

Nevada Rangeland Monitoring Handbook Second Edition

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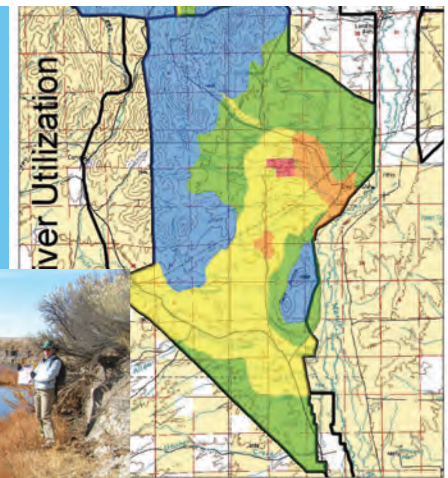







Nevada Rangeland Monitoring Handbook
Second Edition

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PREFACE

In 1980-1984, Nevada rangeland managers recognized the importance of monitoring for managing livestock grazing and came together to create the *Nevada Rangeland Monitoring Handbook.* Published in 1984 by the Nevada Range Studies Task Group of the Nevada Range Committee, the Handbook united rangeland managers behind an agreed upon set of procedures. It helped many people agree about monitoring methods and management changes without resorting to confrontation and courts. More importantly, progress in the management of Nevada rangelands led to better rangeland conditions in many areas.

The 1984 *Nevada Rangeland Monitoring Handbook* recommended the following studies to be conducted at key areas: 1) Production – The NRCS Double Sampling Method and the BLM Weight Estimate Vegetation Inventory Method, 2) Quadrat Frequency, and 3) The Modified Key Forage Plant Method utilization transect. Production data were compared with NRCS ecological site descriptions to determine ecological status. Frequency indicated changes in plant composition. These methods are still valid. The Modified Key Forage Plant Method has been replaced by the Key Species Method. Production data may be interpreted differently as ecological site descriptions are being revised to reflect more recent ecological thought. Production data compared with ecological site descriptions help determine ecological state. They may be compared with Desired Plant Community (DPC) objectives. Frequency studies emphasize nested plots to make data more useable through time as communities change.

While the first Handbook proved useful, it is more than 20 years old. As monitoring is a tool for learning from ongoing management to adjust and improve management, it is fitting that we learn from our past experiences in monitoring to create a new synthesis of current ideas.

The 1984 Handbook emphasized monitoring techniques without emphasizing the reasons for monitoring. Today, management is based on goals and objectives set in a planning process that considers the best science and society's mix of values. Monitoring in the 1980s focused almost exclusively on livestock grazing management. Today, we recognize that, as important as this is, herbivory is only one aspect of land management, and that some monitoring of vegetation change is needed to track and manage problems such as modified fire regimes and invasive weeds that are not resolved with livestock management alone. Riparian issues were not addressed in the first handbook. Today, we have learned the importance of riparian monitoring for adjusting management.

State and federal agencies and range consultants have come together again to formulate this Second Edition. We asked others for creative help and comment to make it as useful as possible for the management of Nevada rangelands.

Appropriate use of this handbook assumes basic levels of professionalism, common sense, objectivity, education, experience, mentoring, and proper application of techniques. Every rangeland management and monitoring case is unique, depending on the initial conditions, site potential, objectives, level of management capabilities (economics, personnel, logistics, etc.), and the relationships among the participants. Where differences (real or imagined) between agency regulations, policy, or guidance and the information provided in this handbook arise, the relevant regulation, policy, or guidance will be used. However, it is intended that this Handbook and the *Ranchers' Monitoring Guide* will meet agency requirements.

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APPENDICES:

A FRAMEWORK FOR MONITORING

"Rangeland is a type of land on which indigenous vegetation (climax or natural potential) is predominantly grasses, grasslike plants, forbs, or shrubs and is managed as a natural ecosystem. If plants are introduced, they are managed similarly. Rangeland includes natural grasslands, savannas, shrublands; many deserts, tundras, alpine communities; marshes, and meadows" (Bedell 1998). In Nevada, some rangelands currently support pinyon and/or juniper trees and may appear to be woodland. Rangeland is a kind of land, not a category of land use. Continuing activities are underway to monitor the general state and well-being of resources, including rangelands, around the world by governmental and other organizations. Monitoring records, taken at regular intervals over time at randomly selected rangeland locations in the United States, are maintained by the Natural Resources Conservation Service. Other entities, including the Environmental Protection Agency, monitor change on rangelands. However, this revised handbook is designed to provide guidance for tracking change relative to management objectives, and making adjustments primarily on ranches and public land grazing allotments.

This handbook describes the context for monitoring, methods of data collection, and uses of monitoring data. The first step in management and monitoring is setting objectives, and this handbook guides objective setting as well as monitoring. Objectives describe a vision of desired future conditions based on the potentials and the limitations of the soils, ecological sites, and their response to management. Objectives are based on planning that often involves many people who describe what the rangeland will look like and/or the resource values it will produce when the plan is successful. Objectives determine what to monitor.

After monitoring information has been collected, it must be analyzed and used to make decisions. This handbook outlines an adaptive management process that emphasizes the use of monitoring data to determine whether or not progress is being made toward management objectives. Monitoring therefore flows directly from the objectives. Thus adequate monitoring helps to justify continuing current management or make appropriate changes. Long-term monitoring focused on the objectives can be interpreted with effective short-term monitoring that keeps track of the management applied each year and the effects of that management. Over time, rangeland managers use monitoring to adjust day-to-day management, adjust management plans, track management, track vegetation changes, interpret causes and relationships, and tell their story. A great deal of monitoring data has been collected using the methods in the 1984 *Handbook*. These data should be retained and used because they provide valuable records for tracking and interpreting long-term vegetation changes as part of a continuing management story.

The number of available monitoring techniques is voluminous. Although some commonly used methods are presented here with instructions, others are simply referenced because they are well described elsewhere. A list of references containing rangeland monitoring techniques is provided to emphasize that additional methods may be needed or may be better for monitoring the attainment of certain objectives. The handbook includes a section on developing a site-specific monitoring plan with clarity, commitments, and a timeline. The *Ranchers' Monitoring Guide* (Perryman et al., 2006) gives specific directions for some monitoring procedures that address questions or objectives that many producers would consider important. Appendix A provides a process for cooperative monitoring.

