

Free-ranging horse management in Australia, New Zealand and the United States: socio-ecological dimensions of a protracted environmental conflict

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Abstract. Management of free-ranging horses (*Equus ferus caballus*) is a complex socio-ecological issue in Australia (AU), New Zealand (NZ), and the United States (US). In these countries, horses are the results of colonial introductions and occupy very harsh rangeland environments exerting a grazing disturbance that has generated ecological concerns. Although many social and ecological concerns are similar, each country also has nuances. In 2018, we conducted a field-based comparison of AU, NZ, and US using an inductive approach to identify similarities, differences, and emerging themes through conversations with >100 individuals from New South Wales Australia, the North Island of New Zealand, and the western US. Additional data sources included field observations and archival documents. Consistent emergent themes identified included: strong public emotion, politicization of management, population growth concerns, negative ecological impact concerns, agreement that horses should be treated humanely, disagreement as to what practices were the most humane, interest and scepticism about fertility control, the need for transparency, compromise to accommodating horses and acknowledgement of social values, and recognition that collaboration is the only means to achieve both healthy rangelands and healthy horses. Unique themes identified included: NZ empowering advocate groups to become part of the solution, conflict between horses and livestock is a mostly US conflict, equids originated in the US, concern about the sustainability of adoption programs, different expectations/options for management on private lands, cultural history such as brumby running in AU, permanent branding of horses in the US, litigation as a uniquely US strategy (although a judgement on recent AU litigation is pending), government data accepted to guide removals in NZ but not always in AU or US, and complex heterogeneous land surface ownership patterns makes management difficult in the US. The difficulty of horse management in these countries is attributed to social intricacies rather than biological/ecological gaps of knowledge.

Additional keywords: ecosystem management, feral horses, grazing management, herbivory, landscape ecology, rangeland management.

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Introduction

The management of free-ranging horses (*Equus ferus caballus*) is a complex socio-ecological issue in Australia (AU), New Zealand (NZ), and the United States of America (USA) (Fleury 2006; Nimmo and Miller 2007; Scasta *et al.* 2018; Driscoll *et al.* 2019) (Table 1). In each country, these horses occupy very remote and harsh environments (Fig. 1) and exert an ungulate grazing disturbance that has generated ecological and conservation concerns (Rogers 1991; Nimmo *et al.* 2007; Davies *et al.* 2014). Management of these horse populations has proven to be quite difficult for several reasons including the cultural value

assigned to the animals and the subsequent intense level of emotion (Scasta 2018) and public outcry against any management (i.e. the ‘political ecology’ of wild horse management, see Rikoon 2006 (USA example) and Notzke (2013) (Canada example)). Consequently, polarising viewpoints about the impacts (‘ravaged western lands’, see Rogers 2016) relative to the subsequent approaches to management (‘government’s systematic removal and eradication of an American icon’, see Wagman and McCurdy 2011) have emerged. In addition to the social and ecological concerns associated with free-ranging horses, the economic burden of these unmanaged horses is

Table 1. Comparison of free-roaming horse characteristics for Australia, New Zealand, and the United States

Characteristic	Australia	New Zealand	United States
Horse population estimate ^A	~400 000	<800	~200 000
Human population estimate ^B	25 203 000	4 783 000	329 065 000
Human : horse ratio	63 : 1	5979 : 1	1645 : 1
Ecological concerns ^C	Yes	Yes	Yes
Welfare concerns ^D	Yes	Yes	Yes
Federally protected ^E	No	Yes	Yes
Jurisdiction ^E	Variable	DoC, army, private	Federal government
Native ^E	No	No	Yes, Extinct ~10000 years
Introduction/reintroduced ^F	1788	1814	1493
Cultural heritage ^G	Yes	Yes	Yes

^AGarrott and Oli (2013); Nimmo and Miller (2007); NZ DOC (2018); Scasta *et al.* (2018); US GAO (2017).

^BUnited Nations Population Estimates for 1 July 2019.

^CBoyd *et al.* (2017); Cowan and Tyndale-Biscoe (1997); Driscoll *et al.* (2019); Hall *et al.* (2016); Rogers (1991).

^DChapple (2005); CPR (2018); Fleury (2006); Hampton *et al.* (2016a, 2016b); ITRG (2016); Monahan (2012); Straight Talk (2015); US GAO (2017).

^ENZ DOC (2018); NSW OEH (2016); Public Law 92-195 (1971).

^FANHM (2018); Mincham (2008).

^GNew South Wales Parliament (2018); NZ DOC (2018); Scasta (2018).

significant. In the US the accumulated cost of managing horses removed from the range and held in captivity from 2013 to 2030 is predicted to exceed \$1 Billion USD by 2030 under the current management scheme, with a predicted annual cost of \$67 million after 2030 (Garrott and Oli 2013; Garrott 2018). An example of the socio-ecological difficulties of managing horses is illustrated in the aerial shooting of 603 horses in Guy Fawkes River National Park in AU in 2000, which led to public outcry and litigation (Chapple 2005). Further complicating the issue at a global scale are the evolutionary origins of horses with humans in an intimate trust relationship up until recent times and anthropomorphism of horses (Kelekna 2009; Karlsson 2012; Scasta 2018). Finally, horses present a persistent natural resource issue with implications for both conflict resolution and governance (Redpath *et al.* 2013).

Origins

Important distinctions about the origins of horses in these three countries are necessary to establish with greater detail the current context relative to evolutionary histories of the flora and fauna of ecosystems. Native equids did occur in North America until their extinction ~10 000 years ago (Guthrie 2003), but in AU (Mitchell 2015) and NZ (Mincham 2008) native equids were never present. In fact the AU continent and NZ island ecosystems evolved without any hard hooved grazers such as cattle, deer or horses until their introduction with European colonisation some 200 years ago (Pickering *et al.* 2010; Wood and Wilmshurst 2017). In North America, these native equids represented at least 12 different species that had a wide range of body sizes and differing foraging preferences as some preferred to browse on shrubs and trees (i.e. the smaller *Hypohippus*), whereas others preferred grasses (i.e. the larger *Dinohippus*) (ANHM 2018). In addition, some even had three toes, different from the single toed horses of today. It is postulated that equids crossed the land bridge to Asia some 20 million years ago and consequently spread across the other continents (Kelekna 2009). The extinction of equids in North America during the late

Pleistocene epoch is speculated to have been caused by a combination of environmental change, disease and human hunting (Barnosky *et al.* 2004; Donlan 2005). Thus, relative to origins, extinctions and anthropogenic dispersion, horses in all three countries are descendants of domesticated horses brought by colonial explorers in 1493 (USA), in 1788 (AU) and in 1814 (NZ) (Cowan and Tyndale-Biscoe 1997; Parkes and Murphy 2003; Mincham 2008; Kelekna 2009; Beever and Aldridge 2011; Mitchell 2015) (Table 1).

The horses of today likely have different evolutionary histories than the native equids of North America given the history of domestication (Levine 1999), anthropogenically-induced migrations (Kelekna 2009) and re-introductions. Consequently, this complex human-horse history can lead to disagreement about labelling of these free-ranging equids as 'feral' or 'wild' animals (Bhattacharyya *et al.* 2011). Although the terms 'feral' and 'wild' are often used interchangeably, they have very different connotations. These connotations can be negative for 'feral', a word implying an organism was once domesticated but is now wild, as an implication of an organism that is out of place and does not belong, or they can be positive for 'wild' as an appeal towards the romanticism of beauty and place (Rikoon 2006). Such labels and status can influence policy. For example, in AU horses were first recognised as a feral pests in the 1860s (Prott 2007), and the notion of 'feral' was reflected in federal legislation in the 1975 Australian National Parks and Wildlife Conservation Act. This Act stipulates that exotic animals are to be exterminated or controlled in order to protect the parks' natural and native values, specifically for federally managed parks, but not necessarily for parks and conservation tenures under separate state legislation, although it is noteworthy that this was repealed by the Environmental Reform Act of 1999 (Australian Government 1975). Similar legislation exists in NZ for all National Parks, but with no such overarching requirement for other public lands. A contrasting example is the notion of 'wild', which is reflected in the 1971 USA Wild Free-Roaming Horses and Burros Act (WFRHBA) that is predicated on these horses as '*living symbols of the historic and pioneer spirit of the*



Fig. 1. Robust populations are a concern in (a) United States of America, (b) New Zealand and (c) Australia.

