus*									
Rhinocerotidae									
**Peraceras*									
**Aphelops*									
**Teleoceras*									
Equidae									
**Archaeohippus*									
**Hypohippus*									
**Megahippus*									
**Merychippus*									
**Protohippus*									
**Pseudhipparion*									
**Neohipparion*									
**Cormohipparion*									
**Hippárion*									
**Nannippus*									
**Calippus*									
**Pliohippus*									
**Astrohippus*									
**Dinohippus*									
**Dolichihippus*									
**Equus* (s.l.)									
Toxodontidae									
**Mixotoxodon*									

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Table 9.1. Stratigraphic Ranges of Late Cenozoic Mammals in North America
(*over 5 kg adult body weight; s.l. = sensu lato)
(continued)

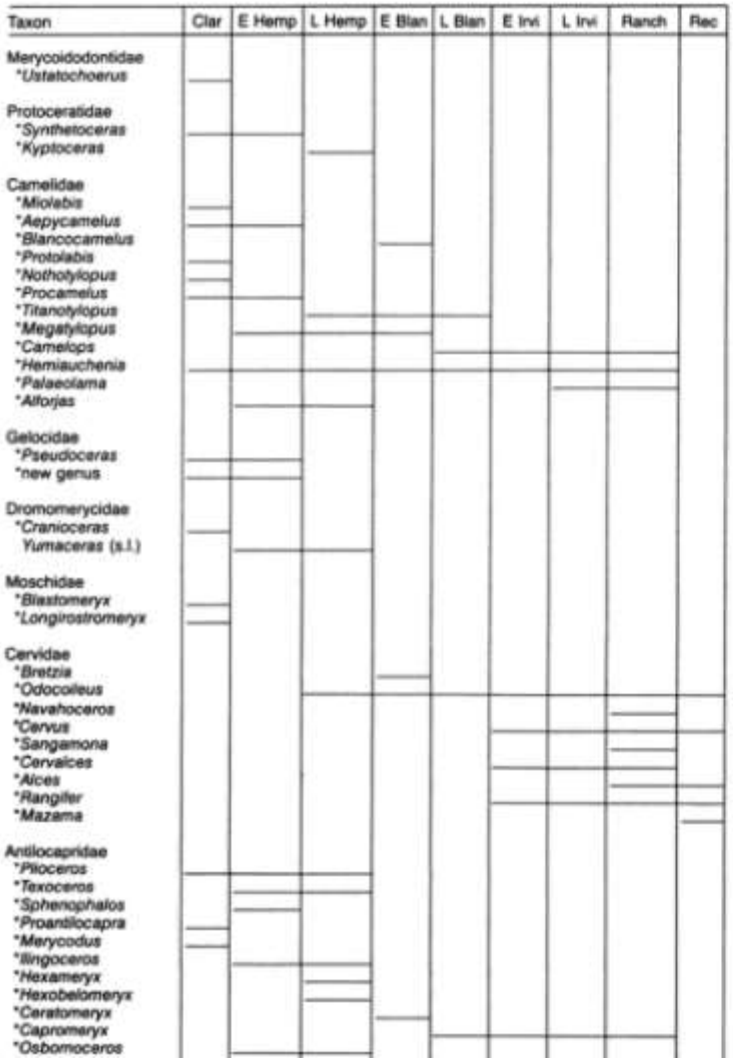

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Table 9.1. Stratigraphic Ranges of Late Cenozoic Mammals in North America
(*over 5 kg adult body weight; s.l. = sensu lato)
(continued)

Taxon	Clar	E Hemp	L Hemp	E Blan	L Blan	E Irvi	L Irvi	Ranch	Rec
Antilocapridae *(cont.)*									
*Ottoceros									
*Hayoceros									
*Stockoceros									
*Tetrameryx									
*Antilocapra									
*new genus									
Bovidae									
*Neotragocerus									
*Euceratherium									
*Bootherium									
*Bison									
*Platycerabos									
*Praeovibos									
*Ovibos									
*Symbos									
*Soergelia									
*Saiga									
*Ovis									
*Neorhaeodus									
*Oreamnos									

The late Cenozoic mammal extinctions coincide broadly with the period of glacial climates. The oldest glaciations in the northern hemisphere appeared nearly ten million years ago as alpine glaciers in southern Alaska (Denton and Armstrong 1969). More importantly, in the southern hemisphere two major ice caps had been emplaced in Antarctica, and this had worldwide effects, such as lowered sea levels and cooling of bottom waters, especially at middle latitudes (Shackleton and Kennett 1975; Schnitker 1980). Donn and Shaw (1977) regard the late Miocene as the time when mean annual temperatures dropped to freezing at high northern latitudes, "accounting for the late Cenozoic glacial age."

Figure 9.3 provides a set of correlations between late Tertiary oxygen-isotope curves from benthic forams in deep-sea cores and North American land mammal ages by way of paleomagnetic chronology and radiometric dates. There is a suggestive relationship between the three sharp reversals in the bottom-water oxygen-isotope curve between five and ten million years ago and the three major extinction episodes in North America during that same interval. Obviously more refined correlations are needed and are rapidly being developed. Nonetheless, it is fair to note a general late Miocene coincidence between sharp cooling trends in the deep sea and the onset of severe extinction episodes on the land.

It is perhaps to be expected that the great majority of the late Cenozoic extinctions on temperate land masses were concentrated in the late Tertiary; for that is when the biota, previously adjusted to more equable conditions, first felt the severity of glacial

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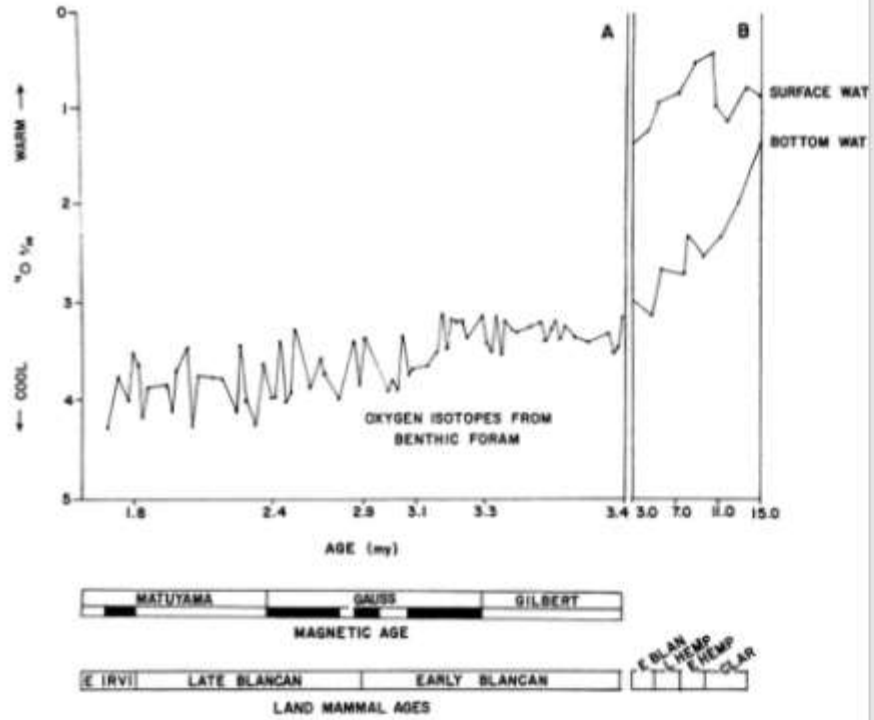

Figure 9.3. Correlations between times of land mammal extinctions and glacial cooling in the late Cenozoic. Compare with Figure 9.2 for times of greatest land mammal extinctions. Notable features are the reversals of cooling trends at about nine, six, and four million years ago. Oxygen isotopes from benthic foram, *Globocassidulina subglobosa*. Oxygen-isotope curves (A) above 3.0 my from Shackleton and Kenneth 1975; (B) below 3.4 my from Shackleton and Opdyke 1977. Note time scale change at this break. (For abbreviations see Figure 9.1 legend.)

vascular plants in North America and Europe and concluded that "the bulk of recorded late Cenozoic extinctions are of late Tertiary, not Quaternary, age." The data for land mammal extinctions corroborate this view, and suggest that the whole biota was most severely reorganized at the beginning of the late Cenozoic ice ages.

Extinctions and Glacial Terminations

A corollary of the climatic hypothesis of land mammal extinctions is that greater extremes of temperature, moisture availability and seasonality suddenly occurred to produce misadaptations of plants and animals in many different localities and habitats.

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Much evidence indicates that extremes of instability and maximum seasonality came during glacial terminations (Dreimanis 1977, Porter 1980). If land mammal extinctions can be shown to coincide with glacial terminations, then the climatic explanation becomes more plausible.

One of the interesting features of the oxygen-isotope curves from Pleistocene deep-sea cores is their saw-toothed (asymmetrical) pattern, showing more rapid heating than cooling. The widest excursions with the steepest slopes occur during glacial terminations (e.g. Shackleton and Opdyke, 1977). One plausible explanation for this pattern was recently advanced by Kukla et al. (1981) to the effect that the cyclical nature of glacial history is determined by earth-sun orbital cycles and that the most important effect is the onset of an interglacial interval, driven primarily by the perihelion. On the continents at temperate latitudes, conditions during the onset of an interglacial were particularly extreme and unstable. The ameliorating effects of glacial masses were lost as they retreated, and the rates of retreats accelerated (Birchfield et al. 1981, Dreimanis 1977, Wright 1970). Thus, the most inequable climates on land might be expected at high latitudes in continental interiors during glacial terminations. Such conditions of climatic instability (the inequability of Axelrod 1967) and drought would have the most devastating effects on land biota.

It is, therefore, intriguing to note that late Cenozoic land mammal extinctions in North America may have been massed at times of glacial terminations. The most familiar case is the late Rancholabrean extinction episode which coincides with the end of the last glacial cycle. Several students of late Pleistocene vertebrates have noted the retreat of many Recent species from much wider Rancholabrean distributions. These often include the breakup of enriched ("disharmonious") faunas, often with the northward retreat of some taxa and the southward retreat of others. Indications include greater drought, colder winters, and hotter summers (Hibbard 1970, Holman 1976, Graham 1976, Guthrie this volume, Lundelius 1967, Graham and Lundelius this volume). Such range restrictions have a suggestive correlation with the late Rancholabrean extinctions and with the end of the Wisconsin glaciation.

Three other mammal extinction episodes from the late Cenozoic of North America evidently correlate with glacial terminations. The late Hemphillian extinction episode apparently coincides with the end of the Messinian glacio-eustatic cycle. As discussed more fully elsewhere (Webb 1983b, Schultz 1977), this extinction episode is dated in the Texas panhandle at about 5.5 mya, and therefore probably correlates with the terminal Messinian transgression cycle, involving a change of at least 40 meters in sea level. The episode falls stratigraphically near the end of the mid-Hemphillian (Webb et al. 1978; Peck et al. 1979). If the Messinian sea level cycle is correctly interpreted as a major glacio-eustatic cycle (Hsu et al. 1977, Adams et al. 1978, Schnitker 1980), then the major mid-Hemphillian extinction episode correlates with the termination of the late Miocene glacial cycle about five mya.

The late Blancan extinction event can be placed rather concisely near the end of a glacial cycle as Repenning (1980) notes. Several magnetochronologic studies (Lindsay et al. 1975, Opdyke et al. 1977, Johnson et al. 1975, Neville et al. 1979) consistently place it in the basal part of the Matuyama magnetozone just below the Olduvai Event. Meanwhile deep-sea oxygen-isotope and magnetochronology records have shown that this same time (about 1.8 mya) was the termination of an early series of intense glacial cycles in the northern hemisphere. These glacials "of a magnitude of at least two-thirds that of the late Pleistocene glacial maxima" extended from 2.4 to 1.8 mya (Shackleton and Opdyke 1977) (see fig. 9.3). A deep core from Searles Lake in California shows that the end of the first long pre-Pleistocene wet period ended just below the Olduvai

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The late Irvingtonian is the third early extinction event that may be correlated with a glacial termination. The Cudahy local fauna (a late Irvingtonian sample) occurs in the lower Brunhes normal magnetochron, well above an ash dated 0.6 mya and below other parts of the section that are Rancholabrean (Kurtén and Anderson 1980). A glacial correlation of the Cudahy local fauna is supported by the small mammal species and molluscs of northern aspect (Hibbard 1970), and thus it ought to be assigned to oxygen-isotope stage 12 (Repenning 1980). From these relationships one may conclude that the Irvingtonian extinctions probably coincided with the end of glacial stage 12.

It remains to be shown why certain glacial terminations apparently produced major extinction events and others did not. In his minutely detailed review of the European history of continental glaciations, Kukla (1977) noted that there were probably 11 glacial terminations (22 oxygen-isotyope stages) during the past one million years, and that the duration of each stage was generally comparable to that of the latest glacial cycle. Kukla (1977) further suggested that, as measured by deep-sea oxygen-isotope data, the magnitude of glacial stages 2, 6, 12, 16, and 22 appeared greater than the others. It is interesting to note that stages 2 and 12 correspond respectively to the Rancholabrean and the Irvingtonian extinction events. Also, according to Kukla's (1977) review, the major Villafranchian extinctions in Europe fell at about stage 22, and Bonifay (1980) finds the extinctions of the first cold-adapted European fauna to coincide with stage 16 or about the end of the first Biharian faunas. Thus it is possible that *the terminations of more intense glacial stages effectively triggered large mammal extinction episodes in the late Cenozoic.*

Mammal Extinctions as a Latitudinal Function

It has long been evident that glacial cycles and their climatic effects were harsher at higher latitudes. If, as is argued above, the climatic changes associated with glacial terminations initiated land mammal extinctions, then would not these extinctions be diminished at lower latitudes? A search for such a relationship between lower latitudes and increased survival of land mammal genera may be regarded as a test of the climatic hypothesis.

First, it is important to support the premise that land areas at lower latitudes were less severely affected by climatic changes during glacial cycles. Few continental Pleistocenes sites yielding climatic data are available for North America below 20° N latitude (Peterson et al. 1979). In the absence of detailed local evidence, especially in the Central American lowlands, it is best to cite the broad results from the adjacent sea surface, as produced by the CLIMAP project (1976). About 17,000 years ago, during the maximum extent of the Wisconsinan glaciation, surface water temperatures in the Gulf of Mexico and at the straits of Florida were only about 2° C cooler than during present winters. At even lower latitudes, the glacial decrease measured by the proxy climatic data of foraminiferal samples was also only about 2° Celsius. At latitudes between 30°N and 40°N, however, sea surface temperatures along the Atlantic coast were about 10° Celsius lower than present winter temperatures. The lowland American tropics thus apparently suffered little cooling during the last glacial interval, and the same may be

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and above the generic level, sloths, capybaras, peccaries, and llamas. A newly discovered example is the peccary *Catagonus*, now living in the Gran Chaco and closely related to the extinct *Platygonus* (Wetzel 1977). Other Rancholabrean "refugees" at low latitudes in the Old World include cheetahs, horses, and elephants (Reed 1970). Thus, nearly half the groups that are counted as Rancholabrean extinctions at temperate latitudes have tropical survivors.

The same pattern of tropical survival applies to earlier extinction episodes. A newly discovered example is the progressive cricetid rodent, *Repomys*, known from California and Nevada in the late Hemphillian and Blancan, but now represented by *Nelsonia* at high latitudes in central Mexico (May 1981). Most such histories are difficult to trace, however, because fossil distributions at low latitudes are poorly known. Larger mammal taxa that evidently survived the Blancan extinction event at low latitudes are gomphotheres, *Stegomastodon* (into the early Irvingtonian in southern Arizona and southern California), hippidion horses, tropical deer such as *Mazama*, peccaries near *Tayassu*, tropical procyonids, and the tropical mustelids *Galictis* (related to Blancan and early Irvingtonian *Trigonictis*), and *Pteronura* (near the Blancan *Satherium*). Several taxa, including *Geochelone*, *Nasua*, *Hydrochoerus*, *Cuvieronius*, and *Glyptotherium*, show a stepwise tropical retreat. Whereas they ranged through high temperate latitudes during Blancan time, they retracted southward to the Gulf Coastal Plain and Mesoamerica during Irvingtonian and Rancholabrean time. The Blancan, Irvingtonian, and Rancholabrean climatic events not only produced extinctions, but they also swept many North American mammals southward. The related effects were total extinction in some cases and tropical restriction in others.

