# TECHNICAL NOTE

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# Monitoring Grazing Lands

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# An Overview of Monitoring

## Why Monitor Grazing Lands?

One primary goal of most managed grazing plans is to maintain or improve the condition of the vegetation and/or soils on rangeland or pasture. Grazing animals have both a positive and negative impact on grazingland resources. The ability to determine how management affects the vegetation and soil resource is essential to determine success of grazing management. Monitoring also helps guide future management decisions. This technical note outlines a variety of commonly used and widely approved methods for rangeland monitoring and record keeping. Monitoring methods are variably suited to situations based on time, resource objectives and goals, environment, potential uses of the information, and technical ability of land managers and natural resource specialists. Monitoring program design should be based on the consideration of all of these factors.

## What Should be Monitored?

The desired attribute to be monitored should be based on the goals and objectives of the grazing operation. Specific resource objectives are critical to a successful grazing plan and must be determined early in the planning process. Common objectives such as increasing ground cover, overall changes in plant species composition, plant vigor and frequency of a desirable key species, livestock grazing use, or improving livestock distribution can all be assessed by established monitoring methods that are easy to use and reliable. In addition, record keeping is an important part of a monitoring program. Detailed information such as weather conditions (particularly precipitation, but also temperature) and records of livestock grazing use must also be kept to assist in the analysis of monitoring data. Weather data can also be used to support drought management decision making.

## Getting Started

The first step when implementing grazing land monitoring is to select the method(s) to be used. Table 1 lists several common monitoring methods useful for measuring grassland attributes for most conditions in South Dakota (SD). Consideration should be given to the amount of time needed to accomplish the monitoring and the technical requirements of the method. If the method is too complex and time consuming, it is not likely to be repeated in the future. The most important factor in selecting a monitoring method is to ensure the analysis of the information collected can be directly applied to resource goals and objectives. The best way to select and initiate a monitoring method or program is to seek the advice and leadership of others who have monitored grazing lands. Assistance can be obtained from other landowners that have developed a monitoring plan, personnel from agencies and departments such as the United States Fish and Wildlife Service (USFWS), the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), SD Game, Fish and Parks (SDGF&P), the United States Department of Interior (USDI) Bureau of Land Management (BLM), the USDA Forest Service (USFS), Cooperative Extension (CES), or from private natural resource consultants or organizations.

Selection of monitoring strategies for most livestock operations should include both short-term and long-term monitoring techniques. Short-term monitoring techniques often assess management goals such as livestock grazing use levels, residue and litter, browse use, livestock grazing patterns, etc. Evaluating grazing land conditions with long-term monitoring assesses changes that happen slowly due to management that have occurred for several years or due to long-term climate conditions. Short-term monitoring evaluates changes to grasslands that occur relatively quickly, such as seasonal utilization or a change in plant vigor. Multiple monitoring techniques can be implemented on the same monitoring site. For example, photographs taken in combination with more quantitative techniques such as Line Point Intercept (LPI) is advisable. Conducting monitoring techniques during the period of peak herbage production (usually mid to late July in SD) or immediately at the end of the growing season ensures both warm- and cool-season plants will be represented. Many of the methods discussed in this technical note are derived from *Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems*, hereafter referred to as “The Monitoring Manual.” The monitoring methods described in the body of this technical note are ordered from simplest and most direct to the most complex and requiring the greatest level of technical expertise.

## Table 1 – Objectives Related to Monitoring Methods

| Monitoring Method | Landowner Objective | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Riparian Condition | Increase Forage Production | Increase Ground Cover | Improve Plant Vigor | Change Plant Species Composition | Wildlife Cover and Habitat | Improve Livestock Distribution | Time Required | Monitoring Method Term |
| Photo Point | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | Low or Medium | Short and Long |
| Use-Zone Mapping | | | | | | | ✓ | Medium | Short |
| Grazing Exclosure | | | | | | | ✓ | Low or Medium | Short |
| Landscape Appearance/ Key Species | | | | | | | ✓ | Medium | Short |
| Paired Plot | | | | | | | ✓ | Medium | Short |
| Cover Pole | ✓ | | | | | ✓ | | Medium | Short and Long |
| Plant Production | | ✓ | | ✓ | ✓ | | | Medium or High | Long |
| Similarity Index | | | | | ✓ | | | High | Long |
| Line-Point Intercept | ✓ | | ✓ | | ✓ | | | Medium | Long |
| Frequency | | | | | ✓ | | | Medium | Long |
| Modified Frequency | | ✓ | | | ✓ | ✓ | | Medium | Long |
| Dry-Weight Rank | | | | | ✓ | | | Medium | Long |
| Modified Dry-Weight Rank | | ✓ | | | ✓ | | | High | Long |
| Comparative Yield | | ✓ | | ✓ | ✓ | | | Medium | Long |
| Cover Board | ✓ | | | | | ✓ | | Medium | Long |
| Belt Transect | ✓ | | ✓ | | ✓ | ✓ | | Medium | Long |
| Line Intercept | | | ✓ | ✓ | ✓ | ✓ | | Medium | Long |

*Selected long- and short-term monitoring methods for SD grazing lands based on common landowner objectives.*

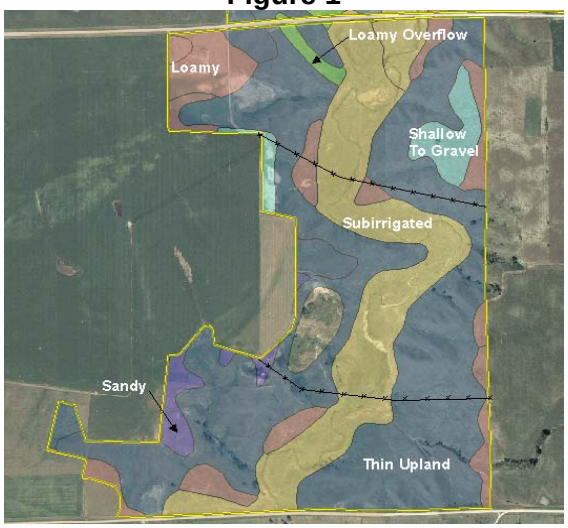
## Selecting a "Key Site or Grazing Area" to Monitor

After management objectives and monitoring methods have been determined, key sites where monitoring will be routinely conducted must be selected. Key sites are small areas within a grazing unit that reflect current grazing management and represent the entire field or a group of fields. Key sites should be areas that are valuable for grazing, represent common sites within management units, and located in an area representative of the grazing unit as a whole (i.e., do not locate key areas near water facilities or in remote areas of the grazing unit that are rarely grazed). For the purposes of long-term monitoring, selected sites must be likely to change in some way as a result of adjustments to livestock grazing or vegetation management. Monitoring sites may also be located in areas where specific resource concerns have been identified and on a site where planned management will produce results. Locations of key areas are usually selected based on a landscape position that reflects grazing units as a whole and represents an important forage base. Representative sites and dominant landscape features can most easily be determined by use of field maps or aerial photography. Sites with similar physical characteristics (slopes, soil textures, depth, etc.,) and ability to produce similar kinds and amounts of vegetation are grouped into Ecological Sites (ES). Determining dominant ESs within a grazing management unit is helpful for choosing the type of sites to target for key management areas, and can help predict the kind of change that can be expected to occur on a particular site. If ESs are determined on the ground for key site selection, it is important to understand the concepts that distinguish each ES.

Mapping and delineating dominant soil types should be done early in the planning process and will provide information regarding dominant soil characteristics that can also be used to select key sites (Figure 1). Information like soil mapping and ES determinations can be derived from NRCS data such as published soil

surveys, Section II of the NRCS SD Technical Guide (SDTG), NRCS Web Soil Survey, Arc-Map and NRCS Soil Data Viewer, and a variety of locally developed Geographical Information System (GIS) tools. Most soil and vegetation resources developed by the NRCS are available online.

**Figure 1**




*Dominant ESs spatially displayed on an aerial photo/plan map.*

## Establishing the Monitoring Point

Once the key sites have been selected, monitoring points need to be established. It is important to permanently mark the point so it can be found repeatedly and to ensure data is collected at precisely the same location each time monitoring is accomplished. If the monitoring method selected utilizes the use of a transect, the end points of the transect should be permanently marked. Transects consist of a tape that is stretched between two or more points, mostly linearly to create a path used for sampling in an orderly and repeatable fashion. Most monitoring methods require sampling at regular intervals in a fixed direction along the tape and are very simple to construct and use. The site selected for monitoring that the transect will occupy is referred to as the plot. If a sampling frame is used to collect data along a transect or within the plot, it is referred to as a subplot. Many methods incorporate the use of a sampling frame, also known as a plot frame or quadrat. This allows sampling to occur within a standardized and known area. The **plot frame** is the physical equipment used as a reference and the **subplot** is simply the area the subplot frame occupies. Standard sizes (Table 2) are important for collecting vegetation production data so conversion calculations can be standardized (usually from grams per plot to pounds of vegetation per acre) and so the subplot sample size is adequate to serve as a representation of the plot. For methods that do not incorporate plant production, other than standardized sizes can be used; however, they should be similar in size to those suggested in Table 2. In most cases, a 1.92 $ft.^2$ plot frame will suffice. In regions with very sparse vegetation larger quadrats (such as 4.8 or 9.6 $ft.^2$) may be desirable. For expanded shrub subplots (described within the production method), 435.6 $ft.^2$ subplots are usually used. Plot frames are typically constructed from polyvinyl chloride (PVC), metal rod, or from a flexible material such as a coated cable or thin rubber tubing.