West (Public Law 92-195 1971). Because such labels can be a distraction from more constructive dialogue (Bhattacharyya *et al.* 2011), we henceforth refer to horses in this paper as ‘free-ranging’. Related to connotations of labels, societal values and the acceptance of science as it relates to invasive species denialism must also be considered in how we communicate about a species (Munro *et al.* 2019).

Status of protection

The status of protection for these horses is also variable among countries. In the USA, the 1971 WFRHBA established protection of horses through the opening statement ‘To require the

protection, management, and control of wild free-roaming horses and burros on public lands.’ (Public Law 92-195 1971). Although the 1971 WFRHBA requires both the management and control of horses, it also establishes that horses ‘contribute to the diversity of life forms within the Nation and enrich the lives of the American people; and that these horses and burros are fast disappearing from the American scene’, or in other words, implementation was out of concern for the persistence of horse populations. In addition, welfare of horses and the inhumane practices being employed at the time were also a large part of the impetus for the 1971 WFRHBA as additional language states that horses ‘shall be protected from capture, branding, harassment, or death’ (Aksentijevich 2014). In NZ, there is not legislative separation between national or regional authorities, and the Kaimanawa horses were provided protection in 1981 in the 4th Schedule of the 1953 Wildlife Act by declaring that they were protected within the specific area they were found at the time, in part due to the historical and intrinsic aesthetic values attributed to the horses (NZ DOC 2018; Kaimanawa Heritage Horses 2018). In AU, free-ranging horses, colloquially referred to as ‘brumbies’, are considered to be a cultural icon (Nimmo and Miller 2007), but have yet to be officially declared by the Federal government. However, recent recognition and protection for the horses inhabiting Kosciuszko National Park has been established through the Kosciuszko Wild Horse Heritage Bill 2018 with the objective to ‘to recognise the heritage value of sustainable wild horse populations within parts of Kosciuszko National Park and to protect that heritage through a wild horse heritage management plan’ (New South Wales Parliament 2018). This process and outcome has been examined in detail (Menyhart 2019; Riley 2019), and has attracted strong criticism, including three unsuccessful attempts so far to repeal the legislation. However, the 2019–2020 wildfires in south-east AU have significantly increased the potential for horse impacts in Kosciuszko and adjacent areas, and new programs for reductions in number have been announced (Reardfern 2020).

Current horse populations

Currently, AU and USA have more free-ranging horses than any other nation globally with approximately ~400 000 and ~120 000 respectively (Nimmo and Miller 2007; Scasta *et al.* 2018) (Table 1). The USA horse estimates are nuanced because the most touted numbers generally only reflect horses on public land under the purview of the Bureau of Land Management (BLM) and do not include tribal lands. For example, March 2020 estimates of BLM horses and burros are 137 073 (71 892 horses on-range and 47 641 in temporary holding; 16 198 burros on-range and 1342 in temporary holding) (BLM 2020). Additionally, USA Forest Service March 2020 estimates of horses they manage are 7100 horses and 900 burros (USFS 2020) and the current estimates of horses on USA tribal lands is estimated to exceed 90 000 today (US GAO 2017). However, even the number of 90 000 horses on tribal lands must be contextualised because this only represents the eight tribes participating in the National Tribal Horse Coalition (NTHC), including Navajo and Yakama, and the GAO report includes a footnote stating ‘For tribes where a population range was reported, GAO generally used the lower end of the range. GAO did not find an estimate for

the total feral population' (US GAO 2017). A 2017 study suggests that the Navajo Nation alone may have more than 38 000 horses (Wallace *et al.* 2017). In NZ there are 2–3 small populations of free-ranging horses with the Kaimanawa herd estimated to currently be 300–400 with no recent estimates for other populations (NZ DOC 2018) (Table 1). The AU history of dealing with other wide-spread invasive mammals such as buffalos, camels, goats, and pigs (Cowan and Tyndale-Biscoe 1997) including free-ranging horses, has included the use of tools such as aerial shooting (O'Brien 1987; Carrick *et al.* 1990; Edwards *et al.* 1997; Drucker *et al.* 2010; Hampton *et al.* 2016a). Aerial shooting has also been used in the USA for feral pigs (Campbell *et al.* 2010). However, the use of these tools has not been without criticism about welfare (Hampton *et al.* 2016b) and public dissent or political risk (Chapple 2005). NZ for example, currently has a fraction (<1/50th) of the horses compared with the USA and AU, and the largest human : horse ratio (Table 1) which has potentially allowed for a more successful adoption program as a population management tool, with advocate groups playing a much larger role in the facilitation of adoptions than in the USA. However, we note that NZ's land area is 28 times smaller than AU and 36 times smaller than the USA, and the NZ free-ranging horse population is orders of magnitude smaller than these countries respectively.

Indigenous perspectives

The perspectives of Indigenous people, relative to free-ranging horses, may be largely unrecognised and functionally different than for other communities (Robinson and Wallington 2012). For the context of this paper, this is referring to Aboriginal communities in AU, Māori tribes in NZ, and Native American Indian tribes in the USA. For all of these, the arrival of the horse into their cultures was transformative to various degrees in everyday life (Mitchell 2015). For some Native American Indian tribes, the transformation was dramatic as the horse allowed for enhanced travel and hunting of buffalo (Mitchell 2015). In 1493, Columbus made his second voyage to North America and brought 50 horses which were noted to have scared the Hispaniola people so strongly that they fled to the interior of the island. By 1550, there were an estimated 10 000 horses in Queretaro in central Mexico. In 1680, Pueblo revolt against Spaniards led to the escape of thousands of horses – the 'nucleus' of the wild mustang herds of the American west (Kelekna 2009). By 1705, the Comanche people had acquired horses, immigrated to the Great Plains region, and emerged as a nomadic horse culture. Acquisition of horses led to the abandonment of farming and a more sedentary lifestyle, and an increase in the size of tribes and the territories occupied (Mitchell 2015).

For Aboriginal people in AU, horses and other newly arrived 'domestic' animals also found a range of places in their societies and livelihoods. Fijn (2017) argues that they 'adopted another kind of co-existence with [these] animals that did not include retaining them within a domestic sphere over successive generations through control, capture and containment'. Across AU, many Aboriginal people worked in the pastoral industry, and a strong identity with cattle and horse work is common still across northern AU (McGrath 1987). Trigger (2008) has argued that Aboriginal people

developed relationships with horses in ways that overlap with but are also different from native animals. In NZ, the outcome of Māori claims against the Crown (Government) for breaches of the Treaty of Waitangi will possibly see a resetting of management objectives for the Kaimanawa horses, and a greater recognition of Māori interest in these horses and the lands on which they roam which has extensive historical significance. In all three countries horses became a sort of security and currency that families depended upon in many ways. However, through time, settlement, and the industrial age, reliance on horses waned for most people in these countries. Yet Indigenous people may be carrying a large portion of the burden associated with growing free-ranging horse populations without the necessary agency. The recognition of this problem for USA tribes is reflected in the Facebook page for the NTHC with the phrase 'Indian Country's Voice on Horse Overpopulation' (NTHC 2018).

Given the complex socio-ecological dynamics of horse management in AU, NZ and the USA, our objectives for this work were to (1) identify broad themes related to social, biological, or ecological categories, (2) determine if themes were consistent across countries, and (3) identify knowledge gaps and information sharing opportunities to inform management in all three countries.

