Sample Design

A practical approach for AIM-based monitoring

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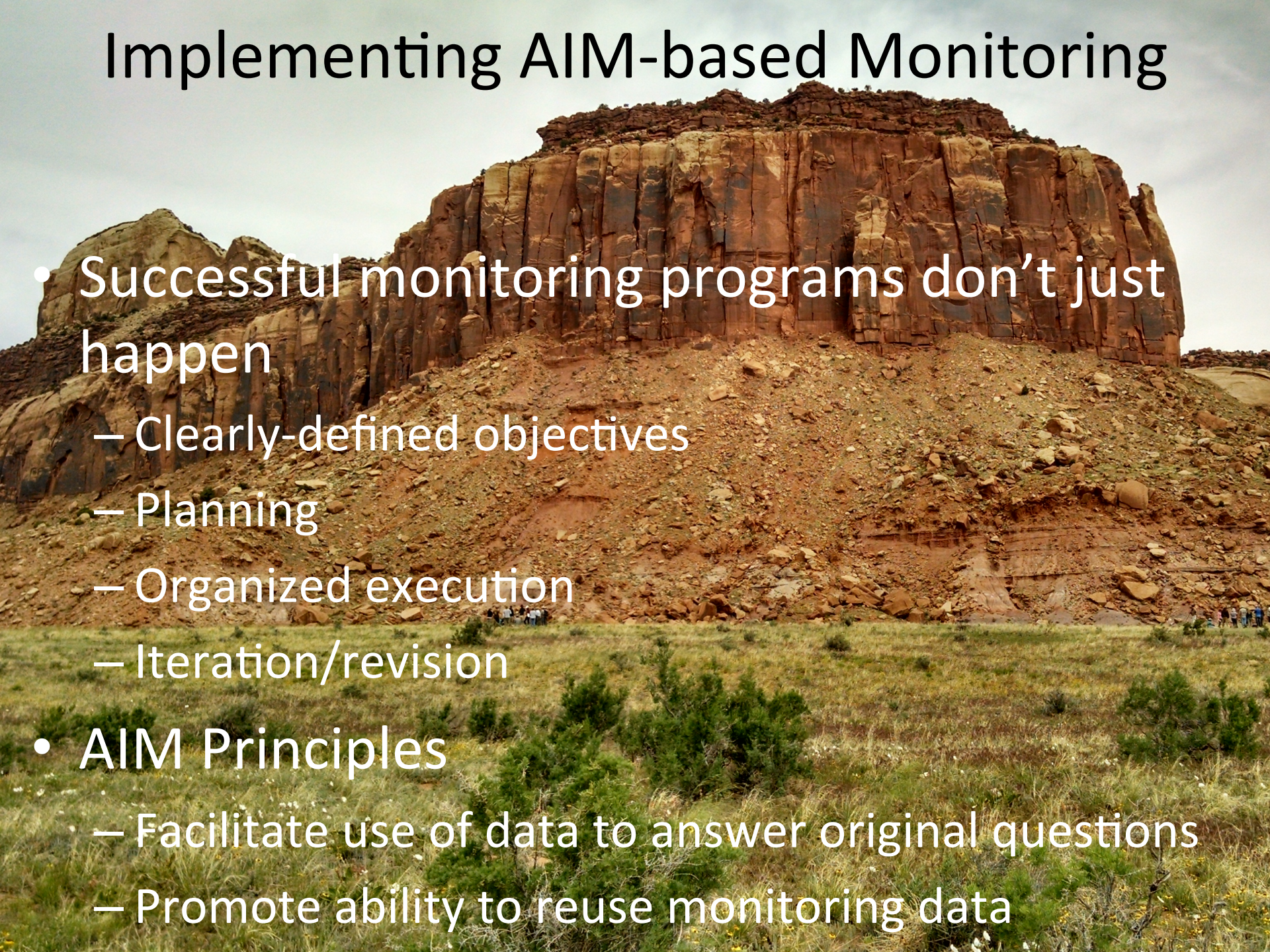
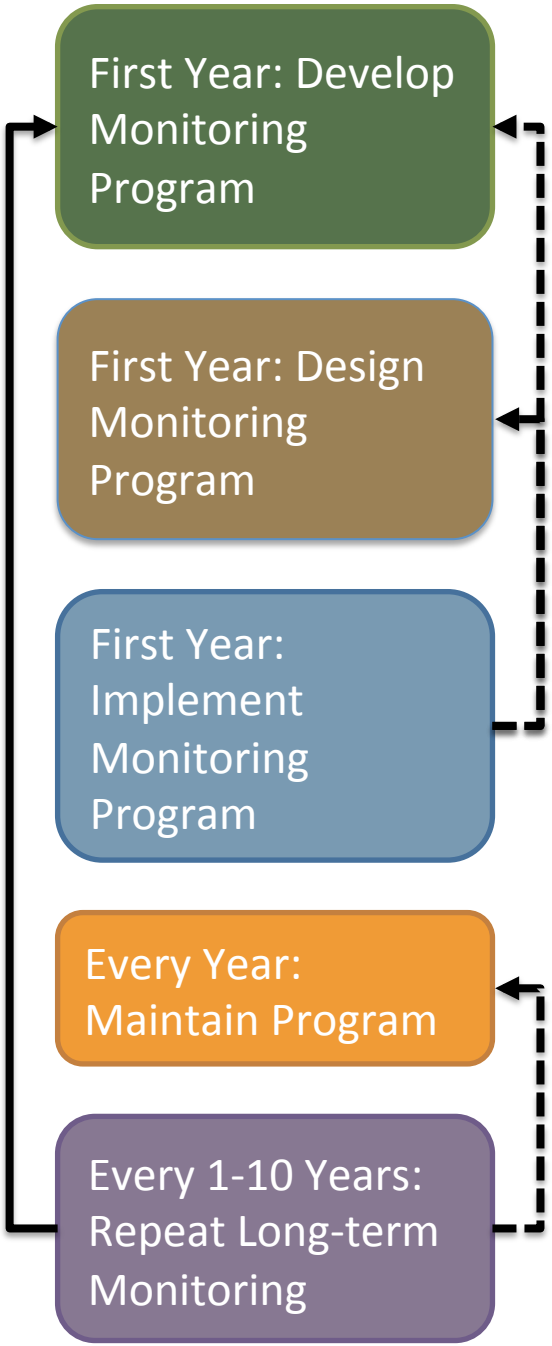
Implementing AIM-based Monitoring



