Outline

Sampling and Experimental Design
- Site selection
- Assess current status
- Select indicators
- Number and frequency of measurements
- Plot placement
- Type of plots

Good Sampling Design
- Based on site-specific information
- Based on objectives
- Assesses population of interest
- Has appropriate sampling units (size and shape)
- Appropriately positioned sampling units

Good Experimental Design
- Causation - allows experimenter to make causal inferences about the relationship between independent and dependent variables
- Control - allows the experimenter to rule out alternative explanations due to confounding effects of extraneous variables (i.e., variables other than the independent variables)
- Low variability - reduces variability within treatment conditions, which makes it easier to detect differences in treatment outcomes

Step 2: Stratify Land into Monitoring Units

Herrick et al. 2005

Figure 11. Monitoring program design and implementation. (a) Design and implementation objectives
(b) Key steps in program design (adapted from Herrick et al. 2005).
Step 2: Stratify Land into Monitoring Units

How to stratify:

1. Collect background information, maps and photographs.
   - Aerial photos, satellite imagery, written and oral histories, property maps, species lists, ecological site descriptions, soil maps

2. Define stratification criteria.
   - Soil-landscape – topography, landscape position, soil
   - Current vegetation
   - Management

3. Divide the area into monitoring units.
   - a) divide the area into soil-landscape units
      - Use NRCS ecological sites
   - b) subdivide the soil-landscape units into soil-landscape-vegetation units
   - c) subdivide the soil-landscape-vegetation units into monitoring units based on type of management

Landscape Unit

Figure 2.2. Example of landscape unit stratification. This type of stratification can only be done with aerial photos. Subdivision into soil-landscape units was not possible due to lack of soil survey information. The use of Soil Survey Maps can make this process easier and more accurate.

Landscape-Vegetation Units

Figure 3.3. Example of the subdivision of landscape units (see in Fig. 2.2) into landscape-vegetation units. Here one of the hills landscape units was subdivided into landscape-vegetation units.

Management Units

Figure 2.4. Example of the subdivision of landscape-vegetation units into different types of monitoring units (1-4) based on management. In this case, one of the Hills Pinyon-Juniper xerorres units was subdivided based on the presence or absence of prescribed fire, and the Hills Blue-grass grassland unit was subdivided based on whether or not woodycutting is permitted.

Land stratification resources
See Herrick Vol. II; Table 2.1; page 15

- Aerial photos
- Topo maps
- Satellite imagery
- Species lists
- Invasive species lists
- Ecological site descriptions
- Soil maps
- Geologic maps
Step 3: Assess Current Status

1. Select assessment system.
   - Both qualitative and quantitative systems
   - Two primary sources of qualitative systems:
     - Interpreting Indicators of Rangeland Health (IIRH) – for uplands (Pellant et al. 2000)
     - Process for Assessing Proper Functioning Condition (PFC) – for riparian areas (Prichard et al. 1998)

2. Verify personnel are qualified.
   - Listed in IIRH
   - Need both field and academic experience

3. Complete assessments.
   - Using IIRH or PFC
   - Focus on areas of change due to management, land use or ecosystem change

4. Identify drivers, threats and opportunities.
   - Drivers – contribute to changes in processes or properties monitored
     - Exs. Grazing patterns, vegetation manipulation, climate change, atmospheric chemistry
   - Threats – drivers that can negatively impact the land
     - Ex. Off-road vehicles, overgrazing, invasive species, drought, insect damage
   - Opportunities – new possibilities
     - Ex. Grants for restoration project, cooperative livestock management with neighbors, climate change and weather

5. Refine long-term management and monitoring objectives.
   - Use new information from assessments, drivers, threats and opportunities list

6. Develop/modify management strategy.
   - Finalize plan before selecting indicators and sites

Step 4: Select Indicators and Number of Measurements

1. Select indicators.
   - Select both short- and long-term indicators
     - Short-term – reflect short-term objectives
     - Long-term – reflect long-term changes in landscape

Short-term Monitoring Guidelines
See Herrick Vol. I; Table 11; page 34

<table>
<thead>
<tr>
<th>Management</th>
<th>How Often?</th>
<th>What?</th>
</tr>
</thead>
</table>
| High-intensity grazing | Daily | Stocking rates by animal and class, 
| Season-long grazing | Weekly | Dates of use, 
| Year-long grazing | | Forest service and Neutron probe use, 
| | | Height of key species, 
| Fire | After fire, after growth | Foliar cover, 
| | and before grazing | Canopy gap sizes |
| Off-road vehicle use | After significant events (e.g., holiday weekend, more often when wet) | Types and approximate vehicle numbers, 
| | | Dates of use, 
| | | Number of tracks, 
| | | Evidence of compaction |
**Step 4: Select Indicators and Number of Measurements**

1. **Select indicators.**
   - Choose cost-reducing measurements that generate multiple indicators

   **Measurements and Indicators**
   See Herrick Vol. II; Table 4.2; page 23

2. **Choose number of plots.**
   Consider four factors:
   1. Amount of variability within ecological site
   2. Size of change you want to detect
   3. Probability that there is no sampling error (statistical certainty)
   4. Scale that you want to detect change
   - *See Appendix C “How many measurements”*

**Step 5: Select Monitoring Plot Locations**

1. Choose and apply site selection approach.
2. Select ‘rejection criteria’ and use to eliminate unsuitable locations.
Step 5: Select Monitoring Plot Locations

Checklist
1. Choose and apply site selection approach.
2. Select ‘rejection criteria’ and use to eliminate unsuitable locations.