Methods

We convened an international exchange to facilitate engagement with University researchers, provincial or federal government managers, advocates, and members of the general public in AU, NZ, and the USA (Fig. 2). This facilitated interaction with 124 stakeholders representing a variety of affiliations in all three countries (Table 2). This relatively unstructured field-based inductive research methodology allowed for first-hand assessments of horses in both countries and for unstructured conversations with $n = 124$ individuals across the three countries to allow for the comparison and contrasting of the horse issues in the western USA to the large and extensive horse population in New South Wales, AU and to the small and confined horse population on the North Island of NZ (Fig. 1).

In our *a posteriori* approach, notes from each visit quantified and qualified consistent and unique/emergent themes within the social construct of each country. These themes were then synthesised into broad categories of 'Social', 'Horse Biology' and 'Ecological' and stratified by consistent (i.e. identified in all three countries) or unique (i.e. identified in only one country). By engaging with multiple stakeholder types in each country, pursuing focused but unstructured conversations, and then coding conversations for consistent and unique/emergent themes, we applied a modified grounded theory methodological approach to identify emerging free-ranging horse themes (Strauss and Corbin 1997). Such an inductive research approach is not bound by *a priori* hypotheses, but rather identifies patterns through a series of emerging themes and hypotheses through the process. By approaching active members of governmental organisations charged with managing horse populations, and stakeholders with an interest in horse welfare and advocacy, as opposed to random members of the public, we addressed

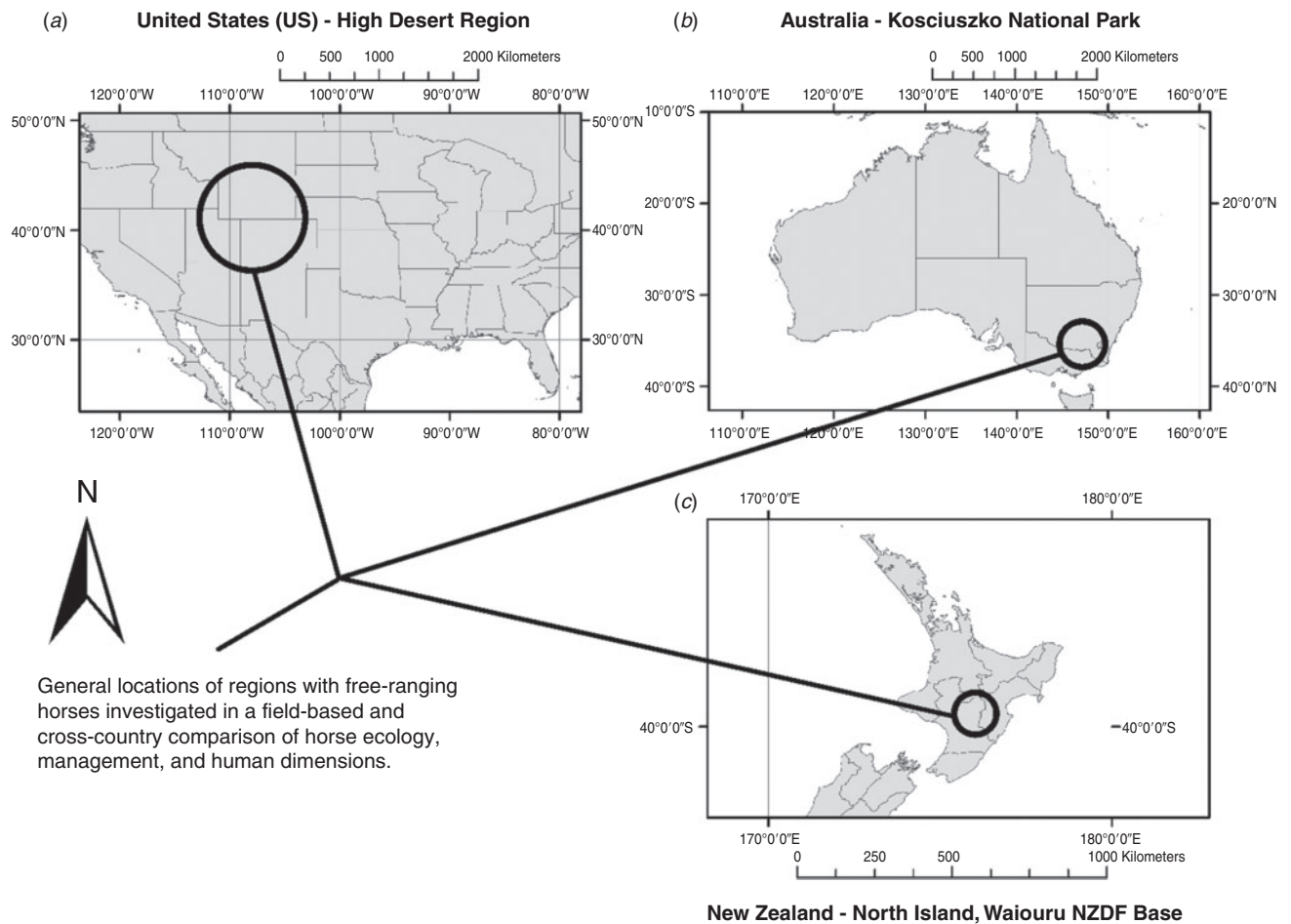


Fig. 2. Map showing the general locations of regions with free-ranging horses used in our first-hand assessments across countries for unstructured conversations with $n > 100$ individuals to allow for the comparison and contrasting of the feral horse issues in the western USA (with a high-desert region with Wyoming as the centre) to the large and extensive brumby population in New South Wales, AU (in mountainous alpine areas) and to the small and confined Kaimanawa horse population on the North Island of NZ (in high-elevation grassy plateaus and steppe-like areas).

Table 2. Affiliations, sample size, and proportions (noted in parenthesis) of stakeholders involved in unstructured field-based conversations about free-roaming horses as stratified by country

Affiliation	Australia	New Zealand	United States	Sum
Activist/advocate	4 (36%)	6 (12%)	5 (8%)	15 (12%)
Equine health representative	0 (0%)	1 (2%)	0 (0%)	1 (1%)
General public	2 (18%)	2 (4%)	10 (16%)	14 (11%)
Government horse manager/pilot	2 (18%)	8 (16%)	7 (11%)	17 (14%)
Indigenous stakeholders	0 (0%)	1 (2%)	2 (3%)	3 (2%)
Media	1 (9%)	1 (2%)	2 (3%)	4 (3%)
Researcher	1 (9%)	4 (8%)	14 (22%)	19 (15%)
Stockmen/women (ranchers)	0 (0%)	3 (6%)	4 (6%)	7 (6%)
University student/faculty	1 (9%)	23 (47%)	20 (31%)	44 (35%)
Sum	11 (8.9%)	49 (39.5%)	64 (51.6%)	124

organisational hierarchies that affect public participation in the free-ranging horse issue. Because we did not have funding to survey all of the experts in each country, our results do not capture all of the diverse perspectives and contexts of

stakeholders, and therefore could be considered a case study that justifies a more robust elicitation survey in the future similar to Wiser *et al.* (2016). Such a survey could quantify what proportions of stakeholder types hold particular perspectives.

Finally, engagements with the range of stakeholders and managers were almost all conducted in field-based settings and actively engaging with the landscapes occupied by free-ranging horses, their managers and supporters. Using this approach allowed the researchers to engage more fully with the world of the interviewees, rather than just extracting information (Mason 2002; Hall 2008). Interviews based in 'landscapes of work' are increasingly used in qualitative research to expand and deepen the quality of data from the 'socio-materiality' of the subject (Dowling et al. 2016).