"Monitoring is the orderly collection, analysis, and interpretation of resource data to evaluate progress toward meeting management objectives. This process must be conducted over time to determine if management objectives are being met" (Bedell 1998). **Monitoring helps:**

1. Determine whether management actions are meeting objectives;
2. Provide a record of environmental and resource conditions, events, and management actions that may influence objective achievement;
3. Determine if management actions are maintaining or improving the rangeland value, productivity, and condition (assuming those are reflected in the objectives);
4. Identify vegetation trends toward ecological thresholds that are unacceptable because they may be irreversible;
5. Evaluate when management changes are needed to meet objectives;
6. Determine whether management objectives are realistic and achievable;
7. Evaluate whether present uses of money and time produce an acceptable benefit;
8. Assist rangeland managers with livestock management or management of other uses.

OBJECTIVES

Ecological Sites - Ecological sites are interpretive units defined and described by NRCS (2003). Rangeland landscapes are divided into ecological sites for the purposes of inventory, evaluation, and management. They are defined by climate, geology, soils, vegetation, and other environmental factors and are separated from each other based on differences in their ability to produce kinds, amounts, and proportions of natural vegetation. An ecological site is recognized and described on the basis of the characteristics that differentiate it from other sites in its ability to produce and support a characteristic plant community. One of the plant communities that occurs in the reference (undespoiled) state of an ecological site, is referred to as the *historic climax plant community* for that site.

Ecological site descriptions are a continuing endeavor to collect, interpret, and categorize knowledge of the physical and biological relationships and temporal nature of natural plant communities. A state and transition model can be used to describe vegetation dynamics and management interactions associated with each ecological site. Ecological sites identify an assemblage of soil qualities and dominating patterns of plant species on a landscape position that operates under a subsystem of the hydrologic cycle and interacts with natural ecosystem processes and disturbances such as precipitation events, fire, and animals. The descriptions and models, by describing disturbance regimes and possible plant communities, help evaluate management, guide further study, and suggest proper use opportunities. More than 900 different ecological sites have been described in Nevada (see ecological site descriptions for each Major Land Resource Area available from the local NRCS office). For a detailed description of ecological sites and their use for management, planning, and monitoring refer to Appendix B. Where ecological sites are not yet described, the concept could be applied to identify units of the landscape with repeating soil and vegetation characteristics.

RIPARIAN AREAS - riparian areas serve as a transition to the upland from streams and other waters. Riparian areas protect the aquatic resource and provide unique habitats for wildlife, livestock, and people. Properly functioning riparian areas (Prichard et al., 1993, 1994, 1998, and 2003) keep water on the land longer, improve water quality, produce important fish and wildlife habitats, produce lush green forage, and retain their stability and beauty for recreation. Everyone benefits when riparian areas function properly. As a natural attractant for wildlife, livestock, and human uses, riparian areas are often used in ways that detract from their ability to function properly. Functional-at-risk riparian areas have one or more attributes that make them susceptible to degradation. Nonfunctional riparian areas fail to dissipate stream or wave energy, fail to enhance infiltration and recharge aquifers, and fail to capture sediment. Rather, they become sources of sediment creating water quality problems, with excessively high dirty flows after precipitation or snowmelt events and excessively low and warm flows in summer. Whereas proper functioning condition riparian areas withstand most floods and droughts (Appendix C), they often improve through theses events. However, some very large and rarely encountered floods may be too large causing even some properly functioning riparian areas to become nonfunctional or at-risk.

Classification of riparian areas is less complete than upland ecological sites. However, some larger meadows or other homogenous vegetation types and soils relationships have been documented (Manning and Padgett 1995; Weixelman et al. 1996 and 1999) and ecological site descriptions are available in local NRCS offices. The Forest Service uses scorecards to provide condition ratings for various rangeland types (e.g., Weixelman et al. 1996 and 1999). Various stream surveys have been used throughout Nevada (e.g., USFS 1985 and BLM 2001b). They combine estimations with measurements and have been used to help set management goals and objectives, and track progress. Stream classification (Rosgen 1996) has also been used to make management interpretations. These and other classification tools can assist in the assessment of riparian proper functioning condition (PFC) in relation to site potential for each stream reach or lentic area.

The checklist for lotic or lentic riparian PFC (Prichard 1993, 1994, 1998, and 2003) helps identify problems that managers could address to promote riparian restoration through management. Focusing on the at-risk areas and negative attributes identified in PFC assessment is helpful in identification of management issues to set objectives. Management objectives for riparian areas could focus on species composition of riparian meadows (Weixelman et al. 1996 and 1999), on the streambank (Winward 2000), or on structural features of vegetation that drive channel form and stability (Winward 2000; Cowley and Burton 2005). Such objectives address factors that are directly influenced by a variety of management activities including livestock, roads, upland watershed, or water storage and use.

Understanding the responses of similar streams or wetland areas to management, helps managers prescribe management and set management objectives. Because the physical characteristics of riparian areas change when they become nonfunctional, such as through channel incision, the original potential may no longer be viable as a management objective, at least for the timeframe of the management plan. However, stream channels as well as lentic riparian areas go through predictable sequences of change in response to management and hydrologic events (see sequence of events in Setting Management Objectives Appendix D).

To help set objectives, managers can interpret the indicators of functionality and predict the sequence of events that must happen for functionality to return (or for it to restore specific riparian values). This defines monitoring needs and methods. Because riparian areas managed to retain proper functioning condition often continue to improve, the cyclic process of setting objectives, managing, and monitoring often spirals a riparian area into a condition that provides the optimum in resource values. Riparian monitoring often focuses on a common set of short-term and long-term indicators, such as the multiple indicators method of Cowley and Burton (2005). Monitoring can document spatial variation and a sequence of changes in condition or values. Objectives can be adjusted to account for spatial variation and changes in conditions and values. This cyclic process helps identify the mechanics of restoration and the variety of tools for management.