## Table 2 – Plot Frame Conversion Factors

| Quadrat Size ($ft^2$) | Side of Square (in) | Radius (in) | Circumference (in) | Conversion Factor |
|---|---|---|---|---|
| 435.6 | 250.45 | 141.30 (11.78 ft) | 887.83 | 0.22 |
| 43.56 | 79.2 | 44.68 | 280.76 | 2.2 |
| 9.6 | 37.18 | 20.98 | 131.8 | 10 |
| 4.8 | 26.29 | 14.83 | 93.2 | 20 |
| 2.4 | 18.59 | 10.49 | 65.9 | 40 |
| 1.9 | 16.63 | 9.38 | 58.94 | 50 |
| 1.2 | 13.15 | 7.42 | 46.6 | 80 |
| 0.96 | 11.76 | 6.63 | 41.68 | 100 |

*Standard quadrat (plot frame) sizes, their dimensions for construction of circle or square designs, and conversion factors to convert grams to lbs../ac.*

There are many different ways to permanently mark a transect or monitoring point; however, selecting a marker that is permanent and easy to find on the ground is best. Depending on the type of monitoring point, either a center spoke style transect, a linear transect (Figure 2), or a single point method (such as for simple photo points) can be used. If a linear transect is used, permanently mark the beginning and ending points of the transect. If a spoke style transect is used, permanently mark the center and each end point of the transect. A spoke style transect is chiefly valuable when the transect is to be situated on small nonlinear sites. Refer to *The Monitoring Manual* for more information on transect design. When in doubt, it is simplest to construct linear transects, which work well for most grazingland sites in SD. Constructing a transect in the field at the time of monitoring consists of pulling a measuring tape tightly between two ground stakes. Using a disk blade that is partially buried in the ground serves well as a permanent marker for each transect. The disk can further be anchored into the ground by welding rebar to the concave side of the disc. Also useful are brightly colored heavy duty plastic survey stakes (usually about 2-inch diameter and about 16 inches long) that can be driven into the ground to a nearly level depth. These stakes are easy to find in the field, are quick to install, and do not pose a hazard to motorized vehicles or livestock. It is advisable to select markers that do not attract livestock as this may cause soil disturbance and congregation in the area of the monitoring point. The general location of the marker should be recorded using a Global Positioning System (GPS) if available, annotating the location on a map, or by noting the direction and distance from a permanent marker. Painting the transect marker a bright color further aids in finding the monitoring point. When establishing monitoring points, it is important to keep the entire transect or plot within a single ecological or soil site type. If transects are located on hillsides, they should only be oriented along the contour of the slope, not up or downslope. The length of each transect should be determined by the number of sampling points required and/or the method of monitoring being employed. Adequate sampling will be discussed within each monitoring method section.

**Figure 2**

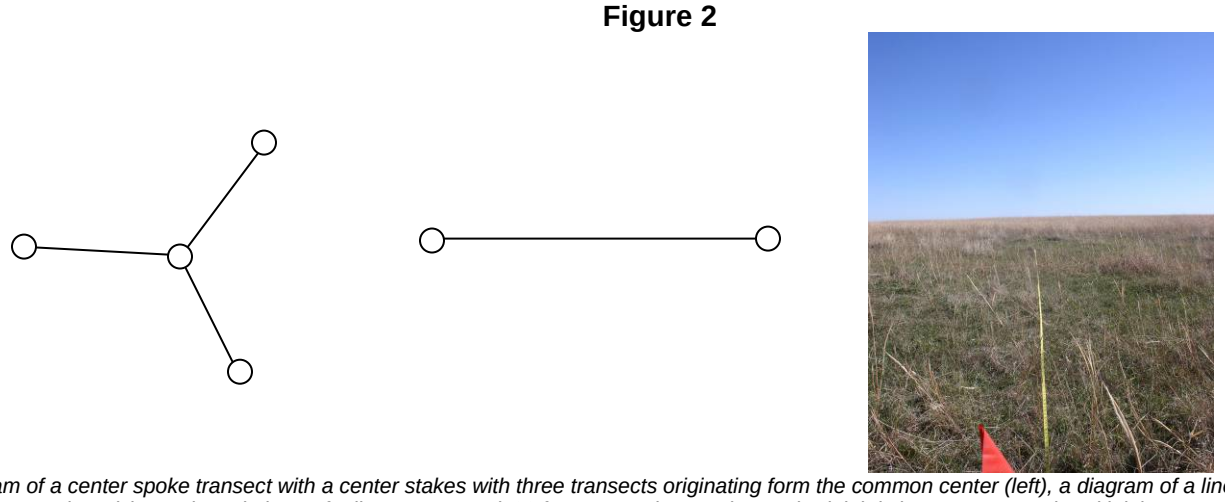


*Diagram of a center spoke transect with a center stakes with three transects originating form the common center (left), a diagram of a linear transect with stakes at each end (center), and photo of a linear transect (100 feet measuring tape) stretched tightly between two stakes (right).*

# Useful Monitoring Methods

## Photo Points

Photo points can be use for both short- and long-term monitoring and are useful to document how vegetation changes over time. They are simple, easy to interpret, and repeatable. Both close-up photos and general photos of the site can be used. Close-up photos provide a better analysis of plant vigor and ground cover; however, general landscape photos provide an adequate view of dominant landscape vegetation and are fast to employ.

## Materials Required

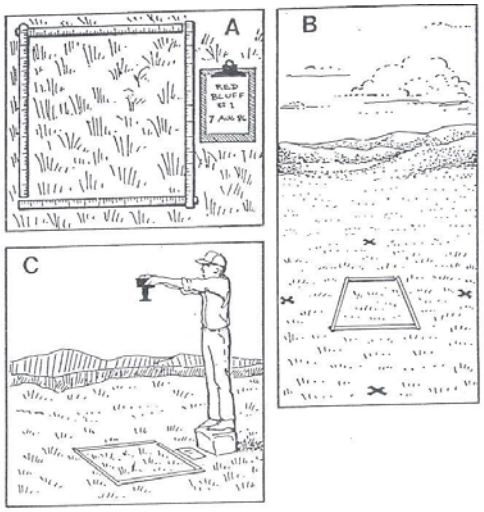
Photo point data sheet (provided in the Monitoring Tool spreadsheet):

- Pen or pencil
- Measuring tape (optional)
- Compass (optional)
- Camera
- Dry erase board or writing pad and pens
- Reference plot frame or folding carpenter's rule (for close-up photo method only)
- GPS unit (if available)

## Steps for Close-up Photos

- Photographs must be taken in the identical spot year-to-year. By using a transect measurement, photos can be taken in the same location each year.
- Transect must be permanently marked at the beginning and end, and a tape of preferably 100 feet extended between each. If a spoke style transect is used, the total length of all transects should be at least 100 feet.
- Determine the location of each photo plot to be taken along the transect. Usually regular intervals are best. Taking at least five photos along the transect is time efficient and provides good representation of the site.
- On a dry erase board or other writing pad, record the date, field, transect (1, 2, 3, etc.,) and the photo plot number (i.e., 20-foot mark, etc.). Ink should be bold enough to view on a photo. A dark colored marker works best.
- Position a reference frame (plot frame) or carpenter's rule (see Figure 4) adjacent to the predetermined locations along the transect. Place the dry erase board or writing pad adjacent to the reference frame in a manner that assures it will be included in the photo. Note: reference frames should be no larger than three feet by three feet to fit in most camera frames.
- Stand directly above the plot frame or photo plot and direct the camera straight toward the ground while taking the photo, zoomed at full extent (zero percent zoom) (Figure 4).
- Optional: Placing objects of known size inside the photo plot such as a golf ball or a tennis ball will help to provide a greater sense of scale in the photo and help illustrate ground cover and plant residue after the grazing season.
- Record GPS coordinates of the monitoring location (if available).

**Figure 3**




*Example of taking a close-up (A and C) and general landscape photo point (B).*

**Figure 4**

*Right: example of a close-up photo point along a transect using a golf ball and tennis ball to illustrate scale and depth.*

## Steps for General Landscape Photos

- Determine the direction from the permanently marked monitoring point that the landscape photo will be taken. If a prominent landscape feature will be included in the photo, make a note of the reference feature. If no prominent landscape features will be included, take a compass bearing in the desired direction and record on the photo point datasheet for reference during subsequent sampling.
- On a dry erase board or other writing pad, record the date, field, and identify the transect or other information. Ink should be bold enough to view on a photo.
- Place the dry erase board or writing pad on the ground or upon a support within the frame of the landscape photo and take a photo. A dry erase board or clip board fixed to the top of a shovel handle with rubber bands works well. Be sure to maintain the camera at a consistent height for each subsequent photo.
- Landscape photos should focus on the vegetation immediately in front of the observer; yet also contain a view of the horizon in the distance. The landscape photo should be about one-third sky and two-third landscape (Figure 5).
- Multiple landscape photographs can be taken from a central point (in multiple directions) and may more specifically document changes to plant communities.

**Figure 5**

*Landscape photos should contain recognizable landmarks and focus primarily on the landscape directly in front of the observer.*

## Riparian Area Monitoring Considerations

Photo points work well to document changes to riparian areas after livestock grazing management has been initiated. Landscape photos that capture riparian area features expected to change such as eroded or degraded banks, areas where woody species generation is a main objective, etc., are very useful to document improvements in riparian cover and function.

## Key Points when Initiating Photo Point Monitoring

- Collect detailed notes when each photo is taken that describes the vigor of the vegetation, plant species composition, livestock use, the date, current management since the last photo, general precipitation comments, etc.
- Photos should be taken annually during the same time of year and should represent peak herbage production (usually midsummer through September).
- Photos should be taken at the same height, zoom, and direction as the year before (e.g., full extent, zero percent zoom).
- Take at least one photo at each monitoring location and both general landscape and close-up photos can be combined. All photos should be in color. Digital cameras usually provide enough resolution for a quality photo point.
- Be sure to document specific methods used such as what side of the transect photos are taken, size of the reference frame used in the photo, and at what interval along the transect photos are taken.
- If landscape photos are taken, it is helpful to include a recognizable landmark in each photo for future orientation and photo analysis.
- Take photos from an angle that does not project a shadow across the image.
- Photo points should be accomplished each year.

