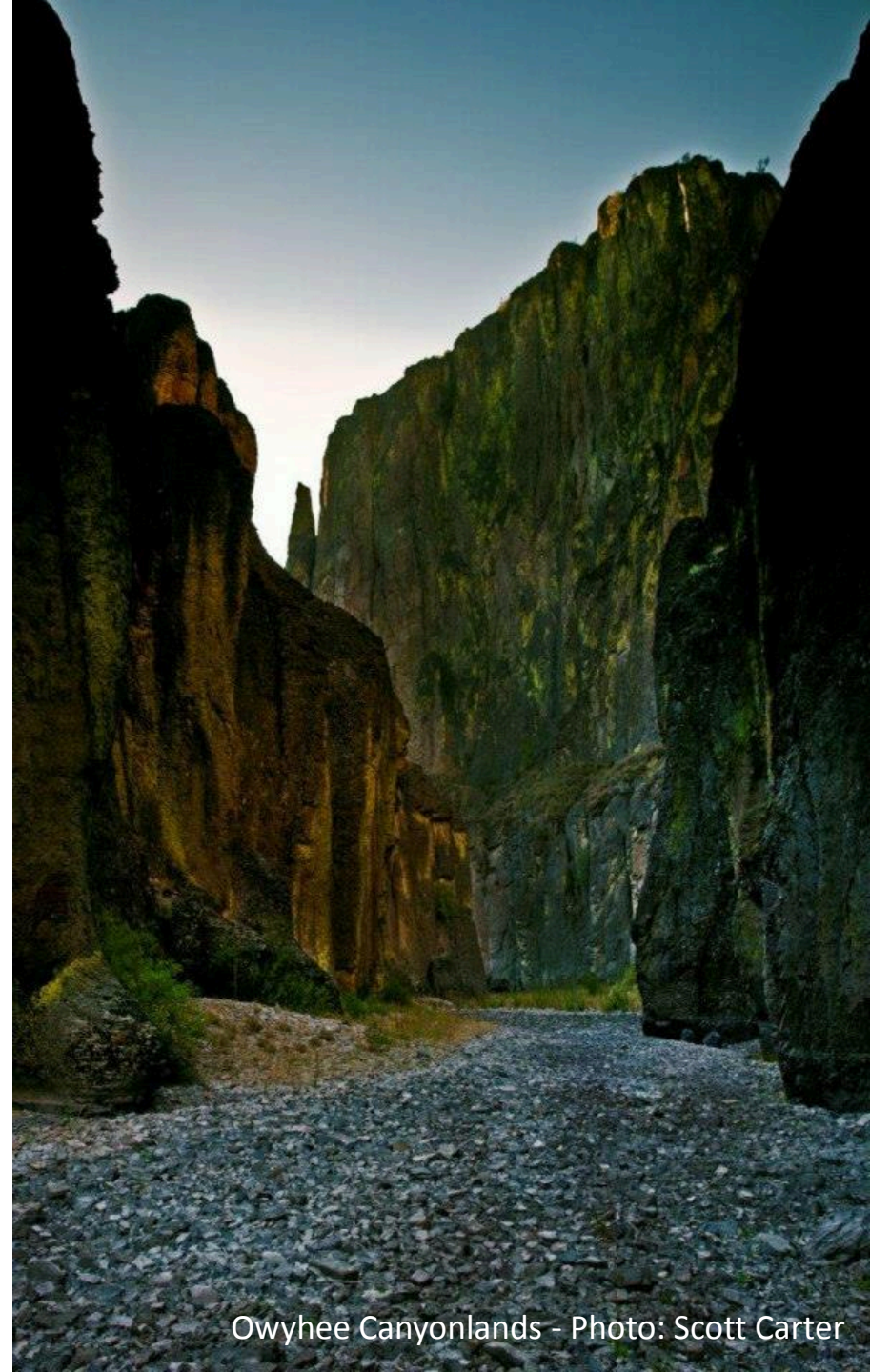
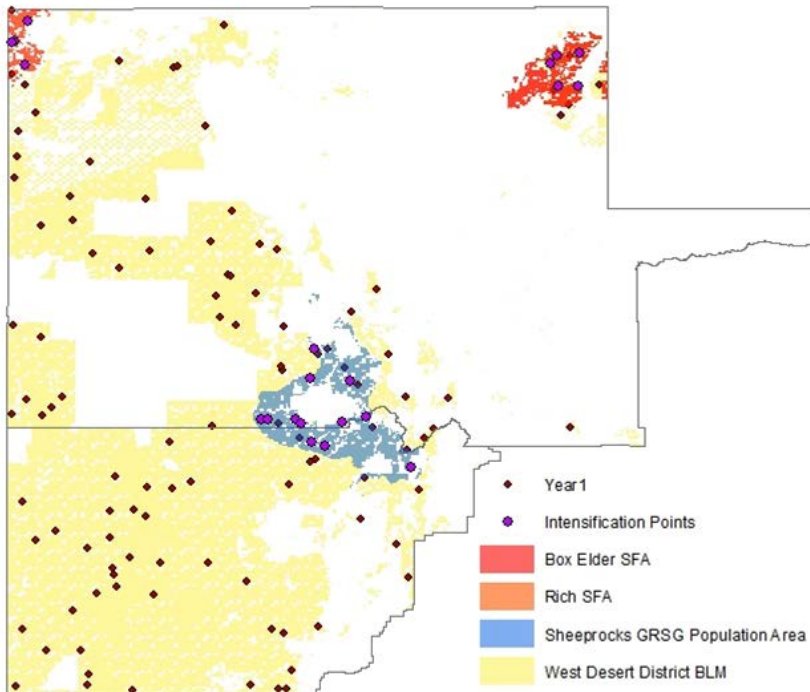


Monitoring Design: Study Area, Reporting Units, Stratification



Owyhee Canyonlands - Photo: Scott Carter

What do you mean by monitoring design?