Inventory and Assessment of Base Resources - Inventory and assessment are different from monitoring. The data collected and information developed in inventories and assessments are important components of the management picture. Often inventories supply the site specific baseline data points. Modern assessment methods such as riparian PFC (Prichard et al., 1993, 1994, 1998, and 2003) and interpreting indicators of rangeland health (Pellant et al., 2005) evaluate the current status of a number of indicators that address basic system functionality. Evaluating several indicators allows the manager to more precisely identify problems and develop management with objectives and actions designed to fix the specific problem, rather than having to try and address the whole system. Although not trend monitoring, when inventories and assessments are repeated through time they can show changes in issues, opportunities, and priorities. Cowley and Burton (2005) provide quantitative methods for measuring riparian trend, just as Herrick et al., (2005a and b) provides methods for measuring indicators of rangeland health. This helps identify issues, states, and transitions, set objectives, determine limitations and select key areas.

Most Nevada BLM offices have Ecological Site Inventory (ESI) and/or Soil Vegetation Inventory Method (SVIM) inventories and the Forest Service too has collected soils and plant community type data that remain on file. These data sets are the best historical vegetation data available for some areas and could be useful for tracking long-term changes in some landscape-scale or site-specific objectives.

Broad-scale assessments or inventories can be interpreted through the lens of classifications or combined with other resource inventories to make interpretations more valid or specific. For example, vegetation data are much more interpretable with the benefit of a soil survey and stream survey data makes more sense with stream classification and proper functioning condition assessment.

Land Use Planning – Large Scale - Federal agency land-use planning does not relate directly to monitoring. Because 70% of the land in Nevada is managed by the BLM or Forest Service and most of these lands are used for livestock grazing and other uses, the source of agency management objectives is important. Land use planning objectives become or lead to the objectives for management of individual grazing allotments. Additionally, BLM has the regulatory requirement to achieve the fundamentals of rangeland health. This is accomplished by meeting the Resource Advisory Councils' Standards and Guidelines for Livestock Grazing. The relationship of this to monitoring is that land use plans, agency activity plans, agency standards, and the Standards for Rangeland Health can directly provide, or can lead to, management objectives applicable to individual allotments and specific areas.

As required by law, both the Forest Service and BLM develop land use plans that at a broad scale allocate resources and set goals and objectives. These plans set the stage for more site-specific planning efforts by describing appropriate uses, desired conditions, and management goals, objectives, or strategies. The BLM has Resource Management Plans (RMPs) and Management Framework Plans (MFPs), which are all being updated to RMPs, and the Forest Service writes Land and Resource Management Plans (Forest Plans). Since these land use plans are of varying ages, include geographically diverse areas, and are completed by two different federal agencies, they contain a range of objectives, flexibility, and specificity. Land use plans also include monitoring plans with requirements that vary from general to specific.

To implement the Fundamentals of Rangeland Health (43 CFR § 4180.2(b)), standards and guidelines for livestock grazing and wild horse management have been developed by three BLM Resource Advisory Councils (RACs). According to BLM's regulations, management of the public lands must be designed to make progress toward and achieve the RAC's standards (43 CFR 4180.2(c)). Revised resource management planning is in progress under guidance in the *Land Use Planning Handbook* (H-1601-1). The newest group of Nevada RMPs are incorporating the applicable RAC standards.

Forest Service standards and guidelines were developed for both the Humboldt and Toiyabe National Forests in forest plans written in the mid 1980s and amended several times in the 1990s. These Forest Plan standards and guidelines include direction specifically for management of livestock such as forage utilization and stream bank disturbance. Future forest plans will be more descriptive of desired conditions and less prescriptive of methods for their attainment. Revised Forest Planning is in progress under guidance in the Forest Service Manual (FSM1900 chapter 1920).

Activity-level plans are often specific to one or two types of activities in smaller areas. Activity level plan types include allotment management plans (AMPs) for livestock grazing, herd management area (HMA) plans for wild horses and burros, and habitat management plans (HMPs) for wildlife or fisheries. Activity plans usually address: 1) an issue or specific use, 2) existing and desired resource conditions, 3) objectives addressing these conditions, 4) standards or guidelines to direct management of the activity and 5) a monitoring plan established to determine whether the activity is meeting objectives and achieving or moving towards the objectives. In BLM Nevada, multiple use decision (MUDs) are equivalent to AMPs. Often the process of developing activity plans is collaborative, using a process like Coordinated Resource Management (Phillippi and Cleary 1993). Currently, not all livestock grazing allotments on either the Forest Service or BLM have an AMP; therefore, management of these allotments is guided by the objectives and standards in the higher level land use plans.

On private rangeland, planning is the responsibility of the landowner. However, others such as NRCS, University of Nevada Cooperative Extension, and Nevada Departments of Agriculture and Wildlife may also help with information, technical assistance, financial assistance, and/or collaboration. Publications such as the National Range and Pasture Handbook (NRCS 2003) help with planning. The best private and public land management plans are developed in collaboration with land owners, managers, and other interested parties. When a use occurs on both public and private lands, it makes sense to plan and monitor across ownerships.

Resource Objectives - Resource objectives state specific attributes of natural resource conditions that management will strive to accomplish, the area or location where this will occur, and the time frame. Resource objectives must be site-specific, measurable, and attainable statements of the desired resource attributes. Qualities or attributes of good objectives are **SMART** (adapted from Adamcik et.al. 2004)):

S – *Specific* – They describe what will be accomplished, focusing on limiting factors, and identifying the range of acceptable change from the present to the proposed condition.

M – *Measurable* – The change between present and proposed condition must be quantifiable and measurable.

A – *Achievable* – They can be achieved within a designated time period and in accord with resource capability. The time period may be in calendar time and/or may incorporate timing in relation to floods or droughts.

R – *Related/Relevant* – They are related in all instances to the land use plan goals and relevant to current management practices. Thus, they must be worthy of the cost of the management needed to achieve them and the monitoring needed to track them.

T – *Trackable* – They must be trackable over time and must include a definite timeframe and location for achievement, monitoring, and evaluation.

For examples of well worded objectives, see Appendix D.

The scale for objectives should match the scale and focus of the planned management and the timeline for making management decisions. Some management objectives should reflect landscape-scale questions such as: Are pinyon and/or juniper trees encroaching? Are invasive weeds expanding? Is the landscape becoming more homogeneous? Other management objectives should focus on important critical areas or key areas such as important species on a large or important ecological site. All objectives should track from the issues through the planned management and into the use of monitoring information for adaptive management.