- Successful monitoring programs don't just happen
  - Clearly-defined objectives
  - Planning
  - Organized execution
  - Iteration/revision
- AIM Principles
  - Facilitate use of data to answer original questions
  - Promote ability to reuse monitoring data

General Approach



Background

Design

Implement

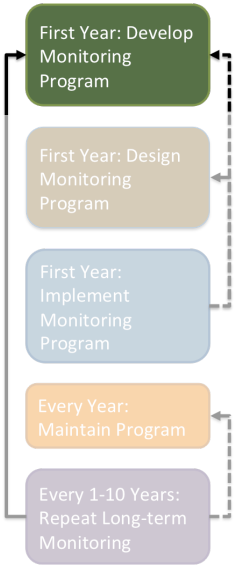
Maintain

Repeat/Use

Design & implementation steps are iterative

Documentation of the process is crucial

Developing a Monitoring Program

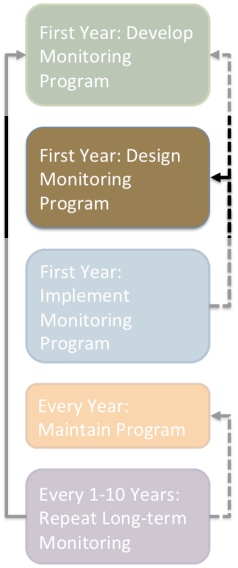


Step 1: Develop management objectives, select additional ecosystem attributes and indicators to monitor

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)

Design the Monitoring Program



Step 4: Select supplemental methods; estimate sample sizes, set sampling frequency, develop implementation rules

Step 5: Collect/evaluate pilot data for sampling sufficiency and evaluating strata

Step 6: Apply stratification to study area, select statistically-valid sampling locations

Step 7: Develop QA/QC procedures and data management plans

Webinar Objectives

- Sample design can be simple or complex
  - Depending on your project needs
- Sampling is technical (and can be somewhat opaque)
  - Basic concepts easily understood
- Objectives
  - Cover some basic concepts related to AIM-based sample design
  - Provide some tips learned through AIM projects
  - Give examples of tools/resources that may help