## Use Zone Mapping

Utilization is typically not uniform across rangelands. This is due to distances from water and feed supplements, topography, and variable site and vegetation types. Therefore, assessing utilization across a pasture may be best accomplished using use zone mapping. This method involves recording utilization "classes" (percent of plant biomass removed by weight) throughout a pasture. This method works well for recording where and how much a field is grazed each year (an example of record keeping), and is important for considering management changes to livestock grazing duration or stocking density.

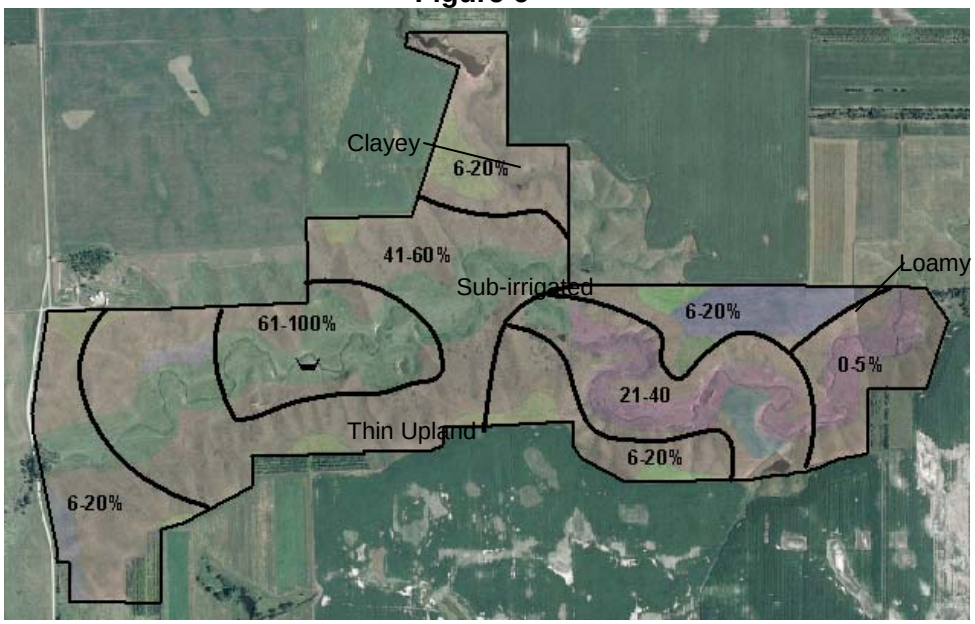
## Materials Required

- A base map of the area of interest that shows ESs or soils, and locations of fences, water sources, and other physical features that may influence animal behavior. Maps developed with GIS tools work well as long as a large enough scale is displayed.
- A pen, marker, or colored pencils to annotate use classes on the map.

## Steps for Use Zone Mapping

- Traverse the area of interest to gain an idea of the patterns of livestock use within a pasture. It is usually easiest to begin near areas of livestock concentration such as water developments. Create use zones based on range/pasture utilization. Use zones should be separated by class. A 5-class system of 0-5 percent; 6-20 percent; 21-40 percent; 41-60 percent; 61-80 percent; 81-94 percent; and 95-100 percent works well (Figure 6).
- As use zones are encountered within the grazing unit, record the area of the boundary between zones on the map and note the percent utilization within the use zone.
- Utilization can be described as entire disappearance or utilization of key species. If the key species method is used, record areas that do not contain the key species. If multiple key species are used, note the key species and use levels on the map.

**Figure 6**




Use zone map reflecting utilization patterns within a single grazing unit.

## Key Points

- This method is not recommended for small grazing units (less than about 300 acres) since their use is generally uniform and not affected by distances within pastures from water or fence boundaries.
- Key species can be stratified within the pasture based on site types in each field.
- It is helpful to have a good concept of utilization levels and be able to visually estimate them when in the field to accurately assess utilization. Calibration of one's eye may come from using a paired plot design for monitoring or referring to the NRCS SDTGs that correlate percent height removed to the percent of weight grazed.
- Use zone mapping should be conducted at the end of each grazing season.

## Utilization: Grazing Exclosure Cage/Modified Paired Plot Clipping

Livestock grazing use can best be evaluated by constructing one or more grazing cages or exclosures within grazing units. Grazing exclosures allow vegetation to grow ungrazed within the cage, while vegetation outside the cage is grazed freely by livestock. An accurate estimation of livestock grazing use can then be made by comparing the cumulative vegetation inside the exclosure to the grazed vegetation outside the exclosure. Estimating current year's utilization and comparing it with planned grazing use is a rapid and useful short-term monitoring technique. An ocular estimate can be used to gauge utilization or a paired plot technique can be employed which compares the harvested weight of vegetation inside the exclosure to similar vegetation outside the exclosure. Regardless of the technique, measurements of utilization should be visually noted throughout the gazing period, and should be used to make grazing management decisions such as livestock rotation timing and future grazing periods. Placement of exclosures should be made with the same criteria other key monitoring areas are selected on and grazing cages can be situated in proximity to the same site where other monitoring activities will occur. Cages should not be placed too near permanent transect locations, as the cage may attract livestock activity (a buffer of about 100 feet should suffice).

**Figure 7**

*Prefabricated and quickly-assembled grazing exclosure cages constructed with wire, steel posts, and rebar. Note the contrast of vegetation biomass in the photos between the inside and outside of the cages.*

### Materials Required

- Grazing exclosure
- Pen or pencil
- Measuring rule (optional)
- Measuring tape (optional)
- Data sheets (all described in this method are provided in the Monitoring Tool spreadsheet) or other record keeping form
- GPS unit if available

### Additional Materials Required for Paired Plot Study

- Clipper and clipping plot frame (1.92 $ft.^2$ plot frame is recommended).
- Small paper bags large enough to hold vegetation samples.
- Gram scale suitable for measuring small paper bags.

## Steps for Estimating Utilization

### Visual Estimates

- Estimate the amount of forage removal by weight (percent weight) within the area near the grazing exclosure by comparing remaining grazed grass height to that inside the exclosure. Table 3 below should be used to determine the percent of height removed. Note: Correlation of height to weight in grasses is not linear and most weight is concentrated at the base of the plant; therefore, it is necessary to determine what height of the grass plant is 50 percent of its weight. This is easily done by balancing a grass plant species of interest or group of the same grass plant species (in the case of bunch grasses) bound by a small rubber band or tied together using a grass stem across your finger. The middle point of the plant's biomass will be the point of balance and will be the height at which 50 percent by weight of the plant occurs.
- Visual utilization estimates should be done by species (usually a key management species such as western wheatgrass). An average of ungrazed height is determined from inside the exclosure and average of grazed plant height is then determined outside the exclosure.
- If the reviewer is experienced overall utilization of all plants on the site may be estimated.
- Estimates should be made routinely to determine level of temporal livestock use and determine necessity of modifications to grazing management.

### Pace and Measure Method

- Determine the average height of the plant of interest (by measuring with a ruler) from along a pace transect. A pace transect is accomplished by maintaining a constant direction while walking in line and recording vegetation information at designated step paces. A line transect can be used to assist with data

collection if desired, but this method may require several observation points and will probably extend past most measuring tape lengths.

- Pace about three steps and measure (using a ruler) and record the height of the plant species of interest closest to the toe of the observer's foot (this plant could be grazed or ungrazed) at each pace interval:
  - If the specimen is a rhizomatous grass, pull the leaves up in an erect fashion and measure.
  - For bunch grasses, measure at the center of the bunch and pull all leaves to an erect fashion and measure.
  - Attempt to measure a majority (>80 percent) of either culmed (those producing a seedhead) or culmless (those that are vegetative or have no seedhead).
- Identify the measured plant as grazed or ungrazed and record accordingly.
- Remember that ungrazed plants encountered along the transect will be recorded as both grazed and ungrazed, as this number is used to determine an average height for that species ungrazed, and is used to determine average "grazed" plant figure, since the plant is part of the population of plants that could be grazed.
- Measure at least 20 ungrazed plants. At lease 20 grazed plants should be selected as well, but 30-40 is ideal. If there are not a sufficient number of ungrazed specimens from the transect area, take measurements from under the grazing exclosure or select them subjectively from the area.
- Calculate percent height removed by subtracting the average height of the ungrazed plants from the average height of the grazed plants. The percent height removed is then determined by dividing this number by the average height of ungrazed plants.
- Using Table 3, determine the percent weight removed based on the percent height removed determined by this method. Percent of weight removed is the utilization of the selected plant species.

## Steps for Measuring Utilization Using the Modified Paired-Plot Method

- Upon completion of the grazing season, at least one-1.92 $ft.^2$ plot frame within the grazing exclosure will be clipped, removing all vegetation at ground level. Clipping two or more plot frames is recommended and only the current-year's growth is harvested. For more information on clipping vegetation, see the "Total Production" method described later in this technical note.
- The same number of plot frames that were clipped within the grazing exclosure will also be clipped outside the grazing exclosure on the same ES where livestock grazing occurred. Subplots outside the exclosure should be located at least 10 feet away from the grazing exclosure cage to minimize effect of the exclosure on the subplot. The subplot locations outside the exclosure are subjectively selected to represent similar vegetation that was clipped from the plot frames inside the exclosure (paired plots).
- Vegetation clippings may be weighed all together from an individual plot frame, or separated by species or a group of species (such as a key species or desirable from undesirable species), depending on the observer's preference.
- All vegetation clippings collected from individual plot frames are placed in a paper bag. Be sure to note the empty weight of the paper bag. Weigh each clipped plot (usually a small gram scale works well), subtract the weight of the bag, and average both the weights of the vegetation inside and outside of the exclosure. Subtract the weight of samples outside the exclosure from the weight of samples inside the exclosure. The percent utilization is calculated by then dividing that number by the weight measured inside the exclosure (e.g., 50 grams (g) outside exclosure – 20g inside exclosure = 30g, (30g÷50g)*100 = 60 percent utilization).
- If dry matter differences are suspected between the exclosed and grazed subplots, the clipped samples should be air dried for about one to two weeks before weights are measured (when the weight remains constant, the sample is considered air-dried).