Since the success or failure of the applied management is determined by tracking resource changes over time, objectives must be measurable attributes of the resources that are directly affected by the management applied. For example, for livestock grazing management, plant species composition or community structure is appropriate to describe a desired plant community within the potential of a specific ecological site. These resource characteristics respond directly to livestock use and are sensitive to changes in grazing management. Likewise, riparian characteristics such as shrub canopy cover and degree of unvegetated banks on a specific stream reach are resource attributes that can be directly affected by livestock use and respond quickly to management changes in many settings. It is paramount that the selected resource objectives be site-specific, within the site's capabilities, and clearly predicted from planned livestock grazing or other management.

Objectives should be quantitative statements of desired future conditions (DFC) based upon the capabilities and limitations of the ecological site. DFC could include such resource attributes as vegetation, soil, and water quality. Desired plant community (DPC) is a quantitative expression of the plant community that exists or may exist on a specific site and that management actions are designed to maintain or produce. The DPC must be within the site's potential, its documented capacity to produce naturally, or through reasonably applied management actions, and it must be sustainable. In places (almost everywhere) where vegetation is expected to continue to change through time or cycle because of disturbances such as periodic fire (or vegetation management that replaces the role of fire) followed by plant succession, the DPC is dynamic. It can be expressed as an approximate proportion of the landscape in various stages of the cycle and/or expressed as a range of conditions that ensures resilience after disturbance. State and transition model concepts can be used to ensure that DPCs represent sustainable resilience of ecological processes. That is plant communities that resist transition across ecological thresholds. Expressly describing disturbance regimes helps to convey the dynamic nature of rangeland vegetation and DPCs at an appropriate spatial and temporal scale. DFC is analogous to DPC but has a broader perspective including other measurable resource attributes or features in addition to the vegetation resource (e.g., channel width, width/depth ratio, soil quality, etc.).

ADAPTIVE MANAGEMENT

Adaptive management (Appendix E) is the continual process of learning from our experiences and managing based on what we have learned. An acceptable plan should include a management program and a monitoring program needed to keep management on track, test assumptions, provide the information needed for future planning, and guide rangeland managers. Adaptive management depends on flexibility. Management plans and monitoring methods flow from objectives. Cooperative monitoring (Appendix A) builds on the same principles as cooperative management. People who depend on public land should take particular interest in monitoring. It is the responsibility of the managing agency or landowner to modify the plan as needed in light of new information gathered through monitoring.

Monitoring methods should be selected to determine whether progress is being made toward achieving management objectives. And, to the extent it is not, why not. Objectives may focus management and monitoring on new questions, types of data, and/or interpretations. Because one change leads to another, monitoring methods used through time in the same way and at the same location gain value and develop significance. Keeping existing data, and periodically remeasuring and interpreting vegetation data using established methods on established plots, is extremely valuable for developing our understanding for rangeland management. Cited references describe the methods for many accepted monitoring techniques.

Once the monitoring data are collected, they must be analyzed along with other useful data and information. Analysis includes organizing, summarizing, and evaluating the information. This can include statistical analysis of data along with assessment of its validity and utility. Because it is often preferable to complete planning and monitoring using a collaborative approach, analysis of monitoring data should also be done collaboratively. This is especially true if different people collect different parts of the whole data set. For example, if the permittee collects short-term monitoring data and agencies collect long-term data, collaborative analysis is preferred.

The result of the analysis is reaching conclusions about whether the objectives are being achieved or progress is being made toward the objectives. Additionally, conclusions must be reached about the causes of meeting or not meeting the objectives. Both kinds of conclusions are essential. Both must be thoroughly reasoned based on all the available information. For application to public lands, that rationale must be documented. The permittee should be included in discussions and development of the conclusions to better understand management practices and conditions for the particular site and season(s) of use.

The conclusions lead to a decision. To generalize, there are three possible decisions; continue existing management, change management, or change objectives. The first two choices are fairly self-explanatory. The third choice, change objectives, would be made when the information, analysis, and conclusions indicated that the objectives were not achievable, or the objectives did not actually relate to or were poor indicators of the identified issues, or the desired future conditions. Changing objectives is also appropriate when new planning sets new goals.

TRIGGERS AND INDICATORS

Within-season triggers and end-of-season (end-point) indicators are guides for managing livestock movement (University of Idaho Stubble Height Review Team 2004). They are included in grazing management plans after cooperative development by land and livestock managers. Triggers and end-point indicators, along with other required management practices, are expected to achieve long-term desired conditions. When using within-season triggers and end-point indicators, the monitoring strategy must not only measure and evaluate whether or not the allowable numeric value was met, but also whether the value is correct. If measures of annual use indicate that the current grazing intensity or strategy is not being achieved or is inconsistent with achieving the desired resource objectives, then the agency and the permittee should implement corrections. This is the adaptive management process.

Triggers are within-season guides for livestock managers to make changes or move livestock, ensuring that end-point indicators (described below) are met. Triggers must be site and management plan specific. Recording use level at the end of grazing is useful even when the move was not triggered by the level of use (See grazing response index in the *Ranchers' Monitoring Guide*, (Perryman et al., 2006)).

End-point indicators are **end-of-season** guides for land managers to assess resource use impacts at the end of the grazing and growing season, whichever comes last. Assessment of both triggers and end-point indicators is to determine if grazing use left resources in an appropriate condition for moving toward objectives. Generally, end-point indicators cannot by themselves determine whether a particular grazing system is contributing to recovery or conversely, contributing to degradation. This is especially true of a single year's values.

Across broad and diverse areas, different values of a given indicator or different indicators would be selected for different vegetation types and management situations. For example, crested wheatgrass, with its resilience to grazing pressure and tendency toward wolf plants, might have a higher utilization level than would be suitable for bluebunch wheatgrass, a species more susceptible to grazing damage. A pasture might have a higher target utilization level if grazed in a rotation with a short-use period than for the same area if grazed every year for a longer period, especially if that grazing use coincided with the reproductive phase of plant growth.