Webinar Outline

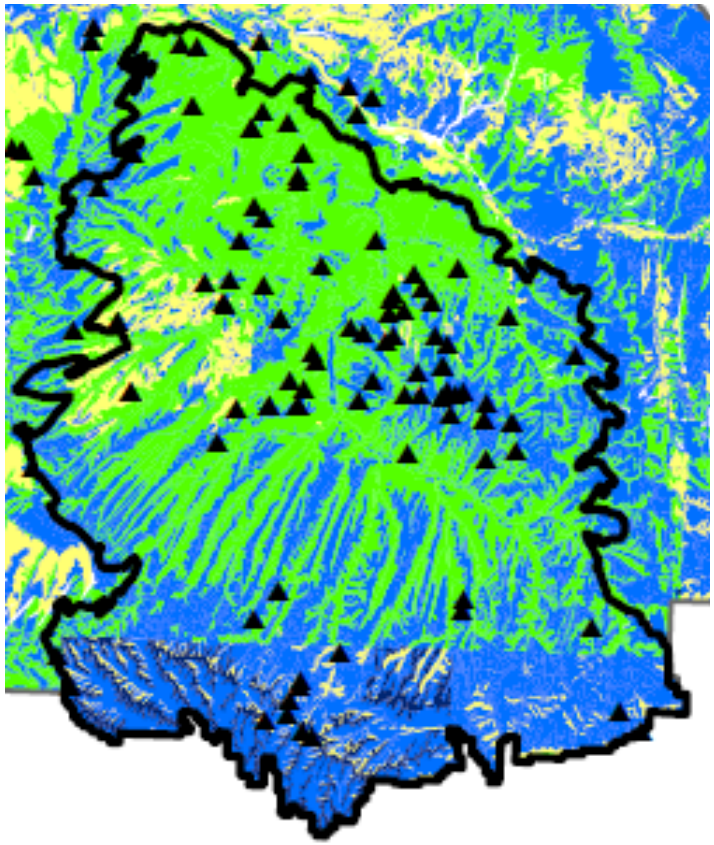
- Role of sample design in monitoring implementation – DONE!
- Goal of sample design
- AIM principles for sample design
  - Probability based
  - Stratification
  - Sample selection
- Implementing/refining sample design
- Tools/resources

Sampling 101

- Most of the time we can't measure everything everywhere.
- **Sampling** – using selected members to estimate attributes of a larger population.
- If sampling is "statistically valid"
  - Gives unbiased estimates of the population

Concepts – Population

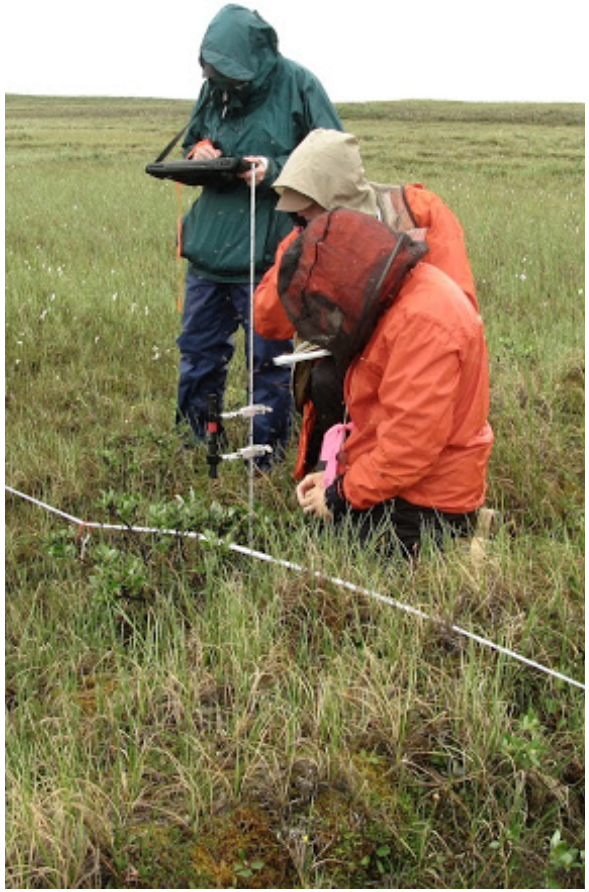
- The entire "universe" to which the results of sampling apply



- Defined by many factors
  - Study area
  - Objectives
  - Constraints
- Every **sample unit** in population must have some chance of being selected for sampling
- Care should be taken to "preserve" preserve the population
  - Avoid inadvertent restrictions

LandscapeToolbox.org: Inference Space – What it is and why it's important

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)
- Non-random points represent an unknown amount of area
  - May be representative for one objective but not another
  - Can be sensitive to change not related to original objectives

LandscapeToolbox.org: When Key Areas Aren't Anymore

What do you mean – sample design?

- Loosely defined term that encompasses technical/statistical aspects of creating a monitoring program
  - A.k.a “survey design”, “sampling plan”, …
- Includes
  - Defining population or study area
  - Stratification
  - Sample site selection
  - Plan for implementing/managing the sample design
  - Other attributes, steps…

Goal of sample design

- To select a statistically representative sample from a population in order to estimate attributes of the population in an unbiased and cost-effective manner.

Be sure to question yourself!

Critical Sample Design Questions

- What is my population/resource (study area)?
- Are there subpopulations or reporting units that I need to consider?
- How should I stratify my population/resource?
- How will I select my sample locations?
- How am I going to implement my sampling?
- How am I going to use my results?

Defining the population

- 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 population
- **Target population**
  - The population that you intend to draw conclusions about
- **Sampled population**
  - That portion of the target population that you could actually sample
- Be careful not to unnecessarily restrict the population
  - Reductions of target population related to land use can bias results!