Results

Consistent emergent themes

Strong public emotion that includes pressure through social media and at times personal attacks on state and federal employees charged with managing horse populations

A shared experience that was articulated by stakeholders in all countries, particularly the state and federal managers, was extremely negative rhetoric from fringe groups directed at agencies and individuals in regards to managing horses. Symanski (1996) reported an example of distortion of facts by 'environmental fringe' groups relative to horse concerns. These have included derogatory remarks, conspiratory accusations, psychological competence questions and ethical implications. In addition, direct physical threats have also been experienced. This is further reflected in the rhetoric of a recent USA media headline that states '...horse advocates saddle up to fight BLM...' (Spillman 2018).

The community and stakeholder engagement process that was conducted to inform the preparation of the Draft Kosciuszko National Park Wild Horse Management Plan (OEH NSW NPWS 2016) experienced similar instances of strong public emotion and inappropriate stakeholder behaviour. The independent consultants noted 'It is important to note the wish to 'own' the conversation, because some of these over-engaged stakeholders have previously engaged in inappropriate and intimidatory behaviour towards those with alternate views. Environmental advocates in particular have felt threatened and intimidated by some of the tactics and past interactions they have had with some horse advocates, to the point that many are reluctant to speak up and express their opinions publicly. Within this engagement process, inappropriate behaviour was demonstrated by some horse advocates - labelling on social media a specific NPWS officer a 'Nazi' and making personal attacks on the character of NPWS staff.' (Straight Talk 2015, p. 3).

In NZ the initial preparation of a management plan for the Kaimanawa horses during 1991–1992 evoked similar responses, leading to the abandonment of the initial plan and the creation of a working group of stakeholders (of all persuasions) who, as a group, ultimately developed a plan for management of the herd that was adopted by Government in 1996. Strong emotions expressed by individuals continued to be a feature of the issue while management was implemented but have become much reduced in the last decade. This example provides a case study for conflict management that demonstrates a link between public response relative to their sense of powerlessness and

strategies that empower the public may be a conciliatory strategy that needs more exploration.

Concerns about the robust horse population growth

In every country, concern about burgeoning horse populations that may be exceeding the forage resources of the rangelands to a point of leading to other consequences were expressed (Boyd et al. 2017; NZ DOC 2018; Scasta et al. 2018; Driscoll et al. 2019). As such, this also included concerns about horses moving out of areas where they could be accommodated, and leading to satellite herds, herds in new areas, herds moving to higher elevations and potentially becoming snow bound, and herds moving into high traffic areas potentially increasing the risk of vehicle-horse collisions. There have also been indications that this may have a negative effect on horse welfare (American Veterinary Medical Association 2018), and in 2018 agencies/volunteers in the USA provided water for horses during dry periods or gathered (mustered) horses in emergency efforts (CPR 2018). In addition, in this year die-offs of large groups of horses (~200 horses) occurred on USA tribal lands around shrinking water sources (Phillips 2018).

Concern about negative ecological impacts in areas with high horse numbers

In every country, there was concern expressed about how high horse numbers and the subsequent grazing could have a negative ecological impact on the soil, plants and animals (Fig. 3a) (Rogers 1991; Boyd et al. 2017; Cherubin et al. 2019). This was very pronounced in Kosciuszko National Park (KNP) where concern about trampling of *Sphagnum* moss in riparian habitat for the broad-toothed rat (*Mastacomys fuscus*) may be negatively affected by horses (Eldridge et al. 2019). This is important because *M. fuscus* has 'Vulnerable' status in AU. Evidence of such horse impact is possible through the establishment of long-term grazing exclosures in the southern portion of KNP near the border between New South Wales and Victoria (Fig. 3a) (Norman 2018). Such concerns for grazing sod tussock wetland areas in general was also expressed and visible (Fig. 3b). Preferences for riparian type areas was obvious in all countries (Fig. 4a), and similar concern surrounding riparian area use and total biodiversity have also been expressed for the USA (Boyd et al. 2017). In AU, The New South Wales Threatened Species Scientific Committee, established by the *Biodiversity Conservation Act 2016* (the Act), has made a Final Determination to support a proposal to list habitat degradation and loss caused by feral horses as a Key Threatening Process in Schedule 4 of the Act (NSW Threatened Species Scientific Committee 2018). Specifically, this determination lists 23 native flora and eight fauna species that are State or Federally listed as vulnerable, endangered, or critically endangered and which are likely to be adversely affected by horses (NSW Threatened Species Scientific Committee 2018) as horses can use a wide range of habitat types (Fig. 4b). Another concern expressed in the USA is the effects that horse grazing has on habitat in the sagebrush steppe and subsequently the 'Near Threatened' Greater sagegrouse (*Centrocercus urophasianus*) populations (Beever and Aldridge 2011) and other more common wildlife species (Hall et al. 2016; Gooch et al. 2017; Hall et al. 2018). In NZ,

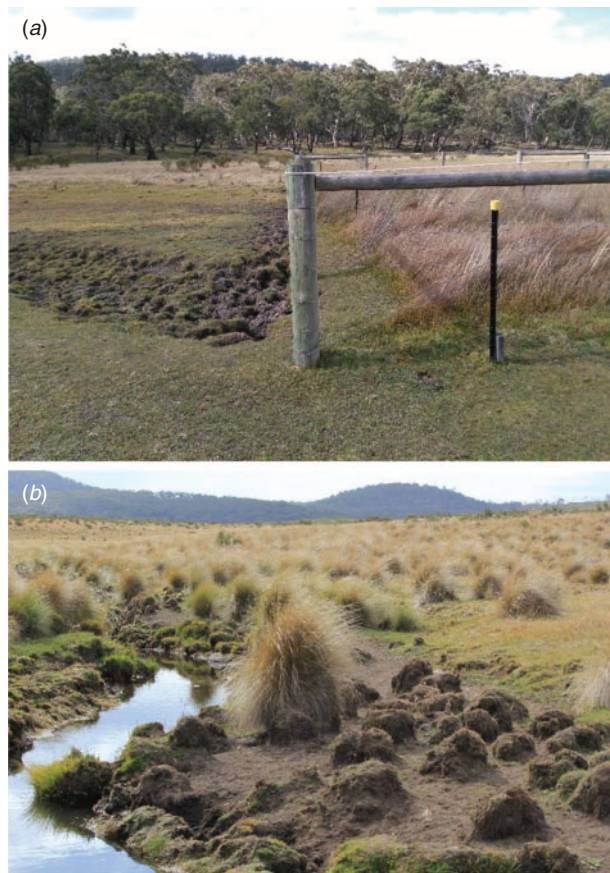


Fig. 3. Negative effects of horse grazing are a concern in all three countries. (a) Long-term horse grazing exclosures at the southern border of Kosciuszko National Park along the division between New South Wales and Victoria. The left side is exposed to horse grazing and the right side is protected from horse grazing. (b) Sod tussock wetland area with horses and deer as the only hard hoofed ungulates grazing the area. Walking in to this particular spot, at least 4 mobs of horses were observed within a 1000 m radius consisting of at least 35 total horses. Incising and draining of the wetland area is apparent.

this concern was (and remains) similar, but horse populations have been able to be managed to largely exclude horses from discrete habitats highly valued for biodiversity, and confined to habitats where environmentally sustainable outcomes are more achievable. Specifically, excessive horse grazing in tussock grasslands of the central NZ plateau could be detrimental to floristic diversity, rare plant populations and landscape conservation values (Rogers 1991). Yet these tussock grasslands are disturbance-dependent systems that may benefit in the long-run from some level of managed herbivory. **The evidence from all three countries suggests that any concentrated or unmanaged grazing could have ecological effects not uniformly accepted by all parties.**

Agreement by all parties that welfare and humane treatment are a priority

In each country, there seems to be strong consensus that treating horses with a high level of humaneness was a top priority. This agreement about the importance of humaneness is evident in the 2015 Community Engagement Report where the



Fig. 4. Horses are documented to use a diverse range of habitat types in all three countries including (a) disproportionate use of the greener and wetter riparian areas and (b) forested and woodland areas in Kosciuszko National Park.

authors of the report reviewed the KNP Wild Horse Management Plan (Wass 2015) and concluded ‘*Although environmental advocates indicated effectiveness was the most important consideration in a control method, both they and horse advocates identified humaneness as being important*’. In addition to the perceptions of the different stakeholders, agencies managing horses also adhere to a high level of welfare and animal care as demonstrated at the NZ horse gather where two veterinarians were on site for all activities and evaluated each horse for any health or injury issues, which is similar to any USA helicopter gather activities. All wild horse management activities within NSW National Parks are conducted in accordance with all relevant national and state animal welfare legislation, regulations, standard operating procedures and codes of practice including consultation with and review by the state animal welfare agency NSW RSPCA (NSW OEH 2016).