MONITORING METHODS – GENERAL CONSIDERATIONS

Statistical Considerations -- Because virtually every measurement of nature shows variation, scientists have developed procedures for sampling and replication to gain confidence that their data represent reliable estimates or statistically significant differences as opposed to accidental or biased measurement errors. Generally, more sampling increases the ability to detect significant differences. In fact, it is possible to detect differences that are so small that they are not important. However, with low budgets for land management and monitoring, the more common problem is collecting enough data to gain confidence that the measurements represent reality rather than simply random variation. Or conversely, monitoring may show that real and important change is hidden by random variation. Some have suggested that all monitoring use the standards of science and statistics. However, seeking the degree of confidence appropriate for research could restrict monitoring to a very few questions that are really important, the questions that drive science. Scientists can afford to sample repeatedly and to design experiments with replication because they seek a change in our knowledge about principles that would be useful in many places, not just in a local management situation.

Therefore, in most cases, managers look for converging evidence of a variety of types. They assemble monitoring information to interpret the effects of management in a manner that makes sense. When such information contains samples from many locations that tell the same story, their confidence increases that this story represents the management situation. To help clarify their thinking, many of the tools of statistics can be used to increase and explain our confidence. For an introduction to study design and data analyses see that section in *Sampling Vegetation Attributes* (BLM 1999a) and in Elzinga et al. (1998).

To be fair and unbiased, sampling uses procedures to randomly select the precise areas and plants to measure. Methods to do this vary. Some use a random number table and locate plots on a grid. Others use a systematic approach that places plots at set distances along a transect with a random starting point within the area of interest.

In monitoring, there is always a trade off between the efficiency of taking multiple samples at one location and the increased information from collecting samples from many different locations. For example, collecting data from an individual plant or plot at a dozen different locations would tell more than the same information from a dozen different plants or plots at one location. If all the data are from one location the question remains, "How representative was this location?" Statisticians would call this no replication and zero degrees of freedom and could not analyze the information to learn about the bigger area. However, traveling a long distance to a new location is expensive and the randomly chosen plant or plot may not be like its neighbors. The middle road is usually best; collect enough information about a number of plants or plots at each location to ensure the data accurately reflect the vegetation there (this produces sample averages with low variability) and collect these data from at least a few different locations (this provides a broader perspective and allows analysis of variance to determine whether differences are significant).

How many plots and how many locations is an age-old question and the answer depends on data variation (more variation leads to more samples), how precisely you need to know (it requires more data to detect smaller differences), how expensive the data are to collect, and how important it is to know. It also depends on the resource objective and when setting management objectives, managers should consider the cost of monitoring. There is an ideal match among the size of the change, the variability and expense of detecting the change, and the importance of the change. To justify an objective that targets a small change in a variable parameter, it must be very important because it will require a great many samples or replicate study sites to measure with enough precision to detect the change (or not) with confidence. Conversely, a change that is very obvious may be recorded with only a photograph, and may be easy to justify based on the low cost of monitoring.

To avoid having to sample an excess number of locations, monitoring often reduces the variability by focusing on key areas that represent the planned management in a stratified random rather than a completely random manner. That is, they focus on areas that are getting the prescribed treatment and where the management objectives would show a change if the management works. They avoid those areas that do not represent management concerns or that the management plan is not expected to address. Key areas are discussed more below and in Appendix F.

Key Areas -- Proper selection of key area(s) is an essential step in a representative monitoring program. A key area is a relatively small portion of a unit selected as a point for monitoring change in vegetation or soil and the impacts of management. It is chosen because of its location, use, and value. It is assumed that key areas, if properly located, will reflect the current management over similar important areas in the unit. Key areas should represent range conditions, trends, seasonal degrees of use, and resource production and values. Key areas may be selected to represent a particular plant community, a specific ecological site, or some other significant portion of a management unit. Rangeland managers, livestock operators, and others who know the range should cooperatively select key areas based on management goals and objectives.

An area may be selected for monitoring where a management problem warrants special attention. This kind of area is termed a critical management area or critical area. Critical areas often represent smaller parts of management units that are more important to managers, such as riparian areas or specific places in riparian areas where there is a need to focus management and monitoring. Designated monitoring areas (Cowley and Burton 2005) are similar. (See appendix F.)

Key areas in a unit may change if management or objectives significantly change. Therefore, key areas should be periodically re-evaluated to assure that the overall monitoring results reflect the situation in the unit and current management objectives. However, the value of long-term data sets should be considered as well. It is very helpful if aerial photographs or other images are available to aid in the process of key area selection. These photos may be available from various sources including the management agencies or from private companies that sell imagery of land areas in Nevada (see Appendix G for a list). (See Appendix F for further information on the selection of key areas.)

Key Species -- Key species are generally an important component of a plant community. They are important forage species. However, non-forage species can also serve as useful indicators of change in resource conditions. More than one key species may be selected, depending on management objectives and data needs. Allotment management objectives are often based on improving or maintaining the health, production, and reproduction of key species. Plants for monitoring wildlife habitat, watershed, or other attributes may be selected for monitoring if they tie land management to ecosystems processes targeted by objectives.

Key forage species indicate the general degree of use on a key area and may indicate grazing use of closely related species. They may also be species targeted by management objectives. Key forage species may refer to species that, because of their importance on the key area, must be considered in the management program. Species with low palatability should not be selected for forage utilization studies since they may give a false lower use rating, leading to higher use on the more palatable forage species. Similarly, plants that are highly palatable "ice-cream" species with low composition in the forage base (<15%) make inappropriate key species. (See Appendix F for procedures and criteria for selecting key forage species.)

Short-term Monitoring -- Short term monitoring addresses three topics:

1) Conformance with the plan,

2) Current, annual, or short-term impacts of the implemented management on resources of interest, and

3) Weather and other unplanned events.

This information guides day-to-day and year-to-year management by monitoring within-season triggers and end-point indicators. Accumulated short-term monitoring records help interpret trend and other long-term monitoring information. Analysis of accumulated data should explain "why," if long-term objectives were not met, and help to plan needed changes in management. If long-term objectives are met, these data will provide a logical and reasonable basis for continuing or adjusting current management practices.

For livestock grazing management, short-term monitoring may include keeping records of observations and gathering data on actual use (See form for this in Perryman et al., 2006), distribution patterns and utilization (Appendix H), streambank alteration (Cowley and Burton 2005), growing conditions, and documentation of insect infestations, fire, and adequacy of range improvements. Techniques used for short-term monitoring may include notes recorded in a pocket calendar or herd book and other livestock management records, precipitation and temperature measurements, use pattern mapping, residual vegetation studies, and photography.

