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Setting Up a Range Monitoring Program for Your Ranch

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Introduction

Due to reduced federal funding for range monitoring and more time commitment of agency personnel to address lawsuits and answer freedom of information requests, less time is being spent by agency personnel for collection of field data. Consequently, sometimes decisions on public grazing allotments are made without the full benefit of current up to date vegetation monitoring data. Many grazing allotments have not had significant vegetation monitoring done on them since original Parker-3-Step clusters were placed on these allotments in the 1950-1960's. Because of this, additional responsibility is being placed upon ranchers to provide data to justify current and future grazing management.

In addition to the obvious reason above for monitoring, there are several other reasons to consider beginning a range monitoring program for your ranch.

1. To provide information to assist in management decisions. Collection of monitoring data not only helps to serve as a gauge for pasture moves but can identify “hot spots” which need addressing through a change in management or location of range improvements like fencing or water. Monitoring will help confirm good management and will help reveal areas for suggested improvement
2. To measure compliance with terms and conditions of grazing permits. This usually means measuring forage utilization.
3. To compare data over time and determine if range condition (trend) is moving in a favorable direction.
4. To provide background information as a record to justify stocking rate adjustments.
5. Monitoring helps you to learn about natural processes. Rangelands have a great deal of inherent natural variability. As you collect vegetation data and compare the data to climatic data, range fires, and other influences, you will begin to see how dynamic rangelands are.

Goals and Objectives

Once you have decided you would like to start monitoring on your ranch, it is important to identify goals and objectives you wish to achieve with this process. Some general goals will be similar to the reasons for monitoring listed above. Other goals will be obvious such as increasing plant cover for areas lacking effective ground cover. However, some objectives may not be readily apparent until you have established some baseline data for your ranch with one or two years of data collection. After collecting this baseline data and comparing it to desired conditions, setting additional goals related to changing current conditions will be possible.

It is important to involve all interested parties in helping identify goals and objectives for monitoring. This includes agency people, your employees and spouse, and outside technical people like NRCS and Cooperative Extension personnel. For some grazing allotments facing intense scrutiny due to endangered species or other concerns, you may wish to include other local people that may be interested in the monitoring plan. Once you have decided what vegetation or watershed characteristics you wish to concentrate on, it will help you in identifying the type of monitoring to do. Tabular checklists are available in monitoring handbooks such as the Interagency Technical Reference, *Sampling Vegetation Attributes* (available free of charge, see last section in this article for information on how to obtain this publication) whi

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allow you to identify those monitoring techniques which will measure the attributes you are interested in. Once you have decided on what attributes you wish to measure, you can then select key areas and develop a monitoring plan.

Selecting Key, Comparison and Critical Areas

Key Areas. Since you will be physically unable to monitor all parts of the ranch, you must select certain areas of the ranch which represent larger portions of the ranch (key areas). Different areas of the ranch can be classified by the soil type and the type of vegetation growing at each location, or by more technical analyses such as ecological sites or Terrestrial Ecosystem Survey units. The selection of key areas will have great impact on the validity of your monitoring results.

A key area has been defined by Ruyle et al. in *Guidelines for Monitoring Arizona Rangelands* as:

> a small portion of a range selected as a monitoring point to represent larger units of the ranch. The key area concept can be used to get maximum amounts of information from a minimum of monitoring locations. Key areas should be sensitive to management changes and represent the most important ecological (range) sites within the unit.

Ruyle et al. further stated that key areas should "be large and uniform so that whatever monitoring method used can stay on one ecological site within the same range condition." This necessitates careful mapping of soil and vegetation types on the ranch followed by on the ground inspection of tentative monitoring sites to verify data from maps. Usually, soil and vegetation types are already mapped and available on either USFS, BLM, Arizona State Land Department, or NRCS maps provided to the rancher.

Key areas should represent areas that are vitally important in the management of the ranch. For example, there may be key areas located on low elevation winter range, high elevation summer range, and transition pastures between the two ranges. Large unique areas of the ranch such as old juniper "pushes" should be considered as well. It is important that key areas chosen be coupled with the current or anticipated management plan. Rancher involvement is invaluable and critically needed in developing any management plan as they usually spend more time on the ranch than anyone else.

Ruyle et al. discussed some factors which should be considered when considering the establishment of key areas. They said that key areas should:

- represent larger areas of the ranch or allotment
- represent areas that provide significant amounts of forage
- be accessible to grazing animals
- not be near water or other areas of animal concentration (Our note: Usually this means not closer than ¼ mile from water. It is also good not to have the key area too far away from water. Key areas should usually not be more than ½ mile from water.)
- not be immediately next to roads or trails
- located on a single ecological (range) site
- have at least a remnant population of the desired forage species
- have some potential to change in a reasonable amount of time
- not be in an area affected by heavy brush or weed encroachment (Our note: The exception to this is natural shrublands which are prevalent in the Arizona Interior Chaparral major land resource area.)

When selecting key areas, it is important to select a reasonable amount of monitoring sites. Choose what you think you can reasonably expect to get done in no more than 3 to 4 days. In our experience, the maximum number of monitoring sites that you can usually expect to complete in a day's time are 2 to 3. This would probably limit you to the selection of from 8 to 12 key areas for the entire ranch. If the ranch is very large and needs to have more monitoring sites located on it, then you could consider rotating the reading of key areas on an every other year basis **after collecting 2 or 3 year's worth of baseline data.**

The approach commonly used to select potential key areas is to have a strategy session involving all ranch, agency, and other interested parties who have an active interest in the ranch. Ranch and agency people outline goals or concerns they have for the ranch and for certain parts of the ranch. For example, ranch and agency people may agree that they would like to increase plant cover by perennial grasses on the sandy loam flats on the ranch. That objective then defines potential key area or areas that will need to be selected for this range site. Strategy sessions usually begin with a careful examination of aerial photos and/or maps. Maps should include soil and range types, roads, range condition (if classified), pasture boundaries, and present and future range improvements (water developments, corral, fences, burns, juniper treatments, etc.). Each major soil and vegetation type on the ranch should be represented in the tentative list of key areas. Following preliminary selection of key areas using maps, the team will need to verify whether or not the key areas considered on the map are in fact well placed. This can only be done by on the ground inspection of the key areas considered. Rancher input is invaluable in this inspection. The rancher or ranch manager can provide much needed input on grazing patterns, location of bedding areas, and accessibility. Oftentimes, key areas will be relocated to an alternate location when the survey team reviews the key areas.