## Table 3 – Height-Weight Relationships of Grasses

| The Relationship Between Percent Height Removed and Percent of Weight Removed for Selected Species | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species** | **Percent of Height Removed** | | | | | | | | | | | | | |
| | **10** | **20** | **30** | **40** | **50** | **55** | **60** | **65** | **70** | **75** | **80** | **85** | **90** | **95** |
| Big Bluestem | 2 | 6 | 11 | 17 | 23 | 30 | 35 | 41 | 46 | 54 | 62 | 71 | 79 | 89 |
| Blue Grama | 2 | 4 | 6 | 9 | 13 | 15 | 17 | 20 | 25 | 28 | 35 | 42 | 53 | 75 |
| Buffalograss | 2 | 5 | 7 | 11 | 18 | 21 | 32 | 35 | 38 | 45 | 53 | 62 | 71 | 77 |
| Crested Wheatgrass | 2 | 4 | 7 | 11 | 18 | 24 | 29 | 33 | 38 | 44 | 53 | 60 | 68 | 83 |
| Green Needlegrass | 2 | 4 | 6 | 11 | 16 | 20 | 25 | 30 | 36 | 44 | 52 | 61 | 71 | 85 |
| Kentucky Bluegrass | 1 | 3 | 5 | 9 | 14 | 16 | 20 | 26 | 34 | 40 | 47 | 57 | 71 | 85 |
| Little Bluestem | 1 | 4 | 9 | 15 | 23 | 27 | 32 | 37 | 41 | 47 | 53 | 61 | 70 | 82 |
| Needleandthread | 1 | 2 | 4 | 6 | 10 | 12 | 15 | 19 | 24 | 29 | 36 | 46 | 56 | 73 |
| Prairie Junegrass | 2 | 4 | 6 | 9 | 13 | 16 | 18 | 21 | 25 | 30 | 35 | 42 | 55 | 69 |
| Prairie Sandreed | 2 | 6 | 11 | 17 | 23 | 30 | 35 | 41 | 46 | 54 | 62 | 71 | 79 | 89 |
| Red Threeawn | 2 | 6 | 11 | 17 | 26 | 30 | 36 | 42 | 46 | 53 | 61 | 70 | 78 | 89 |
| Sandberg Bluegrass | 1 | 2 | 4 | 8 | 11 | 14 | 16 | 19 | 24 | 30 | 37 | 46 | 56 | 75 |
| Sand Dropseed | 1 | 3 | 5 | 8 | 12 | 17 | 21 | 25 | 30 | 35 | 46 | 56 | 68 | 83 |
| Sideoats Grama | 1 | 3 | 5 | 9 | 14 | 18 | 23 | 27 | 32 | 39 | 47 | 56 | 66 | 80 |
| Slender Wheatgrass | 2 | 6 | 9 | 12 | 17 | 21 | 27 | 31 | 36 | 42 | 51 | 59 | 69 | 80 |
| Smooth Brome | 3 | 6 | 11 | 15 | 19 | 27 | 32 | 37 | 45 | 52 | 58 | 63 | 82 | 92 |
| Switchgrass | 2 | 5 | 9 | 13 | 20 | 26 | 30 | 36 | 42 | 50 | 59 | 68 | 76 | 89 |
| Threadleaf Sedge | 2 | 4 | 6 | 10 | 15 | 17 | 21 | 27 | 34 | 41 | 48 | 59 | 73 | 86 |
| Western Wheatgrass | 2 | 6 | 11 | 17 | 26 | 32 | 37 | 44 | 50 | 58 | 66 | 74 | 82 | 91 |

*The percent of height removed for a plant can be correlated to the percent of weight removed by grazing. If the average percent of height removed can be determined for a site or pasture, then the percent utilization can be estimated using this table.*

### Key Points

- If measuring long-term change under grazing exclusion is not a primary objective of the monitoring system, grazing exclosure cages should be moved after each grazing season to ensure the immediate area under the exclosure is not protected from grazing in successive years as this can lead to unintended changes in the plant community.
- Measuring utilization using the modified paired plot method provides an accurate utilization estimate and allows for accurate observer calibration for future utilization estimates.
- Estimates are best made by key species; therefore, a key grazing species should be selected, and utilization focused on that species.
- Grazing exclosure(s) should be anchored to the ground and ensure no livestock grazing while providing about four sq. ft. of ungrazed area. At least one grazing exclosure is required; however, using three or more on the same site is optimum for the paired plot method.
- For specific information and construction specifications regarding grazing exclosures, see the Interagency Manual Fences or the Interagency Technical Reference Utilization Studies and Residual Measurements (Appendix E) which are available in most NRCS offices and referenced at the end of this technical note.
- Utilization should be measured at the end of each grazing season.
- If utilization estimates are recorded at the end of the grazing season, it should be accomplished shortly after livestock are removed. This data can be used for long-term record keeping and supplement other monitoring or grazing plan decision making.

## Landscape Appearance/Key Species Utilization Methods

The landscape appearance method yields an ocular estimate of utilization based on the overall grazing use observed within an area of interest. The level of utilization is determined by comparing what is observed on the ground to written descriptions of seven utilization classes. An optional **key species** method may be employed if utilization of key grazing species is desired.

## Materials Required

- Landscape appearance or Key Species Utilization Datasheet (provided in the Monitoring Tool spreadsheet)
- Pen or pencil
- Measuring tape at least 100 ft. long and ground stakes

## Steps for Measuring Landscape Utilization

- Pull the ends of the measuring tape tightly between each end of the transect and secure with ground stakes.
- At designated points along the transect, observe the grazing use of all plants combined in the area that is immediately visible when standing along the transect while still being able to focus on vegetation clearly.
- Compare what is observed at the observation point to the Utilization Class Interval Descriptions provided on the Landscape Appearance Datasheet. A count of each utilization class encountered is maintained on the datasheet using a dot count method (see the Landscape Appearance Datasheet).

## Steps for Measuring Key Species Utilization

- Pull the ends of the measuring tape tightly between each end of the transect and secure with ground stakes.
- Select a key species. This species is normally a desirable forage plant that makes up at least 15 percent of the plant community.
- Observe the species of interest that falls closest to each designated point along the transect and compare its grazing use to the written Utilization Class Interval Descriptions on the Key Species Utilization Datasheet. A count of each utilization class encountered is maintained on the datasheet using a dot count method (see the Key Species Utilization Datasheet).
- If the species of interest is not in proximity to the designated point, simply move to the next designated point along the transect.
- Up to two key species can be selected.
- If desired, a pace method can be used in lieu of a transect. In this case, the utilization of the species of interest closest to the observer's foot at each pace interval is evaluated.

## Calculations

- The total number of instances a utilization class is encountered is tallied.
- This value is multiplied by the mid point value of the interval class (e.g., the midpoint of class interval 0-5 percent is 2.5) to establish a "weighted" utilization class value. This is done for each class encountered and recorded on the datasheet.
- All "weighted" utilization class values are summed and divided by the total number of observations. This value is the percent utilization of the transect area observed.

## Key Points for Landscape Appearance Method

- This method is fast, easy to employ, and results are repeatable between observers.
- Multiple transects or transects greater than 100 feet in length may be desirable to better gauge utilization levels.
- If the observer is experienced with this method, utilization interval class definitions can be used to quickly estimate utilization across large areas of grazing units without employing transect methods.