Disagreement about what is defined as humane treatment

Stakeholders with whom we have interacted articulated the difficulty in defining humane treatment options for horses. For example, in both AU and NZ we discussed whether it was more humane to (1) capture, load, transport, and place into long-term holding facilities, (2) capture, load, transport, and then slaughter at an abattoir or knackery, (3) slaughter horses with aerial shooting *in situ*, (4) slaughter horses on site in a trap, or (5)



Fig. 5. Strong interest in the use of helicopters for aerial gathering (or mustering) was expressed in Australia and discussions about barriers to the use of aerial gathering also was a common point of discussion. This image is from the 2018 Kaimanawa horse muster on the Waiouru Army Base on the North Island of New Zealand.

allow populations to self-regulate and allow horses to die when populations exceed forage or water capacity. The stress caused by transportation of horses via truck and trailer from very remote areas was also discussed as the roads are often two-track roads with little to no development or potential for aerial gathering (Fig. 5). In addition, the notion of what is ‘remote’ varies across countries, with much greater distances from capture to handling facilities in AU and USA than in NZ, but with expressed concerns about this issue in all three countries. Stakeholders have also expressed a variety of emotional concerns for all of the options, with no clear agreement. This was further reflected in AU by Wass (2015) as ‘... *there is not a shared view of what humaneness means*’. NSW NPWS in preparing its Draft KNP Wild Horse Management Plan (NSW OEH 2016) utilised the *model for assessing the relative humaneness of pest animal control methods* (Sharp and Saunders 2008), which is an empirical model that provides a practical, general means of assessment that can be applied to any control method. The goal of humaneness assessment is to evaluate the impact of a control method on individual animals and to use this assessment to determine which methods are more or less humane compared with other methods (ITRG 2016). Dialogue about humane treatment and horse welfare have also been extensively debated in the USA with varying levels of consensus (Monahan 2012).

Interest and questions about fertility control

In all three countries, one of the most consistently asked questions was about the feasibility of fertility control. Stakeholders of all types wanted to know about the efficacy of chemical immuno-contraception (and in some cases intrauterine devices or IUDs). Specifically, stakeholders want to know if the feasibility of deploying the products to horses with large flight zones on extensive landscapes and the cost of such strategies may limit the practical application and deployment of contraception (Rutberg *et al.* 2017; Kane 2018). *The challenges, practicalities and limited viability of utilising current fertility control technologies to achieve population control objectives within a landscape-level and free-ranging wild horse setting*

such as Kosciuszko National Park was further confirmed through independent expert analysis (Hobbs and Hinds 2018). Specifically, Hobbs and Hinds (2018) concluded that the use of fertility control as the sole technique for halting population growth is not feasible in AU. Thus, it seems that the combination of gathering/mustering coupled with chemical immuno-contraception and horse release would be required to deploy vaccines (Rutberg *et al.* 2017). In addition, single treatment has not been as effective as multiple treatments that include a follow-up booster (Rutberg *et al.* 2017) and sustainable contraception solutions may require single shot and irreversibility (Hall *et al.* 2017). *To date, a ‘good treatment that is safe, practical, effective, and long lasting has not yet been developed’* (Kane 2018). It also appears that if an effective product and cost-efficient deployment method can be developed, stakeholders in all three countries would be highly interested. It also appears that *much of the research on fertility control is being conducted in the USA, particularly on the use of porcine zona pellucida (PZP) and the GnRH vaccine (Gonacon™)*, with a renewed interest in surgical sterilisation and IUDs (Kane 2018). However, the stakeholders in AU and NZ are highly interested in this research and there is a ripe opportunity for more information exchange or international collaborative research.

Transparency is critical for any horse management activity

Contemporary horse management in all three countries requires full public transparency, and every group seems to buy into that concept. Many people in each country clearly expressed that there is no advantage to hiding any activities, and that the more transparent the management approach the better. However, the emotive response from some stakeholder groups and individuals, with the resultant unacceptable behaviour of threats, harassment and intimidation towards management agency staff and the politicisation of horse management has made full transparency challenging. *In the USA, such transparency is mandated through a systematic review and approval of all activities*. Such transparent auditing of wild herbivore management is suggested to benefit community support (Hampton *et al.* 2016a). A small population of horses also occurs today in Argentina, and calls for transparency of authorities during herd reduction programs have been made (Scorolli 2018).

Conservation and land management organisations have shifted their position to accommodate some horses

Our results indicate that the trade-off between completely eradicating horses in some areas, and not managing horses at all in other areas, has been a compromise on behalf of land management agencies to accommodate some horses. An example is seen in the KNP Draft Horse Management Plan (NSW OEH 2016) that articulates the presence of horses as a contribution to nationally significant cultural and social values. It is here that the only AU alpine and subalpine areas exist, and arguably these areas are being negatively impacted by horses. However, the new draft plan explicitly states that cultural and social values can be preserved by permitting a population of 400–800 horses in the long-term in certain areas of the park (OEH NSW NPWS 2016). Similarly in NZ, the Kaimanawa Wild Horses Working

Plan 2012–2017 has articulated the objective of managing a herd of ~300 horses (NZ DOC 2018) although it is noted that the overarching Kaimanawa Wild Horses Plan December 1995 (NZ DOC 2018), under which the working plan was developed, provides for future review of this objective. In the USA, the nationally mandated Appropriate Management Level (AML) is 26 715 horses and burros, although the national population has exceeded that level for many years (Scasta 2018). Another shift has been away from the use of the term ‘feral’ to the use of the term ‘wild’ to more rapidly achieve effective dialogue between groups (OEH NSW NPWS 2016).

Collaboration among all stakeholders is the only way healthy horses and healthy lands are attainable

The need for collaboration between interested stakeholders was articulated in each country as necessary to improve both horse and land management. It is important to note that in each country private organisations are working to help horses, including helping with adoption (NZ), running eco-sanctuaries (USA), training and adopting out horses (AU), and contributing to larger dialogue (all countries). Specifically, the current situation in NZ illustrates this notion because without collaboration it would be significantly more difficult. It is successful because horse advocates, conservation agencies and the land occupier (in this case the NZ Defence Department) are working very intimately to conduct a professional muster based on accepted population estimates, and to rehome as many horses as possible. Horse advocacy groups play a particularly important role in NZ because they run the adoption program. A similar example is also apparent in KNP, where the government agency has proactively integrated input from the public through online forums and in-person meetings to assist in drafting a management plan to actually pursue management objectives. It was found that, ‘*The management of the review of the wild horse management plan, and the community and stakeholder engagement associated with it, is complex. Engaging and negotiating with stakeholders alone will not result in a successful long-term outcome. Listening to, educating and engaging with the broader community is also necessary.*’ (Straight Talk 2015). **Like the issue of transparency, poor behaviour such as threats, harassment and intimidation towards management agency staff, along with politicisation of horse management has presented barriers to effective collaboration.** In the USA, collaboration among all stakeholders will be necessary to improve the current situation. Researchers in NZ described the political nature of horse management as a chance to turn the debate into collaborative opportunity (Linklater *et al.* 2002).