Example

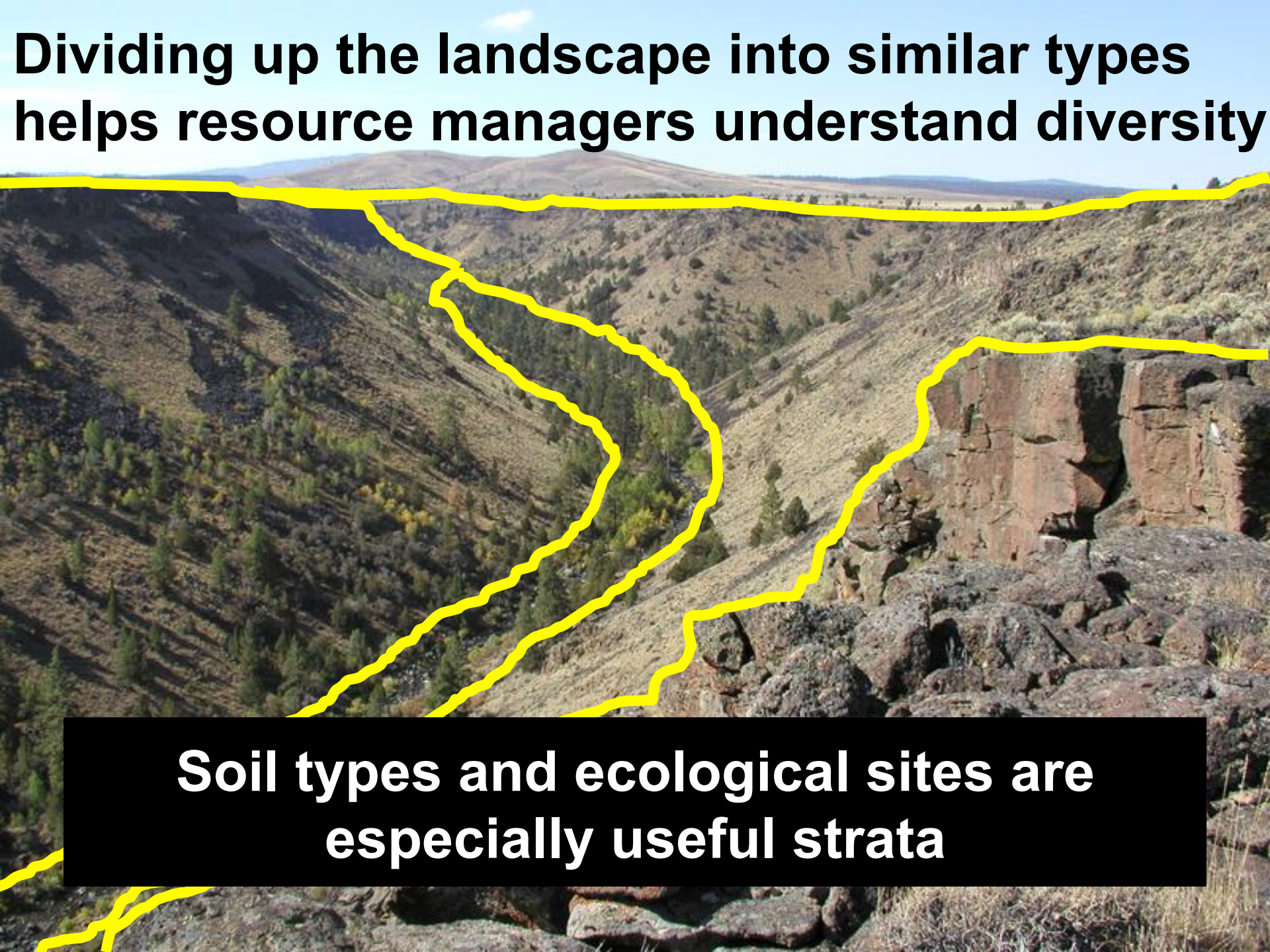
Photo: Lava Lake Land and Livestock, LLC

Questions?