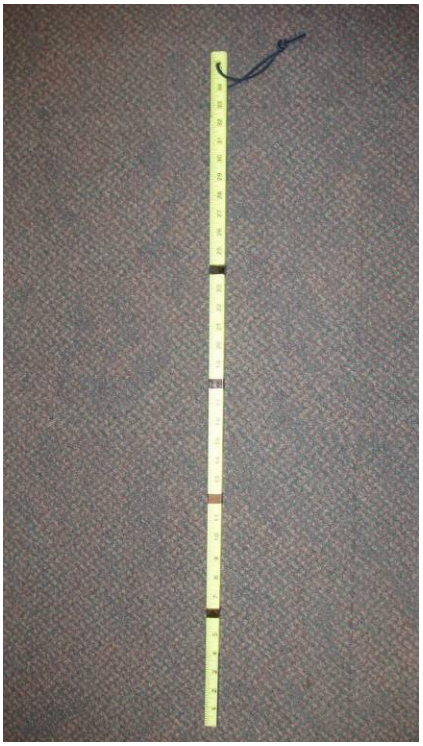
## Cover Pole

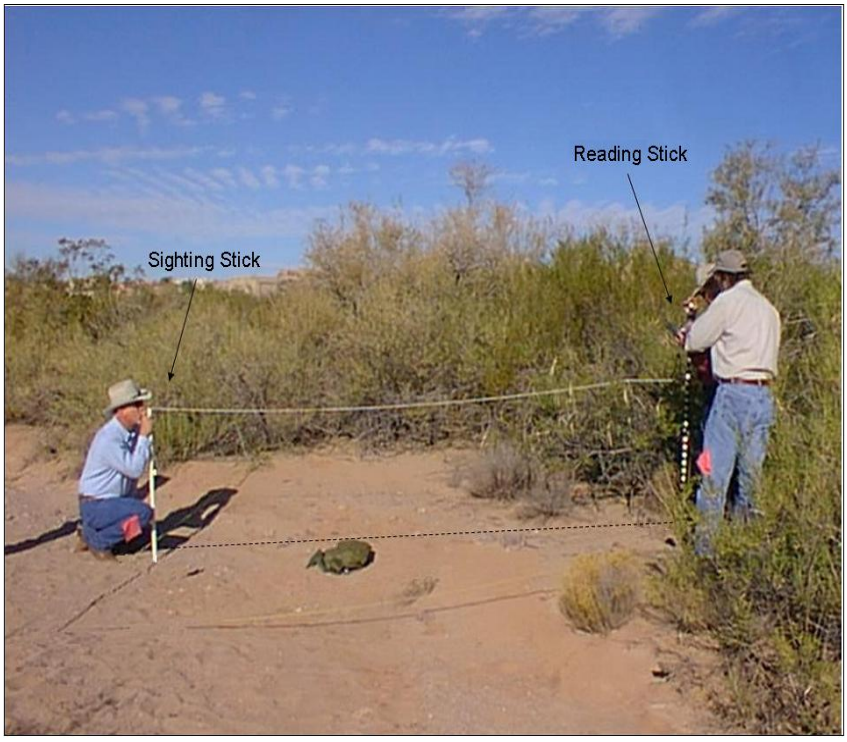
The cover pole method (similar methods are known as Robel Pole or visual obstruction method) is a relatively simple method of measuring the density of vegetation in order to assess the suitability of habitats for specific wildlife species. Visual obstruction readings (VOR) provide an index of wildlife cover or concealment. The VOR can give an indication as to what wildlife species, particularly upland grassland birds, for which the habitat might be suitable.

## Materials Required

- Vegetation structure (VOR) datasheet or other record keeping form (provided in the Monitoring Tool spreadsheet)
- South Dakota grazing sticks (2) or generic yard sticks
- Black electrical tape or a permanent marker
- String or rope about 4 meters (roughly 13 feet) long
- Pen or pencil

**Figure 8**






Left: Grazing stick with bands marked at 6, 12, 18, and 24 inches. Right: Reading visual obstruction in the field.

## Steps for Measuring Visual Obstruction

- On one grazing stick, which will be referred to as the reading stick, wrap black electrical tape around the stick (or "black-out" about a ½-inch strip with a permanent marker) at the 6-inch, 12-inch, 18-inch, and 24-inch marks. Then tie one end of the string or rope to the top or handle end of the reading stick. The other grazing stick, which will be referred to as the sighting stick, can be attached to the other end of the string or rope, or left unattached.
- If using the transect line as described in other methods, go to the 10-foot mark on the transect and stand over this mark with the sighting stick end of the string or rope, and extend the reading stick out perpendicular to the transect line until the string or rope is taut. Then place the reading stick upright in contact with and perpendicular to the ground surface. This will be the first point or Station #1.
- Using the sighting stick, sight over the top of the stick and look back at the reading stick. Consider the 0-6-inch area on the stick or ruler as the 6-inch band (the 6-12 inch area as the 12-inch band, the 12-18 inch area as the 18-inch band, and so forth). Record the band that has 50 percent or more of its area obstructed by vegetation so that you cannot easily see the stick or ruler behind the vegetation. Record this

reading in the first column on the “Station #1” line. If the 6-inch band is less than 50 percent obstructed by vegetation, record a “0” on the datasheet for that reading. If it is greater than 50 percent covered, record a “6” (record a “12” for the 12-inch band; an “18” for the 18-inch band, etc.).

- Then holding the string or rope relatively taut and using the reading stick as the pivot point, rotate around the reading stick until you are roughly parallel to the transect line and take the second reading. Record this reading in the second column for Station #1.
- Then rotate again until the string or rope is once again perpendicular to the transect line and take the third reading. The last reading would be the final rotation so that the string or rope is again parallel to the transect line. These two readings would go on the third and fourth columns for Station #1.
- To complete the readings for Station #1, stand over the 10-foot mark on the transect line again and extend the reading stick out perpendicular to the transect line on the opposite side of the transect. Place the reading stick at that point and repeat the process for taking the four readings as described above. When Station #1 is complete, you will have eight readings in all.
- Then move to the 20-foot mark and repeat the process above for Station #2. When you are done, you will have taken 4 readings at 20 points on both sides of the transect line.
- The average of all the readings would be the average visual obstruction for the site and using the guide on the datasheet, the observer can get an idea of what species would be benefitted.

## Key Points for Visual Obstruction

- Do not worry about being exact when trying to determine if a band is more or less than 50 percent covered. This method works best if you take your reading quickly, record the reading, and move on to the next reading.
- The VOR measurements of vegetation structure is typically considered a long-term technique. However, recent grazing activity can obviously have a major impact on the amount of vertical structure that is present on the sight. If used as a long-term technique, care should be used to take the readings at the same “stage” each time it is used (i.e., just before the last grazing cycle in a field). This method could also be used as a short-term technique, for example, monitoring the availability of habitat at different times during the season.

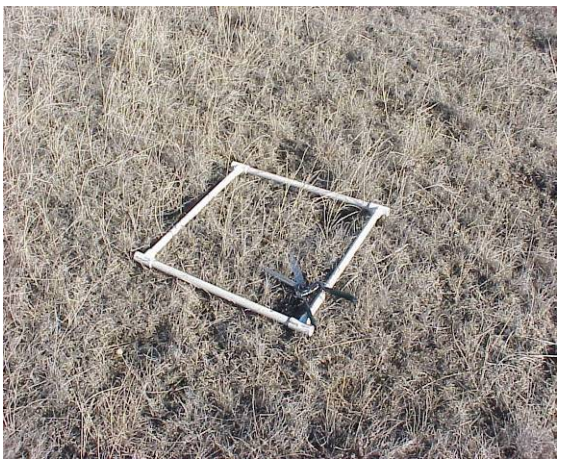
## Total Production

Total production methods are useful to measure total annual plant biomass in grassland or shrubland plant communities. The relative production of species within a plant community is an indicator of plant vigor related to grazing management and measures changes in plant species composition (long-term) over time. Total production is best measured by using a clip-and-weigh method and separating and weighing plants by species is recommended; however, separating plants into groups can be done instead.

## Materials Required

- Production data sheet or other record keeping form (NRCS form SD-ECS-20, Determining Vegetation Production and Stocking Rates, is recommended and is provided in the Monitoring Tool spreadsheet).
- Grass clipper and clipping plot frame or hoop (1.92 $ft.^2$ frame is recommended and can be made from any material, PVC, metal, wire cable, etc.).
- Small paper bags large enough to hold vegetation samples.
- Gram scale suitable for measuring small paper bags.
- Measuring tape at least 100 ft. long and ground stakes (optional for woody shrub production, a short tape at least 12 ft. long or rope 11.7 ft. in length).
- Pen or pencil.

**Figure 9**



*Left: grass clipper and 1.92 $ft^2$ PVC plot frame commonly used to harvest vegetation samples. Right: weighing vegetation samples using a gram scale.*

## Steps for Measuring Total Production

- At the predetermined monitoring location, stretch the measuring tape tightly between each end of the transect and secure with ground stakes.
- Determine what points along the transect will be clipped and weighed. It is recommended that at least five points along the transect be clipped and weighed (increasing the number will increase the accuracy, but five should be considered a minimum). Maintain at least 10-20 feet between sampling points. If more than 10 points are clipped multiple transects or a spoke style transect should be used. When using a 100-ft. tape, it is simplest to sample 5 plots about every 20 ft.
- Place the clipping plot frame along the transect at the predetermined location. If an unusual disturbance is present at the predetermined location (e.g., badger hole, large ant mound, etc.,) move the clipping plot frame five feet up or down the transect and record the location. Adjust the vegetation along the edge of the frame to ensure that only plants rooted within the frame are inside the frame (>50 percent of the plant base is rooted in the frame). In addition, try to eliminate as much of the previous year's growth as possible from within the plot frame. This may require that decadent vegetation be rogued out of the plot before clipping is done.
- Label paper bags with date, sampling location, and sampling subplot number (location along the transect that is clipped). If herbage is clipped by plant species composition, the plant name or type of plant (grass, form, shrub, etc.,) should also be noted.
- Clip the vegetation at the level of the plant base/soil surface from within the plot frame. Clip vegetation at each location along the transect. Separate samples placed in separate paper bags are required for each subplot. Notes should be taken in the field regarding plant phenology (growth stage) and the percent of each species ungrazed. There are two options for clipping:
  - Clip by species option: From within the plot frame clip and separate vegetation by species. Each species is then placed in individual paper bags and labeled accordingly. If very small amounts of a species are in the plot and will likely weigh a trace amount, simply indicate trace on the bag or data sheet and do not collect the specimen in a paper bag. Also, species weighing only a few grams can be clipped and weighed and then discarded. The air-dry weight for these species can be determined from similar species from which a larger sample is obtained. (Note: This method is most time consuming and requires several paper bags, but yields the best information).
  - Clip by group option: If it is unfeasible to separate plants by species, plants may be separated by their general group (grass, forb, shrub, etc.). If possible, further separate key species (usually desirable forage species) from other species within their group.
- Weigh each sample as soon as they are clipped and note the weight on the paper bag. Also note the weight of the empty bag.
- Allow the samples to dry indoors for about two weeks. An air-dry weight can likely be obtained sooner by periodically weighing the bags and recording the weights on the bags – when the weight remains constant,

the sample is air-dried. If necessary, this step can be substituted by calculating the dry weight of the wet sample using dry weight estimates from the National Range and Pasture Handbook (NRPH) or SD NRCS Dry Weight Conversion Tables available from the SD NRCS. After two weeks, when bags are dry, reweigh each bag and record the air-dry weight. Divide the air-dry weight by the wet weight to determine the percent air-dry matter.