For additional guidelines on selecting key areas for rangeland monitoring see *Rangeland Monitoring: Selecting Key Areas* by Jeff Schalau, available at: http://ag.arizona.edu/pubs/natresources/az1259.pdf

Comparison Areas. Ruyle et al. defined a comparison area as "areas which have been protected from livestock grazing or other impacts and show 'natural' fluctuations in vegetation due to weather or other influences." Long term grazing exclosures and relict areas inaccessible to livestock qualify as comparison areas and should be considered in any range monitoring plan. Areas immediately adjacent to the grazing exclosure or relict area can be put in as a paired monitoring site, providing that the soil type and range site are comparable. Data collected from paired monitoring sites should be viewed as ancillary data to complement other data collected on the ranch. Data from paired sites should **not** be used as the only data upon which management decisions are based. Data becomes more powerful as more are collected from multiple sites. Inferences based only upon what the inside of a grazing exclosure looks like compared to what it looks like outside the exclosure are subject to individual bias. It is best to set aside personal prejudice, collect data, and look for all possible reasons why comparison sites look different.

First, are the different vegetative characteristics inside and outside the exclosure statistically different? (See more on statistics below.) If the data for the two sites are truly different, what factors could be affecting the two different sites? Are the two sites on similar soils with similar aspects (orientation toward the sun). Does one of the sites have more canopy cover of juniper or mesquite trees? Is there a cattle trail close to the grazed site? Is active overland flow of rainfall occurring on one of the paired sites due to geological features? Could the pasture fence configuration be funneling livestock into a blind corner adjacent to a grazing exclosure? Was the grazing exclosure a corral prior to being excluded? If the grazed site is truly different from the ungrazed site due to some type of management activity, has it improved over the last 15 years, stayed the same, or gone downhill? It is important to look at trend over a specified period of time and carefully consider all factors which can affect trend.

Critical Areas. Ruyle et al. defined a critical area as "those areas with exceptional resource values or unusual susceptibility to disturbance." Areas which qualify as critical areas include riparian areas occupied by endangered species, highly erodible areas subject to erosion due to a lack of ground cover, and frequently occupied picnic and fishing sites. On public land grazing allotments, it is very important to recognize the existence of critical areas and decide upon a monitoring plan to accommodate concerns. Even if you decide to exclude a critical area from grazing, it is often advantageous to collect trend data from the critical area being scrutinized.

What to Monitor

In setting goals and objectives, the monitoring team should have determined what vegetative characteristics are of interest for monitoring. The characteristics chosen to monitor should be sensitive to changes in management. The following vegetation attributes are commonly considered in setting up a monitoring plan:

Measurements taken to evaluate long term management

- cover
  (portion of ground covered by bare soil, live perennial plants, litter, rock, and gravel)
- plant species frequency
  (does not count plants, rather records whether or not the plant is present in a given area specified by the monitoring frame)
- plant species composition
  (the proportion of the vegetation [usually by weight and volume] by species and/or forage class; useful for range condition and trend; may not be needed to be determined every year)
- density
  (number of plants, more useful for trees and shrubs)
- plant spacing or fetch
  (measured by distance to nearest closest plant from a point on the sampling frame)
- plant biomass production
  (more useful for inventory purposes when stocking rate and carrying capacity are uncertain or in disagreement; obtain over 3 years and average, then repeat as necessary for long term climatic or vegetation changes [e.g. juniper encroachment])

Measurements taken to evaluate short term management

- grass or browse utilization

Other Measurements and Data

- precipitation
  (Annual precipitation can be obtained with a 2 " diameter PVC pipe to which a specified amount [about 2 inches in the bottom of the pipe] of a 50:50 mix of antifreeze and automatic transmission fluid is added. The oil keeps the water from evaporating and the antifreeze prevents freezing.)
- photos

(Obtain at least general landscape photos at each monitoring site. Include a clipboard in the picture foreground with the monitoring site identification, ranch or grazing allotment name, date, initials or names of monitoring crew, and GPS coordinates [if used]. Monitoring locations are more easily relocated if some prominent feature in the photo background is obtained.)

- GPS coordinates or other locating features
- altitude (estimate obtained with GPS unit or topographical quad)
- percent slope

  (Can be estimated with some compasses, a clinometer, topographical maps, or a GPS unit. It is estimated by the GPS unit or topographical map by determining rise/run. Measure or step off the number of feet from the top to the bottom of the slope [or portion thereof] and divide it into the altitude difference [altitude at upper location - altitude at lower location].)
- grazing schedule and other pertinent information

  (On the monitoring forms it is useful to note the annual grazing history for that particular monitoring site along with any other unusual events such as El Nińo winters, droughts, fires, etc.)
- wildlife activity or sign if significant

It is not necessary to record all the above data at every monitoring site. Some monitoring sites may only have a photo, grazing history, and forage utilization recorded. Other sites may have frequency, forage composition, forage production, forage utilization, precipitation, cover, fetch, and photos all obtained. When the monitoring team sets up key areas they should be able to decide what data are important to obtain at each location.