- Loosely defined term that encompasses technical aspects of creating a monitoring program
- Includes:
 - Defining study area (resource of interest)
 - Reporting units
 - Stratification (if any)
 - Sample site selection
 - Plan for implementing/managing the sample design
 - Other attributes, steps...



<http://aim.landscapetoolbox.org>



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ASSESSMENT, INVENTORY, AND MONITORING

SUPPORT FOR BLM AIM PROJECTS AND PROGRAMS

PLANNING & FUNDINGDESIGNDATA COLLECTIONQUALITY ASSURANCE & QUALITY CONTROLDATA MANAGEMENT & PROJECT EVALUATIONANALYSIS & REPORTING

> DESIGN

Design

Management objectives

Study area and monitoring objectives

Benchmarks

Stratifying the study area

Stratifying Using LANDFIRE

Biophysical Settings

Supplemental monitoring, sample sizes, and frequency

Collect and evaluate available data

Apply stratification and select monitoring locations

Data Management Plans

DESIGN

The design phase of an Assessment, Inventory, and Monitoring (AIM) project involves making the technical decisions necessary to address the questions and objectives identified by the ID team. The process of designing a monitoring and assessment effort can be broken down into a series of steps (Figure 1; Steps 1-6). For some steps, standard AIM protocols and language are already in place. The steps are listed in the order they are normally completed, but there is no “single” way to design a monitoring program and the steps should be viewed as an iterative process. Sometimes the discussions around these design requirements even lead to changing some of the decisions made during the planning stage.

First Year: Develop Monitoring Program

First Year: Design Monitoring Program

Step 1: Develop management objectives; select additional ecosystem attributes and indicators to monitor.

Step 2: Set the study area and reporting units; develop monitoring objectives.

Step 3: Select criteria for stratifying the study area into similar land areas (if required).

Step 4: (a) Select and document supplemental monitoring methods; (b) estimate sample sizes; (c) set sampling frequency; (d) develop implementation rules.

Step 5: Collect and evaluate pilot data to determine sampling sufficiency and the validity of the strata.

Step 6: Apply stratification, and select statistically valid monitoring locations.

Step 7: Develop quality assurance and quality control (QA and QC) procedures and data management plans.

As you go through each step, fill out the corresponding **Monitoring Design Worksheet** which provides a step-by-step template for designing BLM AIM efforts. We encourage you to work through the design process as an ID team, but completion of the worksheet should be done in coordination

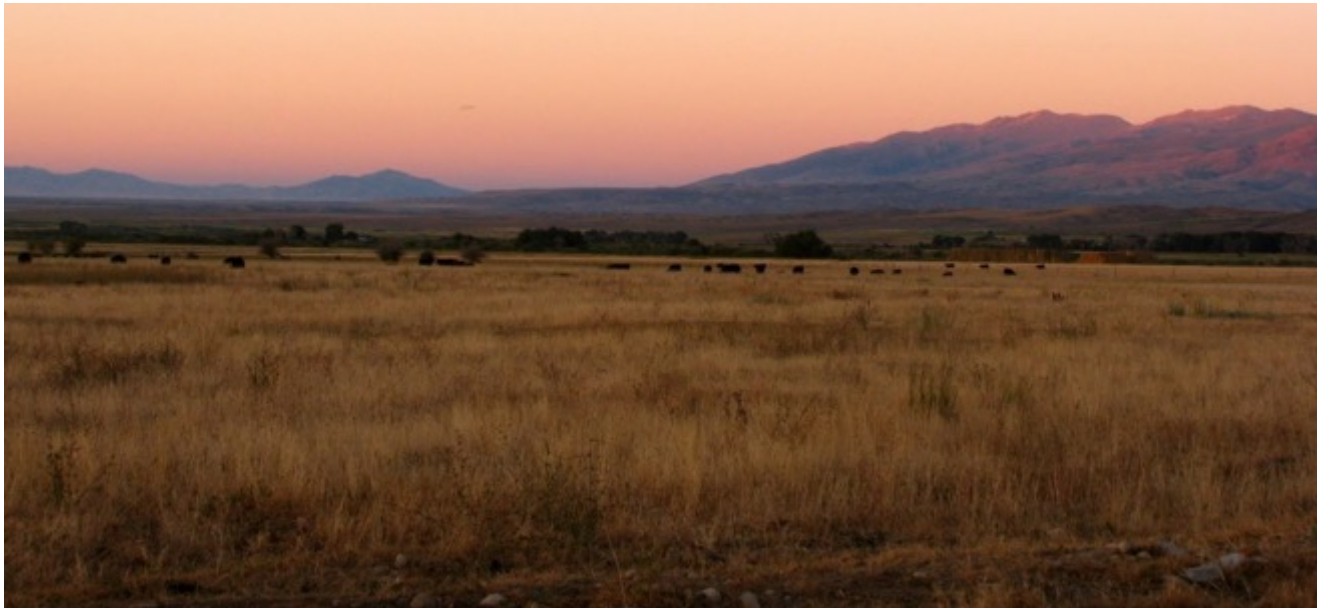
Sampling to Monitor Natural Resources

- Most of the time we can't measure all of the resource we're interested in.
- Sampling – Using measurements from a selected subset to estimate attributes of the entire resource
 - E.g., political polls
 - Lots of different ways to pick a sample
 - Sampling is “statistically valid” if it gives an unbiased estimate of the resource



Goal of Monitoring Design

- Select a **statistically representative** sample from a **resource of interest** in order to **estimate** attributes of that resource in an **unbiased** and **cost-effective** manner.