- Use the NRCS form SD-ECS-20 or the total production datasheet provided with this technical note to analyze the clipped data. The form used should calculate lbs or air-dry weight per acre.
- Determine and note the following for reconstructing plant production on the production form:
  - Account for the percent dry weight by using methods defined above.
  - Estimate or measure the percent growth ungrazed (see "Utilization" above) plant biomass at the time of the clipping, percent growth completed (available from SD growth curve tables, available in the SDTG).
  - Determine the percent of normal production (±100 percent based on current and/or past year's moisture conditions). Percent of normal production can be calculated by using the percent of normal production calculators (available from the NRCS) or based on professional judgment.
  - Determine the percent growth completed. This is the percentage of total growth expected that has already occurred at the time of clipping. This information can be estimated based on experience or by using growth curve tables available from the SD NRCS.

## Additional Steps

- If shrubs (e.g., persistent shrubs that express cumulative woody growth such as western snowberry or big sagebrush) are a significant part of the plant community being monitored or are of particular interest, expanded subplots should be used in addition to the subplots described above.
- Measuring shrubs should be done using at least two subplots 0.01 ac. (435.6 $ft.^2$) in size (about 11.7 ft. radius). These subplots are located at a predetermined location along a transect (usually at transect locations of 20 and 80 ft. for a 100 ft. transect, or at 37.5 and 112.5 ft. for a 150 ft. transect, etc.).
- At the predetermined locations along the transect, extend a tape or rope 11.7 ft. perpendicular from the edge of the tape and anchor the end away from the tape with a stake or pin.
- Using the free end of the tape, slowly move in a circular fashion pivoting around the anchored center (11.7 ft. away from the transect) completing a 360 degree rotation. All shrubs rooted at least 50 percent within the subplot (circle) are to be estimated using the weight-unit method described in the next step.
- The weight-unit method simply involves removing a subsample from a representative shrub (cut a branch or "clump" roughly the size of your hand or whatever size is easy to hold onto and take with you while you are estimating the entire woody plot). This is your weight-unit. Then using your weight-unit, count the number of weight-units within the entire plot. When you have a count of the weight-units, clip the current year's growth from your weight-unit as described in the next bullet, and multiply the number of weight-units in the woody plot times the weight of your weight-unit. Keep this sample to determine the air-dry percentage of the shrub in question.
- In most cases, new shrub growth can be collected by clipping or stripping leaves along the stems. Most plants such as woody sagebrush, rabbitbrush, and other deciduous shrubs, lose all or most of their leaves over the course of a one-year period, so all leaves should be collected. In addition to this, shrub leader growth should also be collected from each shrub. This is usually the tender new growth at the tips of each shrub branch and can be easily pulled or clipped away from previous year's woody growth. Not all shrubs display similar growth patterns and the collection of further information may be required to accurately determine current-year's growth for other shrubs of interest. For estimation of biomass for shrubs such as Rocky Mountain juniper, see the USDA NRCS NRPH, Exhibit 4-4.

## Key Points

- Production data that is separated by plant species can further be used to calculate similarity index. Similarity index is the percent of similarity between the site inventoried and the historic climax plant community or a preselected desirable plant community. These methods are accomplished using information from the NRCS TGs and protocols described in the NRPH.
- Production sampling should be geared toward key areas that are not heavily grazed (close to water, in a travel corridor, etc.,) so a minimum level of reconstruction is required. The greater level of reconstruction required, the greater the opportunity for error.

- Using a grazing exclosure to protect clipping sites is an option to ensure minimum mathematical reconstruction of the plant community (due to grazing use) is required.
- Collect data at around the time of peak herbage production (around late July through late August in most years) when possible. Collect this data at the same time in subsequent years.
- Production is a long-term monitoring technique. It should be accomplished about every two to three years. Baseline data should be collected upon the initiation of new management.
- Direct comparisons of plant total annual production can be made each time production clipping is accomplished. Comparing changes in plant species composition by weight is particularly important. Total annual production may vary between years depending on weather patterns, and not necessarily due to grazing management. These differences can be further explained by weather (precipitation) record keeping.

## Line Point Intercept

Line point intercept is a useful method to measure total ground cover and ground cover by plant species. This method records the percent cover of vegetation, litter, and rocks. Line point intercept is valuable when resource objectives include increasing soil cover and changing plant species composition. Measurements are made at specified intervals (e.g., one ft., three ft, five ft., etc.,) by dropping a fine pointed pin at predesignated locations along a transect and recording what is intercepted by the pin (live plant tissue, plant base, litter, rocks, bare ground, etc.,) (Figure 9). At least 100-point samples per site are recommended, but 300-point samples is optimum.

## Materials Required

- Line point intercept transect data sheet (provided in the Monitoring Tool spreadsheet)
- Measuring tape at least 100 ft. long and ground stakes
- A sharpened or narrow diameter pin (small surveying wire flags with the plastic flag removed work well)
- Pen or pencil
- GPS unit if available

**Figure 10**

Placement of a pin along a transect to collect cover data.

## Steps for Line Point Intercept

- Pull the ends of the measuring tape tightly between each end of the transect and secure with ground stakes.
- Beginning at the zero end of the tape, drop the pin adjacent to the tape from a point just above the vegetation being sampled until it hits the soil surface (see Figure 6). It is important to drop the pin in a controlled manner straight down. Ensure the pin is dropped vertically and is not positioned in an askew angle.

- Record each canopy "hit" on the LPI data form from the highest point at the top of the pin to the ground level. All plant parts intercepted by the pin should be recorded by species if known. If the plant is unknown, identify it as annual forb, perennial forb, perennial grass, etc. If litter from now decadent plants also exists in the canopy, record it as litter. Each species should only be recorded once, even if it is intercepted multiple times by the pin. If nothing is encountered in the canopy by the pin, enter none on the LPI data sheet.
- Next, record what the pin intercepts at the soil surface under "Basal or Ground Level," and again under its respective category "Ground-Level Cover." If the pin encounters the base of a plant (the pin must actually be touching the base of the plant at the point of the soil surface), record that plant species. This is common for bunch grasses, but much less common for rhizomatous grasses. Otherwise, record the following:
  - R=Rock
  - BR=Bed Rock
  - L=Plant litter not rooted in the ground
  - M=Moss
  - LC= Lichen crust on soil
  - Bare soil
- Move to the next sample interval and record data in the same fashion along the transect at regular intervals (one ft., three ft., five ft., etc.).

## Calculations

- Calculate the percent ground level cover of each ground level category by dividing the number of hits in each ground level cover category by the total number of samples (pins dropped).
- Calculate the percent canopy cover by dividing the number of pins with canopy hits by the total number of samples.
- Canopy and basal hits of individual species can be recorded as well by dividing the number of basal or canopy hits of each species and dividing it by the total number of samples.

## Key Points for Line Point Intercept

- Always stand on the same side of the transect tape when sampling to ensure vegetation being sampled is not trampled.
- Drop each pin in a controlled manner, straight to the ground immediately adjacent to the transect tape to avoid "aiming" or other bias.
- Ground level cover is an indicator of soil and hydrologic function for many semi-arid rangeland ecosystems. Plant material at the surface of the soil is important to reduce soil erosion, maximize water infiltration, and recycle nutrients.
- Line point intercept should be accomplished every two to three years.
- If vegetation such as tree canopy exists above the pin, yet the pin would intercept that vegetation if it were extended upward, that vegetation must be recorded as a "hit."

## Modified Frequency Method

Measuring plant frequency (how often a plant is encountered) is a fast and easy way to determine changes in plant species composition on a site. This method consists of placing a standard sized and shaped plot frame along a transect and recording the presence of the species in that plot frame. This method is valuable to record relative presence or absence of plant species over time. Data is summarized as percent frequency of each species recorded on the site.

## Materials Required

- Frequency data sheet (provided in the Monitoring Tool spreadsheet).
- Measuring tape at least 100 ft. long with end stakes. Multiple transects may be used on a single monitoring site for this method to accommodate a greater sample size.
- A plot frame of a known size. Adequate plot frame size varies depending on vegetation characteristics. If possible, use a plot frame of about of at least 1.64 x 1.64 ft. (0.5m x 0.5m). Using the 1.92 $ft.^2$ plot frame

recommended for other methods is an option, but may be too small to accurately measure some grassland plant communities. A carpenter's rule that can be positioned into an approximately $2ft^2$ frame work well to accomplish this method.

- GPS unit if available.

**Figure 11**

*Frames used to determine frequency of leafy spurge (left) and native grasses (right).*

## Steps for Modified Frequency Method

- Pull each end of a measuring tape tightly between each end of the transect and secure with ground stakes.
- Determine the number of subplots that will be sampled. Sample at least 50 subplots. This number may be greater for subplots smaller than 1.64 X 1.64 ft.
- At regular intervals along the transect (i.e., every 2 ft., etc.,) place the frequency plot frame adjacent to the measuring tape and record each species rooted within the frame on the frequency data sheet. If shrubs are present and are a species of concern, and do not occur rooted in greater than 20 percent of the subplots, shrubs with canopy overhanging the subplot may be counted as present.
- At each location sampled along the transect, record the species present on the datasheet.
- Comparisons are then made between years. It is recommended this method be repeated about every three to five years.

## Calculations

- When complete, use the data sheet provided with this technical note to tally each subplot that each individual species is present in.
- Divide the total tally for each species by the total number of subplots sampled. This is the percent frequency of occurrence for each species.