Stratification

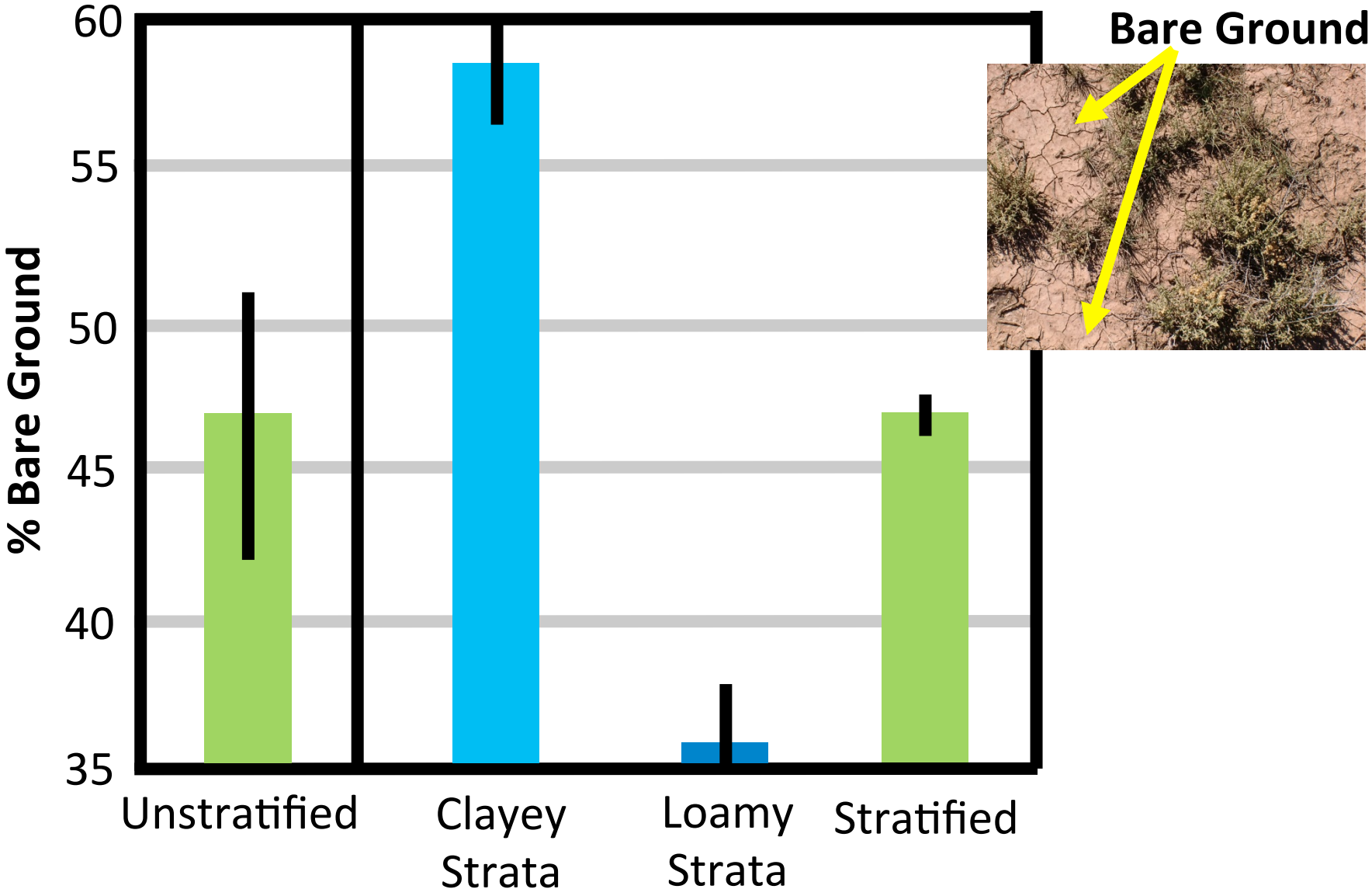
- **Stratification** is dividing a population or study area (e.g., rangeland landscape) up into sub-groups or subunits called strata
- Typically done *prior* to sampling
- Two reasons to stratify:
  - 1) Divide up the landscape into similar units for management – understand landscape diversity, report on useful units
  - 2) Reduce data variability within the strata (i.e., partition variance)

Dividing up the landscape into similar types helps resource managers understand diversity



Soil types and ecological sites are especially useful strata

Effective Strata Example

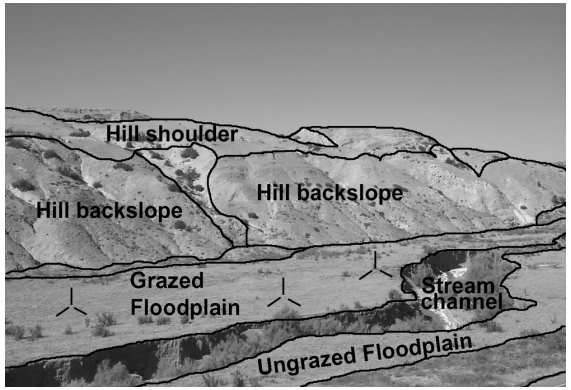


Strata

- **Strata** are subsets of the sampling population
- **Strata** are ideally defined as particular parts of the landscape (e.g., flood basin or hill summit) within which soil type, vegetation, management and current status are **relatively similar**
- All areas classified by the same stratum are expected to **respond similarly** to changes in management and disturbances
- Strata **DO NOT** have to be sampled with the same intensity!
  - Put your effort into strata that are highly variable or expected to see change

Stratification

Two separate steps!