Often short-term monitoring leads to management decisions within the grazing season. Plant phenology may provide evidence that a planned turn-out date is too early or too late (Appendix I). Within-season triggers could include changes in livestock behavior such as a shift in use areas or preferred forage or reaching planned seasonal utilization on specific plants or plant groups. Weather that influences plant growth may also indicate the time to move in order to provide opportunity for regrowth. Monitoring end-of-season indicators (at the end of the growing and grazing season) could include percent of browsed shrub leaders, stubble height, and/or utilization. This documents the accumulated influence or lack of influence of current year's management and establishes the amount of regrowth to assist in planning next year's management. Management changes that are based on multiple years of monitoring are usually more sound than changes based on just one or two. Furthermore, strict adherence to triggers can cause sudden changes throughout a management system (Smith et al., 2005). However, the need for some changes becomes obvious quickly, and early change keeps rangeland more productive. The need for triggers and the strictness of their application ought to vary on a case-by-case basis, depending on the current status of the resource in relation to the objective and the degree to which an action prohibits accomplishing management objectives.

Long-term Monitoring -- Long-term monitoring measures changes in resource attributes such as vegetation, soils, or streams over time and is used to periodically measure progress toward meeting long-term resource management objectives. It also helps determine the applicability of annual indicators or triggers. Long-term studies are usually done at permanent sampling locations in key areas. Techniques used or types of data collected periodically for long-term monitoring may include frequency (Appendix J), percent composition by weight of the vegetation (Appendix K) , resource value ratings, remote sensing including ground and aerial photography(Appendix G), photo plots ((Perryman et al., 2006)) and evaluation of permanent exclosures.

Because management objectives vary by location, long-term monitoring methods also vary (see Sampling Vegetation Attributes (BLM 1999a) and Measuring and Monitoring Plant Populations (Elzinga et al. 1998)). However, because long-term monitoring is intended to detect **trend**, it is very important that methods be used consistently through time at specified locations as long as they continue to provide data that is useful to managers for measuring objectives. Vegetation is the resource monitored most because it is at the heart of most ecological processes and responds to management. However, dynamic soil properties are receiving increased attention (Herrick et al., 2005a and b). Quadrat frequency data have been collected on BLM lands since the early 1980s. Appropriate monitoring methods have been, or could be, described for management of riparian attributes, soils, water quality, and aquatic habitats, etc.

Traditionally, vegetation monitoring methods were designed for use on a key area, or benchmark, on permanent plots with the idea that vegetation changes at the monitoring site reflect the management objective. For many objectives this is quite appropriate. However, some resource management objectives refer to spatial problems like the expansion of woodlands onto other ecological sites or the invasion of weeds, and it may be more useful to measure these changes across broad areas. If such changes are clearly visible, landscape oblique or aerial photographs capture the relevant information very well. Less visible changes may require the use of large-scale maps or transects across edges of community types.

Probably the single most used, long-term monitoring method is repeat photography. Many retrospective studies have documented the nature of long-term vegetation changes (or lack of change). Furthermore, in the absence of quantitative data, or in the presence of conflicting or confusing quantitative data, many people rely on what they can see or think they can see in photographs. In addition, photography can be fast and, with proper labeling and storage, provides a record that can be appreciated in many different ways. Sometimes photographs address issues that were not important when the first pictures were taken.

Roles -- Ideally, monitoring would occur across ownership boundaries in pursuit of the visionary goals and objectives of a coordinated management plan. In reality, landowners (including owners of land leased to others for grazing livestock) and land management agencies have responsibility for both the care of the land and its monitoring. Land management agencies have a legal requirement to monitor land use activities for multiple purposes. Producers may focus on resource productivity. They benefit by active involvement in management of livestock operations and monitoring on private and public lands. All parties should review the information together on an annual basis and use it to plan adjustments and strategies for the following grazing season. Land users other than livestock producers may also take an active part in monitoring.

Animal husbandry is the accepted and common role of the producers. Grazing management aims to provide the quality and quantity of forage needed for successful animal husbandry operation. The ideal relationship between the producer and the land management agencies will result in the identification of monitoring tools and management practices that meet the objectives of each. The idea of cooperative monitoring is embraced by the public lands council in memoranda with the bureau of land management and forest service. Because agencies have requirements about data quality for rangeland monitoring, it is important for producers to use accepted methods. The more a producer participates in or initiates cooperative monitoring (Appendix A), the more influence they may have in improving management. Furthermore, this may encourage agencies to become more effective as partners in monitoring and management. On an annual basis, producers should track weather, growing conditions, and the results of management (such as utilization or stubble height) to help make appropriate grazing management decisions. Appendix I (growing condition indicator checklist) and *Ranchers' Monitoring Guide* section on grazing response index (Perryman et al., 2006) provide forms for recording this information. Costs and economic returns to investment are also important considerations for ranching and rangeland management to remain sustainable.

Management agencies have regulatory responsibilities for short-term monitoring and long-term monitoring to ensure that permitted or leased activities are conducted to meet goals, objectives, and standards, often related to resource sustainability and multiple land uses. To provide guidance for this, the BLM has the 4180 Handbook, *Rangeland Health Standards* (BLM 2001a) and their technical reference, *Rangeland Monitoring, Analysis, Interpretation, and Evaluation* (BLM 1984) and the USFS has *2209.21 Rangeland Ecosystem Analysis and Monitoring Handbook.* The agencies are responsible for coordinating and cooperating with producers in all phases of monitoring. Agencies encourage active producer participation especially in short-term monitoring.

MONITORING METHODS – SHORT-TERM MONITORING

Grazing Use Records – Accurate recording of actual grazing use by livestock, wild horses and burros, and wildlife should be maintained by unit or pasture. Grazing use records contain dates and numbers of livestock gathered and moved, as well as death losses, grazing problems involving water or livestock distribution, salting records, forage conditions, or other important matters. A pocket herd-book or a diary is often used. These data provide information on the season and duration of use and the number, kind, and class of grazing animals that are using and have used pastures. The livestock manager should be primarily responsible for the livestock part of this record, assisted by the agency rangeland manager. An example of a form that can be used to record actual use data is in Perryman et al., (2006).