## Key Points

- Fast and easy method to employ.
- Always use the same transect beginning and end point each time the sampling is conducted and use the same size and shape subplot sampling frame. Be sure to note the size of the plot frame used for frequency sampling.
- Various sized or nested plots can be used within a larger subplot to more adequately gauge appropriate plot size and capture species that are present at different scales. For more information regarding nested plot sampling, refer to the Interagency Guide *Sampling Vegetation Attributes* cited at the end of this technical note.

## Additional Information

This method can be combined with the point intercept method to quickly obtain a general measure of ground cover plant cover (canopy and/or basal), bare ground, litter, and gravel or stone). This is done by specifying one or more corners of the frame for collection of point-intercept data collection. The corners of the frame may be sharpened to a tine or contain a small pin to more accurately specify the exact cover at the point. Each

time the frame is placed along the transect cover data is recorded on the frequency data sheet (space is provided for each on the included data sheet). This method is not as precise as the LPI method previously described, but it is a quick and efficient way to approximate cover while collecting frequency data. See the data sheet provided with this technical note for more information.

## Dry-Weight Rank (DWR)

This long-term method measures the percent species composition along a transect by rating the top three plant species 1-3 (by production) within each subplot (a plot frame no smaller than 1.92 square feet is recommended) placed along a transect. The species rated three is the lowest producing and the species rated one is the highest producing. Each species is then tallied for each rank (one to three) as it occurred on the plot and weighted appropriately to determine the percent composition of each species observed as a dominant along the transect. This method objectively and systematically estimates plant species composition on areas that will yield few empty or very low diversity subplots, such as in rangelands. This method is modified from procedures described in the Interagency Technical Reference *Sampling Vegetation Attributes*.

## Materials Required

- DWR Data Sheet (provided in the Monitoring Tool spreadsheet)
- Measuring tape at least 100 ft. long and ground stakes
- Plot frame 1.92 $ft.^2$ or greater
- Pen or pencil
- Compass (optional)
- GPS unit if available

## Steps for DWR

- Pull each end of the measuring tape tightly between each end of the transect and secure with ground stakes.
- Determine the number of quadrats and sampling intervals (at least 30 subplots should be sampled).
- Place the plot frame at the starting point of the transect and determine which three plant species located within the plot frame are the most productive (by dry weight).
- Rank each species as one, two, or three, based on their relative production (one being the most productive).
- If only 1 species is encountered in the plot frame, all 3 ranks are assigned to the species (100 percent). If two species are encountered, then any combination of the three ranks can be assigned between the two species.
- Repeat for all subplots required for collection

## Calculations

- For each species listed, multiply the total count of ranks (summed in the rank tally column) one, two, and three by seven, two, and one. Sum these three figures and enter in the weighted column.
- Note: The DWR method assumes 70 percent composition for rank species 1, 20 percent composition for rank species 2, and 10 percent for rank species 3.
- Total the weighted column for all species and then divide the weighted value of each species by the total weighted value of all species. This value is the percent composition of each species (entered in the percent composition column).

## Key Points

- This method allows for a large number of subplots to be collected rapidly.
- In most instances, at least 30 subplots should be sampled.
- The DWR form allows 10 species to be entered. If other species are present but not accounted for on the data sheet, they may be noted as present.
- A 1.92 $ft.^2$ plot frame is large enough for many SD grasslands. A larger plot frame may be required for less productive grasslands or in areas of poor vegetation cover.

- If local experience and opinion indicates that the dominant species within a community are represented in a different distribution than 70, 20, and 10 percent, a modification can be made to the calculations.
- This method is best suited to rangelands.

## Modified DWR (MDWR) Method

This method combines using the DWR method useful for determining plant species composition with the comparative yield (discussed briefly later in this technical note) method that measures plant production. This method is most valuable when a large amount of data is desired for collection, but time allowances are short. The MDWR method utilizes production measurements from five clipped plots subjectively located along a transect. These subplots are selected based on their relative representation of the vegetation observed along the entire transect. One subplot each is clipped that represents the most productive plot, the least productive subplot, and three subplots of varying productivity in between. An index is then calculated to represent each subplot. Plot frames are then placed along the transect in an ordered sequence. This interval is usually every 2-5 ft. depending on the number of samples desired (30-50 samples are common). Each subplot is then given a rating based on its comparison to one of the five clipped plots, and its corresponding index is then recorded. While production indexes are assigned, DWR data is also collected by ranking the top three most productive plant species in each clipped subplot (one for the highest producing, etc.). The combination of weight and plant "rank" estimates permit the calculation of plant species composition by percent and weight. Total production is also calculated for the entire transect.

The MDWR method requires a moderate to high level of technical ability and is best used when detailed plant species composition and production data is needed. This method is most suited to data collection and analysis activities associated with inventory rather than monitoring; however, very sophisticated monitoring activities may utilize this method. These data are mostly required for tasks such as ES Description (ESD) development and soil survey data collection activities. A suitable substitute for this technique is the production method using the plant species option. It is recommended that an electronic auto-fill data form such as the MDWR form provided with this technical note is used to compile and analyze this data due to the quantity and complexity of calculations required.

## Materials Required

- The MDWR method data worksheet, comparative yield/DWR versions (provided in the Monitoring Tool spreadsheet).
- Measuring tape at least 100 ft. long and ground stakes
- A standard sized plot frame of 1.92 $ft.^2$ or larger
- Grass clippers
- Gram scale (100 and/or 300g)
- Paper bags
- Pen or pencil
- GPS unit is available

## Steps for MDWR

- Pull each end of the measuring tape tightly between each end of the transect and secure it with ground stakes.
- Perform the Comparative Yield Component of MDWR.
  - Beginning at the zero end of the tape, walk along the transect to determine areas of high production and low production.
  - Select the location along the transect that is judged to be the highest producing, place the plot frame along the transect at that spot and clip all of the vegetation in that frame. Place clipped vegetation in a paper sack. Clip and weigh vegetation using the same techniques described in the "Production Method," data can be recorded in the comparative yield production worksheet included as part of the MDWR datasheets. This data sheet also reconstructs the production data (for dry matter, utilization, percent normal growth, etc.).

- Perform the above method (clipping total production) for the lowest producing site along the transect and also three sites in between the lowest and highest producing sites, preferably three sites that represent an even gradient between the highest and lowest producing subplots.
- Identify the clipped subplots as one, two, three, four, and five, with one being the most productive, five being the least productive, etc.
- If the site is relatively uniform in production and species composition, three subplots may be clipped (high production, low production, and one in between). The electronic forms version of this technical note provides an alternative three comparative yield subplot alternative.
- When production and reconstruction values are entered into the MDWR datasheet, a production index (the relative yield index) is automatically calculated for each of the clipped plots. This index is a relative figure based on the heaviest subplot which has a value1.0, with each additional subplot value between 0.01 and 0.99, based on its relative comparison to the 1.0 subplot. See the MDWR data form instructions sheet for further data sheet entry descriptions.

- Perform the dry weight rank component of MDWR:
  - Place plot frames systematically along the transect at regular intervals (i.e., every two ft.) and record with an "X" for dry weight rank (one to three, for the three most productive species present). The species in the plot estimated to be the most productive by dry-weight is ranked as "one," the second most is ranked "two," and the third most is ranked "three." A "rank value" is then assigned to the subplot as 0.7, 0.24, and 0.06 for ranks 1, 2, or 3 respectively (0.7, 0.24, and 0.06 are based on assumptions of species existing in each plot as 70, 24, and 6 percent of the subplot, respectively).
  - If only one species is located in a plot frame, then rank the species as one, two, and three for that subplot. If two species are located in the plot frame, then any combination of rankings can be made for each species based on what is observed in the plot frame.
- The comparative yield of each subplot must also be noted by assigning the appropriate production index (computed when production data is reconstructed and calculated) based on its similarity to one of the clipped plots. Simply entering in which clipped subplot each sample plot most represents (one, two, three, four, or five) will auto-fill the comparative yield field.
- Repeat for each of the subplots to be sampled.

## Calculations

Using the MDWR datasheet, calculations are made for total production, production by dominant plant species, and percent composition of each dominant species (for up to 15 species).

- Species weight values are automatically calculated by multiplying the rank value of 0.7, 0.24, or 0.06 by the relative yield indices (e.g., 1.0, 0.85, etc.).
- Percent species composition is calculated by one) summing the weight value assigned to each species and two) summing the weight value of all species recorded. Dividing the weight value of each individual species by the sum of all weight values yields the percent composition for that species.
- Total production (lbs./ac.) of the transect is calculated by calculating the average of all weight values and multiplying by the weight of the most productive comparative yield subplot.
- Production by species is then calculated by multiplying the total production by percent species composition.

## Key Points

- Collect at least 30 subplots.
- Option for data collection for the ESD or other technical development: Fifteen plant species are allowed on the DWR data sheet. If other species occur within the subplots, especially small forbs which are rarely accounted for, a note of them should be made and an estimate of production from the transect (trace, 5 percent, 10 percent, etc).
- This method will work well on most SD grasslands; however, due to the limitations of 30 ranking subplots and no greater than 5 comparative yield subplots, use of this method is somewhat restricted to limited diversity of dominant species and sufficient plant density.
- If sites basically similar in productivity, site type, and cover are to be sampled, the same production indices may be used for multiple sites. This concept is similar to an expanded "weight unit" method.
- When summarizing and computing data, a fillable automated form (available within the electronic forms version of this technical note) is recommended. If manual calculation is preferable, see the electronic

version of the Monitoring Manual via the "Rangeland Database" at http://usda-ars.nmsu.edu/monit_assess/rangedb_main.php, version 1.5 or greater.