Steps to Monitoring Design

- Define a study area (population)
- Define your reporting units
- Select a stratification approach

} Focus today on understanding these concepts

- Evaluate existing/pilot data
- Determine sample sizes, sampling frequency
- Select sampling locations

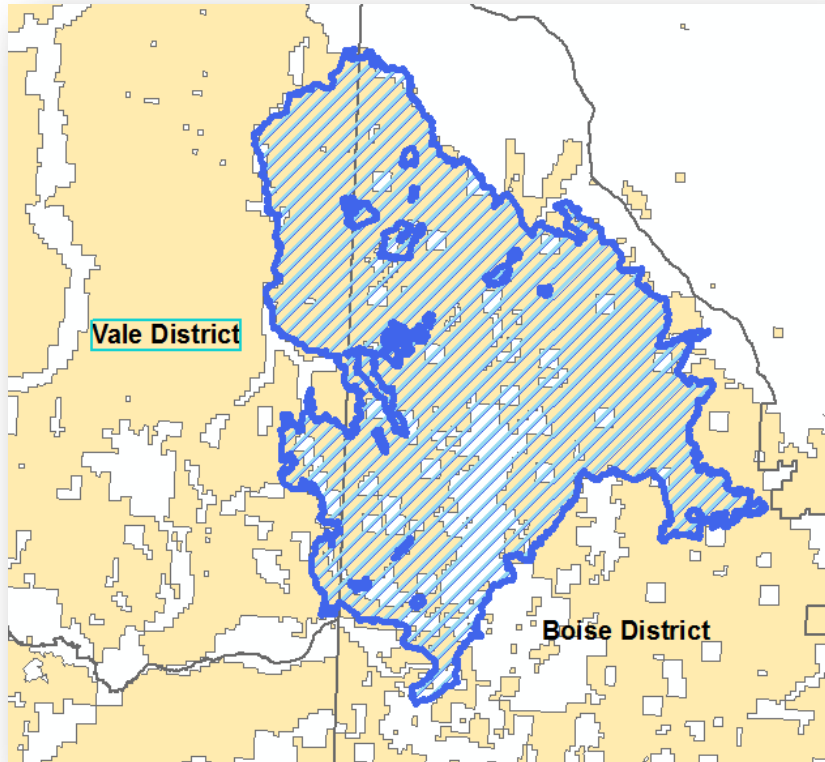
} These happen in cooperation with the NOC/Jornada

Concept: Study Area

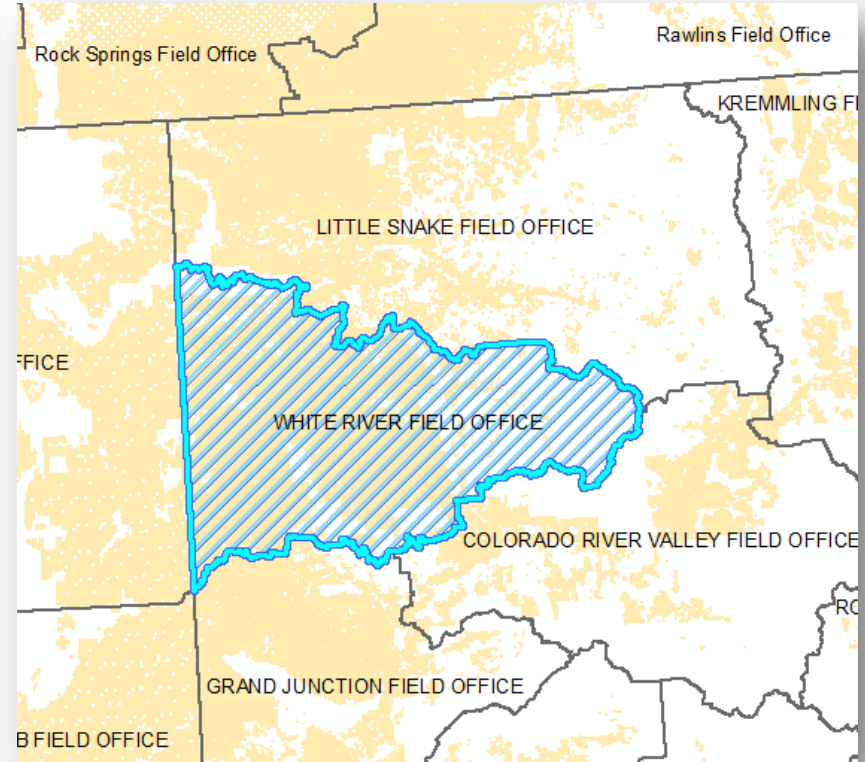
- Defines the extent of the resource you're interested in
 - E.g., All BLM lands in a Field Office, All perennial streams within a allotment, All fire treatments within a fire boundary
- Maximum area you want to draw conclusions about
- Figuring out the area/population you want to monitor isn't always a trivial task
 - If you need to make conclusions about an area, it should be in your study area!
- In statistical parlance, called the **population**
 - **Target population** – what you want to know about
 - **Sample population** – what you can actually get to!
 - Be careful not to unnecessarily restrict the population

