Monitoring Tips

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The following are practical suggestions for deciding how to monitor rangelands. Sections are referenced to parts of the "Guide to Rangeland Assessment and Monitoring" published by the Arizona Grazing Lands Conservation Association in 2012 that provides further information on the topic. (Find it here on the NACD website.)

Why Monitor?

Every monitoring manual, including this one, stresses that it is necessary to have specific management objectives or decisions in mind when deciding upon a monitoring program. Monitoring without knowing what decisions the data will be used to support is "monitoring for monitoring's sake" and is not worth the time and money invested. That is good advice, especially for short term monitoring, but in the real world we sometimes cannot anticipate the manner in which the data may be used in the future.

By definition, monitoring requires measurements over a period of time, and usually the value of the data increase as the time period increases. A good example is weather records. Over a period of time, management objectives and resource concerns change, but we can't always anticipate what those changes will be. Therefore, a good record of ground cover and plant species or life form composition, along with weather data, will provide information that is basic to most resource decisions.

What to Monitor?

What **can** be measured? Some processes are interesting and important, but not capable of measurement for routine monitoring purposes. For example, documenting erosion rates may be the objective, but it can't be practically measured. So, the amount/pattern of ground cover, which is related to erosion and fairly easy to measure, is used instead (Chapter 3).

What can be measured with sufficient **accuracy or precision** to be useful? For example, a measure of "forage production" may be desirable, but it is expensive to obtain estimates with sufficient accuracy for inventory or sufficient precision for monitoring because it varies so much in both time and space.

How should the attributes be defined to improve **repeatability or interpretation**? Is it necessary or desirable to collect data on an individual species basis given the difficulty most people have in making certain identification of minor (and sometimes major) species, especially in dormant seasons or grazed situations? Does the inclusion of annual plants help or hinder the interpretation of trend data, since the production and composition of annuals is highly influenced by current weather? Would more emphasis on life forms serve the purpose just as well and provide greater confidence that data are accurate?

Where to Monitor?

Most rangeland monitoring is done on **selected areas** within a pasture or ranch, not on a randomized sample. Selection of those areas (key areas, critical areas, comparison areas) depends on the objectives and judgment of the manager (Chapter 15).

Sampling within the area (e.g., key area) selected should meet two requirements:

1. The area sampled should be confined to a **uniform** area. This means that plots or transects should not contain more than one ecological site (or TES unit) and not more than one plant community type on that site (Chapter 10 and 11).
2. The area sampled, which is a function of the number and spacing of sampling units (quadrats, transects) should be adequate to **account for local variability** in soil and plant species distribution within the "uniform" area sampled. This is an essential requirement so that there is confidence that trends are due to actual changes not just difference in the location of sampling units over time (Chapter 14).

When to Monitor?

In general, monitoring is best done when the vegetation reaches its best development near the **end of the growing season**, or shortly after. This is the time when the cover, production, height, and other vegetation attributes are usually best expressed and identification of species is easiest. In areas with a variety of life forms and long or multiple growth periods during the year, selecting a single time to monitor is made more difficult (Chapter 16).

In some cases, other considerations may be more important. For example, measuring utilization on a winter grazed pasture would be done in the spring, or ground cover might be most usefully measured just before the onset of the rainy season.

How Often to Monitor?

The most desirable situation is to monitor annually, or in some cases, even several times a year. That is often not practical or economical. If possible, it is desirable to monitor annually for the first 3-4 years of a monitoring program just to establish the amount of yearly variation to be expected. For perennial plants and soil cover, it is usually sufficient to monitor every 3-5 years after that.

If there is time to measure 5 locations each year, it is better to select 15 locations and measure 5 each year than to select only 5 locations to measure every year.

Vegetation changes tend to occur at unpredictable times due to weather extremes, wildfire, or the interaction of grazing with these variables. Monitoring may show no change for years, but miss a major change is not done often enough, making it difficult to document cause and effect. Therefore, the monitoring plan should be flexible enough to change the schedule to document unusual events.

How to Monitor?

The suggestions below assume you are establishing a new monitoring program (Section 5). If you are remeasuring plots that have already been established, then the monitoring procedures should be the same as were used for previous data (as nearly as you can determine what they were) even if you don't think they were the most appropriate procedures. If the previous methods need to be improved or replaced, it is a good idea to use both the previous methods and the revised or new methods in at least one year to help provide some continuity for interpretation.

The location of the sample should be accurately marked and recorded. GPS coordinates (with Datum noted) are a good way, but a reference stake or pile of rocks should be used to mark the exact location in the field. (We have seen a data sheet in government files that said, "the transect started 375', N21^{0}W from the pickup" is not a good reference.)