The number of species in the Recent North American mammal fauna shows an impressive inverse correlation with latitude (McCoy and Conner 1980). Increasing from latitude 38°N, the number of species decreases markedly; below that latitude the number of species increases more gradually toward the equator to 25°N latitude. Farther south the numbers decrease, presumably because the rapidly decreasing area of Central America has an overriding effect. This latitudinal species gradient is equally apparent in large and small animals. The 38th parallel coincides closely with the southern limits of the last system of Pleistocene glaciers. Presumably the recurrent effects of late Cenozoic glacial climates produced this strong latitudinal decline in mammal species above 38°N in temperate North America. The tropical North American fauna includes a much greater percentage of old native groups than the temperate fauna, which is more heavily loaded with Asiatic immigrant groups. This pattern indicates the effectiveness of large mammal extinctions correlated with latitude.

Possible Effects of Immigrants

Elsewhere I have elaborated the view that major extinction episodes can be produced by either of two fundamentally different mechanisms: one resulting from biological interactions following immigration, the other from environmental stress accompanying climatic change (Webb 1969). I have shown how the two basic types of extinction can be distinguished in the fossil record (Webb 1983b). The role of immigrants and climatic change with respect to the late Cenozoic land mammal extinctions provides an interesting comparison.

Figure 9.4 records the number of large land mammal genera in North America, divided into new immigrants (allochthonous genera) and natives (autochthonous genera). In the Clarendonian, few immigrant genera entered North America. The number increased slightly in the early Hemphillian and still more in the late Hemphillian. While

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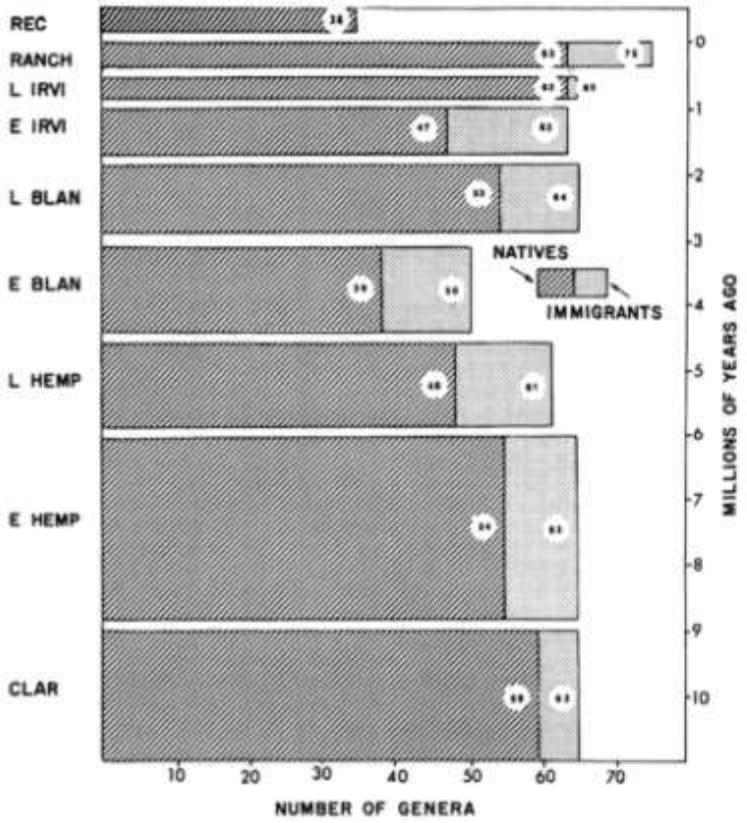

Figure 9.4. Large mammal genera in North America, divided into natives and immigrants. Times of high immigrant numbers do not correlate with times of low native numbers. Instead, immigrant rates seem independently to undergo a general increase through the late Cenozoic. (For abbreviations see Figure 9.1 legend.)

The early Blancan rates also remain high. And thereafter immigration rates increase still more to the very high rates of the Irvingtonian and the Rancholabrean. The record suggests that immigrations generally tracked extinctions. In effect, immigrant taxa filled the vacuums produced by prior extinctions.

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cricetid rodents, omnivorous carnivores such as *Ursus* and *Parailurus*, browsing Cervidae, and the large mesic flying squirrel *Cryptopterus* (Repenning 1967, 1980; Robertson 1976; Tedford and Gustafson 1977). Most of these immigrants had become well established before the next great extinction episode in the late Blancan.

During Irvingtonian and especially during Rancholabrean time, the number of trans-Beringian immigrants rose markedly. This greatly unbalanced the rate of faunal interchange between Asia and North America which previously had been balanced or, in the Hemphillian, unequal in the opposite direction (Repenning 1967, Webb 1969). Furthermore, these Pleistocene immigrants from Asia were virtually all scrub, steppe, or steppe-tundra inhabitants, reflecting the evolutionary importance of that vast Asiatic terrain during the Pleistocene. The new immigrants were predominantly small grazers (microtine rodents), large grazers (bovids and mammoths), and large browsers (moose and elk). Possibly the last major waves of Asian immigrants bore a causal relationship to the final great extinction episode. Gingerich (this volume) favors such a view. On the other hand, it is difficult to show a closely synchronous relationship between immigrations and extinctions in the late Pleistocene of North America. Immigrations continue generally to increase throughout the late Cenozoic record, often in the wake of extinctions.

Another biological interaction of some interest is the possible complementary relationship between large mammal and small mammal diversity. Webb (1969) showed an apparent correlation between late Cenozoic decreases in large mammalian herbivore genera and increases in small mammalian herbivore genera. Figure 9.5 shows clearly the broad shift from a preponderance of large mammal genera in the late Miocene to a preponderance of small mammal genera at present. There was also a decline at the end of the Hemphillian that was restored by late Blancan time. From over 60 percent of genera in the Clarendonian, large mammals (those >5 kg) have declined to less than 40 percent of genera today. Much of this diversity shift involves loss of large grazing herbivores in the late Miocene, as exemplified by the Equidae. In their place, during the Pleistocene came a dramatic increase in small grazers, derived from various stocks of Cricetidae (Repenning 1980). These data suggest that the replacement of ungulate diversity by rodent diversity occurred not because of direct competition, but as a consequence of most major extinctions more adversely affecting large ungulates. In the late Cenozoic the net result was that small grazing herbivores filled the vacancies left by large grazing herbivores.

Conclusions

During the last ten million years, six major extinction episodes have devastated the land mammal fauna of North America. The greatest of these, according to available records, was the late Hemphillian (nearly five million years ago) when more than sixty genera of land mammals (of which thirty-five were large, weighing more than 5 kg) disappeared from this continent. The late Rancholabrean extinction pulse (about 10,000 years ago) was the next greatest; over forty genera became extinct, of which nearly all were large mammals. If these events are prorated by the durations of their respective ages, the Rancholabrean is the most severe. Three lesser, but still major, extinction episodes, each involving a score of genera, occurred in the late Clarendonian (about nine million years ago), the early Hemphillian (about six million years ago), and the late Blancan (1.9 million years ago). The sixth was the late Irvingtonian.

Some evidence shows that these extinction episodes were correlated with terminations of glacial cycles, when climatic extremes and instability are thought to have reached their maxima. The best documented correlation is that between the late Rancholabrean and the Wisconsinan termination. Correlation between the late

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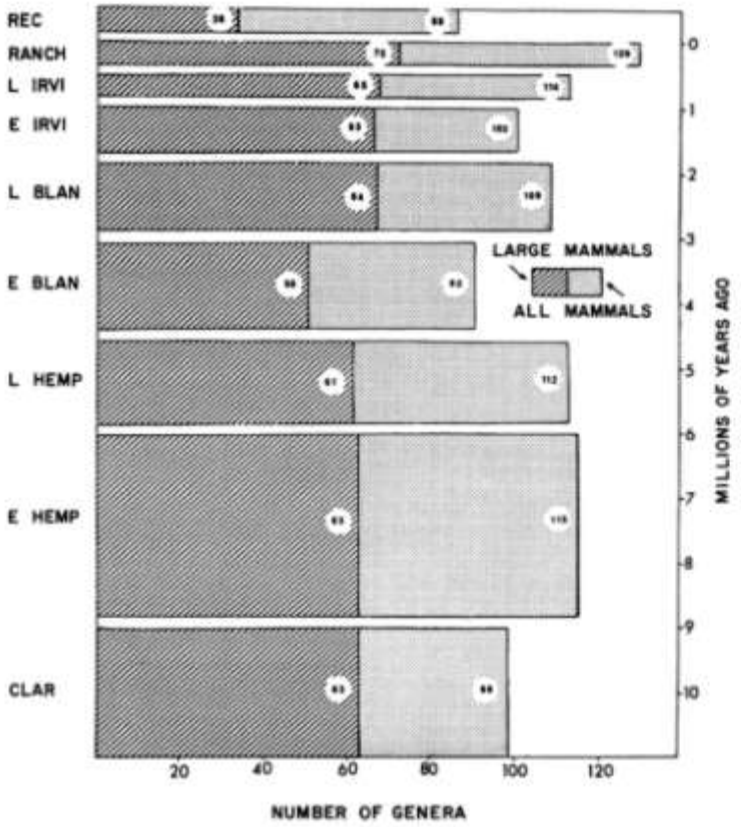

Figure 9.5. Numbers of all land mammal genera and large land mammal genera during the late Cenozoic in North America. From about 65 percent during the Clarendonian, the large mammal contribution to the total land mammal genera has declined to about 40 percent at present. The relative decline continued more or less regularly through the late Miocene and then again during the late Pleistocene. (For abbreviations see Figure 9.1 legend.)

Hemphillian extinctions and the end of the Messinian (latest Miocene) and also between the late Blancan and termination of the latest Tertiary glacial phase may also indicate such a relationship.

In addition to the temporal correlation between the glacial terminations and large mammal extinctions, there is an inverse latitudinal correlation. In temperate North

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The net result of the late Cenozoic extinctions has been a major transformation in the character of North American land mammal fauna. In the late Miocene (late Clarendonian and early Hemphillian), climatic deteriorations destroyed the large browsers of North America as the extensive midcontinental savanna gave way to steppe (Gregory 1971). And in the latest Miocene (late Hemphillian) mixed feeders and even grazers, including peccaries, horses, rhinos, antilocaprids, and gomphotheres, were decimated. By late Pliocene (late Blancan) time, the diversity of all groups was again severely reduced. A net trend toward replacement of large herbivores by small herbivores has been documented (Webb 1969). With the climatically induced extinctions of old native ungulate groups, rodents have risen to become generically the most diverse herbivores in North America.

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Feral Horse Demography: A Preliminary Report

MICHAEL L. WOLFE, JR.

Abstract

The demographic characteristics of 18 feral horse *(Equus caballus)* populations in five states are discussed. As estimated primarily from the results of composition counts, foals comprised an average 19 percent (post-parturition) of the populations analyzed. Various procedures were employed in an attempt to estimate survival rates within the populations. Provisional estimates of first-year survival rates span the general range of 50-70 percent, while those for adults may approximate 80-85 percent. Annual rates of increase, predicted from simulation runs with the estimated population parameters, were considerably lower than those "observed" from aerial inventories in successive years. Possible explanations for these discrepancies and management implications are discussed.

Feral horses (*Equus caballus)* represent one of the most complicated problems of contemporary wildlife management. Under the protection afforded them by the provisions of the Wild Horse and Burro Act (PL 92-195), enacted in 1971, populations of these animals have increased rapidly in recent years in many areas of the western United States. The acutal rates of increase remain the subject of considerable controversy. Aside from the stringent protective provisions of PL 92-195, the rational management of feral equid populations is hampered by a paucity of reliable information on the ecology (particularly demographic characteristics) of free-ranging horses and burros (*E. asinus*) on the one hand, and on the other, the constraints imposed by the demands of special interest groups and the emotional issues involved.

The following report summarizes provisional information on the population ecology of free-ranging horses in several locations. It should be emphasized that the estimates of the demographic parameters given herein are tentative at best and that a primary objective of this paper is to point out the shortcomings of the existing data as well as areas requiring additional research. Perhaps this may serve as the impetus for the future collection of more reliable data.

Data Sources

This study grew out of a short-term (1976-77) investigation of feral horses on Dinosaur National Monument in northwestern Colorado. The field data, collected in the course of that investigation were supplemented by information obtained from the Bureau of Land Management records for feral horse populations from several locations. Some of the data from the California, Nevada, and Oregon populations that are analyzed herein have been reported previously (U.S. Dept. Interior 1976, Heady and Bartolome 1977).

The basic data derive from three primary sources: (1) aerial inventories; (2) classification counts of sex and age composition; and (3) the age distributions of animals captured during reduction operations, or in one case, simply found dead. The ages of these animals (#3) were estimated by criteria of tooth succession and wear (Emsminger 1951, Bone 1964). Since these data were collected by different personnel under a variety of conditions and undoubtedly with varying degrees of reliability, the results of the analyses thereof should be interpreted with due caution.

In order to simplify the presentation of data, the various populations studied were assigned coded designations, which are given in the Appendix. Figure 1 shows approximate locations of the respective populations. The term "population" is used advisedly throughout the following report. In some cases the demographic entities constitute merely the horses within the boundaries of an arbitrarily defined administrative unit. In reality, these entities may comprise only a sub-population of a larger population or two or more discrete populations.

Results and Discussion

Implied Rates of Increase

Aerial trend counts constitute the source of demographic information most routinely collected from feral horse populations. Indices of the average annual rates of increase (λ) for the populations studied here were derived from regressions of the count data from the respective populations as a function of time. These time series were fit to an exponential function of a form analogous to the standard model of

Fig. 1. *Approximate locations of feral horse populations analyzed in this study.*

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exponential population growth (vide: Caughley 1977).

$$N_t = N_0 e^{rt}$$

where: N = population size
e = base of the natural logarithms
r = exponential rate of population increase
t = time interval (years)

Note that the finite rate of increase (λ) is equivalent to e^r.

The use of an exponential growth model was predicted on the perhaps tenuous assumption that the populations analyzed were well below their respective carrying capacities and increasing in the absence of any obvious density dependent effects (i.e. in the exponential phase of a logistic growth curve).

The results of these regression analyses are given in Table 1. In some cases the count data for different years are not comparable, since some were obtained from fixed-winged aircraft while others were made with helicopters. No attempt was made to separate these data in the computation of the regression equations. Given the questionable reliability of regression measures developed from time series and the problems inherent in the population estimates from which they were computed, the implied rates of increase are suspect.

Reproduction

Productivity indices were estimated from the relative age composition (percent foals) in the respective populations, as determined in most cases from the results of aerial or ground-based classification surveys. These indices are summarized in Table 2. The table includes only the results of counts in which at least 100 animals were classified. The substantial procedural differences—both temporal and methodological—involved in the various surveys preclude any meaningful statistical analysis of the data or compari-

Table 1. Implied growth rates for several feral horse popultions.

Population	Time span and range of population estimates	Regression equations and correlation coefficient	Rate of increase (λ)
Calif-1	1973-1975 (1,491-2,487)	$y = 1173.60e^{0.26t}$ $r = 0.99$	1.30
Colo-1	1972-1978 (150-608)	$y = 127.33e^{0.22t}$ $r = 0.98$*	1.25
Neva-1	1973-1975 (127-148)	$y = 117.62e^{0.08t}$ $r = 1.00$**	1.08
Neva-2	1973-1975 (177-236)	$y = 153.94e^{0.14t}$ $r = 1.00$**	1.15
Neva-3	1973-1975 (179-287)	$y = 141.64e^{0.24t}$ $r = 1.00$	1.27
Ore-4	1972-1974 (94-140)	$y = 76.64e^{0.20t}$ $r = 1.00$**	1.22
Utah-2	1972-1977 (132-413)	$y = 103.71e^{0.25t}$ $r = 0.96$**	1.28
Wyo-1	1974-1976 (151-238)	$y = 121.20e^{0.23t}$ $r = 0.97$	1.26
Wyo-2	1974-1976 (647-1,002)	$y = 535.74e^{0.22t}$ $r = 0.97$	1.25
Wyo-3	1974-1976 (517-667)	$y = 464.73e^{0.13t}$ $r = 0.96$	1.14
Wyo-4	1972-1976 (213-538)	$y = 153.73e^{0.20t}$ $r = 0.83$ (NS)	1.22
Wyo-5	1972-1976 (535-1,132)	$y = 439.30e^{0.18t}$ $r = 0.99$**	1.20

*Significant at 0.05 level
**Significant at 0.01 level

Table 2. Relative age composition (foals and yearlings) of several feral horse populations.