Study Area Examples

Soda Fire, Idaho/Oregon



White River FO, Colorado

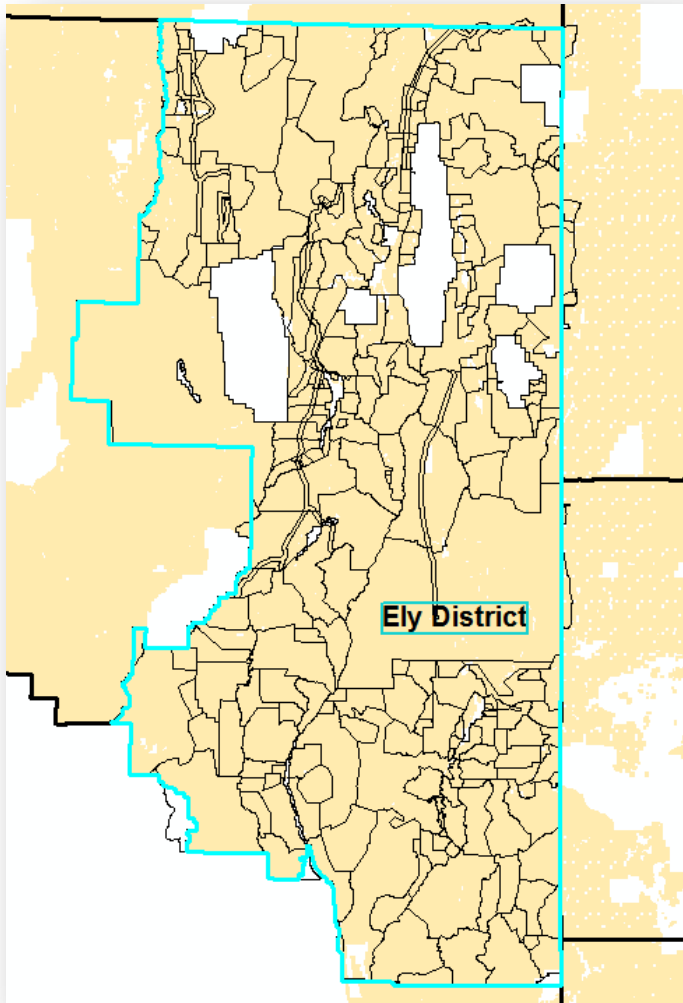


Reporting Units

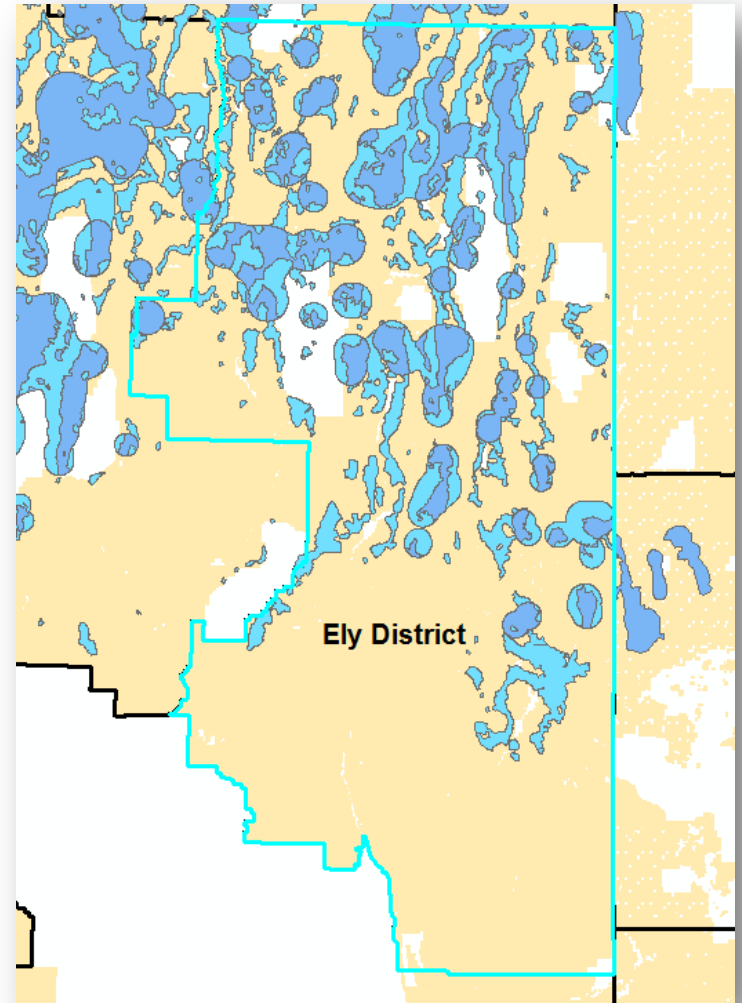
- Subsets of the study area that you need summary information about
 - E.g., watersheds, allotments, GRSG habitat units
- Reporting units should be stated in your monitoring objectives
- A study area can have different types of reporting units.
- Knowing them ahead of time helps ensure adequate sampling
- You can have different sets of reporting units
 - They can even be overlapping!