Size, shape, and number of sampling units (points, quadrats, transects, etc.). The optimum size, shape and number of sampling units are interdependent to some extent. The repeatability of the sample taken depends on the number of sampling units (n) and the variability among sampling units (variance). The emphasis should be to get a large number of sampling units or observations but minimize the difference among them.

Differences among sampling units are related to size and orientation. Quadrats should be large enough (or transects long enough) to include a reasonable amount of variation within the quadrat (or transect), but not so large as to take an excessive amount of time on each quadrat (transect). If more than about 5% of the sampling units do not contain the species of interest, a larger unit should be adopted.

Selecting the optimum sampling unit size and number depends on previous experience in sampling similar vegetation tempered with some professional judgment, unless there is time and commitment to do a comparison of different sizes or shapes.

The optimum sampling unit size and number depends on the attribute being measured. Estimating the cover, production, or frequency of a group of plants (for example, all perennial grasses) can be done with smaller sampling units and fewer of them than estimating the cover, production or frequency of a given species. Therefore, it is impossible to get one combination of sampling unit size and number that is optimum for all species or species groups. Most methods will not provide data adequate for statistical analysis on more than 1-10 species, even though there may be 30 or more species present. Combining species into groups or life forms will improve the precision of the sample, but may sacrifice interpretation.

Obtaining a repeatable sample depends more on a large sample size than on increased precision of measurement on each sampling unit. For example, it is better to estimate plant weight in 200 quadrats rather than to clip and weigh it in 5-10 quadrats, assuming you have some reasonable ability to estimate plant weight. This principle is the basic strength of quadrat frequency, the dry-weight-rank method, the comparative yield method, the Daubenmire canopy cover method, or similar procedures that use qualitative or semi-quantitative estimates on individual quadrats in order to get a large total sample size that is more representative of the monitoring site.

Statistics should be your servant, not your master. Achieving data with a small confidence interval often takes more time and effort than it is really worth. For example, statistical considerations may indicate that 200 frequency quadrats or 1,000 points for ground cover are required for desired precision. However, practical experience has shown that 100 quadrats or 200-400 points will often produce repeatable data that are sufficient for management purposes. (They may not stand up in court if you get a statistician on the stand).

Sampling units (points, quadrats or transects) should be spaced as widely as feasible to cover the sampling area selected and remain on uniform site/vegetation situation. Be sure the layout of quadrats and/or transects selected will fit on the area to be sampled before starting the work. Wider spacing between sampling units will help reduce the variability among sampling units and help meet the assumption of randomness essential for statistical analysis. Practical considerations also have to be considered, for example, several points may be located on a quadrat rather than independently placed. This procedure may compromise the statistical assumptions to some extent, but is a practical way to get a larger sample without excessive extra time.

Record ground rules on the data sheets on how the size, shape, and location of sampling units, and how measurements or estimates were made. You will not remember them accurately the next time if you don't, and if someone else repeats your measurements, they must know how you did it. How did you decide whether a plant is in or out of the quadrat? How did you treat spaces within the canopy for cover measurements? How did you define the difference in bare ground, gravel, and rock? Did you separate older plant material from green material? And so on.

If you are using paper data sheets, keep data sheets and field recording as simple as possible to reduce time and errors. Record on only one sheet at a time if possible. It is hard and time consuming to shuffle data sheets in the wind or rain, or when you are wearing gloves. Field work often involves wind, cold, heat, rain, bugs, fatigue, hunger, or haste to get through with a plot before it gets dark or the weather changes. All these factors contribute to mental errors or sloppy work. It is much easier to manipulate the data in the office later and less subject to mistakes.

Record the soil attributes or plant species in the same order on each sheet if possible – it reduces time of recording the data and possibility for error. After the first year's sampling it is good to pre-print the data sheets with the species to be expected.

Increasingly, range managers are using electronic data recording devices to collect field data. One system widely used for field data collection in Arizona and other states is the

Vegetation/GIS Data System (VGS) developed by the University of Arizona: https://vgs.arizona.edu/sites/default/files/VGS40Help/index.htm
This system uses a small field computer for data collection. It presents many advantages over paper data sheets. It is less subject to issues with weather. Any calculations required are done as the data are entered, and done correctly, so you can see the results as soon as the work is done while you are still on the site. This can help identify mistakes while you can correct them, rather than discovering them months after the data were collected when you finally get around to summarizing the data for a report. If previous data have been collected the results can be compared immediately. This is valuable, especially when there are several interests involved in the monitoring, because discussions can be had while everyone is still on the site. Use of this type of data recording is highly recommended and worth the cost of the equipment and training to do it.