Data Interpretation

One of the main purposes in collecting monitoring data is to gather information to assist in management decisions or to evaluate proposed actions. Oftentimes, changes in data from one year to another are the result of factors over which managers may have little control (precipitation, range fires, wildlife populations, etc.). However, if land managers are creative, there can be a great deal of flexibility in how one responds to an outstanding forage year or one in which a crisis appears imminent. Monitoring data can be invaluable in evaluating management alternatives. Improperly evaluated, monitoring data (or the lack thereof) can be used to favor an individual bias that may not accurately reflect what is actually occurring on the land. Although there is no way around professional judgement when interpreting monitoring data, decisions made should be grounded on data correctly collected and evaluated. If a change in an area is believed to have occurred, then it is imperative to know that the change is real and not the result of some sampling error or personal bias. Statistics are a tool that should be used whenever possible to increase the probability of making informed and fair decisions. Correctly used, statistics are not “magic math” to support a preconceived bias. Rather, statistics should be used to determine probabilities of change being “real” and to determine the “confidence level” one can express for a given assumption.

Unfortunately, decisions are sometimes made using faulty data or faulty data interpretation. Let’s consider two examples.

Error A - Sampling Error. Paired clipped plots were obtained from both inside and outside a utilization cage in a pasture. The forage was separated into forbs and grasses and the estimated forage utilization obtained by difference. From the ungrazed cage, the weight of grasses was 2.2 grams and the weight of the forbs was 4.7 grams. The clipped plot outside the cage in the grazed area had 2.4 grams grasses and 1.8 grams forbs. The interpretation for these data was that there was 0% use on grasses, possibly due to forage dormancy, and at least 60% use on forbs, possibly because cattle shifted preference to forbs due to the dormant nature of grasses.

In reality, we don’t have a good idea at all of what forage utilization was for either grasses or forbs in the above situation because of the small sample size (1 sample in the cage and 1 sample outside the cage). As a matter of fact, it takes at least two samples for each average to be able to even do a statistical test. **If** there had been two samples obtained in the above example for both grazed vs ungrazed, and **if** we assumed the sample weights varied by only 25%; the confidence interval (similar to a margin of error) for utilization for grasses would have been from -44.6 to + 44.6% and from 15.4 to 104.6% for forbs. If there had been 10 grazed and ungrazed plots clipped from different areas of the pasture (and only varying by about 25%), then the confidence interval for forbs would have changed to about 56 to 68% utilization and for grasses to about -5.8 to + 5.8% utilization. Given the above, we can not support the assumption of a shift in diet for cattle from grasses to forbs.

Error B - Faulty Techniques. One of three transects of a Parker-3-Step cluster was reread 42 years after the original data were collected. However, the same technique was not used to reread the Parker. The monitoring crew chose to overlay the Parker with an entirely different technique (Daubenmire monitoring) and extrapolate the results from the Daubenmire monitoring to the Parker-3-Step method. Since the original stakes for two of the transects could not be found, the monitoring crew could only reread one transect. In 1958, this particular transect had 14 point hits for curly mesquite and all other closest grass plants were curly mesquite. In the midst of the drought of 1996, the Daubenmire monitoring for this particular transect showed 9% canopy cover of curly mesquite and 95% of frames had curly mesquite. However, the monitoring crew did not compare data from the two transects across time. Rather, they compared the 1996 single transect to all three 1958 transects (two of which could not be found). When all three transects in 1958 were considered, there were more perennial grasses species present besides curly mesquite.

In the final report for the above site, the monitoring crew stated,

> "Curly mesquite is almost a pure stand but not vigorous. Snakeweed appears to be going out of the stand but there seems to be more of it than we hit. I feel this is a degraded and eroded site. I expect that it has been grazed season long and heavy most of the last 100 years. I believe it is a good range site but has lost productivity and species diversity. It probably has and could again produce but currently shows no sign of doing so."

In the example immediately above, the monitoring crew not only failed to repeat data collection with the same technique; they also failed to compare the same area in their final report. Additionally, they applied some value judgments to the site (degraded and eroded) which may or may not be true, but was not supported by the data collected.

Understanding and Using Statistics

So how do we use statistics to assist in data interpretation? Although statistics can be a complex study, there are few basic principles that can be understood and applied to range monitoring.

Understanding Statistics. Simply put, in range monitoring you will wish to compare one average from different sites or across time to see if they differ. Differences must be couched within certain parameters: (1) if the two different means (or averages) occur on two range sites that are greatly different in respect to precipitation, soil type, and vegetation type, then there is a good reason for the two sites to differ; (2) differences may be statistically different, but may be the result of something like climate rather than management; (3) you may not be able to show a statistical difference between two sites only because you have not collected enough samples or because the site is highly variable. In some cases, a site may be so variable that it would be impractical to collect enough samples to be statistically relevant. For example, forage production in Ponderosa pine range sites can be quite variable in areas with a great deal of tree canopy, depending on if you land on a clump of forage or under a pine tree. The best choice in this case is to choose a sample size that will be relevant in most cases and accept the fact that statistical power is not always possible.

If you understand the following statistical principles, you should be able to apply statistics to monitoring data collected:

1. Sample Variation
2. Sample Size
3. Random Samples
4. Confidence Intervals

Whether or not two different averages truly differ depends upon how widely separated the averages are, the variation among samples encountered in a sampling population, and the number of samples obtained. If a population being sampled does not differ greatly from one individual to another, then a smaller sample size is needed. Conversely, if individuals in a population vary greatly in some measured value, larger sample sizes are needed.