Population	Survey date	Sample size[a]	Percent foals	Percent yearlings
Calif-1	Feb. 1973	834	7.7	———
	Aug. 1973	1491	19.8	———
	Aug. 1974	2023	20.2	———
	Feb. 1975	1925	14.9	———
	Aug. 1975	2487	18.0	———
Colo-1	June 1977	138[b]	21.0	7.2
	June-Nov. 1977	423[c]	13.9	9.7
Neva-1	Feb. 1973	116	14.7	———
	Aug. 1973	127	21.3	———
	Aug. 1974	137	22.6	———
	Feb. 1975	147	19.0	———
	Aug. 1975	148	20.3	———
Neva-2	Feb. 1973	136	14.0	———
	Aug. 1973	177	19.8	———
	Aug. 1974	207	13.0	———
	Feb. 1975	215	17.7	———
	Aug. 1975	236	18.6	———
Neva-3	Feb. 1973	222	13.1	———
	Aug. 1973	179	17.9	———
	Aug. 1974	228	18.0	———
	Feb. 1975	223	13.9	———
	Aug. 1975	287	19.5	———
Neva-4	Oct. 1974	120[b]	11.7	———
	Mar. 1975	118	5.1	———
Ore-1	Apr. 1975	208	13.0	———
Ore-2	Apr. 1975	147	12.9	———
Ore-3	Apr. 1975	1128	15.6	———
Ore-4	Apr. 1975	222	16.2	———
Ore-5	Apr. 1975	444	14.6	———
	Dec. 1975	255[c]	19.6	10.2
Utah-1	Jan. 1975	173	17.9	———
	Aug. 1975	165	12.1	7.9
	Jan. 1976	134	17.9	———
	June 1976	219	18.7	7.3
	Feb. 1977	124	17.7	———
Utah-2	1976	536[b]	18.5	———
Wyo-1	Summer 1975	233	20.6	7.7
	Mar. 1976	238	11.3	———
	May 1976	224	17.4	———
	Aug. 1976	307	17.6	———
Wyo-2	Winter 1975	881	9.1	———
	Feb.-Mar. 1976	1002	13.0	———
Wyo-3	Winter 1974	517	5.8	———
	Summer 1974	536	15.7	———
	Winter 1975	625	11.7	———
	Feb.-Mar. 1976	667	14.8	———

Unweighted mean percentage of foals in "post-parturition" (June-August) counts = 18.6

Unweighted mean percentage of folas in "pre-parturition" (January-March) counts = 13.3

[a]Unless otherwise noted animals were classified in aerial surveys.
[b]Animals classified in ground-based composition counts.
[c]Animals collected in reduction operations.

sons between populations.

The protracted foaling period (March-July in some horse populations complicates the determination of a parturition peak and population anniversary data. Actually, the annual parturition pattern in many populations probably constitutes an intermediate variant of the "birth-pulse" and birth-flow" types (vide: Caughley 1977). Consequently, productivity indices computed from composition counts conducted in virtually any month of the year probably incorporate an unknown source of error as the result of non-discrete generations. Heady and Bartolome (1977) have even suggested a bimodel annual distribution of births, with approximately 10% of foalings occurring in November. For the purposes of this discussion classification counts conducted in the months January-March and June-August were arbitrarily treated as pre- and post-parturition inventories, respectively.

Another significant source of error is the fact that productivity indices expressed simply as the fraction of young animals in a given population constitute a notably poor statistic for comparison between years or demographic units due to the confounding effects of differing sex ratios. In the case of most of the populations analyzed here the lack of information on the sex composition precluded the computation of more refined measures of productivity (e.g., foals/female).

In view of these problems the mean values given in Table 2 are probably of questionable validity. This notwithstanding, they do indicate that the fraction of foals in the population shrinks considerably during the course of the animals' first year of life. Moreover, most of the figures for the percentage of foals obtained in spring and/or summer counts exceed that (13%) obtained in a mid-August classification by Feist and McCullough (1975) for feral horses with a nearly balanced sex ratio (48 males: 52 females) on the Pryor Mountain Wild Horse Range in Montana and Wyoming.

Survival Rates

A crude approximation of first-year survival may be derived from the shrinkage in the incidence of foals between post-parturition composition surveys and comparable classification counts conducted prior to parturition the following year. Assuming that July and February represent the median months for post-parturition and pre-parturition classifications (as defined above) respectively, then the difference in the mean percentage of foals (Table 2) implies a survival rate of 72% over the 7-month interval separating the respective inventories. Such a composite estimate is admittedly speculative because it is based on data from several populations and different years. At best it probably underestimates the total mortality occurring over a 12-month period.

Fig. 2. *Feral horses probably sustain substantial losses due to various causes during their first year of life. The photograph shows the carcass of a foal (approximately 1 month old), found dead in June 1977 at the edge of a dried-up waterhole on Douglas Mountain on Dinosaur National Monument, Colorado. Presumably the animal became inextricably mired in the mud earlier in the season, thus meeting its demise.*

Additional indices of first year survival rates were estimated from the differential incidence of foals and yearlings in time-specific samples from the respective populations as derived either from the composition figures given in Table 2 or from the age distributions of animals captured in reduction operations (Table 3). The "Rawlins" and "Rock Springs" age series in the latter table represent composite samples obtained from populations Wyoming 1-3 and Wyoming 4 and 5, respectively. The implied survival rates estimated by this procedure are given in Table 4.

The validity of these survival rates is difficult to assess. Intuitively, they appear low. By comparison estimates of first-year survival rates, computed from the data reported by Feist and McCullough (1975) for Pryor Mountain horses

Table 3. Sex and age distribution of animals removed from feral horse populations in reduction operations.

Age class (years)	Number of animals in respective age classes							
	California-1		Colorado-1		Rawlins composite		Rock Springs composite	
	Males	Females	Males	Females	Males	Females	Males	Females
0	0	1	26	33	50	73	50	52
1	19	12	14	27	17	18	15	18
2	10	9	35	38	37	62	33	29
3	2	6	9	32	36	70	16	43
4	1	5	25	24	36	51	20	64
5	0	6	2	15	3	12	11	18
6	1	1	17	28	7	24	3	21
7	3	3	23	15	6	19	4	8
8	1	2	4	5	10	18	2	7
9	1	2	10	7	6	9	3	9
10	0	0	1	4	2	11	0	3
11+	0	2	11	18	26	38	20	22
Totals	38	49	177	246	236	405	177	292

Table 4. Estimated first-year survival rates of feral horses.

Population	Year	Implied Survival Rates
Colo-1	1977	0.34[a]
	1977	0.70[b]
	Mean	0.52
Ore-5	1975	0.52[b]
Utah-1	1975	0.65[a]
	1976	0.39[a]
	Mean	0.52[a]
Wyo-1	1975	0.37[a]
Rawlins (composite)	1977	0.28[b]
Rock Springs (composite)	1977	0.30[b]

[a]Computed from the realtive percentages of foals and yearlings in classification surveys
[b]Computed from the age structure of animals captured in reduction operations

range from 75 to 80%. Returning to the populations in question, the survival rates are undoubtedly conservative, because they were estimated from increasing populations. Survival rates estimated from the standing age distribution of a population that has been growing at the same rate (i.e. constant birth and death rates) for some time will be underestimated by a factor equivalent to the rate of increase. Lacking reliable estimates of the growth rates in the respective populations, no attempt was made to adjust the implied survival rates.

Errors in differentiating yearlings from sub-adult and adult animals in classification surveys could also result in underestimation of first year survival rates. Given the protracted parturition period in some feral horse populations and the inherent shortcomings of age determination by criteria of tooth replacement and wear, it is conceivable that a similar bias occurred in the classification of horses handled in round-up operations. From examination of Table 3, it appears that the 2-year old class in Rawlins and Rock Springs samples is disproportionately strong.

In view of these reservations any conclusions regarding juvenile survival in feral horses remain speculative. It does appear, however, that the populations in question sustain substantial first year mortality rates, perhaps approaching 40-50% in some cases. Considering the harsh and variable nature of the desert and semiarid environments that these animals inhabit, these are probably not unreasonable.

An attempt was made to estimate adult survival rates by the Chapman-Robson method (Robson and Chapman 1961). Explanations and examples of the use of this technique for the estimation of survival rates for large herbivores are given in Eberhardt (1969), Seber (1973), and Kimball and Wolfe (1974). This method allows estimation of a survival rate from the age distribution of a population (or a segment thereof). The technique is predicted on the assumption that the age frequency series constitutes a geometric distribution. In other words, survival is constant in the age classes within the segment of the age series from which the survival rate is computed. The validity of this assumption may be tested statistically by the use of contingency tables and appropriate nonparametric statistics.

For the most part the age distributions given in Table 3 do not constitute geometric series, thereby precluding the reliable use of this technique. Given the large sample sizes for the Colorado and Wyoming populations the incongruities in the data are probably attributable to errors in age determination. For example, the Colorado and Wyoming samples obtained in 1977 all reveal an apparently "weak cohort" for the 5-year old class. An additional 119 animals were removed from the Douglas Mountain (Colo-1) population between August 1978 and January 1979, i.e. a year later than the initial collections. The age distribution of those animals was quite comparable to those shown in Table 3 and contained the same apparent discrepancies in the 2- and 5-year old age classes. This evidence points to a problem in age determination and rules out the possibility of varying cohort strength as the primary source of the observed incongruities in the age structures of the populations in question.

It was possible, however, to estimate survival rates from certain segments of these age distributions by means of the Chapman-Robson model for a truncated geometric distribution. The survival rates thus obtained and their respective confidence intervals ($p \leq 0.05$) are given in Table 5. The table also contains survival rates similarly derived from composite samples of males and females from populations in Oregon and Utah. Generically, the Utah sample differs from the others in that it is derived from the age structure of 62 animals that died of an unknown cause at a single location within a period of a few days (July 1976). All the other samples were derived from the age distributions of animals captured alive in reduction operations.

The estimated survival rates in Table 5 are conservatively biased, because they could not be adjusted to account for the growth rates of the respective populations. This notwithstanding, actual survival rates probably exceed the implied values.

This source of error may be partially offset by several counteracting biases arising from the extrapolation of a single survival rate across all "adult" sex and age classes. Among large herbivores, males generally sustain higher mortality rates than females. While this generalization cannot be substantiated statistically from the estimated survival rates, it appears to be compatible with the results shown in

Table 5. Implied adult survival rates of feral horses.[a].

Population	Sex and age segment	Sample size[b]	Implied survival rate and 95% confidence interval[c]	x^2 value for fit to geometric distribution
Calif-1	males (2-9)	19	0.67 (0.54-0.80)	3.36 (df = 1)
	females (2-9)	40	0.79 (0.66-0.92)	0.43 (df = 3)
Colo-1	females (2-5)	109	0.75 (0.69-0.81)	1.41 (df = 2)
Ore-4	Composite (2-9)	86	0.80 (0.71-0.88)	8.30 (df = 6)
Ore-5	Composite (3-9)	135	0.76 (0.68-0.83)	6.05 (df = 5)
Rock Springs	males (2-9)	92	0.66 (0.59-0.74)	4.65 (df = 3)
	females (6-9)	45	0.71 (0.61-0.81)	3.84 (df = 2)
Utah-1	Composite (3-9)	23	0.67 (0.51-0.84)	2.27 (df= 2)

[a]Estimated from the age distributions of the respective populations by means of the Chapman-Robson survival estimator Robson and Chapman (1961).
[b]Sample sizes given represent the number of animals in the truncated segments of the age distribution from which the survival rates were computed.
[c]Survival values given were not adjusted to account for rate of population change.

Table 6. Results of computer simulation studies of a hypothetical feral horse population.[a]

Case	Fecundity (foals/female)	Survival %		λ (= rate of population change)	Years required for population to double
		Foals	Adults		
I	1.0/female 4 yrs	70	85	1.04	18
II	Same as I	85	85	1.07	10
III	Same as I	90	90	1.13	6
IV	1.0/female≥3 yrs	Same as III		1.17	5
V	1.0/female≥2 yrs	Same as III		1.22	4
VI	0.5/female 2 yrs 0.75/female 3 yrs 1.0/female≥4 yrs	70	90	1.14	6

[a]Initial population = 200 animals (sex ratio = 50:50)

Table 5. Furthermore, survival rates among yearlings are often lower than those in the young and middle-aged adult age classes. Finally, despite the comparatively small fraction of the population that they comprise, old-age animals are generally subject to higher mortality rates. Thus the estimated survival rates are probably not indicative of the mean rate for all animals older than 1 year. In view of the unknown magnitude of these counteracting biases, the actual adult survival rate remains subject to conjecture. Realistic figures probably lie within the range of 80 to 85%.

Population Simulations

The dynamics of feral horse populations were investigated further by means of simulation studies. A computer model of a modified Leslie (1945, 1949) matrix was employed to determine the projected rates of population increase under varying combinations of fecundity and survival. This program, developed by Innis (1975) allows the manipulation of age- and sex-specific and survival rates as well as several other demographic variables. The pertinent input parameters and results of several simulations are given in Table 6. All runs were executed in deterministic and density-independent mode. In each case the initial population vector comprised a population of 200 animals, apportioned geometrically in 10 age classes, each with an even sex ratio.

The results in Table 6 indicate that a very slowly increasing population (λ=1.04) is obtained by applying survival rates of 70 and 85 percent for foals and adults, respectively, and assuming that no mares produce any foals until their fourth year of life. The only conditions that yield an annual increase rate exceeding 20 percent are those of Case V in which all females breed as yearlings and the annual survival rate for all age classes is 90 percent.

Comparison of these admittedly artificial results with the "observed" rates of increase of the various populations (Table 1) leaves considerable room for speculation. The primary implications are twofold:

(1) Either the survival rates derived above (especially the rate for foals) are erroneous; or

(2) The seemingly exceptional parameters used in Case V are indeed unrealistic and other factors may account for the observed rates of increase.

Given the crude and fragmentary empirical evidence that presently exists on feral horses, this question cannot be answered conclusively. Intuitively, however, it appears unlikely that survival rates in a free-ranging horse population would exceed considerably 90%. In this respect, the validity of annual rates of increase for feral horse populations in the range of 20-30%, as suggested by some authors (e.g. Cook 1975, Heady and Bartolome 1977), are highly questionable.

The subject of age-specific reproductive performance, especially that among 2- and 3-year old females remains a virtual unknown in our knowledge of feral horse population biology. Hall (1972) maintained that the majority of mares in the Pryor Mountain herd do not enter estrous until they are three years old. This contention is consistent with the findings of Feist and McCullough (1975) who reported that 7.4 percent of the Pryor Mountain mares classified as 3-year old females bore foals. Likewise, twins are generally considered to be a rarity among equids (Klingel 1969, Tyler 1972). In the Pryor Mountain herd Freist and McCullough (1975) observed only two sets of twins (5.7 percent) among 35 mares which bore foals. In summary, this fragmentary evidence indicates that the reproductive parameters applied in cases IV-VI (Table 6) may indeed be too liberal.

On the other hand, the apparent discrepancies between observed and predicted rates of increase are at least partially attributable to the numerous problems involved in the census procedures (i.e. aerial trend counts) employed. For example, increasing observer experience or differential intensity of aerial counts from one year to the next may be reflected in spurious rates of increase. These and related problems are well documented in the literature with respect to aerial inventories for other ungulates (Gilbert and Grieb 1957, Le Resche and Rausch 1974, Caughley 1974). Frei et al. (1979) contend that a major portion of the purported increases in feral horse populations can be attributed to the noncompensating errors inherent in aerial surveys. This is an admittedly speculative explanation for the problem at hand, but it does underscore the fact that implied rates of increase based on the results of consecutive aerial censuses should hardly be accepted at face value.

Recommendations

Future classification surveys would yield more useful information if data on the sex composition of the adult segment were collected in addition to that on the relative age structure. This would entail careful classification of animals in ground-based rather than aerial surveys, necessarily with some sacrifice in sample size. Ideally, classifications counts should be conducted shortly following the peak of the parturition period (May/June), while yearling animals are still recognizable as such. Such surveys would be advantageous in several respects. The data thus obtained would permit further correction of productivity indices to exclude largely non-reproducing yearling females. More importantly, the information on the fraction of yearlings present in the popu-

lation would allow the estimation of first-year mortality rates by the methods described above. Finally, horses exhibit post-partum breeding, with mares coming into estrous after foaling. The associated sexual activity could facilitate sex determination among adult animals.

The estimation of survival rates by the procedures described above would be greatly facilitated by more accurate age determination of animals captured in reduction operations or carcasses found randomly or in systematic searches. Unlike cervids and some other ungulates, horses do not obtain their full complement of permanent teeth until 5 years of age, thus permitting the use of tooth replacement criteria for age determination among younger animals. Reliable results are of course predicted on careful examination by experienced personnel. Estimation of age among older animals by tooth wear becomes increasingly difficult and less accurate with increasing age. Indeed these criteria, established for domestic animals (Ensminger 1951), may not apply to free-ranging horses, especially those inhabiting areas of sandy or gritty soils (cf Bone 1964).