Horses as cultural icons in the media

In each of the three countries, horses have a special cultural heritage that is unique yet similar in terms of popular horse stories available in print, shows and movies. Movies such as ‘Flicka’ (USA; Pickel-Chevalier 2017) and ‘The Man From Snowy River’ (AU; White 2009), cartoons such as ‘Spirit Riding Free’ (USA) and ‘The Silver Brumby’ (AU) and reality television shows such as ‘Keeping up with Kaimanawas’ (NZ) have established wild horses as a cultural icon representing freedom. In each of these examples, generations of Aussies, Kiwis and Americans have been exposed to the idea of wild horses. In some

cases, a high level of anthropomorphising is a central theme of the media product which has been referred to as the ‘*invention of the contemporary human-horse relationship through an ‘alter ego’ paradigm*’ (Pickel-Chevalier 2017), whereas in others the demonstration that horses have value is the central theme. Recent media efforts have also sought to bridge the gap between demonstrating horse value while articulating the difficult and contentious situation, including the recent USA movie ‘Unbranded’ (<http://watch.unbrandedthefilm.com/>, accessed 18 May 2020; Fin and Fur Productions, LLC 2018) and the AU documentary, ‘The Man From Cox’s River’ (<https://www.themanfromcoxriver.com/story.html>, accessed 18 May 2020).

Innovative efforts to demonstrate value of horses

Similar efforts to demonstrate the value of free-ranging horses as saddle horses have been undertaken in all countries. This includes the ‘Stallion Challenge’ in NZ (Kaimanawa Heritage Horses; <https://kaimanawaheritagehorses.org/20142015challenge/results/>, accessed 18 May 2020), ‘Australian Brumby Challenge’ in AU (<http://www.australianbrumbychallenge.com.au/>) and the ‘Extreme Mustang Makeover’ in USA (<https://extrememustangmakeover.com/>, accessed 18 May 2020). In each of these efforts, trainers are given an untamed horse and a set time period to train it. The time period to go from wild to tamed in the competition events is 150 days in AU and NZ, and 100 days in the USA.

Unique examples

Empowering advocate groups to become part of the solution

This aspect is particularly evident in NZ where Kaimanawa Heritage Horses and Kaimanawa Wild Horse Preservation Society, both private advocacy groups, are running the adoption and re-homing efforts (Kaimanawa Heritage Horses 2018), and have agreed on a common approach to potential adopter approval. This is a substantial undertaking that includes taking applications, inspecting homes in order to approve adoptions and coordinating the trucking. As part of the process of taking applications, potential adopters must have two professional references from such reputable professionals as veterinarians, must have certain height of fences, and must convey a general sensibility about adopting the horse. In addition, equine products companies have partnered with the groups to provide health products to go home with each horse adopted. Although the process and collaboration seems to work very seamlessly today, multiple individuals indicated that it is the result of ~20 years of efforts to get to this point. No such proxy exists in AU or USA, where advocates run the adoption and re-homing program from start to finish.

Within Kosciuszko National Parks wild horse management program, NPWS attempts and encourages rehoming or domestication of wild horses via established rehoming or rescue groups and interested individuals within the community. Since 2010, NPWS has publicly advertised and maintained a register of individuals who are interested in rehoming a Kosciuszko wild horse. Public demand for wild horses from the trapping and removal program varies, but has averaged around 26% of the 3600-plus horses removed from KNP since 2002. NPWS and wild horse rehoming groups have identified several issues and concerns around the rehoming and domestication process

including: (1) low public demand, (2) illegal release of adopted horses on public lands, (3) need for more training and better facilities for adopters, (4) need for greater public awareness of the adoption program and value of horses, (5) need to streamline holding and pick-up process of adopted horses, (6) need for more volunteers for rehoming/rescue groups, and (7) concern adopted horses will be used for rodeo/brumby running events with questionable animal welfare standards. These issues present challenges to both NPWS and rehoming and rescue groups in terms of resourcing capacity, as well as relevant jurisdictional responsibility (NSW OEH 2016).

Conflict between domestic livestock and horses is a uniquely USA conflict with some exceptions in Australia

In the USA this is a major issue because most horses occur on BLM land that may also be leased for livestock grazing or may adjoin private land leading to concern about competition for forage (Scasta *et al.* 2016, 2018). In NZ, there are few livestock grazing on the Waiouru Army Base or other areas where free-ranging horses occur. This was not always the case, with cattle, sheep and horses sharing range until the early 1990s. NZ Army cancelled grazing licenses in part to reduce pressure on natural grasslands in pursuit of the goal to retain the natural character of the area. In AU the conflict between livestock and horses is highly variable. In KNP livestock grazing begun to be phased out in 1944, with all stock grazing access removed by 1969. Similarly, in Victoria livestock grazing was phased out from these conservation areas by 2005; however, these areas continued to be occupied by horses. Moreover, in the Northern Territory the co-occurrence of livestock and horses is not uncommon (Symanski 1994). In South AU, private land with free-ranging horse populations became national park, stimulating controversy about the ongoing presence of the horses (Peace 2009).

Arguing that contemporary free-ranging horses are a restored native species requiring endangered species protections is a uniquely USA situation

Given the evolutionary history of native equids in North America, there has been some advocating for the management of contemporary free-ranging horse herds as a restored native species (Kirkpatrick and Fazio 2010). Although the complexities of that argument are beyond the scope of this paper, the point is that this is a uniquely North American theme. Moreover, this argument has also been part of the basis, along with the notion of North American horses on USA public lands as a distinct population segment of horses, in the petition for listing horses as an endangered species under the Endangered Species Act (ESA) (Harris 2014). It is also important to point out that the USA Fish and Wildlife Service (USFWS) found that listing horses as an endangered species was not warranted (US Federal Register 2015). Both claims, horses as native and threatened/endangered species, are unique to the USA.

Is adoption a sustainable solution even for extremely small and discrete horse populations like in New Zealand?

Although the current role of adoption of mustered horses as the management strategy in NZ is very positive and

encouraging, questions about its long-term sustainability arise. Specifically, can the adoption rate keep pace with the removal rate in the small island nation? In the USA and AU adoption has proven to not be the solution, but there are many more horses in these countries than NZ by several orders of magnitude. Moreover, the number of horses adopted in the USA has been on a downward trend over the last two decades (Scasta *et al.* 2018), but if horse populations were at AML the potential effectiveness of adoption might be greater.

Different expectations for private management of free-ranging horses

In the USA as stipulated in the 1971 WFRHBA, there is a penalty for harassing or killing horses when they are on private land. The 1971 WFRHBA explicitly states that any party that removes a horse from public land, converts one to private use, harasses or kills a horse without approval is subject to a maximum fine of \$2000 and/or a 1 year maximum prison sentence (Public Law 92-195 1971). This is quite different from AU, where there is an expectation for private citizens to manage horses on their private land and ultimately take management responsibility when appropriate. In NZ the adopted horses come under the umbrella of NZ's Animal Welfare Act 1999. This law has a purpose to ensure that owners of animals and persons in charge of animals attend properly to the welfare of those animals. In the USA however, it is important to note that the BLM has the responsibility and authority to remove horses from private lands when they wander onto them (Public Law 92-195 1971).

Cultural management of horses

The history and advocating for local citizens to manage horses with historical cultural practices varies across the three countries. For example, 'brumby running' or roping is an activity with historical significance in parts of AU where it was common practice for many years (Prott 2007). At certain times, brumby running by private citizens may have been the only active management of horses in the Australian Alps National Parks of the Australian Capital Territory (ACT), New South Wales and Victoria. Brumby running has been considered as a form of 'recreational harvesting' that can be a management strategy that suppresses populations to below carrying capacity (Dawson 2005; Prott 2007). Today, in some places, brumby running may still be practiced or advocated, however there have been growing management and stakeholder concerns as to the animal welfare, humaneness and efficacy aspects of the activity of brumby running or roping as a legitimate population control approach (ITRG 2016). In the USA such activities did occur in the late-1800s through the mid-1900s (Price 1996) but today would be a criminal offence. Regarding NZ Kaimanawa horses, this is not an issue as access to the land is not freely available because it is a military area. However NZ has a similar cultural history and occurrence of such activities is not implausible at the current time.