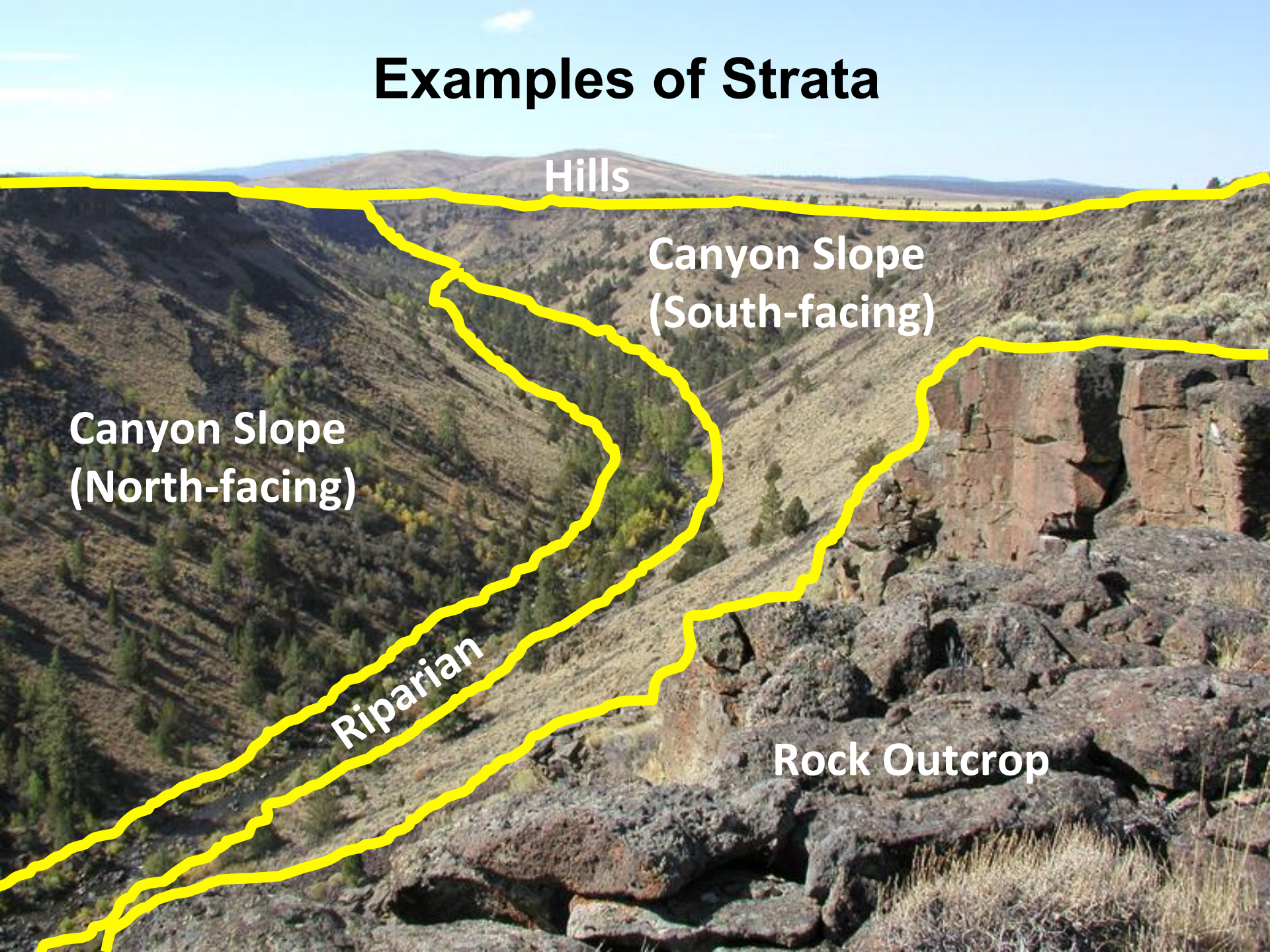
Develop stratification criteria

- *Conceptual focus*
- Factors affecting variability of indicators
- May include other units for ensuring adequate sampling
- Often many potential criteria
- Iterative process to arrive at final criteria

Apply stratification

- *Technical focus*
- Translate the criteria into a set of units for sample design
- Calculate areas, design weights for data analysis
- Stratification layers often imperfect

Examples of Strata



Benefits of Stratification

- Helps land managers set realistic objectives
- Enables data collection to focus on questions
- Supports interpretation of monitoring, inventory, and assessment information
  - Separates variability
  - Reduces variability



Why Stratify?

- Reduce the number of plots that need to be monitored
- Ensure that small areas get monitored
- Focus monitoring on priority areas
- Aid in interpretation of results
- Report on units that are meaningful to management
- Compare current conditions to ecological potential/reference

How to stratify?