As an example, let's consider the height of two different sampling populations: curly mesquite grass on a south facing low elevation slope vs. the height of sideoats grama on a north facing slope 500 feet higher in elevation. If you obtained an average height only for curly mesquite, a smaller sample size would be required than for obtaining an average height for both species of grasses. *This example is only for illustration purposes. In reality, the two populations are so different, it means very little to obtain the average height of both species.*

We can calculate sample variation using a statistical procedure called standard deviation. Standard deviation is related to the difference between a measurement (such as one plant's height) and the average for a population (such as the height for all sideoats grama plants sampled at a location). Standard deviation can be obtained with a scientific calculator or a spreadsheet program. Whenever we measure more than one individual in a population, we can always estimate the variation among samples using standard deviation. Table 1 immediately below illustrates standard deviation for a sample of a population of sideoats grama plants.

Table 1. Variation for Plant Height

Average Height = 24"; standard deviation = 2.16"

Observation	Difference from Average
26"	2
25"	1
24"	0
21"	-3

Standard deviation squares differences, adds them, divides by the number of observations (minus 1 observation), and then takes square root. It is a way of categorizing data.

In the above example, standard deviation when four plants were measured was 2.16" Standard deviation allows us to categorize data. If the difference between two sample averages is greater than two times the standard deviation, then these two samples are considered to be different. A similar calculation to standard deviation which is often used to decide if two averages are different is called standard error. Standard error is obtained by dividing the standard deviation by the square root of the number of samples. For example the standard error for the sample of sideoats grama plants obtained in Table 1 above would be calculated by [2.16 ÷($\sqrt{4}$)] or 1.08". Standard deviation allows for a quick check as to sample variation and standard error allows for a closer look for comparing sample averages (or sample means as they are sometimes called).

Consider the graphic representation in Figure 1 to better understand using standard errors. Add the standard error to a mean (or average) twice and compare it to a larger mean from which you subtract the standard error twice and see if the two means overlap. If there is an overlap, then it is generally assumed that the two means are not different. Conversely, if the two means do not overlap, then the two means can usually be assumed to be different.

The more variable a particular sample is, the larger the standard deviation will be and the less likely it will differ from another sample drawn from the same population. More samples must be obtained from the population to increase the precision of the sampling procedure. In Table 2, notice how the standard deviation for sideoats grama plant heights shrinks as four additional individuals are sampled from the sampling population. The influence of the one shorter individual (21") in the sampling population was minimized somewhat when the sample was expanded from 4 to 8 plants.

Figure 1. Determining if Two Means are Different

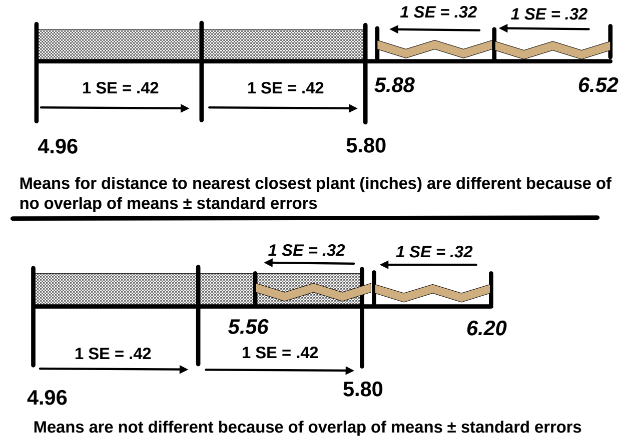


Table 2. Variation for Plant Height

Average Height = 23.6"; standard deviation = 1.69"

Observation	Difference from Average
26"	2.4
25"	1.4
24"	0.4
21"	-2.6
23"	-0.6
23"	-0.6
22"	-1.6
25"	1.4

Standard deviation squares differences, adds them, divides by the number of observations (minus 1 observation), and then takes square root. It is a way of categorizing data.

We have established some general guidelines for sampling size for different monitoring procedures used in Arizona. For forage utilization at least 100 data points should be collected to obtain overall utilization at a site. For forage production as estimated by clipped 40 x 40 cm plot frames, at least 20 plots should be clipped on lower desert sites and 30 plots for higher elevation (Ponderosa pine range sites). For frequency (40 x 40 cm plot frames) monitoring, 200 plot frames should be read on each key area. For ground cover, at least 400 points should be read. Cover can be evaluated at the same time frequency and dry weight rank monitoring are done by incorporating 1 or 2 point locating screws into the monitoring frame.

Sometimes, you may end up reading less than 200 plot frames on a key area because of the size of the key area. For example, the key area may be located on a narrow ridge top and have rocky slopes on either side. In these circumstances, it is well to remember that sampling variation will increase with the smaller sample size.

Another aspect of monitoring we have not mentioned yet is that of random sampling. If sampling is not random, then it can be referred to as being biased, stratified, or systematic. Being systematic or stratified are not usually problems, but being biased is.

Systematic sampling is used to aid in data collection to make it more time efficient. For example, plant frequency data sampling frames are usually placed on the ground in the key area every two to four steps along the transect line. Collecting the plant frequency data in a truly random fashion would require that each frame be randomly placed, such as by tossing a locating dart backwards over your head. Since locating 200 sampling frames in this manner would make monitoring extremely time consuming and laborious, we usually accommodate some systematic data collection procedures when extensive data collection is to be done. Although the samples are being collected in a regulated fashion, there is no intention to skew the results. Also, with a large sample size for frequency monitoring (200 plot frames), chances are very good that a representative sample is being collected at the key area.

Stratification is the process of separating data collection into categories in order to strengthen statistical power or incorporate principles of biology. For example, each key areas is confined to a particular vegetation type, not allowed to splash across multiple vegetation types. You would not usually establish a key area so that the transect lines crossed from a loamy bottom into a caliche slope. If vegetation monitoring were not stratified by vegetation type, the collection of data would be unfocused and fail to address the reasons for why the data is being collected.