- At the time of release of this publication, the MDWR Method is pending further development for wider scale use and standardization for use with the Rangeland Database; however, most of the essential elements are expected to remain the same.
- If persistent woody shrubs are a point of interest (such as western snowberry, big sagebrush, etc.,) production from expanded shrub plots as described in the "Production Method" can be added to the total calculation and factored in with total production by species and percent species composition. For more information on this added technique, see the Rangeland Database, Version 1.5 or greater, or contact a NRCS rangeland specialist.

# Record Keeping and Other Grazing Land Monitoring Considerations

Record keeping is an important companion to vegetation monitoring data. Weather data serves as both long-term and short-term information, while management (particularly livestock grazing management) may help explain some of the changes observed on rangeland. Analyzing this data in concert with monitoring data will help draw final conclusions regarding changes to grazing lands over time.

Livestock production information such as calving, weaning, shipping dates, and turn-out and turn-in dates can be collected on a variety of forms like pocket notebooks, government forms, specially designed record books, notebook paper, etc. The SD NRCS currently uses the SD-CPA-16, Record of Livestock Grazing form. The important part of record keeping is recording information in a format and location that can be recounted later on. Considering grazing land monitoring analysis, critical information includes dates in and dates out of livestock in each grazing field, and the class of the livestock. This creates a record of grazing pressure on rangelands of interest during particular periods of the year. This is further strengthened by continuous years of grazing information. Identifying the timing and intensity of grazing pressure is part of determining drivers behind the changes observed on rangelands over a period of years.

The next variable necessary for analyzing monitoring data and the changes observed on rangeland is precipitation. Precipitation information is critical to assess conditions on grazing land and should be formally collected and analyzed regularly. Precipitation varies significantly across ranches and multiple rain gages may need to be established. This is especially true for very large operations or ranches that span different landscape forms such as uplands, river bottoms, and foothills. Rain gages should be located in an area representative of monitoring locations when possible to more accurately couple weather and vegetation monitoring data. If these are locations that are infrequently visited, a small known quantity of mineral oil can be added to the rain gage to prevent evaporation of rain water. It is recommended that rain gages be checked at no greater than two-week intervals, and rain gages in areas frequently visited should be checked daily. Precipitation data should begin no later than in March and end no earlier than the end of October. Precipitation occurring during these dates is considered to be most responsible for cool-season grass growth that characterizes most SD grasslands. Analysis of precipitation data should occur regularly to assist with the assessment of livestock forage conditions on the ranch, especially if the data is going to be part of a drought contingency determination. If precipitation data is recorded for several years, long-term precipitation averages can be determined on various locations and detailed evaluation of drought conditions can be made across a ranching operation.

A variety of rain gages are available commercially; however, few are large enough to store enough rainfall to allow rain gage measurement intervals of one to two weeks. Homemade rain gages are relatively easy and cheap to make, with numerous designs that yield the same result. Using thin wall PVC pipe with a diameter of about six inch is a cheap and easy option. The depth should be about one ft. to ensure enough capacity for large rain events. A PVC cap can then be glued to one of the open ends of the PVC pipe to create a floor. Then attach the PVC pipe to a fence post using large hose clamps, ensuring that the top of the rain gage is well above the top of the fence post. If there is a long period of time between rain gage checks, then add enough mineral oil to the container that will cove the area of opening of the rain gage to prevent evaporation. This method will easily suffice for periods of about two weeks.

Measuring precipitation within the rain gage can be best accomplished using one of two methods. The first is to simply use a measuring ruler to measure the amount of rain occupying the gage. If a wooden ruler is used the level on the ruler wetted is the amount of rainfall. A second method (and sometimes preferred method) is to measure the contents using a graduated cylinder or other container. The calculation for depth of rain water is Depth of rainfall=Volume of rain water ÷ Area of funnel opening. Most graduated cylinders contain units of milliliters (ml). In this case, a conversion must be done to inches (area and volume measurements must be in the same units). The calculation is: Depth of rainfall (in) = (volume of rainfall (ml) X 0.061) ÷ Area of funnel opening (in.). When measuring rain gage volume using a graduated cylinder, try to remove large dead insects, plant debris, etc., before measuring volume.

# Other Selected Monitoring Methods

## Step Point

The step point method is similar to the LPI method, except instead of sampling systematically along a transect edge, a pin is dropped at the tip of the observers boot. The observer repeats this step at regular paces (usually two or three) while a consistent direction is maintained, usually by compass bearing or by focusing on an object on the horizon. All vegetation intercepted by the pin in the vegetation canopy and what is contacted with the ground hit is recorded the same as for the LPI method described above. The observer may fashion a small notch at the tip of the boot to eliminate bias and aiming. This method is faster than the LPI as no transect is constructed; however, consistency of location of the data collection is not maintained between monitoring years. The LPI data sheet included with this technical note can be used with this method.

## Cover Board

The cover board method measures changes in vegetation structure over time by estimating the percent of vegetation coverage against a profile board. Cover classes or percent coverage are estimated against the backdrop of the board from random angles at a given distance or along a transect. Readings are taken from precisely the same spot each year and changes noted between years. Photographs are also useful with this method. The cover board method requires the construction of a homemade cover board usually made of cloth, plywood, or plastic. This method works particularly well for measuring cover in shrub communities or woody riparian vegetation cover. For more information, see *Sampling Vegetation Attributes* Interagency Technical Reference 1734-4.

## Comparative Yield

Comparative yield measures the total herbage production of a site. Total production is sampled by harvesting five subplots subjectively selected along a transect. The highest producing, lowest producing, and three plots in between are harvested and weighed. These subplots are noted as one, two, three, four, and five. Other subplots are then placed along the transect (at least 10) and rated as 1-5, depending on the plot that best represents them. The unclipped subplots that are rated can be used to develop an indices of production to represent greater portions of the transect past the five harvested plots. Comparative yield can be adapted to other similar sites if a mental image of the reference site can be maintained. For more information, see *Sampling Vegetation* Attributes Interagency Technical Reference 1734-4.

## Belt Transect

The belt transect is primarily used to measure the density of woody or invasive species. This method involves walking down the center of a transect holding a rod or PVC pipe of about 10 ft. at its center. As one moves down the center of the transect, each species that occurs rooted under the span of the rod or PVC pipe is counted. The density of each species (e.g., plants /ac.) of interest is then calculated. For more information, see *Sampling Vegetation Attributes* Interagency Technical Reference 1734-4 or Volume I of *The Monitoring Manual*.

## Daubenmire

This long-term method measures plant cover by species by systematically placing a 20 x 50 cm frame along a transect. Each species within the frame is rated by a cover class (one to six). The percent cover by species

and the total species composition by cover are then calculated using indices derived from each cover class assigned. For more information, see *Sampling Vegetation Attributes* Interagency Technical Reference 1734-4.

## Other Methods and Resources

There are many resources available that provide guidance to individuals interested in rangeland monitoring. Private rangeland consultants are another source of monitoring expertise that can ensure monitoring information is collected that meet landowner objectives. Private consultants can also help with monitoring procedures, data interpretation, and equipment procurement. Rangeland staff from agencies and departments such as the BLM, NRCS, and CES can be helpful when starting a monitoring program. Many online resources are available that describe a variety of monitoring methods from start to finish. Some of the most commonly used and accepted Web links are below:

http://www.blm.gov/nstc/library/pdf/samplveg.pdf *Sampling Vegetation Attributes.* This Interagency technical reference was referenced for a variety methods described in this technical note. It includes method descriptions and data sheets for many accepted monitoring techniques.

http://www.blm.gov/nstc/library/pdf/utilstudies.pdf *Utilization Studies.* This Interagency technical reference details various livestock or wildlife utilization determination methods. Many of the utilization methods described in this technical note are adapted methods described in this publication.

http://www.fs.fed.us/pnw/pubs/gtr526/ *Photo Monitoring Handbook*. Photo monitoring, helpful techniques, and recommendations for most levels of photo monitoring are discussed. Techniques discussed range from simple to advanced.

http://www.fs.fed.us/rm/pubs/rmrs_gtr047.pdf *Monitoring the Vegetation Resource in Riparian Areas*. This publication is an essential primer for riparian monitoring and evaluation for most areas of the greater western US. Concepts central to the Greenline riparian evaluation are discussed as well.

ftp://ftp.blm.gov/pub/nstc/techrefs/Final%20TR%201737-15.pdf and
ftp://ftp.blm.gov/pub/nstc/techrefs/Final%20TR%201737-16.pdf *Riparian Area Management. A user guide to determine proper functioning condition and the supporting science for lentic [and lotic] areas.* This interagency technical reference describes the method used to determine "Proper Functioning Condition" of riparian areas by evaluating hydrology, vegetation, and erosion/deposition. This method is accepted by a variety of agencies and organizations.

http://usda-ars.nmsu.edu/Monit_Assess/monitoring_main.php *Monitoring Manual for grassland, shrubland, and savannah ecosystems*. This is the gateway Web page to the Monitoring Manual that serves as the basis for the quantitative monitoring methods of this technical note. It is widely regarded as the standard monitoring resource for most federal agencies and many private rangeland consultants. This Web page also allows access to the **Rangeland Database**, an interagency Microsoft Access-based database that allows data entry, storage, and analysis for each monitoring method described in the Monitoring Manual. This database can be loaded to any personal computer and is the culmination of efforts by university and various agency personnel.

ftp://ftp-fc.sc.egov.usda.gov/OR/Grazing Lands/Fences%20e-version.pdf *Fences.* A publication by the BLM and the Missoula USDA FS Technology and Development Center. This publication describes the construction of utilization cages or grazing exclosures (pgs. 150-155) for use on grazing lands. These cages are used in conjunction with paired plot monitoring and ocular utilization methods used to determine livestock or other herbivore grazing use.

# References and Additional Resources

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