Stratify by **relatively static** factors related to variability of indicator values within a study area, such as:

- Land potential
- Differences in soil types or ecological sites
- Topography
- Climate
- Management
- And other factors

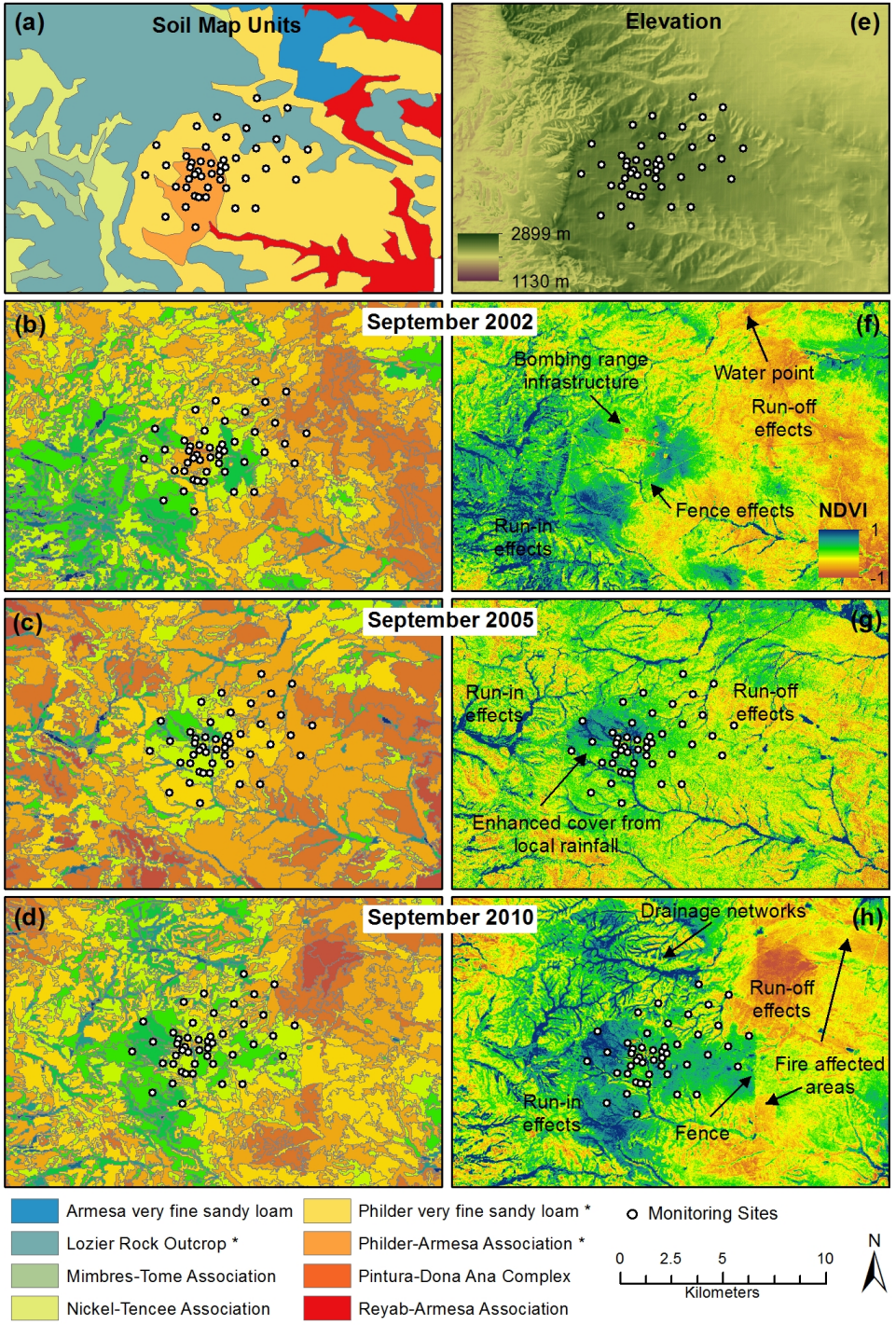
Stratification gone awry

Monitoring effects of Centennial Bombing Range, Fort Bliss.

A cautionary tale –

You may not know as much as you think.

Keep it simple!



Questions?