Biased data collection is exactly what is sounds like; data are collected either consciously or subconsciously to support preconceived ideas or beliefs **while intentionally ignoring other data collection that may challenge the hypothesis we wish to test**. Holding certain beliefs may not be a problem unless we choose to ignore data collection procedures or locations that may provide data to counter our beliefs. Since we are a product of our life experiences, all of us have some inherent beliefs that are a part of us. It is important to look past our beliefs and design a monitoring plan that paints the ranch accurately and fairly. View yourself painting the ranch as if you were illustrating a scientific journal as opposed to a political cartoon. Collect data in order to provide information to not only justify certain management actions, but also to change them if need be. Some rules for monitoring by Ruyle et al. were discussed earlier in the article. If we set certain rules for ourselves, it will help ensure that we are obtaining as unbiased a sample as possible.

Whenever collecting monitoring data and at each key area, have a standard procedure for how far away from the witness post the start line will be, how far away transects (lines along which data are collected) are from each other, how long the transects will be (usually means how many paces are stepped off), and how many paces (2 steps) separate each plot frame or utilization point hit. You may vary the distance between plot frames at key areas depending upon the size of the area. Standardize procedures that will always be the same such as placing the center of the plot frame at the toe of your boot and measuring grass utilization at the nearest closest plant to the toe of your boot. Other things to remember to ensure that the sample is unbiased is to pick a landscape point on the horizon to focus on and walk towards. By looking at the horizon instead of down at your feet as you walk, you will be less likely to “pick” the spot at which you place the monitoring frame.

With monitoring procedures requiring smaller sample sizes such as forage production, the samples can be randomly collected. For forage production using clipped plots, use a random number generator on your calculator or spreadsheet to specify the number of feet (usually 1 to 150') to walk for each sample. Random direction for the clipped plots is obtained by using the second hand on your watch or with the random number generator (from 0 to 360°compass bearing) of your computer spreadsheet or calculator. If a particular random compass bearing or distance walked will take you off-site from the key area, reverse it according to your best judgment. The University of Arizona has an Excel based spreadsheet that has random number generators built into data collection sheets for forage production by clipped plots.

Figure 1 illustrates a comparison of different samples using some estimate of sample variability. A confidence interval allows you to attach an estimate of the degree of confidence you can place around a particular mean. Confidence intervals are similar to political polls which have margin of errors attached. Confidence intervals are usually expressed as either a 90% or 95% confidence interval. For most range measurements, a 90% confidence interval is usually sufficient. This means that we have 90% confidence (statistically speaking) that the true mean lies somewhere within the range specified by the mean + or - the margin of error. For example, 20 clipped plots were obtained at an Upper Sonoran Desert range site. When the average grams clipped per monitoring frame was converted to pounds per acre, the average forage production was 551 lbs. per acre. However, we want to know what confidence we can attach to that particular average. When the 90% confidence interval was calculated, it was determined to be ± 110 lbs. In other words, we are 90% confident that forage production at the site measured for that particular year was somewhere between 441 and 661 lbs. per acre.

The size of a confidence interval depends upon three factors: 1) sampling variability; 2) sample size; and 3) the degree of confidence desired. Confidence intervals for the same sample with greater confidence attached (e.g. 95% or 99%) will have a larger margin of error attached than for a confidence interval with lesser confidence desired (e. g. 90% confidence interval). For those of you who desire to know how a confidence interval is calculated, Table 3 shows the formula for 90% confidence intervals.

Table 3. Formula for 90% Confidence Interval

$$\text{Mean} \pm \frac{\text{CI Multiplier X Standard Deviation}}{\text{(Square Root of \# of Observations)}}$$

# of Observations	CI Multiplier
2	6.31
3	2.92
4	2.35
5	2.13
6	2.02
7	1.94
8	1.89
9	1.86
10	1.83
12	1.81
14	1.77
16	1.75
22	1.72
28	1.70
30 or >	1.65

e.g. Forage utilization mean = 55 %
standard deviation of 25
10 observations

$$CI = 55 \pm \frac{1.83 \text{ X } 25}{(\sqrt{10})}$$

So CI is from 40.5% to 69.5 %

Range Monitoring Case Study

Several ranches chose to participate in a USDA grant for range monitoring called "Reading the Range" (**RTR**). Ranchers who chose to participate assisted in selecting key areas and in collecting data. A "toolbox" of monitoring techniques were identified by a technical review committee consisting of prominent range professionals in Arizona. Monitoring techniques consisted of the following:

1. Frequency: 200 plot frames
2. Cover: 400 points
3. Distance to Closest Plant (Fetch)
4. Dry Weight Rank (For Species Composition)
5. Production when appropriate (By Clipping)
6. Utilization
7. Precipitation
8. Photos
9. Riparian when appropriate (Still in Planning Mode)
10. Browse when appropriate (Line Intercept & Age & Hedging Form Classes)
11. Reread a portion of old Parker-3-Step transects
12. Other data desired by rancher

Not all the above data were collected at each key area. Goals and objectives for monitoring for each ranch were determined by consultation with agency personnel. Each key area was evaluated for importance and data were collected which addressed the major concerns of the rancher, agency personnel, and other concerned parties. Key area selection on the ranches which participated in the RTR grant program was reviewed by agency personnel who administered the grazing permit and validated by on the ground inspection. Soil survey information, elevation, and vegetation type were considered in selecting key areas. Comparison and critical areas were also identified for monitoring. Figures 2 to 11 illustrate some of the key areas and other locations chosen for monitoring and justification is presented for the selection of these key, comparison, or critical areas.