Permanent branding of horses only occurs in the USA

In the USA, any horse gathered receives a unique tattoo on the neck (Fig. 6). The method of choice in the USA is a freeze brand that is cryogenically cooled brand applied to the dermis



Fig. 6. Horses from the Bureau of Land Management (BLM) Antelope Valley Herd south of Wells, NV, USA displaying temporary identification tag and a permanent freeze brand tattoo on the left side of the neck. The freeze brand mark uses the International Alpha Angle System and includes the registering organisation, year of birth, and a registration number. Photos from the BLM public domain of (a) 4-year-old brown female, and (b) 3-year-old sorrel female (<https://wildhorsesonline.blm.gov/animals/14623850>, accessed 8 May 2020; <https://wildhorsesonline.blm.gov/animals/15623665>, accessed 8 May 2020).

of the left side of the neck (USDA APHIS 2017) (Fig. 6). The cold method of branding (as opposed to hot branding) has gained popularity in recent decades for welfare reasons (USDA APHIS 2017). In the AU and NZ, horses are not always branded or permanently marked. This creates difficulty in tracking horses once they leave the management and oversight of the agency. For example, it is virtually impossible to identify horses that have been captured, transferred to private ownership and then re-released back into the wild, or track and audit trapped and removed wild horses that enter the domestication or rehoming stream only to be later disposed of at abattoir or knacker. In NZ, agencies are of the view that there must be a clear change of ownership and therefore legal obligation on the new owner for its welfare once the horse is adopted.

Litigation seems to be a tool employed more frequently in the USA

The USA is considered to be the most litigious society in the world (relative to gross domestic product (GDP) and suits filed per capita), and suing the federal government is a common tool employed by different groups relative to agricultural, environmental, or conservation issues (Ramseyer and Rasmusen 2010; McKnight and Hinton 2013). Specific to the management of free-ranging horses, litigation is often filed 'for' managing horses and 'for not' managing horses which tends to paralyse horse management in the USA (Scasta *et al.* 2018). Stakeholders in AU and NZ indicated that litigation is not a tool employed by different parties in their countries at this time, but did articulate the concern that it could be employed in the future – a concern that has been realised as of December 2018 when the Australian Brumby Alliance Inc. filed suit against Parks Victoria Inc. in the Federal Court of Australia (Victoria Registry) challenging management authority of free-ranging horses on the Bogong High Plains within Alpine National Park (decision pending; Federal Court of Australia 2019). NZ's Department of Conservation noted that there had been legal challenges to its management proposals during the 1991–1996 period.

Government data accepted to guide removals

Advocates in NZ seem to accept government data that suggested horses were at excessive population levels and that appropriate management was necessary in order to improve horse health. This was articulated by advocates that confirmed that at higher populations the horses were in lower body condition with abnormalities noted by supervising veterinarians, and that gathering and removal has horses in better condition with more foals. **Census methods and populations estimates are a point of disagreement among stakeholders in the USA**, with variable opinions noted in AU (Walter and Hone 2003). In AU specifically, there is concern about visibility bias relative to the types of habitat horses might occupy (open rangeland versus woodland) that must be accounted for in census methods (Bayliss and Yeomans 1989). Population surveys and estimates along with environmental impact assessments and research carried out by government conservation land management agencies, regardless of their scientific rigour, are contested ground and refuted by horse advocacy groups (AALC 2015).

It has been further noted in the Australian Kosciuszko NP wild horse management situation, '*For many of these horse stakeholders there is also a complex history of government land management decisions and actions, such as the removal of high country grazing access, wilderness area declarations, and restrictions on recreational horse riding access, which have all created a sense that they have been displaced and disenfranchised by the declaration of the park.*' (Straight Talk 2015).

For example, in the USA the BLM conducts **annual population census** of horses and then develops population management strategies, yet a paper published in a law journal suggests that this is actually a 'national injustice' intended to 'eradicate an American icon' (Wagman and McCurdy 2011). In NZ similar conflicts over population estimates pervaded initial management efforts (Linklater *et al.* 2002), but the estimates are now rarely challenged as count efforts and techniques have improved (Linklater *et al.* 2004).

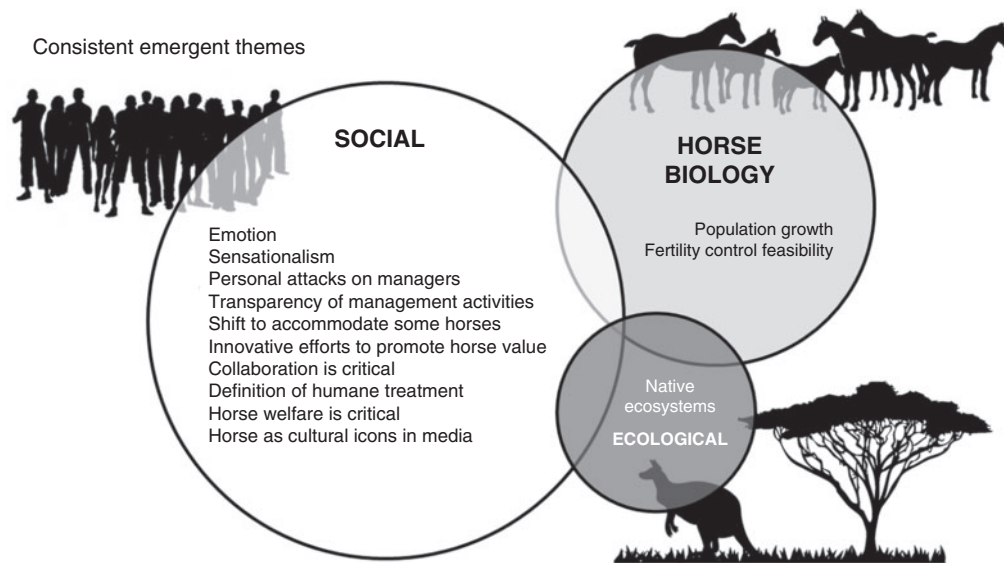


Fig. 7. Consistent emergent themes regarding free-ranging horses identified from a conducted a field-based cross-country comparison of USA, AU, NZ using an inductive research approach through conversations with more than 100 individuals from New South Wales, Australia including Wollongong and the Kosciuszko National Park region, the Kaimanawa horses and biannual muster from the Waiouru Military Training Area on the North Island of New Zealand, and from the western United States specifically Wyoming, Utah, Nevada, and California.

Heterogeneous surface ownership makes management difficult in the USA

In the USA, horses sometimes occur on large homogeneous areas in terms of surface ownership, but not always. For example, in the west there is an area known as the ‘checkerboard’ that consists of square mile sections that alternate in ownership between public and private, creating an unfenced checkerboard like pattern that extends 25 km both directions from a major highway easement (Hennig *et al.* 2018). In these areas, horses easily move through privately owned land. In NZ the Kaimanawa horses are mostly on public land, but some occupy adjoining private land where they are not managed as part of the management program. There are variable situations in AU.

Discussion

Our inductive field-based international comparison of free-ranging horses in AU, NZ and USA identified several consistent themes largely centred around social questions, with a few specific gaps in horse biology and population management knowledge (Fig. 7). The unique themes for these countries also centre around social questions, in addition to strong public emotion regarding horse management (Fig. 8). Moreover, each of these countries has examples of media efforts (cartoons, shows, movies) that have established horses as cultural icons and innovative approaches to demonstrate the value of these horses as riding horses. Thus, it appears that progress in horse management largely hinges on social aspects of how to do it appropriately, rather than simply asking more ecological questions and understanding how these themes emerge and change throughout the course of horse management projects.