These problems might be circumvented by the use of counts of annular structures in cementum of sectioned teeth for age determination. Obviously, the logistics of age determination in horses captured alive are inherently more difficult than is the case for the remains of animals found dead. The animals must be restrained or drugged, whether for the purpose of more than a cursory examination of the dentition or to extract a tooth for sectioning.

Unfortunately, these procedural modifications will not rectify the underlying dilemma of our inability to accurately estimate survival rates from time-specific samples of the age structure of changing populations. A partial solution to this problem may lie in an alternate approach, namely, the estimation of survival rates by following the fate of a single (or multiple) cohorts over time. While by nor means free from error, such an approach is not subject to the restrictive assumption of population stationarity. It would require, however, identification of "sample cohorts" by means of marked animals. This, in turn, would necessitate the establishment of fairly extensive annual trapping and tagging programs for specific populations of interest and the continuation of such programs over a minimum of several years. The actual number of animals that would need to be marked would depend upon several factors, the most significant of which are: (1) size of the population; (2) recapture frequency of previously marked animals; and (3) desired precision of the survival rate estimate. While this approach might reasonably be expected to yield more reliable survival rate estimates, the logistics involved would probably limit its application to a relatively few regional "study" populations rather than as a standardized data source at the local level.

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Appendix

Coded designations and locations of the feral horse populations analyzed in this study.

Designation	Location and/or administrative unit[a]
California-1	Twin Peaks Management Area, northeastern California/northwestern Nevada, Susanville District, California
Colorado-1	Douglas Mountain, Dinosaur National Monument, northwestern Colorado
Nevada-1	Massacre Lake Management Area, northwestern Nevada, Susanville District, California
Nevada-2	High Rock Management Area, northwestern Nevada, Susanville District, California
Nevada-3	Tuledad Management Area, northeastern California/northwestern Nevada, Susanville District, California
Nevada-4	White Pine Division, Humboldt National Forest, Ely, Nevada
Oregon-1	Cold Springs Management Area, Vale District, Oregon
Oregon-2	Morger Allotment, Vale District, Oregon
Oregon-3	Sheephead's Basin/Barren Valley, Vale District, Oregon
Oregon-4	Jackie's Butte, Vale District, Oregon
Oregon-5	Three Fingers, Vale District, Oregon
Utah-1	Cedar Mountains, northwestern Utah
Utah-2	West Desert Area, western Utah
Wyoming-1	Seven Lakes Planning Unit, Rawlins District, Wyoming
Wyoming-2	Adobe Town, Rawlins District, Wyoming
Wyoming-3	Atlantic Rim, Rawlins District, Wyoming
Wyoming-4	Little Colorado Area, Rock Springs District, southwestern Wyoming
Wyoming-5	Northeast Area, Rock Springs District, Wyoming

[a]Unless otherwise specified all management and administrative units involve Bureau of Land Management lands.

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Relating Fire Occurrence to Weather Conditions on the Great Basin Rangelands

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Abstract

Results are presented to demonstrate the association between weather conditions and fire danger on the rangelands of the Great Basin. It was found that precipitation frequency and duration are physically related to fire occurrence in a complex manner. A climatic relationship also exists between monthly temperature and the corresponding total number of fires for a specific area.

On sparsely inhabited Bureau of Land Management (BLM) rangelands in the Great Basin, fire weather stations are separated by great distances. Consequently, large areas of land are unobserved. Furthermore, there is the question of whether individual station location and exposure are representative of fire problem areas. Current observations of fire weather and danger are made in conjunction with the National Fire Danger Rating System (NFDRS). This system was developed by the National Forest Service Personnel and has been described in detail (Deeming et al. 1978). Other references concerning fire weather (Schroeder et al. 1970) and wildfire behavior (Albini 1976) are also available to relate the impact of weather on fires and fire danger.

Use of the NFDRS by fire management personnel involves the input of weather data on a daily basis as a requirement for predicting an index or component of fire danger. The principal parameters which are output to field personnel are described in Table 1. Instructions concerning actual applications of these predictions are given in Deeming et al. (1978) in which the stated purpose of the system is to evaluate 'the near upper limit of the behavior of fires that might occur on a rating area during the rating period'.

The purpose of the study was to examine the NFDRS indices and components with respect to actual fire occurrence and behavior in the Great Basin area, to examine other weather data in regard to fire conditions, and to indicate zones within which the fire occurrence and behavior would be homogeneous in response to existing climate characteristics. In this paper findings with regard to the first two objectives listed above are discussed.

Methodology

Fire occurrence on the rangelands of the Great Basin was examined in the light of weather data presently available for the purpose of determining efficiency of the existing fire weather network. Fire weather station data (Fisher et al. 1972) was obtained from the National Fire Weather Library (Furman et al. 1975). National Weather Service stations were used to supplement data from the fire weather stations. The average impact of climate, as well as the day to day influence of weather on fire occurrence, was studied. Fire reports were examined to determine the location and occurrence of individual fires.

Results and Discussion

Fire frequency data from individual BLM districts showed that the fire season was generally May through October (e.g., Fig. 1a and 1b). The highest frequency of fires was usually in July for the Great Basin Fire Districts examined. In a few districts August was the month of highest fire frequency which probably reflects a different vegetative regime.

Seasonal Relationship

Examination of temperature data showed that a seasonal relationship exists between fire occurrence and average

Table 1. Fire danger indices and components which are calculated using the National Fire Danger Rating System (NFDRS).

Fire Behavior Potential	
	Spread Component (SC)—the forward rate of fire spread.
	Engergy Release Component (ERC)—the potential available energy released per unit area in the fires flames.
Fire Occurrence	
	Ignition Component (IC)—related to the probability that a fire would result if a fire brand (lightning, spark, etc.) were introduced.
	Lightning Risk (LR)—a combination of thunderstorm prediction or observation and a local factor derived from records of lightning activity.
	Man-Caused Risk (MCR)—a rating assigned by the fire manager to reflect the activities of man in the area of concern.
Fire Control Planning	
	Lightning Occurrence Index (LOI)-a combination of LR and IC (see above).
	Man-Caused Occurrence Index (MCOI)—a combination of MCR and IC (see above).
	Burn Index (BI)—related to the difficulty of fire containment (from SC and ERC above).
	Fire Load Index (FLI)—combination of fire occurrence and behavior into a single number.

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The impact of feral horses on grassland bird communities in Argentina

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Abstract

The impact of introduced herbivores on the composition and structure of plant communities has been widely studied. However, little is known about how they affect wildlife. We studied the impact of feral horses under different grazing regimes on the communities of birds in a nature reserve in the Pampas grasslands in Argentina. The areas that had predominantly tall grass (enclosures and areas of moderate grazing intensity) showed the greatest species richness and total abundance of birds. Some species, e.g. the southern lapwing (*Vanellus chilensis*), were associated with the presence of horses, while others, e.g. pipits (*Anthus* spp), were more common in lesser grazed areas. The presence of feral horses was associated with an increase in the rate of predation of eggs which varied from 12.5% within the enclosures to 70% in grazed areas. It is suggested that the increase in predation rate was due to the increased visibility of the nests and an increase in the density of opportunist carnivores. Small areas of grassland in a good state of conservation could serve as sources that would maintain communities of birds in the more transformed sections.

INTRODUCTION

It is internationally recognised that the introduction of species by man, whether directly or indirectly, to regions far from their centres of origin, is one of the main causes of biodiversity loss (Coblentz, 1990; Macdonald, 1990; Waage & Berks, 1997; Baskin, 2002). There are practically no natural areas left in the world that are free from this problem (Macdonald & Frame, 1988; Usher, 1988). Invasive species alter biogeochemical cycles and may act as competitors, predators, parasites or pathogens of native species affecting their survival (Diamond & Case, 1986; Vitousek, 1990; Usher, 1991; Cronk & Fuller, 1995).

In particular, it is known that introduced herbivores can cause significant impacts on biological diversity (Lever, 1994). Grazing produces changes in the composition of plant communities, modifies the horizontal structure of the vegetation creating open shrublands and increasing the percentage of bare ground, which in turn causes changes in the associated wildlife (Holechek, Pieper & Herbel, 1989; Hobbs, 2001). This has been shown for grassland birds, where the presence of cattle implies the replacement of entire sets of species with different tolerances to grazing (Cody, 1985; Baines, 1988; Bock & Bock, 1988; Sutter, Troupe & Forbes, 1995; Chamberlain *et al.*, 2000; Gates & Donald, 2000; Söderström, Pärt & Linnarsson, 2001) and even the disappearance of the most sensitive species, usually replaced by generalist birds with wider ranges of distribution (Knopf, 1996). Among the mechanisms responsible for this impact, it is generally accepted that herbivores can affect the breeding success of birds, both directly by reducing the number of available nesting sites or by nest trampling (Barker *et al.*, 1990; Grant *et al.*, 1999) and indirectly by exposing them to predators (Martin, 1993; Brua, 1999; Willson *et al.*, 2001).

Invasive herbivores differ from the typical situation of cattle since they are free-ranging and non-managed, but despite this they have received very little attention. Only scant information is available concerning the impact of feral horses on birds (Dobbie, Berman & Braysher, 1993: 33), although Levin *et al.* (2002), working in salt marshes in North Carolina, reported the replacement of dominant species and a subsequent increase in the diversity of foraging birds in sites subject to grazing by feral horses.

In Argentina, studies of the effect of exotic wild herbivores on natural ecosystems focus on their impact on the vegetation (Veblen *et al.*, 1992; Raffaele & Veblen, 2001; Chaneton *et al.*, 2002). Recently Vázquez (2002) discussed multiple effects associated with the presence of alien mammalian herbivores in the temperate forests of Argentina and Chile, pointing out their impact as competitors, as prey for opportunist predators and as carriers of transmittable diseases to the native fauna.

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In this paper we have compared the communities of birds found in sites of high grazing intensity by feral horses with closed-off areas or sites of moderate grazing intensity in a protected area of natural grassland in the Pampas. We also looked at the possible role of nest predation as the selective force responsible for the observed variations.

STUDY AREA

Our field work was carried out in the Ernesto Tornquist Provincial Park (ETPP), a nature reserve in the south of Buenos Aires province, between 38°00′–38°07′ S and 61°52′–62°03′ W. The reserve was established in 1940 and covers 67 km^2 of valleys and hills ranging from 450–1000 m in height. It has a temperate climate (Burgos, 1968) with a mean annual temperature of 14°C and mean annual rainfall of 800 mm (936 mm during the study year). The vegetation type is grass steppe dominated by *Stipa* and *Piptochaetium* (Cabrera, 1976; Frangi & Bottino, 1995). The reserve is one of the last relicts of more or less well conserved areas in the Pampas ecoregion where several endemic taxa can be found (Long & Grassini, 1997).

In 1942, five horses were introduced into the reserve, the population grew at a fast rate and has reached approximately 30 horses/km^2 at the present time (Scorolli, 1999). Their impact on the vegetation is notable, by reducing the biomass and replacing species (Barrera, 1991; Kristensen & Frangi, 1992), but their effects on wildlife have not yet been evaluated.

MATERIALS AND METHODS

Bird communities

We carried out surveys in eight sectors of valleys under different grazing regimes: one fenced area (enclosure) that had not been grazed for 6 years (area of exclusion), three areas with moderate grazing intensity and four open sectors where feral horses are free to graze. The minimal distance between plots was 300 m. The characteristics of each study plot are shown in Table 1.

In each of these areas we recorded the birds present using strip transects (Eberhardt, 1978) that were 400 m long and 50 m wide for a total of 44 transects in the enclosure and moderately grazed areas and 32 in the intensively grazed areas (36 transects were studied during the winter of 2001 and 40 in the summer of 2001). The transects were placed randomly at intervals of more than 50 m and more than 50 m from the streams to avoid the effect of the presence of birds typical of that habitat. We used 7 × 50 binoculars for all bird observations (Bibby, Burgess & Hill, 1993; Ralph *et al.*, 1994).

The vegetation in each sample was recorded using 4 m^2 quadrats, the first being placed 50 m from the start of the transect and then at 100 m intervals. We estimated the percentage of vegetation cover in three height categories (up to 15 cm, between 15–30 cm and more than 30 cm), the percentage cover of woody species and tussock paspalum (*Paspalum quadrifarium*) and the percentage of bare soil. We used average values from this data to characterise the vegetation of each transect. The ground cover data for tussock paspalum were noted separately, since this species creates a special habitat with its characteristic group of birds (Comparatore *et al.*, 1996).

In order to ordinate the samples by means of their vegetation structure we carried out a principal components analysis (PCA) using the matrix of variance–covariance of the variables of the vegetation measured in each transect, having previously modified the data by the arcsine of the square root (Gauch, 1982).

Using the percentage cover data for the three height categories and the percentage of bare soil we calculated the habitat diversity for each transect using the Shannon–Weiner index (H: Moore & Chapman, 1986). We compared the diversity of habitats in areas with high grazing intensity and those with moderate grazing or no grazing using a *t*-test.

We calculated the total density of birds, species richness and diversity for each transect and studied their correlations with the six variables of vegetation structure and with habitat diversity. We used analysis of variance to determine the differences between bird density, richness and diversity in the eight sectors under study, in the two different seasons and in order to compare the corresponding averages in areas under intensive grazing with those of moderate or no grazing. We used Bartlett's test to verify the homogeneity of variance, using the natural log values when necessary.

We compared the density of the most common birds in all three grazing regimes using a *t*-test. We carried out a correlation analysis to evaluate the relationship between the first principle component of vegetation structure and the density of these bird species. We carried out a PCA using the matrix of variance–covariance of the densities of bird species in each transect, leaving out the species that occurred in less than 5% of the samples.

Egg predation

We selected two replicates from each grazing regime to compare egg predation in areas of intensive grazing by feral horses with that in sectors of moderate or no grazing. We placed 10 quail (*Coturnix coturnix japonicus*) eggs, which are similar in size to the eggs of typical Pampas grassland birds (De la Peña, 1987), in each of two 100 m transects in each replicate. We put the eggs directly on the ground underneath the bush or clump of grass closest to the sampling point, in order to mimic the nesting habitat described by De la Peña (1987) and to avoid unconscious bias in their placement. We visited the transects every 3 days over a period of 14 days and recorded the number of broken or missing eggs per transect and we compared the percentage of predation in each habitat using a *t*-test.

The use of quail eggs in testing the risk of egg predation in wild birds is controversial. Some authors consider it a reliable indicator (Gottfried & Thompson, 1978; Loiselle & Hoppes, 1983; Martin, 1987), while others suggest that it can lead to erroneous conclusions

Table 1. Characteristics and grazing history of each study plot

Study plot	0–15 cm vegetation strata	15–30 cm vegetation strata	+30 cm vegetation strata	Woody species	Tussock paspalum	Bare ground	Diversity of habitats	Area (km^2)	Grazing history and current density of horses
E	4.58 (±3.55)	8.72 (±6.32)	86.25 (±9.32)	3.85 (±4.66)	2.08 (±7.22)	0.73 (±1.35)	0.67 (±0.34)	0.2	Under horse grazing since 1942, enclosed for the last 6 years.
M 1	29.38 (±11.69)	22.03 (±8.90)	45.55 (±16.32)	7.27 (±5.19)	1.41 (±3.26)	3.05 (±3.95)	1.54 (±0.21)	0.70	Under horse grazing since 1942. Currently holds a herd of 12 adult horses (17 horses/km^2).
M 2	14.91 (±9.82)	17.86 (±9.14)	64.55 (±19.12)	3.48 (±3.93)	5.54 (±8.70)	2.05 (±5.23)	1.23 (±0.38)	6.00	Currently holding a herd of 10 adult horses and 60 cattle (1.6 and 10 herbivores/km^2, respectively).
M 3	60.88 (±18.48)	18.63 (±9.19)	19.13 (±13.15)	3.75 (±3.33)	5.88 (±8.50)	1.13 (±3.56)	1.23 (±0.36)	0.50	Under horse grazing since 1942, enclosed but partially accesible to horses because of failures in fence maintenance. Current approximate density: 6 horses/km^2 (pers. obs.).
I 1	84.86 (±9.71)	7.08 (±7.86)	4.03 (±4.18)	3.33 (±4.33)	0.14 (±0.42)	3.89 (±6.69)	0.70 (±0.34)	0.15	Under horse grazing since 1942, currently holding 30 horses/km^2, with a 1:1 sex ratio, and a population structure of 74% adults, 11% yearlings and 15% foals (A. Scorolli, pers. comm.).
I 2	86.82 (±3.85)	3.75 (±1.94)	5.57 (±5.49)	6.02 (±5.09)	0.00 (±0.00)	3.86 (±4.13)	0.69 (±0.16)	0.15	
I 3	87.40 (±7.45)	6.04 (±5.27)	3.54 (±2.71)	3.23 (±2.03)	0.00 (±0.00)	3.23 (±4.04)	0.67 (±0.28)	0.15	
I 4	86.72 (±7.82)	7.50 (±7.62)	3.91 (±2.05)	3.13 (±1.49)	0.94 (±2.65)	1.88 (±2.91)	0.67 (±0.23)	0.15	

E, enclosure – no grazing; M1–M3, moderate grazing; I1–I4, intensive grazing. Vegetation variables are given as % cover, except for diversity of habitats (see the text). Values in parentheses are standard deviations.