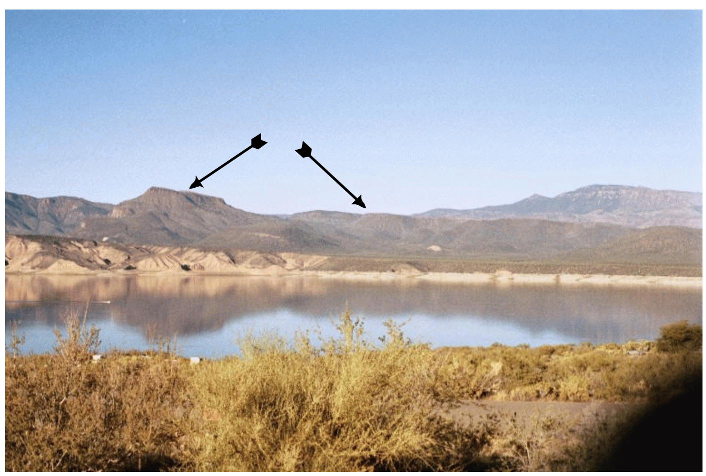


Figure 2. A comparison area was identified on one ranch in Gila County. The butte located on the left has never been grazed by domestic livestock. The mesa on the right is grazed and is a continuation of the ungrazed butte. Over geologic time, the area on the right appears to have separated from the butte. Both comparison areas have similar slope, soil type, and aspect, though the one on the right is about 300-500 feet lower in elevation.

Figure 3. On the same ranch, key areas were selected from low, mid-, and higher elevation range sites. A monitoring site was located on this mesa. A new water tank had been recently installed on this mesa and is shown at the right center of the photo.

Figure 4. Just over the hill from the arrow shown in the above picture is the new water tank described in Figure 3. At the arrow in the picture above, a pipeline from the previous water tank will be run to a water trough. With this range improvement, the rancher desired to see if it would have an effect upon range condition. A key area was installed at the saguaro cactus. This area had an excellent understory of curly mesquite for a site dominated by shrubs. Preferably, it would have been desirable for this key area to be located 1/4 mile closer to the water trough. However, the key area chosen was right on the road and easily accessible. Note: *The ungrazed butte chosen as a comparison area is shown in the background.*

Figure 5. A large belt of land in the mid-elevation zone had been burned over previously by a lightening ignited burn. An old Parker-3-Step was located downslope from the above picture. However, it was decided not to locate the key area at the old cluster because a water trough had been installed in the middle of the cluster.

Figure 6. Just below the clipboard is located a stake from an old Parker-3-Step transect. Since some historical data is available, a key area was located at the location of the old Parker-3-Step. This cluster was located at the high elevation part of the ranch. Several hours were expended to try and locate this old cluster. When the key area is read in succeeding years, it will be a good idea to pinpoint this key area with GPS coordinates.

Figure 7. On another grazing allotment, important grazing areas were identified as possible key areas. Upslope from the arrow shown above, a key area was located at the location of an old paced Parker-3-Step transect. The ellipse shown in the background identifies a large grazing area which cattle use lightly.

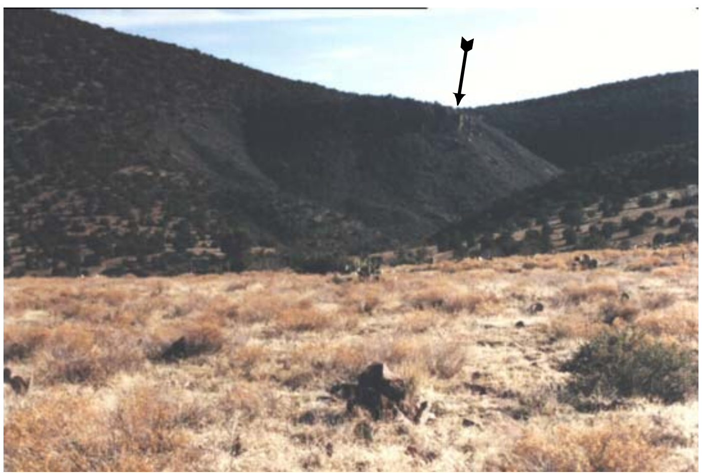


Figure 8. The grazing area shown in the ellipse in Figure 7. The viewpoint in Figure 7 is indicated by the arrow.

Moving to the north from the picture above, Figure 9 provides a viewpoint for another prominent grazing area. The grazing area shown in Figure 9 receives more grazing pressure than the grazing areas immediately above. Collecting forage utilization from this grazing area and comparing it to utilization from the two previous grazing areas was deemed to be important. Short term grazing management can be assisted by this type of information. Forage utilization zones can also be mapped out to help plan future grazing improvements.

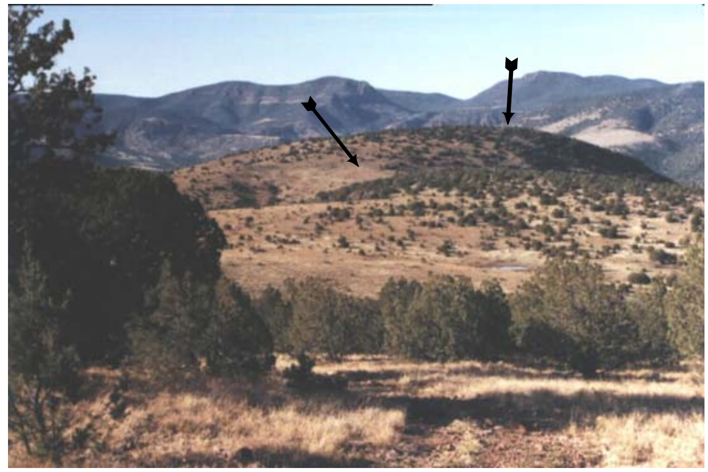


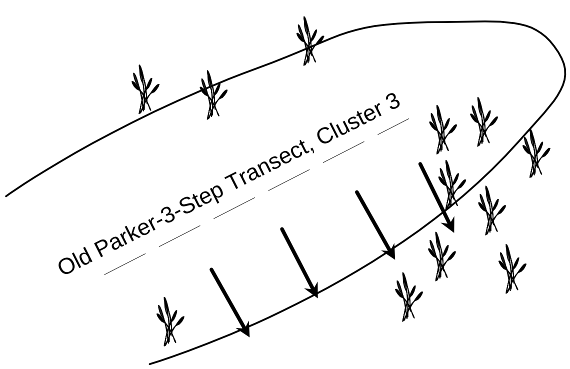
Figure 9. Looking to the northwest from the top of the hill of the previous picture, another important grazing area is shown. Near the center of the picture is a stock tank. At the arrow to the left of the stock tank, is a heavier used portion of the allotment. The arrow in the background spots the location of a critical area shown in Figure 11.