Plots must be:
- Random
- Interspersed

Types of Random Sampling

1. Simple random sampling
   - All points are possible locations
   - Each sampling spot is independent
   • Advantages:
     1. Represents all areas
     2. Easy to apply
     3. Statistically sound
     4. Clearly unbiased
   • Disadvantages:
     1. Costly – time
     2. Plots may overlap (can fix though)
     3. May miss portions of macroplot (i.e. sensitive or ‘special’ areas)

Elzinga pp. 115-135
Table 7.2

2. Stratified random sampling
   - Units within strata are similar
   - Units between are different
   • Advantages:
     1. Represents all areas
     2. Statistically sound
     3. Cost-effective
     4. Sensitive to areas of concern
   • Disadvantages:
     1. Requires pre-stratification

3. Systematic sampling
   - Must be far enough apart to be independent
   • Advantages:
     1. Easy to locate plots
     2. Samples evenly across area
   • Disadvantages:
     1. Location of each plot depends on other

Simple Random

FIGURE 7.3. Locating points using the simple random-coordinate method (adapted from Chambers and Brown 1985). Although this method will work to position points or square quadrats, the grid-cell method is much better for locating long, narrow quadrats or lines.

Stratified Random

FIGURE 7.6. A stratified random sampling scheme. This example, from the North Carolina Wetlands Inventory (Dail and Johnson 1998), shows how a sample of many plots, each 4 x 4 ft, was allocated to three strata in the state of North Carolina.
Systematic Sampling w/ random starts

Graph showing systematic sampling with random starts.

Step 5: Select Monitoring Plot Locations

4. Subjective sampling
   • Advantages:
     1. Sensitive to local patterns and land-use
     2. Does not require maps or photos
     3. Inexpensive
   • Disadvantages:
     1. High potential for bias
     2. Difficult to extrapolate
     3. Not statistically sound

Step 6: Establish Monitoring Plots

Checklist
1. Establish and permanently mark plots and transects
2. Describe monitoring plots and record GPS locations
3. Record long-term data
4. Error check and make back-up copies of data

Sampling Unit

• Transects (lines) – density, frequency, biomass, cover

Sampling Unit

• Quadrats (plots) – density, frequency, biomass, cover
Temporary vs. Permanent Plots and Transects

- **Permanent best in most situations**
- **Advantages:**
  - Use when high correlation between sampling units between time periods (Ex. perennial grasses & shrubs)
  - Statistical tests are more powerful (i.e. samples are dependent on each other and reduces variation)
  - Results in fewer needed sampling units
- **Disadvantages:**
  - Permanent markers are expensive & hard to carry
  - Difficult to re-locate

Step 6: Establish Monitoring Plots

1. Establish and permanently mark plots and transects
2. Single transect plots

### Quadrat Size

**Rules of thumb:**

- Larger than average-sized plant
- Too small if <10% of plot contains your plant of interest
- Sparse vegetation requires larger size
- One size does not fit all – scale dependent
  - Soil biological crust vs. forbs vs. grass vs. shrubs vs. trees

### Quadrat Shape

- Number and size of quadrat most important
- However, shape can reduce variation
- **Perimeter to Area Concerns**
  - Want to minimize borderline decisions, thus reduce perimeter:area
    - Perimeter:area decreases as quadrat size increases
    - Perimeter:area depends on shape
Circle
- Less perimeter area than square or rectangle
- Perimeter decisions difficult when clipping so often used for biomass
- Good for clonal plants

Square
- Greater perimeter:area than circles but less than rectangles
- Good for frequency because easy to estimate presence/absence
- Good for cover but easier with rectangles

Rectangle
- More likely to cut across plants than contain entire plants
- Rarely occupied completely by bare spaces
- Reduces variability in sparse vegetation
- Easier to estimate cover

Step 6: Establish Monitoring Plots
2. Describe monitoring plots and record GPS locations
   - Average precipitation, ecological site, soil series slope, aspect, etc. (See Vol. II; page 35)
3. Record long-term data
   - Excel files available online at http://usda-ars.nmsu.edu
   - Calculations available in Excel files using formulas
4. Error check and make back-up copies of data
   - Review all forms for completeness and legibility before leaving plot
   - Quality check data after entered into computer
   - Store data in at least two different buildings