Table 2. Bird species observed during the study period

Frequency	Scientific name	Common name
Common species, seen in more than 5% of the transects	*Nothura maculosa*	Spotted tinamou
	Milvago chimango	Chimango caracara
	Vanellus chilensis	Southern lapwing
	Speotyto cunicularia	Burrowing owl
	Hymenops perspicillatus	Spectacled tyrant
	Anthus spp	Pipit
	Sicalis luteola	Grassland yellow-finch
	Zonotrichia capensis	Rufous-collared sparrow
	Embernagra platensis	Great pampa-finch
	Pseudoleistes virescens	Brown-and-yellow marshbird
	Sturnella loyca	Long-tailed meadowlark
Occasional species present in less than 5% of the transects	*Rhynchotus rufescens*	Red-winged tinamou
	Falco sparverius	American kestrel
	Columba picazuro	Picazuro pigeon
	Zenaida auriculata	Eared dove
	Cyanoliseus patagonus	Burrowing parrot
	Colaptes campestris	Field flicker
	Geosita cunicularia	Common miner
	Muscisaxicola macloviana	Dark-faced ground-tyrant
	Tyrannus savana	Fork-tailed flycatcher
	Cistothorus platensis	Grass wren
	Mimus triurus	White-banded mockingbird
	Mimus saturninus	Chalk-browed mockingbird
	Carduelis magellanica	Hooded siskin
	Molothrus bonariensis	Shiny cowbird
Species seen outside the transects	*Chloephaga picta*	Upland goose
	Geranoetus melanoleucus	Black-chested buzzard-eagle
	Polyborus plancus	Crested caracara
	Spiziapteryx circumcinctus	Spot-winged falconet
	Columba maculosa	Spot-winged pigeon
	Colaptes melanolaimus	Golden-breasted woodpecker
	Furnarius rufus	Rufous hornero
	Pitangus sulphuratus	Great kiskadee
	Pyrocephalus rubinus	Vermilion flycatcher
	Tachycineta leucorrhoa	White-rumped swallow
	Troglodytes aedon	House wren
	Turdus falklandii	Austral thrush
	Passer domesticus	House sparrow
	Sicalis flaveola	Saffron finch
	Sicalis lebruni	Patagonian yellow-finch

(Willebrand & Marcström, 1988; Yahner, Morrell & Rachael, 1989; Haskell, 1995; Ortega *et al.*, 1998). In general the objections refer to the fact that different groups of predators might consume quail eggs and wild bird eggs, which would affect the relative rate of true nest predation. Differences may also arise due to the presence of adult birds defending their nests and due to the fact that, in general, quail eggs are larger than the wild birds' eggs and so they are not attacked by certain groups of predators with small beaks or jaws (Pärt & Wretenberg, 2002). According to data compiled by De la Peña (1987) eight out of the 21 species of birds that nest on the ground in the grasslands in the south of the Pampas have eggs with diameters that are larger than quail eggs, while six of the remaining 13 species have eggs just 20% smaller, thus reducing the described problem.

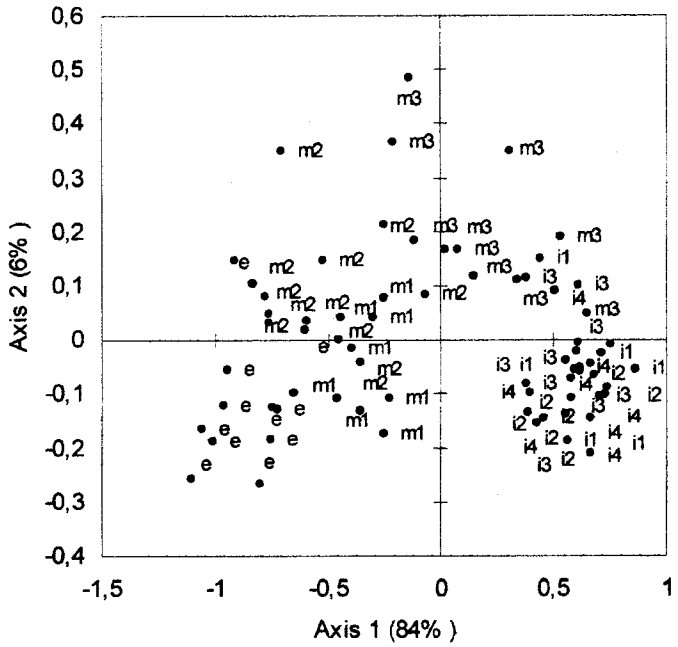
RESULTS

Bird communities

We recorded a total of 40 species of birds, 25 of them within the transects and 15 in additional observations (Table 2).

The PCA carried out using the vegetation data clearly separates the enclosure from areas with a high density of horses on the first component (84% of total variance). The transects in moderately grazed areas are found in an intermediate position (Fig. 1). This separation corresponds essentially to a dominance of the taller vegetation strata in the enclosure and a greater representation of the shorter strata in the grazed areas.

The diversity of habitats was significantly greater ($t = 6.52$; $P < 0.01$) in the moderately grazed and enclosed



	PC1	PC2
0-15 cm	0.9939	-0.0033
15-30 cm	-0.3743	0.6187
+ 30 cm	-0.9910	-0.0705
Woody spp.	0.0540	-0.3431
Tussock paspalum	-0.2980	0.7169
Bare ground	0.2802	-0.3792
Eigenvalue	0.3592	0.0239

Fig. 1. Principal components analysis (PCA) ordination of transects when considering their vegetation characteristics and the correlations between the initial variables and the principal factors. e, enclosure; m1–m3, moderate grazing; i1–i4, intensive grazing.

areas ($H = 1.20$, standard error (SE) $= 0.45$, $n = 52$) than in the sectors of intensive grazing ($H = 0.68$, SE $= 0.25$, $n = 40$).

The mean density and species richness of birds showed a positive correlation with the vegetation cover in the 15–30 cm and >30 cm strata and a negative correlation with the <15 cm strata. The diversity of birds showed a negative correlation with the cover of woody species. The three variables of structure of bird communities showed a positive correlation with the cover of tussock paspalum and the diversity and density of birds showed negative correlations with the percentage of bare ground. No significant correlations were found between these parameters and the diversity of habitats (Table 3).

Considering each area separately we noted that moderately grazed areas showed slightly higher values of density, species richness and diversity of species in comparison with areas of exclusion (the enclosure) and of high grazing intensity, although these differences were not statistically significant (Table 4).

The mean values for species richness and diversity of birds under each grazing regime did not show any significant seasonal differences ($P > 0.1$). However, the analysis of density showed a highly significant interaction ($P < 0.01$) between sectors and seasons and so an analysis of variance was repeated, separating the data for winter and spring. The moderately grazed areas and the enclosure showed higher values for richness of species and diversity during the whole year and greater density during the spring (Table 5).

We found that certain species were exclusively or significantly associated with the enclosure or with moderately grazed areas, e.g. *Sicalis luteola*, *Sturnela loyca*, *Anthus* spp and *Embernagra platensis*. However, *Vanellus chilensis* preferred habitats with a high grazing intensity, while *Pseudoleistes virescens*, *Nothura maculosa*,

Table 3. Correlation indexes between the vegetation variables and the diversity, density and species richness of birds for the total number of recordings ($n = 76$)

Vegetation variables (expressed as % cover except for diversity of habitats)	Species diversity (Shannon–Weiner index)	Density (birds/ha)	Species richness (number of species)
0–15 cm	0.06	−0.77**	−0.46**
15–30 cm	0.01	0.87**	0.46**
+30 cm	−0.05	0.69**	0.41**
Woody species	−0.38**	0.14	0.03
Tussock paspalum	0.60**	0.68**	0.64**
Bare ground	−0.37**	−0.49**	−0.21
Diversity of habitats	0.21	0.14	0.14

**, $P < 0.01$, highly significant correlation.

Table 4. Means and standard deviations for the three variables of bird community structure in the eight sectors sampled

	Density (birds/ha)		Species richness (number of species)		Species diversity (Shannon–Weiner index)	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
E	3.32	2.08	2.09	1.04	0.82	0.70
M1	4.63	10.47	1.63	1.06	0.43	0.48
M2	2.42	1.94	2.08	1.08	1.09	0.83
M3	3.65	2.80	2.90	1.37	1.20	0.78
I1	2.00	2.76	1.67	1.03	0.50	0.82
I2	0.86	0.56	1.29	0.49	0.26	0.45
I3	1.00	0.79	1.33	0.50	0.55	0.57
I4	2.63	1.73	2.00	1.07	0.70	0.61

E, enclosure – no grazing; M1–M3, moderate grazing; I1–I4, intensive grazing.

Table 5. Results of the analysis of variance between the three parameters of bird community structure and the two grazing regimes

	Species richness (number of species)	Species diversity (Shannon–Weiner index)	Density in winter (birds/ha)	Density in spring (birds/ha)
Moderately grazed areas and enclosure ($n = 44$)	2.38 ± 0.20	0.87 ± 0.11	2.68 ± 0.59	4.52 ± 1.34
Intensively grazed areas ($n = 32$)	1.65 ± 0.16	0.48 ± 0.10	1.78 ± 0.85	1.52 ± 0.32
F	7.19	6.04	0.38	12.59
P	0.009	0.016	0.54	0.001

The mean species richness, diversity and density of birds are shown for both areas, together with their standard errors.

Hymenops perspicillatus, *Milvago chimango* and *Speotyto cunicularia* were found to be equally abundant in both habitats (Fig. 2). These results are consistent with the analysis of correlation between the density of each species and the first principal component of vegetation structure. Density of *Anthus* spp. was significantly associated with the values of this component corresponding to areas of exclusion (i.e. the enclosure) and moderate grazing whereas those of *Speotyto cunicularia* and *Vanellus chilensis* were associated with areas of intensive grazing (Table 6).

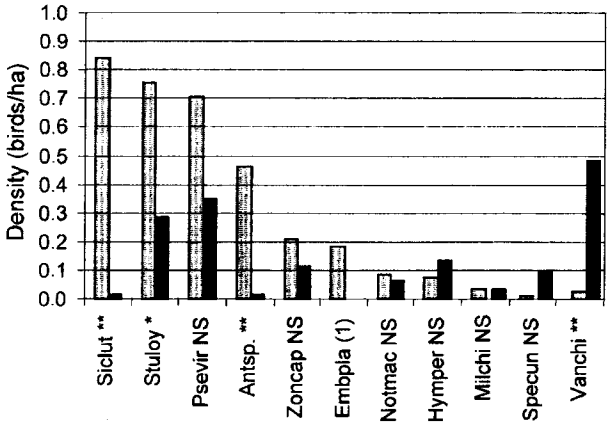


Fig. 2. Density (birds/ha) of the species recorded in more than 5% of the transects in the areas of exclusion (enclosure), moderate grazing and intensive grazing. Siclut, *Sicalis luteola*; Stuloy, *Sturnella loyca*; Psevir, *Pseudoleistes virescens*; Antsp, *Anthus* spp; Zoncap, *Zonotrichia capensis*; Embpla, *Embernagra platensis*; Notmac, *Nothura maculosa*; Hymper, *Hymenops perspicillatus*; Milchi, *Milvago chimango*; Specun, *Speotyto cunicularia*; Vanchi, *Vanellus chilensis*; *, $P < 0.05$; **, $P < 0.01$; NS, no significant difference; ▨, moderate grazing and enclosure; ■, intensive grazing; (1), species exclusively from moderate grazing and enclosure.

The PCA using the bird community data concentrates the intensively grazed samples (75% of the total) in the third quadrant of the ordination space defined by the first component (46% of the variance) and the second component (23% of the variance: Fig. 3). This separation is essentially based on the fact that these transects have lower densities of *Sturnella loyca* and *Pseudoleistes virescens*.

Egg predation

Egg predation showed a highly significant difference between both habitats ($t = 4.86$; $P < 0.01$). The sectors with higher grazing intensity showed a mean predation rate of 70% (Standard deviation (SD) = 21.60), contrasting with 12.5% (SD = 9.57) in areas of exclusion and moderate grazing.

DISCUSSION

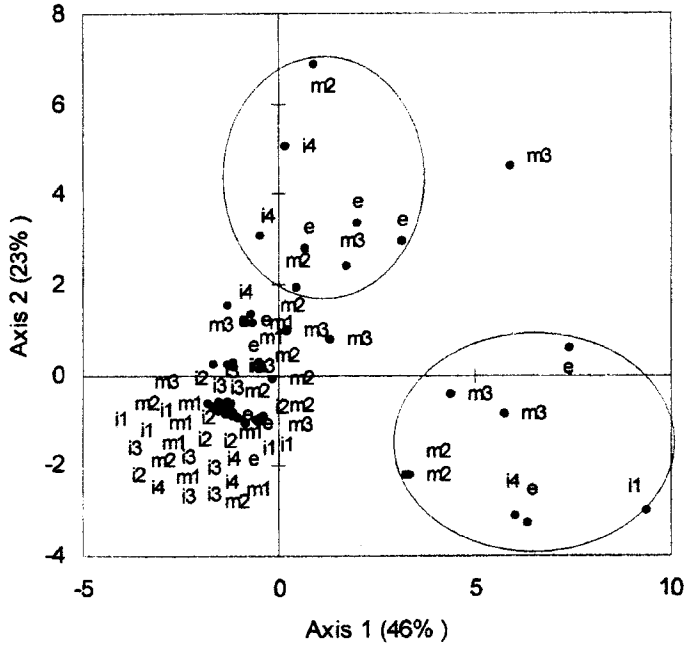
The area that we studied shows a situation of overgrazing, which can be seen as an exception among traditional

Table 6. Correlations between the density of the most common species of birds and the co-ordinates of the first axis of the PCA for vegetation data

Species	First principle component (vegetation structure)
Nothura maculosa	−0.08
Milvago chimango	−0.11
Vanellus chilensis	0.38**
Speotyto cunicularia	0.25*
Hymenops perspicillatus	0.02
Anthus spp.	−0.41**
Sicalis luteola	−0.11
Zonotrichia capensis	−0.09
Embernagra platensis	0.04
Pseudoleistes virescens	−0.16
Sturnella loyca	−0.21

*, significant correlation ($P < 0.05$), **, highly significant correlation ($P < 0.01$). Negative correlations represent an association with the areas of exclusion and moderate grazing while positive correlations represent an association with areas of intensive grazing. PCA, principal component analysis.

cattle raising (Knopf, 1996), but is usual in the case of invasive herbivores (Lever, 1994) where the stocking rate is usually not regulated for political or economic reasons (Dobbie *et al.*, 1993; Symanski, 1996; Beever & Brussard, 2000). In Tornquist Park this results in great changes in vegetation structure, which, in extreme cases turns into grassy meadows 15 cm high in contrast to grasslands free from exotic herbivores that are over 1 m high. These variations reflect on the richness and diversity of birds, which are greatest in areas subject to moderate levels of grazing, slightly lower in the enclosures and much lower under high grazing pressure, coinciding with changes in the diversity of habitats. In particular it is interesting that the richness and diversity of species are slightly greater in areas of moderate grazing than in the enclosures, as predicted by the theory of intermediate disturbance (Connell, 1978). These results are interesting in the light of the discussion concerning whether or not exotic herbivores should be eradicated from protected natural areas (McCoy, 1994; Houston & Schreiner, 1995). Levin *et al.* (2002) showed many ecological effects of feral horses in salt marshes leading to conflicts between the goals of maintaining horse populations and functional marshes. Nevertheless, they also discussed the possibility that those habitats may have shared Pleistocene times with an arrangement of large herbivores that made them function more like modern horse-grazed marshes than like present-day marshes where horses are excluded. In the same fashion, Argentinean Pampas were historically subjected to grazing by native herbivores, such as deer and guanaco (Chebez, 1994) that formed remarkably large herds (Darwin, [1898] 1967; Hudson, [1918] 1963), so it is likely that typical grassland birds have evolved in habitats subjected to high to moderate grazing regimes. Could feral horses be considered equivalent to extinct or rare native herbivores? What would be an optimal density (above zero) of introduced herbivores for a grassland reserve? The answers to these questions will, no doubt, vary as a function of the objectives of each reserve, but it is important to consider at least four factors in any analysis. (1) The possible long term effects of the presence



	PC1	PC2
Nothura maculosa	-0.10	0.20
Milvago chimango	-0.05	0.00
Vanellus chilensis	-0.27	0.02
Speotyto cunicularia	-0.14	-0.03
Hymenops perspicillatus	-0.11	0.14
Anthus spp.	0.21	-0.08
Zonotrichia capensis	0.27	0.04
Embernagra platensis	0.29	0.16
Pseudoleistes virescens	0.97	-0.22
Sturnella loyca	0.41	0.91
Eigenvalues	6.20	3.07

Fig. 3. Principal components analysis (PCA) ordination of transects when considering the density of bird species present in more than 5% of the samples and the correlations between the initial variables and the principal factors. The circle on the bottom right shows the samples with greatest relative abundance of *Pseudoleistes virescens*, while the one at the top of the graph shows those with a predominance of *Sturnella loyca*. e, enclosure; m1–m3, moderately grazed areas; i1–i4, intensively grazed areas.

of alien herbivores on critical habitats e.g. waterholes in arid environments (Dobbie *et al.*, 1993), or under unusual environmental conditions e.g. severe droughts (Bock & Bock, 1998). (2) Their effects on species that are especially sensitive to grazing (Detling, 1998). (3) The dynamics of the native species on a wide geographical scale since, for example, some species only tolerate the presence of herbivores if better conserved areas exist in the same region (Wiens, 1992*b*: 217; Knopf, 1996). (4) The effects of exotic herbivores on the composition of the communities, rather than on species richness or diversity (Parker *et al.*, 1999).