Figure 10. This is the key area shown to the left of the stock tank in Figure 9. Since forage utilization is an issue on this allotment, a key area was located at the site shown and both trend and forage utilization monitored. At the bottom of the slope is a bedding ground. Not shown at the top of the slope immediately above this key area is another bedding ground. The water tank in the previous picture is about ½ mile from this key area. Slope for this key area is around 13%. Therefore, forage utilization at this key area has every opportunity to be greater. End of year forage utilization at this site has ranged from 28 to 38% over three year's time. Species richness at this site (as indicated by frequency) is good, though it was felt that it would be good to locate a cross fence between this basin and the other grazing area shown in Figure 8.

Figure 11. This is a critical area that has had historic concentration of cattle on the flat mesa top. There were no cross-fences present on the allotment to prevent livestock congregation on these flat mesa tops. At the time that monitoring was instituted, there were still no cross-fences present. As range improvements are placed on the allotment and livestock distribution is better controlled, it is important to see how vegetation at this site responds. Currently, annual grasses and shrubby buckwheat predominate at this site. Yet, there is a good component of perennial grasses present on the side slopes. An old Parker-3-Step cluster is present on the center of this ridgetop and is indicated by the dashed line. The arrow in the background indicates the general location of the key area shown in Figure 10.

Since the perennial grasses for this critical area must fill in from the sides of the slope, it will take a long time before the Parker-3-Step cluster in the center of the ridge will show an upward trend. In order to better evaluate the effects of fencing, pasture rotation, and increased livestock management, frequency, dry weight rank, and cover transects were placed perpendicular to the above Parker-3-Step cluster (Figure 12). By doing so, it will allow progress in trend to be monitored over a more reasonable time span.

Figure 12. Frequency Monitoring on Ridgetops



200 plot frames, 4 steps between each to edge of ridge top and beginning of perennial grasses

Unexpected Problems

As you monitor, you will probably encounter some species of grasses, forbs, and shrubs which you or the people with you are unable to identify. Collect and label a good sample of the unidentified plant, place it in a paper lunch bag (plastic will sweat), and list it on your data sheet as unidentified grass # 1, etc. Bring the sample into your local Cooperative Extension office or land management agency office and see if someone can identify the sample. If not, then you can have them send it into the University of Arizona Herbarium for identification. Once you have identified the sample, then you can correct the final data sheet.

Conclusion

The purpose of rangeland monitoring is to document change over time in vegetation or other aspects of the rangeland resources, usually as these changes relate to management. Correctly designed and appropriately interpreted monitoring can be very powerful in evaluating management. Range monitoring can help furnish an unbiased “second opinion” to supplement professional judgment and on the ground experience.

Resources

The University of Arizona has developed an Excel based computer spreadsheet which has worksheets for most all the monitoring described in this article except riparian monitoring. The spreadsheet program has field data sheets which can be printed off and formulas are built into the computerized summary data sheets which automatically calculate vegetative and ground cover characteristics of interest. There are also some simple statistics incorporated into the spreadsheet program which assist in evaluating data collected. This spreadsheet program is free of charge and is available by contacting this office. You will need to have Excel version 5.0 or higher loaded on your computer in order to use this software program.

If you have a grazing allotment on public land, most likely there are past monitoring records available for your allotment. It is a good idea to request any monitoring information which is pertinent to your monitoring plan. In particular, historical monitoring data such as old Parker-3-Step data can be useful. Photos taken at the time the Parker-3-Step data were collected should be available for copying. See Ruyle et al. (1995) for additional guidelines on securing monitoring information and in interacting with land management agencies.

A grass identification book which contains drawings and information about several grasses common in Arizona is available from Publication Distribution Center, University of Arizona, 4042 N. Campbell, Tucson, AZ 85719-1111, (520) 318-7275. The book is entitled *Arizona Range Grasses* and is edited by Ruyle and Young. The approximate cost is $9 + $3 shipping and can be ordered at www.ag.arizona.edu/pubs .

For trees, shrubs, cacti, and forbs, a book with numerous color pictures to aid in identification is entitled *A Field Guide to the Plants of Arizona* by Anne Orth Epple. This book can usually be purchased from United States Forest Service District Offices.

For determining forage utilization, a helpful tool is the USFS forage utilization wheel. It is available from CSU Bookstore, Ft. Collins, CO 80523, (970) 491-6692, Fax (970) 491-0224 [personal contact: Kris Townsend (970) 491-1658] The approximate cost for the utilization wheel is $5 + shipping.

Low cost spring gram scales [100 grams x 1 gram (stock #P100G) and 300 grams x 10 grams (stock #P300G)]are available from Pesnet at www.balances.com/pesnet.html The approximate cost is $46 for both scales combined. These scales are needed if you will be determining forage production.

Two fairly comprehensive manuals about rangeland monitoring are: *Sampling Vegetation Attributes*: *Interagency Technical Reference*, 1996, BLM/RS/ST-96/002+1730 and: *Utilization Studies and Residual Measurements Interagency Technical Reference*, 1996, BLM/RS/ST-96/004+1730. At this time, copies are available free of charge from the Bureau of Land Management's National Applied Resource Sciences Center. To order by FAX, send: title, publication number, quantity needed, and UPS shipping address to (303) 236-0845. To order by mail, send the information to: BLM-PMDS, Building 41, DFC, Denver, CO 80225.