Photography – Photographs capture a variety of useful information, especially when they include an object that indicates scale such as a ruler or hat. Any photograph of an area should be labeled and dated in the photograph (it should be easy to locate and re-photograph in the future). Hall (2001) provides other useful information in his photo point monitoring handbook. See photography in the *Ranchers' Monitoring Guide* (Perryman et al., 2006) (and see Appendix G).

Project Implementation Records – Many resource management plans call for projects of various types, including range seedings, fences, water developments, etc. Records of implementation should be documented. Precise records of the what, where, when, and how helps managers learn from the experience of projects, especially those that involve many variables such as seedings. A plan for recording this information, as well as project success and maintenance, should be part of project plans. Depending on the lifespan of the project, this may require short and/or long-term monitoring.

Weather Data – Weather is the most important single factor influencing variation in forage production. When properly recorded, weather data are an essential part of both **short-term monitoring** and long-term interpretation. General observations on growing conditions and any applicable measured weather data should be considered when making changes in grazing use. Monitoring plans should include gathering information on weather (temperature and precipitation) and growing conditions (soil moisture). Ranch weather stations can be extremely useful. It may be useful to obtain ranch and pasture-specific data.

The Western Regional Climate Center provides weather data for 141 locations in Nevada at http://www.wrcc.dri.edu/summary/climsmnv.html. Other sources are the Natural Resources Conservation Service, the Forest Service, the Bureau of Land Management, Nevada Agricultural Experiment Station Field Stations, other agencies such as the Nevada Department of Transportation, and any ranchers who maintain records. Relationships between seasonal precipitation patterns and temperatures can be used to interpret production and vegetation dynamics.

Insects, Disease, and Rodents – All rangeland vegetation is subject to disease, insect, and rodent impacts. Monitoring records should include notes on the location of significant occurrences and impacts. It can also be informative to read existing long-term studies following an insect or disease episode to document the effects and rate and patterns of recovery.

Use Mapping – Mapping of areas for proportions of the annual production that has been consumed or destroyed by animals is one of the most important tools in grazing management for short-term monitoring. Use mapping helps to establish key areas, identify distribution problems and solutions, develop objectives and grazing plans, locate range improvements, and make adjustments in management plans. The utilization map for an allotment or pasture can help range managers determine whether or not the grazing plan is functioning as designed. The map can identify and indicate the relative extent of areas underused, overused, and properly used. Problem areas can be identified for closer study to determine causes and potential solutions. Photographs and/or Global Positioning System (GPS) points at use areas may be taken to display utilization levels at certain locations.

Making and regularly updating utilization maps is a joint responsibility of rangeland managers and livestock operators. It is also essential for adaptive management. This process helps them become familiar with the allotment. These periodic visits and observations help identify needed adjustments in grazing plans. Adjustments might be in the form of new or relocated water developments, fences or salt grounds, or changing the intensity of grazing by modifying livestock numbers or the season or length of use period. An approach to use mapping is discussed in Appendix H and in *Utilization Studies and Residual Measurements* (BLM 1999b).

Utilization – Utilization is the estimation of the proportion of annual production consumed or destroyed by animals. The proper time to measure utilization depends on the purpose for which the data will be used. Seasonal use is estimated during the growing season. End-of-season utilization is estimated at the end of the grazing and growing season. Most studies on forage utilization are based on end-of-season utilization levels. Both types of utilization measurements help with adaptive management. The Key Species Method (formerly the Modified Key Forage Plant Method) has been widely recommended (Nevada Range Studies Task Group1984) and used to monitor utilization on upland key areas. See Appendix H for a description of this method. Utilization (or residual vegetation) may be more effective than stubble height for tall bunchgrass rangelands because of the uneven use by grazers. It may be easier to observe stubble height on meadows, or residual vegetation in annual grasslands. It is easier to see the amount remaining than to estimate the portion removed. The key is to choose methods that best measure progress toward objectives and note that utilization or residual vegetation are management tools, not long-term resource objectives.

Residual vegetation or stubble height – Stubble can be useful for providing roughness that slows water and encourages sediment deposition and retention. Therefore, stubble height is often used as an indicator of the effectiveness of riparian grazing management. Because intensity of use during the growing season is important to plant physiology and regrowth, seasonal use (measured within the growing season) is often used as a trigger for livestock movement. Residual vegetation, stubble height, or utilization at the end of the growing season indicates the net effect of grazing. It can be measured in key areas, critical areas, or designated monitoring areas and estimated and mapped throughout riparian areas. They should not be used as long-term resource objectives. For guidance on measuring residual vegetation or stubble height, see (Perryman et al., 2006) or BLM (1999b). The proper use of stubble height is discussed in Clary and Leininger (2000), University of Idaho Stubble Height Review Team (2004), (Appendix H), Hall and Bryant (1995), and Cowley and Burton (2005).

Woody Species Use – Willows, aspen, and other woody riparian species play an important role in some riparian systems, providing shade, nesting and foraging habitat for wildlife, and roots and stems for roughness and streambank stability. Other woody species provide important wildlife habitat in uplands. Many of these species are palatable or preferred by livestock and/or wildlife over other forages during certain seasons. Excessive use of woody species can prevent regeneration and limit density, height, canopy volume, or habitat quantity and quality. Specific use levels on woody species are often used as triggers for livestock movement. Use levels for woody species should not be used as a long-term resource objective. A method for monitoring the use of woody species is addressed in Utilization Studies and Residual Measurements (BLM 1999b) and modifications of that technique for riparian areas in Cowley and Burton (2005) and the *Ranchers' Monitoring Guide* (Perryman et al., 2006). These methods estimate the proportion of available leaders that have been browsed.

Streambank Alteration – In addition to the use of vegetation, large herbivores can cause physical disturbance to riparian areas. When streambanks are trampled or altered too much, there may be more damage than recovery in other periods. Therefore, streambank alteration may be used as a trigger for livestock movement or as an indicator of effects in short-term monitoring. It should not be used as a management objective. However, it is related to streambank stability, which may be an appropriate objective where it is a concern. Cowley and Burton (2005) provide guidance for monitoring both streambank alteration and streambank stability. Because of other issues with riparian functionality, streams may incise and streambank alteration may increase while stability decreases for reasons that do not reflect current grazing management. Measuring streambank alteration is more useful on certain stream types and certain periods of channel change.