Reporting Unit Examples

Allotments



GRSG Population Areas



and/or

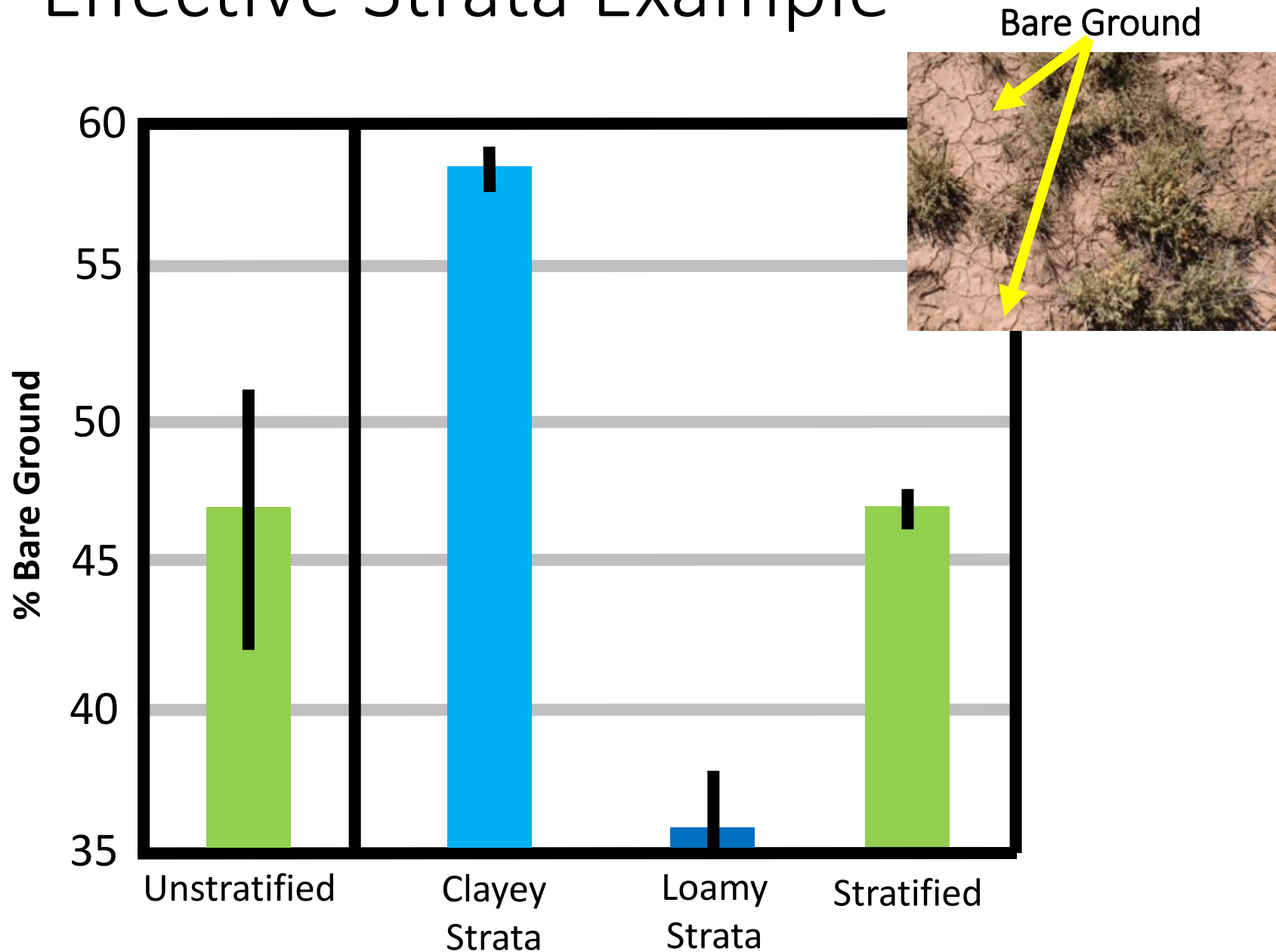
Stratification

- **Stratification** is dividing a population or study area (e.g., rangeland landscape) up into sub-groups or subunits called strata
- Typically done *prior* to sampling
- Reason to stratify:
 1. Variability in indicators is different across types of land
 - Stratify to reduce data variability within the strata (i.e., partition variance)
 2. Ensure different types of land or uncommon portions of a study area get sampled
 3. To deal with differences in land potential

Dividing up the landscape into similar types of land is a common stratification approach



Effective Strata Example



Strata vs. Reporting Units

Strata

- Mutually exclusive – cannot overlap
- Can have only a single stratification
- Strata must be sampled
- Strata are fixed once sampling begins