Another excellent manual on monitoring is *Guidelines for Monitoring Arizona Rangelands* by Ruyle et al. It is available from U of A Cooperative Extension at a cost of $7. A very useful feature found in this book are the confidence interval tables for frequency monitoring. These tables enable you to determine whether or not different plant species frequencies differ across time or space.

Web resources include http://ag.arizona.edu/agnic/ which has many resources related to range management. Embedded in the above site is a web page with NRCS range site guides and land resource areas. There is a map feature available where you can click on an area of the state and receive more information about Arizona vegetation types. The range site guide web page is at: http://ag.arizona.edu/OALS/agnic/siteguides/guides.html A few more range related articles are available in the Arizona Rancher's Managment Guide. Contained in this handbook are guidelines on monitoring browse by Ruyle and Frost (1993). The handbook can be accessed at: http://ag.arizona.edu/AREC/pubs/rmg/ranchers.html

Concerning film development, there are several film companies which will develop your film and scan photos on a CD so you can have a permanent electronic record of your monitoring photos. One such company is Photoworks.com at http://www.photoworks.com/

Following this article are plans by Dr. Phil Ogden for a 40 cm X 40 cm PVC breakdown monitoring frame. This size frame is what has been found to be the most effective for frequency monitoring on most of Arizona rangelands.

The information given herein is supplied with the understanding that no discrimination is intended and no endorsement given by the University of Arizona Cooperative Extension is implied.

Literature Cited

Ruyle, G. and B. Frost. 1993. Monitoring rangeland browse vegetation. In: R. Tronstad, J. Sprinkle, and G. Ruyle (eds.), Arizona Ranchers Management Guide. Arizona Cattle Growers Association, Phoenix, Ariz. Available at: http://ag.arizona.edu/AREC/pubs/rmg/ranchers.html

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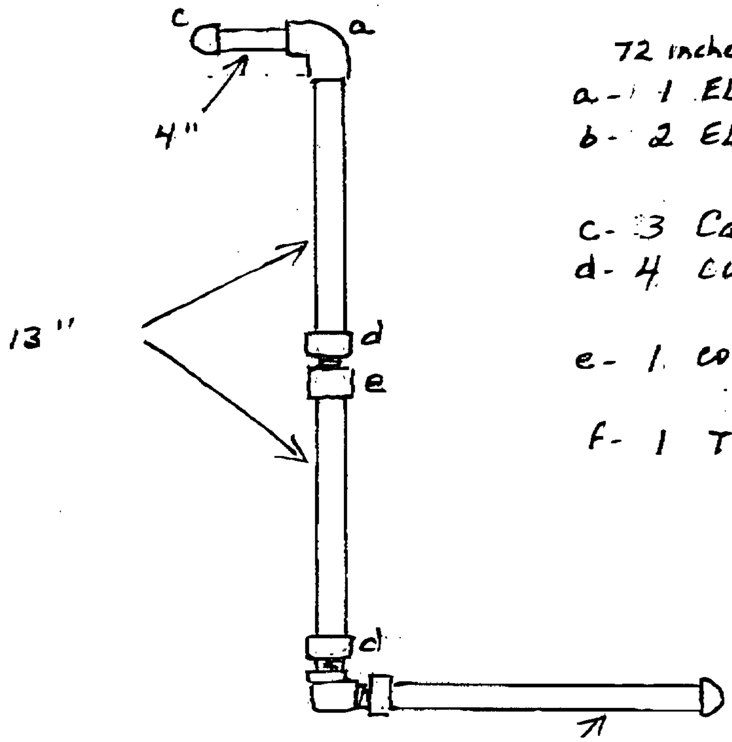
DIMENSIONS AND MATERIALS TO MAKE A 40-X40-cm (15¾") BREAK-DOWN PLOT FRAME



MATERIALS

72 inches ½-inch Schedule 40 PVC

a- 1 ELL, both ends glue joints

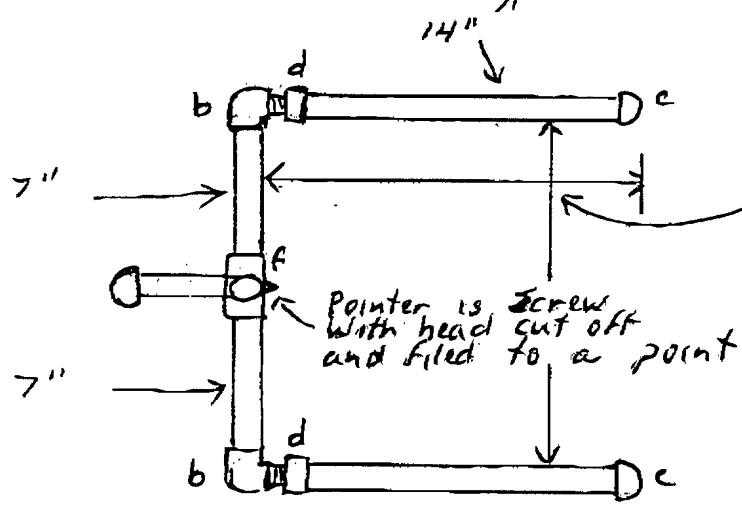
b- 2 ELLS, one end glue joint, other end female thread joint

c- 3 Caps, glue joint.

d- 4 connectors, female glue and male thread

e- 1 connector, female glue and female thread joints.

f- 1 T, center is female thread, and sides are female glue joints.



Finished dimensions 40- x 40-cm (15¾- x 15¾-inches)

Check dimensions prior to gluing and adjust glue joints as needed.

Pipe fits into glue joints about ¾ inch.

Male thread joints fit into female threads about ½ inch.

PHIL R. OGDEN
JUNE 1997