Our work suggests that there are consistent differences in the composition of bird communities according to grazing intensity, with some species preferring areas of intense grazing and others found exclusively, or more abundantly, in areas with a low density of feral horses. It is tempting to classify these species as increasers or decreasers in response to grazing, however, this might be an over-simplification if not complimented by other information such as the history of the pasture management, or ecological factors such as soil type or rainfall (Knopf, 1996). Possible causes of differential distribution of bird species in environments with different grazing regimes include the availability of food supplies, the expected reproductive success and predation risk (Cody, 1985; Wiens, 1992*a*: 339).

In our case, despite the caution that must be exercised in using quail eggs as indicators of natural predation, the magnitude of increase in egg predation associated with severe grazing seems to be sufficient evidence to suggest that grazing intensity could have a significant impact on the population dynamics of grassland birds and that their survival in the area would depend on the existence of patches of vegetation free from excessive grazing.

It has been suggested that the existence of high and low quality habitats results in a sink-source metapopulation structure where the excess of individuals from productive patches emigrate into less productive ones (Pulliam, 1988). One particular point of interest would be to determine whether small, well-conserved areas of grassland act as 'sources' with a high rate of reproduction, or whether they can become 'ecological traps' for the birds. An 'ecological trap' is a site that has clues that enable it to be perceived as a high-quality site by wildlife, but which includes characteristics that increase the death rate or reduce the rate of reproduction (Ratti & Reese, 1988; Kokko & Sutherland, 2001). In the case of moderately grazed patches of grassland, the density and height of the vegetation could indicate that they are 'safe' areas for nesting, but their high proportion of border could increase the probability of nest predation. This phenomenon has been shown in numerous studies on the effect of fragmentation in forests (Wilcove, 1985; Martin, 1988; Keyser, Hill & Soehren, 1998) and more recently in natural grasslands (Phipps, 2002). In our study we observed that although the area of exclusion was as small as 20 ha, its predation rate was significantly lower than in the grazed areas. Unfortunately there were no other similar enclosed areas available that could have acted as replicates. However, we feel cautiously optimistic about the value of small relictual areas of grassland in helping to maintain the diversity of birds in the region. The presence of feral horses could result in other indirect impacts on the breeding success of grassland birds due to the increase in the abundance of opportunistic predators and brood parasites.

The interaction between exotic herbivores, opportunistic predators and native prey has been studied by Courchamp, Langlais & Sugihara (1999) and Norbury (2001) in Australia, where high densities of rabbits are associated with an increase in the abundance of cats, foxes and ferrets, which, in turn, increases the impact of these carnivores on native species of birds and lizards. Vázquez (2002) reports many cases that indicate that the presence of exotic herbivores, such as the European hare and the rabbit, could favour native avian and mammal predators in the temperate woods of Argentina with a consequent impact on the populations of native prey. In our study area it is clear that at least one carnivorous species, the Pampas fox (*Pseudalopex gymnocercus*), takes advantage of feeding on the carrion of feral horses and, as shown by diet analysis, also preys on wild birds (Castillo, 2002). This could be the explanation for the observed increase in the abundance of foxes in the ETPP with respect to the surrounding area (Lucherini, Birocchio & Luengos Vidal, 2001). As well as the food source provided by dead horses, some native predators also feed on placentas during the breeding season and on the invertebrates that live in the manure, as in the case of the Chimango caracara (*Milvago chimango*) in Chile (Willson *et al.*, 2001).

However, the Shiny cowbird (*Molothrus bonariensis*) is a brood parasite that is relatively abundant in the area and it feeds on external parasites of feral horses (pers. obs.). The association between cattle and cowbirds has been recognised for a long time (Mayfield, 1965) and, *a priori*, it seems reasonable to assume than with any increase in the population of horses the cowbirds would be at an advantage and the breeding success of grassland birds would decrease due to parasitism of their nests. We were not able to detect a significative correlation betwen cowbird abundance and grazing intensity, nevertheless our experience in the area seems to indicate that the overall abundance of the species in the park has rised in the past 7–8 years, co-incidentally in with the increase in the feral horse population. Cowbirds are capable of covering long distances daily between feeding and nesting grounds, as Goguen & Mathews (2000) have shown for the brown-headed cowbird (*Molothrus ater*) and these movements could obscure differences in abundance between habitats. If our observations were correct, brood parasitism could be a long-distance edge effect that must be carefully evaluated when determining the conservation value of small areas of grassland under moderate grazing regimes.

In conclusion, the importance of analysing the problems caused by biological invasions by means of studies in areas with and without the invasive species has to be emphasised, as does that of experimental analysis of their effects on parameters at the level of the individual

organisms as well as of populations (Parker & Reichard, 1998; Parker *et al.*, 1999; Byers *et al.*, 2002). This approach would help to set research priorities concerning the impact of the invader, to adjust the necessary management interventions so as to reduce their impact and to gain objective information to support the control strategy from a political point of view.

Our results emphasise, moreover, the relevance of managing herbivore stocking rates for the conservation of grassland bird communities and, fundamentally, the importance of the preservation of patches with moderate grazing regimes which would act as a 'source' areas for reproduction, and repopulating neighbouring areas.

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Influence of Nonnative and Native Ungulate Biomass and Seasonal Precipitation on Vegetation Production in a Great Basin Ecosystem

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INFLUENCE OF NONNATIVE AND NATIVE UNGULATE BIOMASS AND SEASONAL PRECIPITATION ON VEGETATION PRODUCTION IN A GREAT BASIN ECOSYSTEM

Linda C. Zeigenfuss[1,5], Kathryn A. Schoenecker[2], Jason I. Ransom[3], Drew A. Ignizio[4], and Tracy Mask[1]

ABSTRACT.—The negative effects of equid grazers in semiarid ecosystems of the American West have been considered disproportionate to the influence of native ungulates in these systems because of equids' large body size, hoof shape, and short history on the landscape relative to native ungulates. Tools that can analyze the degree of influence of various ungulate herbivores in an ecosystem and separate effects of ungulates from effects of other variables (climate, anthropomorphic disturbances) can be useful to managers in determining the location of nonnative herbivore impacts and assessing the effect of management actions targeted at different ungulate populations. We used remotely sensed data to determine the influence of native and nonnative ungulates and climate on vegetation productivity at wildlife refuges in Oregon and Nevada. Our findings indicate that ungulate biomass density, particularly equid biomass density, and precipitation in winter and spring had the greatest influence on normalized difference vegetation index (NDVI) values. Our results concur with those of other researchers, who found that drought exacerbated the impacts of ungulate herbivores in arid systems.

RESUMEN.—Los efectos negativos de los equinos herbívoros en ecosistemas semi-áridos del oeste americano han sido considerados desproporcionados en comparación con la influencia de los ungulados nativos de estos sistemas por causa de su gran tamaño corporal, la forma de sus pezuñas y corta historia en el paisaje en relación con los ungulados nativos. Las herramientas que pueden analizar el grado de influencia de varios herbívoros ungulados en un ecosistema y separar esos efectos de aquellos causados por otras variables (clima, perturbaciones antropomórficas) pueden ser útiles para que los encargados puedan determinar la localidades de impacto por los herbívoros no nativos y para que evalúen el efecto de las acciones de manejo dirigidas a diferentes poblaciones de ungulados. Utilizamos datos de sensores remotos para determinar la influencia de los ungulados nativos y no nativos y del clima en la productividad de la vegetación en los refugios de vida silvestre de Oregon y Nevada. Nuestros hallazgos indican que la densidad de biomasa de ungulados, particularmente la densidad de biomasa de equinos, y las precipitaciones de invierno y primavera tenían la mayor influencia sobre los valores del índice normalizado de diferencia de vegetación (INDV). Nuestros resultados concuerdan con los de otros investigadores que descubrieron que la sequía exacerbó los impactos de los ungulados herbívoros en sistemas áridos.

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Herbivory has profound effects on vegetation production, composition, and structure in many different plant communities (Hobbs 1996, Wisdom et al. 2006). Herbivores directly (Knapp et al. 1999) and indirectly influence ecosystem processes in plant structure and function and in both aboveground and belowground processes (Schoenecker et al. 2004, Bardgett and Wardle 2010). The influence of herbivory on ecosystem processes is shaped by the types of plants consumed, intensity of herbivory, evolutionary history of grazing, and availability of water and nutrients to plants (Milchunas and Lauenroth 1993). Herbivory by native and nonnative ungulates can exert impacts on vegetation production that stimulate compensatory plant production ("grazing optimization") at one end of the spectrum or suppress vegetation production ("undercompensation") at the other (McNaughton 1983, Maschinski and Whitham 1989). Evaluating the response of vegetation is one method to

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investigate the importance of abiotic inputs and disturbances on a system and to determine if ungulate herbivores exert significant impacts.

The effect of horse grazing on semiarid ecosystems has been widely documented (Hanley and Hanley 1982, Beever et al. 2003, 2008, Beever and Herrick 2006, Catorci et al. 2012). Presence of horses increases soil compaction, increases soil penetration resistance (particularly in drier soils; Beever et al. 2008), leads to soil nutrient depletion (due to reduction of vegetation cover), and increases soil erosion (Beever and Herrick 2006). Horse grazing promotes plants with low nutrient requirements and robust defense strategies (Catorci et al. 2012). However, the impacts of grazing by horses on arid environments are highly influenced by animal density and abiotic factors (Ostermann-Kelm et al. 2009). Whereas biogeography and abiotic factors may show a greater influence than horse grazing on variables such as percentage of vegetation cover and cover of key plant species (often highly palatable grasses; Fahnestock and Detling 1999, Beever et al. 2003), numerous studies have reported impacts of horse grazing on nesting bird communities (Zalba and Cozzani 2004), reptile species richness and abundance (Beever and Brussard 2004), nonnative plant cover (Loydi and Zalba 2009), and disturbance-sensitive variables, such as soil surface hardness and number of ant mounds (Beever et al. 2003).

Managing free-roaming[1] horse (*Equus caballus*) and burro (*Equus asinus*) herds and their habitats is an ongoing challenge for public land managers due to high reproduction and survivorship of horses and burros, diverse land-cover and land-use conditions, and regulatory constraints on management options (National Academy of Sciences 2013). Free-roaming horse populations may increase at rates exceeding 20% annually (Eberhardt et al. 1982, Garrott et al. 1991) and have a wide array of influences on native flora, fauna, and ecosystem processes (Smith 1986, Levin et al. 2002, Beever and Brussard 2004, Zalba and Cozzani 2004, Beever and Herrick 2006, Beever et al. 2008, Loydi and Zalba 2009). Herds can range across management and political boundaries and compete with native wildlife and domestic livestock for forage. Therefore, understanding the relationship between herd management and habitat condition is an important need for managers across rangelands of the western United States.

The Sheldon National Wildlife Refuge (NWR) and Hart Mountain National Antelope Refuge (NAR) were established in 1931 and 1936, respectively, for conservation of high desert habitat for pronghorn (*Antilocapra americana*) and other sagebrush-obligate species. Together, the refuges comprise over ~323,750 ha (800,000 acres) of sagebrush-steppe ecosystem. Feral horses and burros have been present on Sheldon NWR since before the refuge was established. Burros became feral when domestic animals were released into the wild after the decline of mining and the advent of railroad and motorized vehicles in the American West (McKnight 1958, Douglas and Leslie 1996). Similarly, horses became feral as animals escaped or were released from ranches and grazing allotments. Recently, these refuges have experienced expanding utilization by feral horses and burros, leading to wildlife and habitat management challenges. Sheldon NWR hosted a feral horse population ranging from 200–300 horses in the mid 1990s to an estimated 973 horses by 2012. The burro population is generally small, with ~200 burros on the refuge in 2012. Hart Mountain NAR, which removed all horses from the refuge in the mid-1990s, now only occasionally contains a small number of animals that move onto the refuge from adjacent BLM lands (no horses from 1999 to 2005 and an average of 117 horses from 2006 to 2012), requiring periodic removal to maintain the refuge as horse-free. Hart Mountain NAR eliminated all domestic livestock grazing in 1990, and Sheldon NWR removed most livestock in 1990 and became completely livestock-free in 1994.

Animals (in this case, grazing animals) can influence the ecological health of natural systems. Analyzing these animal-ecosystem relationships to determine specific effects can provide support and direction for management actions. We analyzed the relationship of annual aboveground net primary productivity (ANPP) with ungulate populations and climate variables across the Sheldon–Hart Mountain

[1]The terms "free-roaming," "free-ranging," "feral," and "wild" are used interchangeably by horse and burro management agencies and in scientific literature, and refer to horses and burros that live in an untamed state but have ancestors that were once domesticated. In this paper, we refer to the animals in general as free-roaming and those horses occupying Sheldon NWR as feral.

Fig. 1. Location of Sheldon–Hart Mountain National Wildlife Refuge Complex in the western United States.

National Wildlife Refuge Complex. We assessed the impact of ungulate density on temporal and spatial patterns in ANPP at the landscape scale by using a novel approach that accounts for ungulate body mass as well as population size. Our objective was to provide managers with a more comprehensive ecological understanding of the system and a better understanding of the potential impacts and habitat interactions of feral equids.

METHODS

Study Area

The Sheldon–Hart Mountain National Wildlife Refuge Complex (Fig. 1) is located in the Great Basin Ecosystem, which encompasses a portion of the Columbia Basin Plateau in eastern Oregon and southern Idaho, as well as the Great Basin Region, which extends from the Sierra Nevada in eastern California, across most of Nevada north of the Mojave Desert, to the Rocky Mountains in western Utah (Suring et al. 2005, USDI 2012). Lower-elevation portions of this ecosystem are defined by sagebrush (*Artemisia* spp.) steppe, salt desert shrub, and pinyon (*Pinus monophylla*) and juniper (*Juniperus* spp.) woodland habitats. Both refuges are dominated by expansive communities of sagebrush steppe, which predominantly consists of sagebrush shrubs and an understory of native bunchgrasses and forbs.

The Hart Mountain NAR is 114,335 ha (~282,500 acres) of high desert habitat located in south central Oregon. The refuge was established in 1936 as a range for remnant herds of pronghorn (*Antilocapra americana*). Hart Mountain NAR is located on a massive fault block ridge that ascends abruptly nearly three-quarters of a mile above the Warner Valley floor in a series of rugged cliffs, steep slopes, and knife-like ridges (USDI 1994; www.fws.gov/sheldonhartmtn/hart/index.html). The east side of the mountain is less precipitous, descending in a series of rolling hills and low ridges to the sagebrush-grasslands typical of the Great Basin region. Ungulate species include pronghorn, California bighorn sheep (*Ovis canadensis californiana*), mule deer (*Odocoileus hemionus*), and occasionally small numbers of trespass horses from adjacent BLM lands. Since 2007, a small group (≤11 individuals) of elk (*Cervus elaphus*) has been observed occasionally during summer surveys. Elevations on the refuge range from 1350 to 2450 m (4450–8000 ft).