Reporting Units

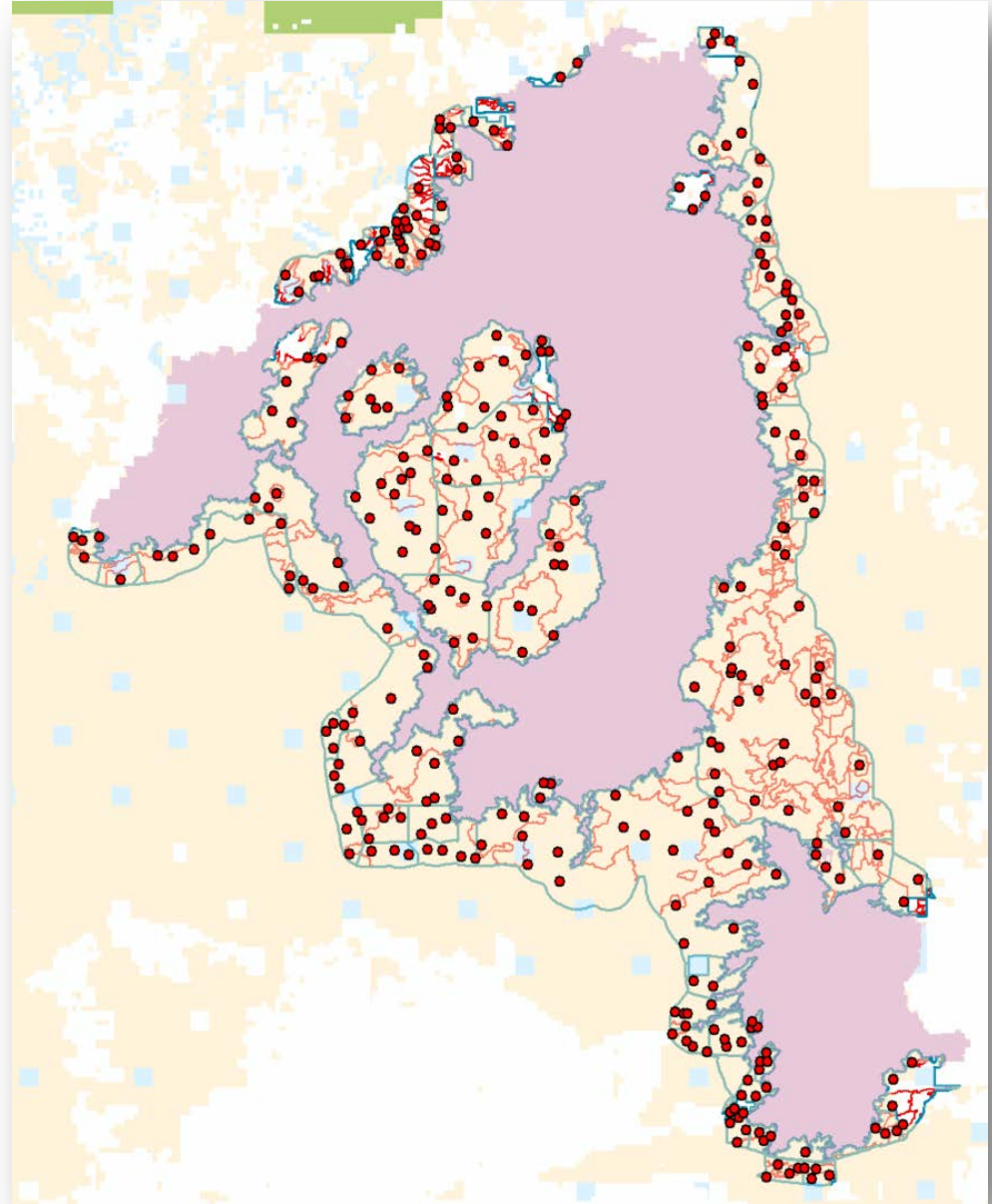
- Reporting units can overlap
- Can have multiple sets of reporting units
- Not all reporting units must be sampled
- Reporting units can change over time

Pros/Cons of Stratification

- Stratification pros
 - Can help make sampling more efficient
 - If strata are related to indicator variability
 - Can help ensure coverage of all land types
 - Can target uncommon/important areas
- Stratification cons
 - Adds complexity to the sampling design
 - Must use stratified random estimators
 - Can make sampling LESS efficient
 - If strata not related to indicator variability
 - Easy to over stratify

Over-stratification example

- Craters of the Moon, ID – HAF Assessment
- Stratified by
 - Pasture
 - Ecological Site
- 108 Strata!
 - 324 points
 - All sampled in 1 year