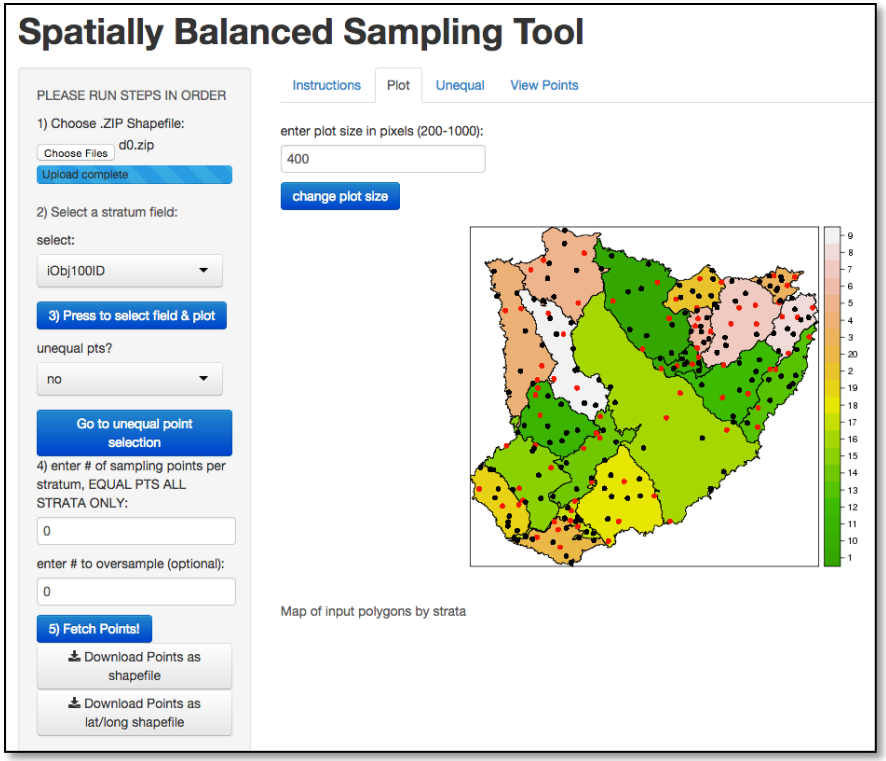
Sample site selection

- Where the "rubber meets the road"
  - Selecting sampling locations within the strata
- Lots of different techniques for doing this
  - **Important that a randomized method be used!**
- Many AIM projects use some form of spatially-balanced algorithm for selecting sample locations.

http://www.landscapetoolbox.org/monitoring-design/sample-design/

Spatially Balanced Sampling

- Spatially Balanced – samples are evenly spaced across study area and ordered to maximize spatial dispersion of any sequence of units
  - Good technique for drawing backup sample locations
- Solves problems of clumping with many other random selection techniques.
  - **Don't use minimum sampling distances in a regular sampling tool to force spatial balance!**



Spatially-balanced Sampling Tools

- ArcGIS Create Spatially-balanced Points
- GRTS function in R spsurvey Package
- Spatially-balanced Sampling Tool http://shiny.landscapetoolbox.org/shinyspatialbal/

Sample site selection – best practices

- Determine how many samples you need per stratum
  - http://shiny.landscapetoolbox.org/SampleSize
  - Or other sample size calculator
- Draw an "oversample"
- Define rejection criteria beforehand
  - **See AIM rejection criteria document.**
- Screen points in the office before going to the field
- Define rules for replacing rejected sample points
- Document what happens to each of your points!

Design/implementation info to track

- Critical information for using monitoring data
- General documentation
  - What you did and why
- Study area (spatial layer)
- Stratification
  - Spatial layer, stratum areas, weights
- Sample points
  - Stratum membership (designed, actual)
  - Point draw (base or oversample)
  - Panel (i.e., year intended to be sampled)
  - Status designation(sampled, non-target, inaccessible, other)
  - Point weight (if using unequal probability design)
  - Date visited

AIM Sample Design Geodatabase – *in development*

Conclusions

- Sample design is iterative
- Keep it simple
  - Complex designs take complex analyses and are hard to tweak and combine
- Document the process!
  - Decisions made
  - Stratification info (areas, spatial data)
  - Sample sites and their fate
- Ask for help!

Resources for more information

- Landscape Toolbox (http://www.landscapetoolbox.org)
  - Info on stratification, sample design, implementation
  - Spatially-balanced sampling tool http://shiny.landscapetoolbox.org/shinyspatialbal/
  - Sample sufficiency tool http://shiny.landscapetoolbox.org/SampleSize/
- US-EPA Resources
  - Survey Design FAQshttp://www.epa.gov/nheerl/arm/surdesignfaqs.htm
  - Article on Sound Survey Designs http://digitalcommons.unl.edu/usepapapers/143
  - What is a GRTS sample design? https://www.monitoringresources.org/Designer/Home/GRTS
- Other resources
  - Elzinga et al. (1998). Measuring and monitoring plant populations. http://www.blm.gov/nstc/library/pdf/MeasAndMon.pdf
  - Gitzen et al. (2012). Design and analysis of long-term ecological monitoring studies. Cambridge University Press.
  - Herrick et al. (in revision). Monitoring manual for grassland, shrubland, and savanna ecosystems. Volume 2. http://www.landscapetoolbox.org/manuals/monitoring-manual/

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BLM AIM Sharepoint Site: https://connect.doi.gov/blm/BLMAIM/