The field-based approach in this study also allowed for the comparison of successful gather (muster) approaches,

particularly in NZ, where transparency among stakeholders is foundational, and collaboration across stakeholders is critical, particularly as it relates to the relative size of both human and horse populations and the ability to empower (Table 1). The notion of transparent collaboration was articulated as necessary to optimise land and horse health in all three countries, but how to facilitate collaboration, particularly of empowering advocate groups, remains a persistent difficulty in AU and USA.

We have also identified the need to better incorporate Indigenous voices in the discourse of horse management in all three countries. This need is underscored by the numbers of horses present on Indigenous lands, because Indigenous people may interact uniquely with introduced species, and because Indigenous people may be particularly sensitive or vulnerable to authoritarian management (as demonstrated for the Xeni Gwet’ in First Nation in British Columbia, Canada; Bhattacharyya and Larson 2014). This type of approach has been called ‘boundary work’ when describing the engagement of Indigenous knowledge systems to management of feral species in Kakadu National Park which has horses, pigs, and water buffalo, and worked to engage knowledge systems in co-management of these species (Robinson and Wallington 2012). In northern AU, novel approaches using fencing to manage a suite of species, including horses, helped to elevate Aboriginal preferences while preserving the socioeconomic value of horses (Ens *et al.* 2016). Such approaches could be particularly novel for American tribes that currently have robust populations of free-ranging horses but few to no mechanisms facilitating co-management. This may require the integration of novel management strategies with traditional methods, and a more prominent role of stakeholder engagement and participatory decision making, particularly in contributing to the foundational evidence for iterative management applications (White and Ward 2010). In the example of

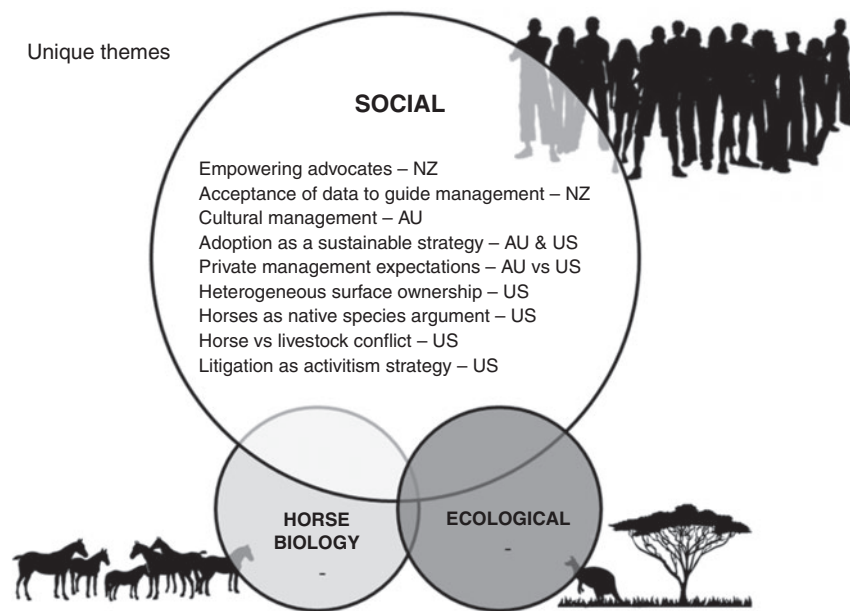


Fig. 8. Unique and emerging themes regarding free-ranging horses identified from a conducted a field-based cross-country comparison of USA, AU, NZ using an inductive research approach through conversations with more than 100 individuals from New South Wales, Australia including Wollongong and the Kosciuszko National Park region, the Kaimanawa horses and biannual muster from the Waiouru Military Training Area on the North Island of New Zealand, and from the western United States specifically Wyoming, Utah, Nevada and California.

managing feral swamp buffalo in northern AU, this type of situation has been called a ‘convergence of culture, ecology and ethics’ (Albrecht *et al.* 2009). Finally, it is imperative that Indigenous opinions receive more attention because they are likely not homogenous and include a diversity of perspectives (Vaarzon-Morel 2010).

An additional consistent theme across countries was the need for more systematic evaluations of humane treatment and welfare, particularly in the AU and USA. Examples that could be followed include the ‘Humaneness Assessment Panel Matrices’ approach that quantifies level of suffering in a 2-dimensional approach for less-more suffering for welfare before death and mode of death (Sharp and Saunders 2008). Such approaches should also evaluate these in the context of overpopulation and natural mortalities. These types of frameworks have a wide-range of applications beyond mega-fauna such as horses, and can help to balance human and animal health, ecological balance and economics (Littin *et al.* 2014). There is also a need to better understand all options, including no action or relocation, which could have health and behaviour consequences for free-ranging horses (Hampson *et al.* 2011; CPR 2018; Phillips 2018).

A critical knowledge gap that seems to have emerged from all three countries is the practical application of fertility control. There are no reliable methods that are easily administered in a cost-effective manner at a landscape scale. However, the majority of stakeholders appear to agree that fertility control is the tool in the toolbox that has the most promise but is least developed. The view that fertility control may be the answer to this dilemma must however be tempered with the scientific consensus which remains that their application as a sole management approach for

reducing wild horse population size is not an effective strategy in most situations (Hobbs and Hinds 2018). Certainly encouraging examples are available, such as horses on Assateague Island; however it is critical to note that the majority of horses were darted annually, that the number of horses at the beginning of the program was fewer than 150, and that it took 13 years for a decline in horse numbers to be achieved, with several additional years until the population target was reached (Kane 2018). In addition, fertility treatments may have other consequences including altered social structure (Nuñez *et al.* 2009; Madosky *et al.* 2010), delayed reproductive physiology (Nuñez *et al.* 2017; Nuñez 2018), increased stress physiology (Nuñez 2018), and increased reproductive behaviour from stallions towards treated mares (Ransom *et al.* 2010), that collectively justifies further investigation as fertility treatments develop or are widely applied. It is important to note finally that acceptance of fertility control is predicated on the assumption that horse populations need to be reduced, and not all stakeholders uniformly maintain that viewpoint.

Conclusions

The difficulty of free-ranging horse management in AU, NZ and USA is clearly attributed to the social intricacies of population management and the emotions humans express for horses. Pitt (1984) referred to the situation in the USA since the passage of the 1971 WFRHBA as a melodrama due to the ‘... *sensational, romantic, often violent action, extravagant emotions...*’ features that are characteristic of a fine melodramatic performance. Caught in the middle of the social disagreements and tensions are the horses themselves, which can suffer due to thirst and

starvation attributed to overpopulation on rangelands of limited productivity, particularly during periods of drought. In addition, the native plants, animals and ecosystems can also be negatively impacted and the lessons learned from horse management may be applicable to other species management issues.

A major result from our study indicates that there is a shift on the part of management agencies in both language used (feral vs wild vs free-ranging) and willingness to accommodate at least some horses. It also seems that there is an opportunity to further empower advocate groups through constructive solutions similar to that being done in NZ where volunteers run the re-homing efforts. Indigenous perspectives may also help guide western thought such as the Aboriginal cultural opposition to 'killing to waste', where both cultural and economic perspectives suggest that if it is necessary to take a life then the outcome should be useful in some way, either directly as food or other resources, or more indirectly as income. This is especially relevant in the remote regions of these counties such as in remote AU where there are very limited economic opportunities, and harvesting wild introduced species including camels, goats, water buffaloes, and horses are all sources of work and income.

Conflicts of interest

Scasta has received state and government funding to study horse spatial ecology. Gibbs and Fleury work for governmental agencies that manage horse populations.

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