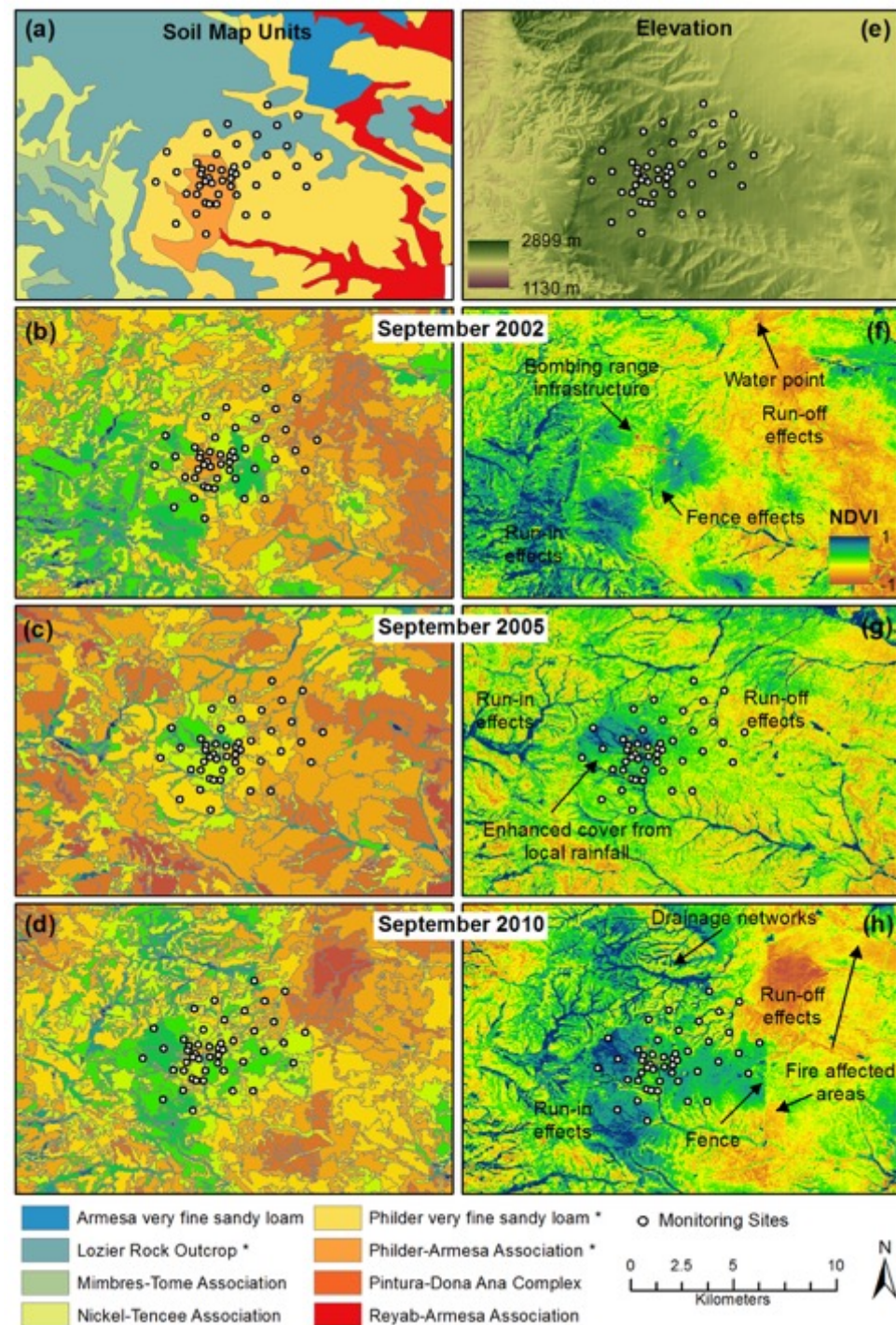


Stratification gone awry

Monitoring effects of Centennial Bombing Range, Fort Bliss.

A cautionary tale –
You may not know as much as you think.

Keep it simple!

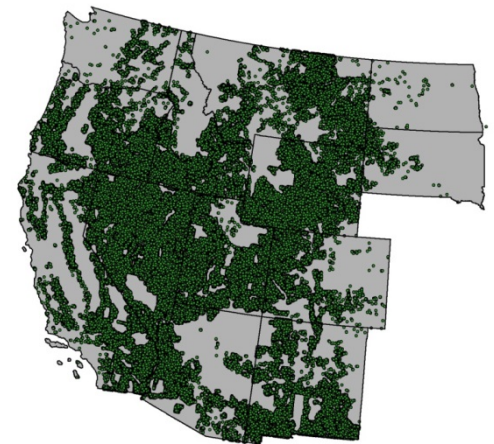
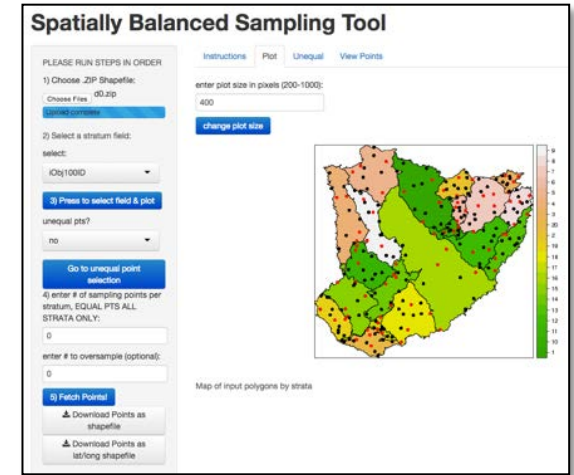


Alternatives to Stratification

- Stratification is not always the best approach to addressing sample design concerns
- For ensuring representation of land types or uncommon areas: **Multi-density categories**
 - Varying probability of selection to get better representation
 - No minimum sampling requirement
- Indicator differences by land potential: **Benchmarks**
 - Values against which indicators are evaluated vary by land type = apples/apples comparison
 - Do not need to formally stratify by land type (as long as you have good representation)

Sample site selection

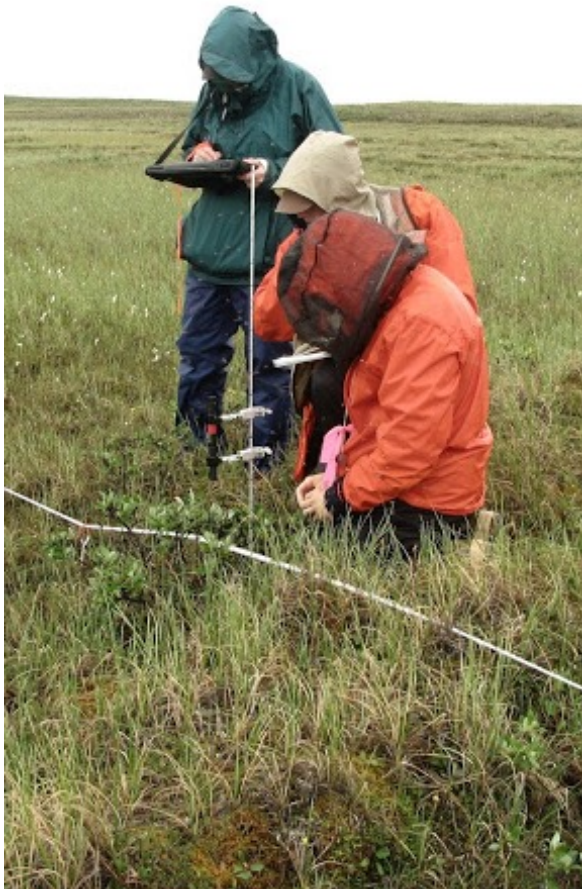
- Where the “rubber meets the road”
 - Selecting sampling locations within the study area
- Lots of different techniques for doing this
 - **Important that a randomized method be used if you need to draw inferences to a larger area!**
- Many AIM projects use some form of spatially-balanced selection algorithm
 - Small projects, treatment effectiveness = R, Shiny tool
 - Large projects, LUP effectiveness, regional = Master Sample



Terrestrial Master Sample,
2.2 million points

Concepts – Randomization

- Each unit/location within population must have some (known) chance of being selected for sampling
- A randomly selected location represents a known amount of area (from a statistical perspective)
- A sample of randomly selected locations provide unbiased estimates of indicators
 - Allow uncertainty of those estimates to be calculated as well.