The Sheldon NWR is located in the northwestern corner of Nevada. This refuge was set aside in 1931 by executive order, primarily for the conservation of pronghorn and other native wildlife species. It protects 234,703 ha (~580,000 acres) of high desert habitat for large summering herds of pronghorn, scattered bands of California bighorn sheep, mule deer, and feral horses and burros. The landscape is vast, rugged, and punctuated with waterfalls, narrow gorges, lush springs among rolling hills, and expansive tablelands of sagebrush and mountain mahogany (*Cercocarpus montanus*) (http://www.fws.gov/sheldonhartmtn/sheldon/index.html). Elevations on the refuge range from 1250 to 2200 m (4100–7200 ft).

Mean annual precipitation is approximately 26 cm (10 in.) on both refuges but ranges from as little as 15 cm (6 in.) at lower elevations to 45 cm (18 in.) at high elevations, with roughly one-third falling as snow. Water resources are typical of the closed watersheds in the Great Basin. Streams, ponds, and playas within these watersheds are intermittent and typically dry during the summer months. Numerous wetlands and springs, as well as developed water

TABLE 1. Minimum population estimates for ungulate species at Hart Mountain (Hart) and Sheldon (Shdn) National Wildlife Refuges, 2000–2012. These data were used to calculate ungulate biomass density for parameters/dependent variables in the model. Census data were provided by G. Collins of the U.S. Fish and Wildlife Service. Estimates are provided for mule deer and for Sheldon NWR bighorn (*italics*). Missing data points (**bold type**) were estimated by calculating midpoints between census dates (Sheldon) or applying local horse population growth rates of 17.5% (Hart). Missing data points shaded gray were estimated based on available census estimates and numbers of animals removed in years with missing data points. Horse and burro removals took place in years marked with an asterisk (*).

	Horses		Burros		Pronghorn		Bighorn		Mule Deer	
Year	Hart	Shdn	Hart	Shdn	Hart	Shdn	Hart	Shdn	Hart	Shdn
2000	0	**628***	0	**31**	1759	1190	235	*150*	*200*	*200*
2001	0	654	0	37	1617	1193	240	*150*	*200*	*200*
2002	0	847*	0	**97***	1905	**1112**	198	*150*	*200*	*200*
2003	0	**867**	0	136*	2444	1031	305	*150*	*200*	*200*
2004	0	1178	0	74*	2474	**1404**	301	*150*	*200*	*200*
2005	0	**1296***	0	68*	2372	**1777**	286	*150*	*200*	*200*
2006	147	1065*	0	75	2716	2150	229	*150*	*200*	*200*
2007	218	786	0	88	2052	1091	230	*150*	*200*	*200*
2008	101	1148*	0	161	2024	1883	212	*150*	*200*	*200*
2009	270*	1210*	0	127*	1942	1836	147	*150*	*200*	*200*
2010	22	1225*	0	94*	2203	1727	130	*150*	*200*	*200*
2011	31	1104*	0	**138**	1795	1974	134	*150*	*200*	*200*
2012	28	973*	0	182	3723	2508	147	*150*	*200*	*200*

resources (reservoirs, stock ponds, guzzlers, and pit reservoirs), are found throughout the study area. Water supply is dependent on the accumulation of winter snowpack. Snowpack depth and persistence into the early summer determine how much water will accumulate in playas and reservoirs and how much will flow through the creeks (USDI 1994, 2012).

Both refuges have a history of livestock grazing of both sheep (*Ovis aries*) and cattle (*Bos taurus*). Signs of excessive grazing (vegetation cover depletion, topsoil erosion) were noted at both refuges in the 1920s and 1930s (USDI 1994, 2012). Grazing decreased in the 1930s due to the Great Depression, and all domestic sheep grazing was eliminated from Sheldon in the 1950s and Hart Mountain by 1960. From 1940 to 1976, approximately 20,000 animal unit months (AUMs) of domestic horse, cattle, and sheep grazing occurred on Sheldon (USDI 2012), dropping to approximately 17,721 AUMs of cattle in the 1980s (Anderson and Franzen 1978). Most cattle grazing was seasonal from April through October. At Hart Mountain, seasonal livestock grazing ranged from 10,406 to 17,228 AUMs (USDI 1994). All livestock grazing ceased in 1990 on Hart Mountain and by 1994 on Sheldon.

Ungulate Population Density

We obtained minimum population estimates of all large grazing species present on Sheldon NWR and Hart Mountain NAR from the U.S. Fish and Wildlife Service (Table 1; G. Collins, USFWS, personal communication, April 2013). The same suite of ungulate herbivores (pronghorn, bighorn sheep, mule deer, horses, and burros) was present in both areas during the study period, with the exception of burros, which have never been present at Hart Mountain NAR, and a few elk (≤11) that have been observed there periodically during summer over the past 5 years. Horses, burros, and bighorns occupy the refuges year-round. Typically, pronghorn and mule deer are on the refuges April through October. A portion of the pronghorn population is resident year-round in years with mild winters, but pronghorn leave the refuges in average or harsh winters. The majority of mule deer migrate off the refuges in winter, but a small group does reside in a sheltered valley at Sheldon NWR through the winter. Annual minimum population counts were conducted in July for California bighorn sheep at Hart Mountain, pronghorn at both refuges, horses at both refuges, and burros at Sheldon. For years when population data were not available, population size estimates were made by assessing the change in population over the time period between data points and assigning population numbers to missing years that assumed a steady rate of increase or decrease between the 2 data points. At Hart Mountain all horses were removed by 1999, but sometime in 2005–2006, a herd gained access to the refuge and increased until it was

removed in 2009. Small numbers of trespass horses used the refuge between 2009 and 2012.

Using these ungulate population data for each year and refuge, we estimated total ungulate biomass density (UBD) using the following equation:

$$UBD = \frac{\sum_{i=1}^{n} (P_i \times wt_i \times s_i)}{a},$$

where i = an individual species, P_i = refuge population size for species i, wt_i = average body mass (kg) for species i (Table 2), s_i = seasonality factor (the proportion of the year that species i is on the refuge; Table 2), and a = area (ha) of the refuge. We included a seasonality factor to account for migration of animals off the refuges during winter. Only pronghorn and mule deer were regularly migratory, and patterns were highly variable depending on winter severity. Therefore, for these 2 species, we assumed that in most years the majority of the population was only resident from April through October (0.58 year). We partitioned ungulate biomass density into equid (horse and burro) and nonequid (all other ungulates) components for statistical analysis. Because the number of elk was so small and elk were only occasionally observed (G. Collins, U.S. Fish and Wildlife Service, personal communication), ungulate biomass density estimates did not include elk.

Vegetation Productivity

We conducted refuge-scale assessments of aboveground net primary production (ANPP) throughout the year by using remotely sensed satellite images from the Moderate Resolution Imaging Spectroradiometer (MODIS) platform. We used the normalized difference vegetation index (NDVI), which is particularly well-suited for this application because it can be used for characterizing land surface biophysical properties and processes, such as primary production (https://lpdaac.usgs.gov/products/modis_products_table/mod13q1). NDVI is a well-established index used to identify the "level of greenness" of a landscape. This greenness is measured using satellite-based sensors that measure the intensity of light being reflected off the Earth in visible and near-infrared wavelengths to quantify the photosynthetic capacity of vegetation in a given area of land surface. Several sources of NDVI imagery exist, but we selected MODIS because of its higher spatial resolution (250-m resolution) and greater temporal resolution (16-day interval) compared to other available sources. The MODIS platform was launched in 1999, and the first year of complete MODIS data for the Sheldon–Hart region is 2000. Our analysis covers the period from 2000 to 2012. Data were downloaded from the MODIS website for the years 2000 to 2012 (http://earthexplorer.usgs.gov/). The data used represent the MODIS 250 m resolution, 16-day interval vegetation products.

After we downloaded the tiles, we extracted data using the Geospatial Data Abstraction Library (GDAL) utility in conjunction with Python code. Raster data sets were assigned proper spatial reference, rescaled (raster values were multiplied by 0.0001 to adjust NDVI values, as they had been modified to address file size limitations), and reprojected into a WGS 84 Sinusoidal Projection. This projection was chosen to limit data loss by preserving a projection as similar to the native format as possible but also to transform the data into a more commonly used datum to facilitate proper processing. Finally, we mosaicked the raster data sets to produce single raster files representing NDVI readings for a large multistate region covering the area of interest (AOI) for each date of imagery capture.

We used individual polygons representing the 2 refuge areas to calculate zonal statistics using the ESRI ArcGIS desktop software package (ESRI 2010). For each refuge, we considered all of the raster cells from the NDVI data set that fell within the spatial extent of the refuge, and descriptive statistics (mean, minimum, maximum, range, and standard deviation of the values within the polygon) were then calculated. These values were captured and saved into formatted tables for every 16-day time step throughout each year for all years between 2000 and 2012. We then averaged over all sample dates within the growing season for each year to get an average growing season NDVI for each refuge. Maximum growing season NDVI scores were taken from the date within each year that had the highest NDVI score for each refuge polygon.

We estimated vegetation phenology metrics (green-up date, browndown date, and date of peak greenness) for each year at both refuges from the MODIS data, following algorithms described by Tan et al. (2011). For the years

2000 and 2008–2012, MODIS coverage of the study area was poor for several dates, causing the Tan et al. (2011) algorithm to perform poorly when estimating green-up and browndown dates. For these years, we estimated green-up and browndown date by fitting a 3-period moving-average trendline (MSExcel) to the mean vegetation index values for each study area throughout the year. We then visually inspected the graph for the sampling date at which vegetation index values began to increase steadily (green-up), the date of the maximum index value (peak value), and the date when the vegetation index ceased to decrease steadily (browndown).

Climate Variables

We obtained climate data for both refuges from 1999 to 2012. We gathered precipitation and temperature data for Hart Mountain NAR from the Rock Creek weather station (#GHCND:USR0000OROC; National Climatic Data Center, http://www.ncdc.noaa.gov). We obtained climate data for Sheldon NWR from the Sheldon SNOTEL site (#NV19H05S; Natural Resources Conservation Service, http://www.wcc.nrcs.usda.gov/snow/snotel-precip-data.html).

Statistical Analysis

We combined data from Sheldon NWR (large horse population) and Hart Mountain NAR (few horses, more pronghorn) over 13 years to determine the relative impact of free-roaming equid population densities on vegetation productivity measured by NDVI ($n = 26$). Due to the scale of the sensor (ground resolution: 250 × 250 m cell), this assessment did not provide fine-scale indication of range conditions as would be provided by field assessment. But this resolution, combined with the frequent temporal interval of a new composite image every 16–32 days, provided the spatial and temporal resolution needed to assess patterns and impacts across the entire refuge complex.

We formulated a set of candidate statistical models that were based on likely ecological relationships by using additive formulations of the following variables: (1) estimated ungulate biomass density (total, equid, and non-equid); (2) precipitation metrics including total precipitation during growth period (from green-up to peak of growing season [date of maximum greenness index value]), total growing season precipitation (from current year green-up to browndown), and total winter–spring precipitation (from previous year browndown to peak greenness); and (3) temperature metrics, including mean daily temperature and mean maximum daily temperature during the growth period, winter–spring temperature, and full-growing-season temperature. Growing season commencement and duration are tied to climatic conditions, which vary from year to year. Because we had information available on green-up and peak greenness from the NDVI data, we decided to use this information to tailor the precipitation and temperature data more precisely for each year, rather than use standardized dates across years to calculate these variables. The resulting list of candidate models had a maximum of 6 variables for maximum growing-season NDVI and 8 variables for average growing-season NDVI. Maximum index values were only tested with growth period and winter–spring climate data, since temperature and rainfall occurring after the peak of the growing season would not have the opportunity to affect this value.

We conducted all statistical analyses using SAS version 9.2 (SAS Institute, Cary, NC). We first tested for differences in slopes of parameters for each refuge to determine if models needed to be compared separately for each refuge using PROC GLM in SAS. Model selection was based on adjusted R^2, and strength of evidence for models was evaluated using Akaike's information criteria for small sample sizes (AIC_c: Burnham and Anderson 2002).

We tested all variables (precipitation, temperature, ungulate biomass density) for correlations, and when significant correlation between 2 variables was found, we excluded models with correlated variables from consideration.

We compared the absolute values of t statistics for each parameter of the model to provide a measure of the relative importance of predictor variables (Bring 1994). For each model, we identified the variable with the highest t value as being the most important, and then determined the relative importance of all other variables in relation to the most important using a ratio of their t statistics.

Caveats and Limitations

The parameters that were used to examine relationships represent available data, but in

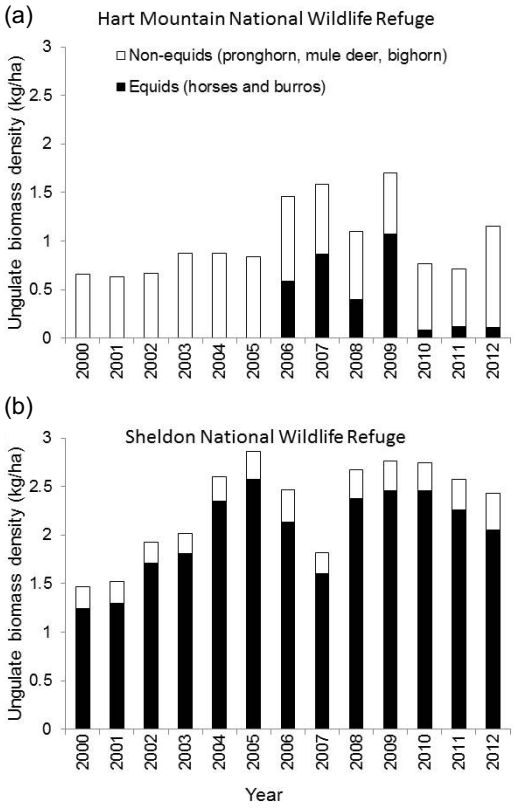

Fig. 2. Annual equid and non-equid ungulate biomass densities at (a) Hart Mountain and (b) Sheldon National Wildlife Refuges, 2000–2012.

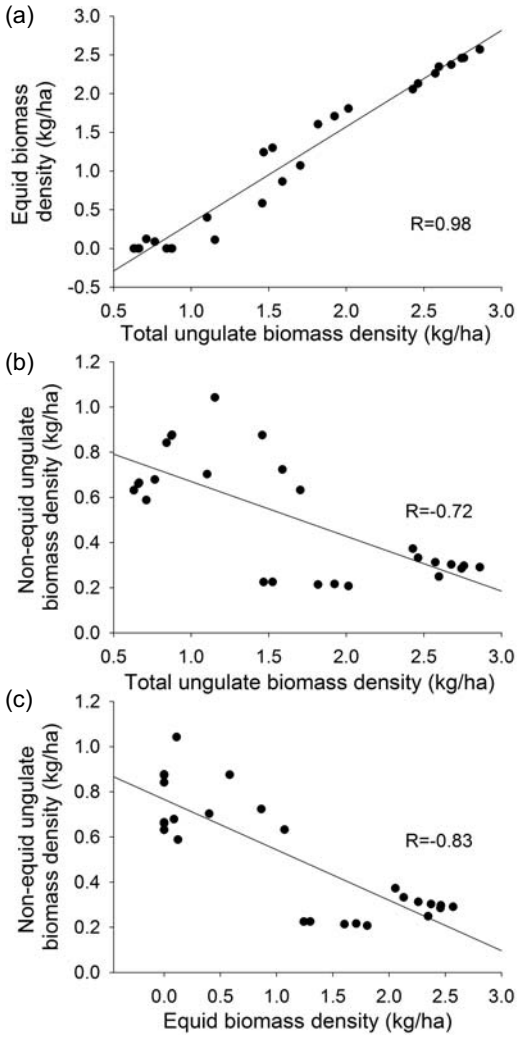

Fig. 3. Correlations of (a) equid and (b) non-equid ungulate biomass density with total ungulate biomass density and (c) with each other at the Sheldon and Hart Mountain National Wildlife Refuge Complex, 2000–2012.

many cases the parameters are generalized approximations of actual field conditions or are limited by methods used to collect data. Satellite imagery is subject to problems related to cloud cover at the time of sampling and shading effects. These issues, in turn, affect NDVI values derived from these scenes. Population data were gathered once per year from surveys of the entire study area, and no corrections to account for sampling error were made. In years when population surveys were not conducted, estimates of population size (based on surveyed population size for the years previous to and following the missing years) were used. The study areas have varied topography and microhabitats, and we simplified NDVI to represent the entire study area with a single value. This landscape has been heavily influenced by historic livestock grazing, and residual effects of decades of livestock grazing at high intensities may continue to influence this landscape but would not be detected by our study. Our objective was to find general patterns in the data under the current conditions at the scale of the refuge, and these patterns are not necessarily applicable to individual vegetation types or other smaller habitat/vegetation units.

RESULTS

Estimates for ungulate populations at both locations varied greatly from 2000 to 2012 (Table 1). The following factors contributed to

TABLE 2. Average body mass constants used to calculate ungulate biomass density. Data for seasonality factor was provided by G. Collins, U.S. Fish and Wildlife Service, Sheldon–Hart Mountain National Wildlife Refuge Complex.