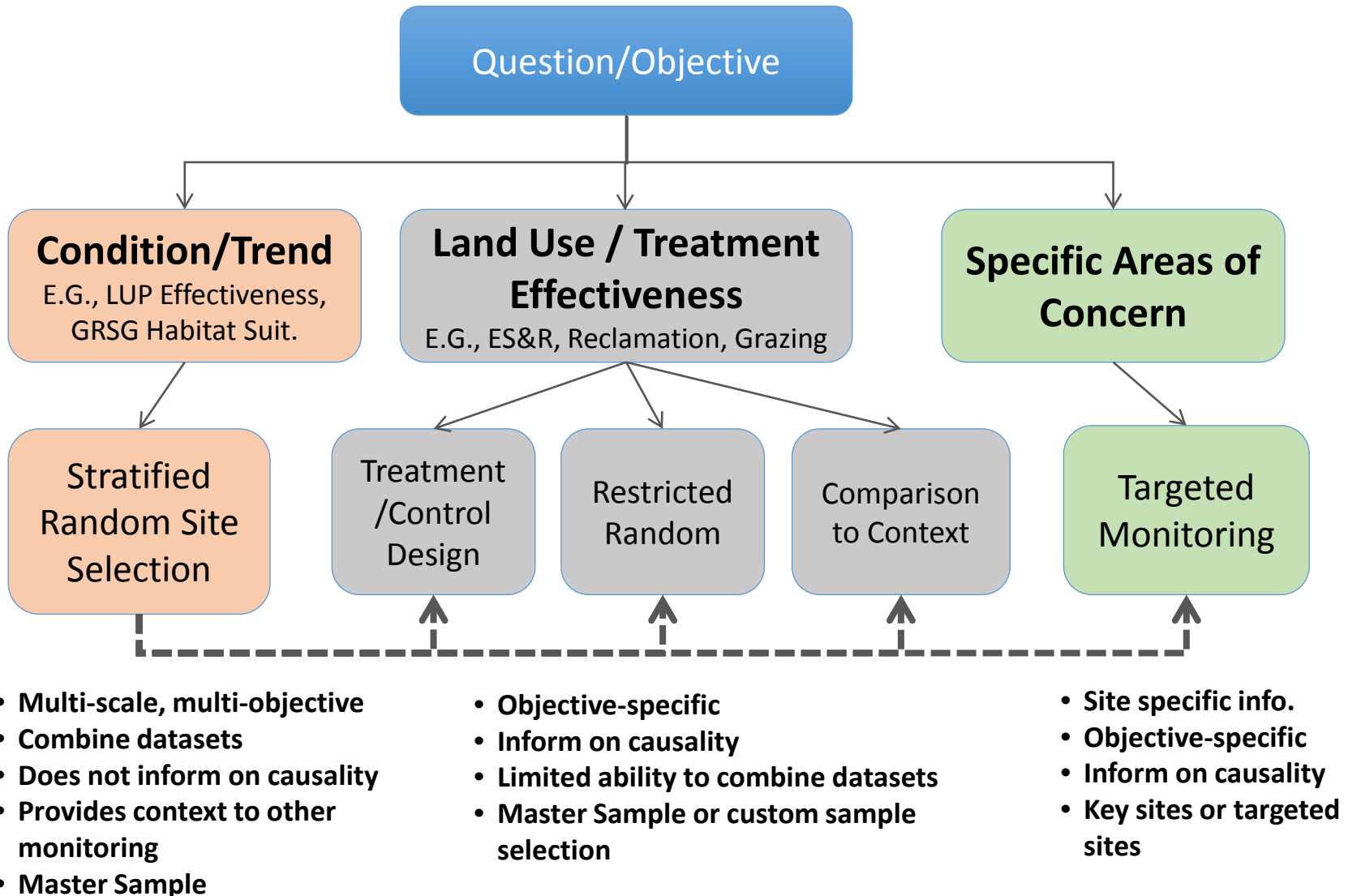
Key areas & targeted monitoring

- Targeted to specific land uses (e.g., grazing)
- Results cannot be statistically extrapolated to larger population
- Can underestimate heterogeneity
- Representative of a single land use
 - May not represent other uses
- Sensitive to loss or disturbance
- **Key areas are informative for land use effects**
- **Key areas and statistical sampling can complement each other**
- **Strong monitoring programs often have a mix of both**



Key Area
was here

Choosing a sampling approach



Conclusions

- Sample design is iterative
- Keep it simple
 - Complex designs take complex analyses and are hard to tweak and combine
 - Design for your monitoring objectives, but don't over-design
- Document the process ([Monitoring Design Worksheet](#))
 - Decisions made
 - Stratification info (areas, spatial data)
 - Sample sites and their fate
- Get help!
 - State AIM Leads, NOC, Jornada



Concept Review

- Study Area
 - Maximum extent/area you want to draw conclusions to
 - The resource you're interested in for management
 - E.g., All BLM lands in a Field Office, All perennial streams within a allotment, All fire treatments within a fire boundary
- Reporting Units
 - Sub-areas of the study area for which you need to generate indicator estimates
 - Can have multiple sets of reporting units, can overlap
- Strata
 - Subdivisions of the study area to divide up sampling efforts to control for heterogeneity
 - Cannot overlap, all strata must be sampled