Ungulate species	Average body mass (kg)	Grazing season	Seasonality factor
Horse[a]	454	Year-round	1.00
Burro[a]	227	Year-round	1.00
Pronghorn[b]	45	April–October	0.58
Bighorn[b]	91	Year-round	1.00
Mule deer[b]	68	April–October	0.58

[a]Body mass value obtained from the U.S. Bureau of Land Management Wild Horse and Burro Program (http://www.blm.gov/or/resources/whb/files/adoption_requirements.pdf).
[b]Body mass value obtained from Wassink (1993).

annual population fluctuations: removal of horses and burros from both populations throughout the study period (Table 1), unquantified errors in population estimation, occasional movement of horses and burros from adjacent lands in both populations, and increased use of water sources on the refuge complex by pronghorn during drought years (G. Collins, USFWS, personal communication).

Throughout the study period, total and equid ungulate biomass density were greater at Sheldon than at Hart Mountain, with the exception of 2007 (Fig. 2), which followed large decreases in horse (due to removals) and pronghorn populations at Sheldon. Throughout the study, Hart Mountain had greater nonequid biomass density than Sheldon (Fig. 2). All biomass density variables were correlated. Total ungulate biomass density was highly correlated with equid biomass density ($R = 0.98$, $P < 0.0001$; Fig. 3a). Equids, due to their large body size, drove the total ungulate biomass density in these study areas, despite their lower population size compared to pronghorn (Table 2). In addition, total ungulate biomass density was negatively correlated with non-equid biomass density ($R = -0.72$, $P < 0.0001$; Fig. 3b). We found a strong negative correlation between equid and non-equid biomass density ($R = -0.83$, $P < 0.0001$; Fig. 3c). However, we did not test for, and our results do not necessarily demonstrate, a causal relationship (i.e. high equid biomass density is leading to lower non-equid biomass density), because equid populations are controlled in these areas and because man-made water sources on the refuges may influence both equid and non-equid population size in any given year. We tested all 3 ungulate biomass density variables to see which had the greatest effect on NDVI, but because of correlations, we did not consider models that had more than one of these variables.

Similarly, all precipitation variables were highly correlated with each other ($R \geq 0.85$, $P < 0.0001$) so no model that included more than one precipitation variable was considered. This high correlation is not surprising because the selected periods for precipitation overlapped. Mean temperatures during all periods evaluated (winter–spring, growing season, and growth period) were positively correlated with mean maximum temperatures during the same period ($R \geq 0.71$, $P < 0.0001$). As with precipitation, temperature variables were also correlated across time periods, so no models with more than one temperature variable were included in the set of candidate models.

The top-ranked models for both average growing-season NDVI and maximum growing-season NDVI included equid biomass density or total ungulate biomass density and total winter–spring precipitation (Table 3). Although the model for predicting maximum growing-season NDVI was significant ($P = 0.009$), the modeled relationship was not strong ($R^2 = 0.34$). Increases in equid biomass negatively influenced NDVI, whereas increases in winter–spring precipitation positively influenced NDVI (Fig. 4). Relationships of average growing-season NDVI to predictor variables were much stronger (R^2 ranged from 0.63 to 0.66) than those for maximum growing-season NDVI ($R^2 = 0.24$–0.34).

A comparison of t statistics provided a measure of the relative importance of each model variable (Bring 1994). We found that biomass density (both equid and total ungulate) had greater importance than total winter–spring precipitation for average growing-season NDVI (Table 3). However, winter–spring precipitation was slightly more important than biomass density in predicting maximum growing-season NDVI (Table 3).

TABLE 3. Top-ranked models (based on AIC_c score) that best predicted vegetation indices of greenness at the Sheldon–Hart Mountain National Wildlife Refuge Complex. All models within 2 AIC_c points of the highest-ranking model are included.

Response	R^2	Model *P*	AIC_c	Independent variables	*P*	β	*t*	Importance
Mean NDVI	0.65	<0.001	–212.2	Equid biomass density	<0.001	–0.016	–4.82	1
				Winter–spring precipitation	0.001	0.002	3.84	0.87
				Intercept	<0.001	0.231	20.11	—
	0.63	<0.001	–210.2	Ungulate biomass density	<0.001	–0.019	–4.46	1
				Winter–spring precipitation	0.001	0.002	3.90	0.87
				Intercept	<0.001	0.242	18.14	—
	0.66	<0.001	–210.1	Equid biomass density	<0.001	–0.016	–4.67	1
				Winter–spring precipitation	0.002	0.002	3.62	0.78
				Winter–spring max temp	0.510	–0.001	–0.67	0.14
				Intercept	<0.001	0.247	9.38	—
Max NDVI	0.34	0.009	–164.4	Ungulate biomass density	0.040	–0. 022	–2.18	0.91
				Winter–spring precipitation	0.025	0.003	2.40	1
				Intercept	<0.001	0.307	9.53	—
	0.33	0.010	–164.3	Equid biomass density	0.042	–0.017	–2.15	0.93
				Winter–spring precipitation	0.030	0.003	2.31	1
				Intercept	<0.001	0.029	10.15	—
	0.31	0.013	–163.6	Ungulate biomass density	0.071	–0.020	–1.89	0.85
				Growing period precipitation	0.037	0.003	2.21	1
				Intercept	<0.001	0.329	12.48	—
	0.31	0.015	–163.3	Equid biomass density	0.084	–0.015	–1.81	0.88
				Growing period precipitation	0.051	0.003	2.06	1
				Intercept	<0.001	0.315	14.51	—
	0.24	0.016	–163.1	Winter–spring temperature	0.079	0.012	1.84	0.82
				Winter–spring precipitation	0.035	0.002	2.25	1
				Intercept	<0.001	0.230	7.06	—

DISCUSSION

Different species of ungulates can influence plant communities in different ways. Large-bodied grazers and browsers have a higher demand for forage; thus even small populations of such species can exert an influence on their habitat that is proportionately greater than the effect of a larger population of smaller, lighter ungulate herbivores. The data from Sheldon and Hart Mountain refuges appear to illustrate this point. At population levels represented in our study, equid biomass density had a negative effect on greenness (i.e., ANPP). The effect of ungulate herbivory became more pronounced over the length of an entire growing season. Equid biomass density was more important than winter–spring precipitation in models of *average* growing-season NDVI. This result likely indicates that herbivory is a greater determinant of how much productivity is sustained on the landscape during the growing season, regardless of the favorability of growing conditions. However, the relative importance of equid density in our model of *maximum* NDVI (i.e., maximum ANPP) was slightly lower, indicating that precipitation has the greatest influence in determining peak production.

This landscape has a history of heavy grazing. Prior to the elimination of domestic livestock grazing in the early 1990s, biomass density attributable to cattle grazing was 2–4 times greater (3.4–5.6 $kg \cdot ha^{-1}y^{-1}$) at Hart Mountain than the current maximum ungulate biomass density. At Sheldon, cattle biomass density was roughly equivalent (3.0 $kg \cdot ha^{-1}y^{-1}$) to current ungulate biomass density (equids, bighorn sheep, mule deer, and pronghorn). However, for many of the years when cattle were present, pronghorn and horse numbers were substantially lower than they are currently. In the case of Sheldon, increases in pronghorn and horse numbers following cessation of livestock grazing may have led to a much lower reduction in overall grazing pressure than anticipated, because horses are filling some of the void and they are on the refuge year-round. Vegetation communities at Sheldon have likely not had an extended rest and recovery period from grazing by populations of large-bodied herbivores. At Hart Mountain, where previous livestock density was much greater and horse populations have been much lower, ungulate biomass density has dropped substantially and recovery of plant communities is much more likely.

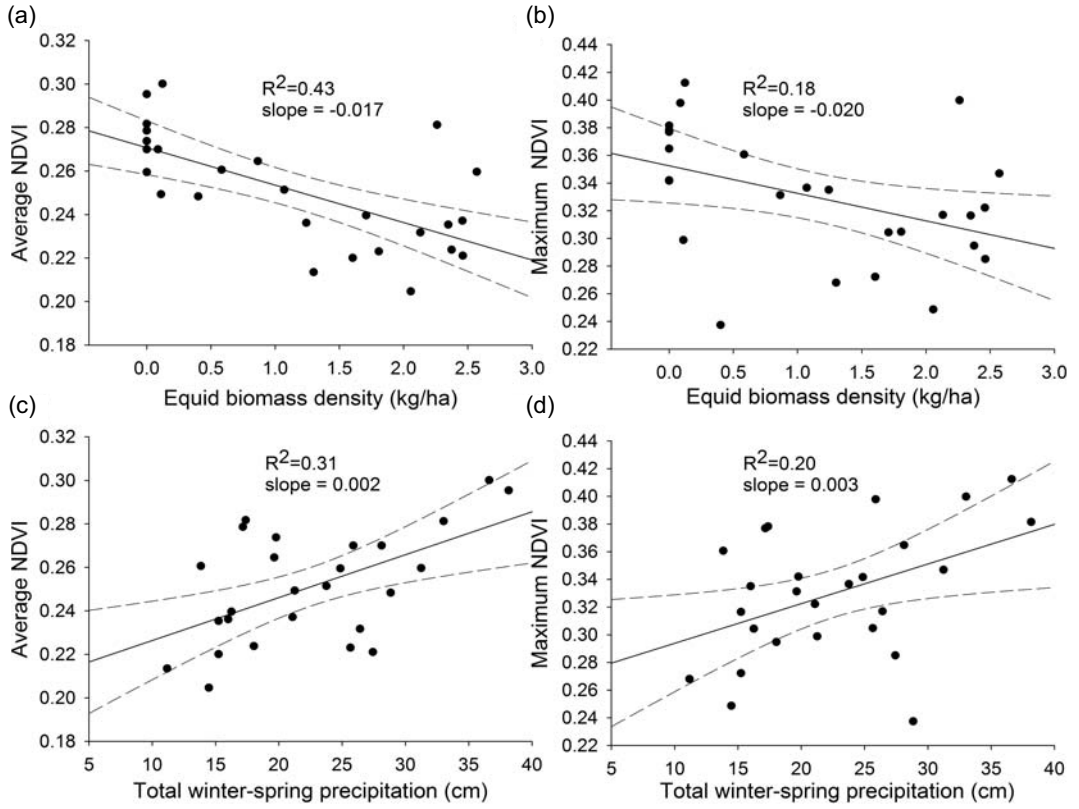

Fig. 4. Average and maximum NDVI were negatively influenced by increases in equid ungulate biomass density (a, b) but responded positively to increases in total winter–spring precipitation (c, d) at Sheldon and Hart Mountain National Wildlife Refuges. Dashed lines show 95% confidence intervals around the regression lines.

Feral horses are the least selective ungulate herbivores in the western United States (Hanley and Hanley 1982, Beever 2003). In contrast to other ungulates present in this area, horses are cecal digesters. This characteristic, in combination with large body size, places more time-energy constraints on the animal, thus reducing selectivity (Beever 2003). Due to this low selectivity, fewer plant species may remain ungrazed in areas populated by feral horses (Beever 2003). Compared to rumination, cecal digestion also requires higher consumption of forage per kilogram of body mass. These factors may increase the likelihood that equids in particular have a greater impact on vegetation communities during drought years. Herbivory does have a greater impact on forage in dry years than in wet years (Fahnestock 1998), as grazing can exacerbate the effects of lower precipitation on ANPP. Other studies have reported an herbivore effect on growing season NDVI that was greater in dry years than in wet years and greater at arid sites than at wet sites (Blanco et al. 2008).

Vegetation indices, such as NDVI, use light reflectance from green vegetation to determine a "greenness" level of a portion of a landscape. Therefore, increases in the amount of green biomass in a landscape should result in increases in this index. Conversely, factors that cause senescence of green vegetation or that reduce the amount of green vegetation would be expected to contribute to decreases in NDVI. Precipitation is directly correlated with plant productivity in semiarid grassland ecosystems (Sala et al. 1988). Abundant moisture can lead to higher plant biomass production (greening), whereas lack of moisture may lead to early senescence (browndown) or plant death. NDVI is more tightly coupled with precipitation in drier ecosystems (Fabricante et al. 2009), and interannual variation of annual NDVI is

also highly and widely correlated with precipitation accumulated during previous periods, depending on season and site (Fabricante et al. 2009). The relatively important rank of precipitation in our models for average and maximum NDVI during the growing season agrees with these findings. NDVI was lower, indicating lower ANPP, during years with low precipitation. Bradley and O'Sullivan (2011) observed no relationship between livestock grazing and NDVI at elevations above 2300 m in south central Idaho, and they attributed this result to greater amounts of precipitation at higher elevations.

Other factors that may decrease landscape greenness are reduction of biomass through removal by grazing and plant mortality caused by overbrowsing of shrubs and trampling of herbaceous vegetation. Bradley and O'Sullivan (2011) modeled livestock (domestic sheep and cattle) grazing interactions with NDVI and observed that decreased NDVI was most likely in areas with livestock grazing, but the extent of impact differed depending on land use and elevation. The presence of horses reduces vegetation cover (Beever and Herrick 2006), which agrees with our model results of lower NDVI values (thus lower ANPP) in areas with equids. Although the use of remotely sensed greenness data is a useful tool in examining these long-term trends, these data may be limited when used in the absence of empirical information from the field. Bradley and O'Sullivan (2011) cautioned that low grazing levels may result in decreased NDVI if ungrazed grasses appear less green in subsequent years due to standing dry biomass. These authors acknowledge that NDVI changes in most locations are due to a change in percent cover of some combination of grasses, shrubs, and forbs, but they caution that the exact cause of these changes cannot be determined without field study.

Our results emphasize the importance of considering both biotic and abiotic factors when examining vegetation productivity. Management actions based only on the influence of climate variables on NDVI without consideration of the density, body mass, and foraging habitats of herbivores (or, conversely, actions aimed only at reducing herbivore numbers or distribution without regard to factors such as elevation, precipitation, and temperature) could result in continued or greater negative impacts of herbivory, particularly in arid systems. In scenarios of potential climate change, increased temperatures may not only drive plant greenness, but also ungulate use of the landscape (Allred et al. 2013, Beschta et al. 2013).

Anecdotal evidence from Hart Mountain suggests that pronghorn use increased on the refuge during drought years due to available water sources. How herbivores use the landscape relative to annual precipitation was not investigated in this study, but that relationship could well be an important factor in determining herbivore impacts on NDVI. Additionally, the timing of precipitation can be important. In tallgrass prairie, greater late-summer precipitation increased weight gain of large ungulates, but greater midsummer precipitation decreased ungulate weights (Craine et al. 2008). The decrease in weight gain with greater midsummer precipitation was associated with increased grass stem production, which is synonymous with lower forage quality. Although quantity of overall vegetation biomass increased, the quality of vegetation decreased, resulting in lower weight gains for ungulates (Craine et al. 2008). We used NDVI as a proxy for ANPP, a measurement of vegetation productivity; however, NDVI cannot be substituted for measures of vegetation quality, which can also greatly impact the dynamics of large herbivore–habitat interactions. Therefore, NDVI data alone may not be sufficient for management use if the goal is to determine the habitat quality that is sufficient for animal health and production.

In September 2012, following 4 years of public involvement and planning, the U.S. Fish and Wildlife Service approved its Comprehensive Conservation Plan (CCP) for managing Sheldon NWR (USDI 2012), including the decision to remove horses and burros from the refuge by 2017. This decision was made in the interest of eliminating damage to habitats, including riparian areas; eliminating displacement of native wildlife and competition for forage and water resources; and removing risk to public safety by preventing collisions with vehicles on the highway through the refuge. It is difficult to predict the length of time to recovery of an ecosystem in response to horse removal. Several studies in western North America report no significant recovery of various ecosystem components even one to several decades after removal of the disturbing agent

(McLean and Tisdale 1972, Rice and Westoby 1978, West et al. 1984, Heske and Campbell 1991, Knapp 1992). Other studies from the same region have found that ecosystems experiencing removal of grazing disturbance can exhibit significant changes over both short- and long-term time scales (Laycock 1967, Dormaar et al. 1994, Dobkin et al. 1998, Beever and Brussard 2000, Beever et al. 2003). Beever et al. (2008) found that removing horses from landscapes where they once roamed can result in a variety of vegetation changes, including increased shrub cover, greater total plant cover, greater plant species richness, and higher frequency of native grasses in as short as a decade. Resource managers also need to consider the effects of global climate change and management strategies for mitigation. Researchers suggest that reducing the impact of current stressors on landscapes is a management strategy that can facilitate adaptation to climate change on public lands in the western United States (Beschta et al. 2013).

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