MONITORING METHODS – LONG-TERM MONITORING

Ground Photography – Representative photographs taken at permanent locations are effective and efficient for documenting existing conditions as well as displaying change over time. Consistent techniques are essential. These techniques are discussed in the photography section of the *Ranchers' Monitoring Guide*, (Perryman et al., 2006) and in Appendix G.

Remote Sensing – Procedures involving new and old satellite and aerial imagery coupled with GIS and GPS techniques provide strong potential for detecting change in vegetation, soils, waters, and other landscape attributes. See Appendix G.

Frequency – Frequency measurements often indicate changes in species composition density or dispersion. This objective tool for recording the number of plots or quadrats that contain each species can be used to assess trend in long-term monitoring (refer to Appendix J for detailed field procedures). As the frequency concept has evolved, nested frequency is now highly recommended because of the importance of quadrat size and the need to have frequency data in the mid range (10-90%) for proper analysis. A change in frequency may trigger the need to collect more detailed data regarding species density, cover, or composition by weight. Frequency data have also been used to evaluate riparian community condition by the Humboldt Toiyabe National Forest (Weixelman et al. 1996 and 1999).

Production – There are several different methods for measuring production, including clip and weigh, volumetric, comparative yield, dry weight rank, and estimation techniques (BLM 1999a). Specific changes in production by species (species composition) may indicate successional progression or retrogression or transitions among states (as described in state and transition models (See Appendix B). Production has been used to describe ecological sites and is used to describe and assess plant community objectives.

Cover – Plants can be easily measured by cover, the amount of area covered by plant materials. Because different decision rules can lead to very different cover numbers for the same vegetation, it is critical to be clear which technique is used and to follow the rules carefully (canopy cover, foliar cover, ground cover, and basal cover are defined in the glossary, Appendix P).

Canopy/Foliar Cover – Canopy cover, the percent of ground covered by a vertical projection of the outermost perimeter of the natural spread of foliage, including small openings, may exceed 100%. This is often collected using line intercept (BLM 1999a) and can also be collected with grid plots or Daubenmire frames (BLM 1999a). Canopy cover provides many useful interpretations, (e.g. sagebrush cover has often been used to describe habitat values and make management recommendations (e.g., Rassmussen et al., 2001)). However, canopy cover of herbaceous species varies greatly from year to year and is not recommended for grasses and forbs.

Ground Cover – Ground cover is an important vegetation and soil-surface attribute. It is most often referred to as the percentage of ground surface covered by vegetation at the root crown. In long-term monitoring, it may be desirable to measure the percent bare ground, litter, rock, biological soil crusts, as well as basal cover of live vegetation by species, life form, or functional groups. These cover characteristics can be determined in conjunction with frequency sampling by recording "hits" at marked points on a tape, or corners of a frequency frame or grid. However, this sampling intensity may not provide an adequate measure of basal cover of individual plant species, and conclusions about basal cover should not be made without a large enough sample size.

Change in ground cover is an important aspect of trend. It is very useful for establishing planning objectives. It is also used to determine if favorable or unfavorable conditions exist for germination and establishment of new plants, and to assess nutrient cycling. Appendix L further describes a procedure for obtaining ground cover data.

Community-Type Transects -- In riparian areas, where the number of species is often greater than on uplands, and where many plant species are rhizomatous, community types can be used as the unit of measure. In areas where community types are not well classified or understood by the observers, vegetation can also be observed and recorded by noting the dominant species in plots or in patches of similar vegetation.

Cross-valley transect data are collected along five parallel transects that cross the riparian area perpendicular to the long axis of the riparian area (e.g., valley) (Winward 2000). They are used where management objectives relate to vegetation away from the stream edge.

More commonly, community types or dominance types are monitored along the greenline (Winward 2000) or streamside (Perryman et al., 2006) because of the tremendous importance of vegetation where it can buffer the forces of flowing water and influence sediment deposition. The greenline is the first line of perennial vegetation on or near the low water edge. Most often it occurs at or slightly below the bankfull stage. For more details about these methods see Winward (2000) or Cowly and Burton (2005). Similar data without the species identified can be collected by life form along the water's edge (see the *Ranchers' Monitoring Guide*, (Perryman et al., 2006)).

Winward (2000) presents guidelines for setting long-term management objectives by riparian capability groups. Objectives for designated monitoring areas should also be based on an understanding of stream dynamics and the processes of stream recovery after channel incision or other problems using Rosgen (1996) stream classification or a geomorphic analysis and PFC assessment (Prichard et al., 1998).

Greenline transects sometimes measure revegetation on pointbars. However, they may not if the greenline happens to be well above the revegetating pointbar. To capture vegetation trends quickly, the pointbar may be a place of focus in management objectives.

Greenline-to-Greenline Width – Another way to assess pointbar revegetation and the narrowing of streams is to measure the greenline-to-greenline width (Cowley and Burton 2005). Often pointbars are the first places to show changes in riparian vegetation when management allows colonizers to take root, capture fine sediment, and start succession or move it toward stabilizing plant species. For this reason pointbars are featured in lotic riparian

PFC assessment (Prichard et al., 1998). However, point bars are also places of natural sediment deposition, and colonizers may be washed away or buried. Therefore, pointbar measurements, although often interesting and useful, can also mislead if not interpreted in light of intervening flow records.

Riparian Shrubs – Winward (2000) and Cowley and Burton (2005) also describe methods for monitoring woody species regeneration. Both methods may require some practice in order to collect consistent results (Coles-Ritchie et al. 2004). Riparian shrubs can also be monitored with line intersects or air photos for canopy cover, which can be augmented with height for measurements of canopy volume. Doing this requires careful consideration to match methods with site potential and management objectives. Where wildlife habitat considerations warrant, a robel pole can be used to measure visual obstruction at various heights (BLM 1999a).

Streambank Stability – Cowley and Burton (2005) describe streambank stability as a combination of cover and stability against erosion or mass wasting. Streambanks are covered and stable if they are covered with perennial vegetation, cobble-size or larger rock, or anchored wood, and they do not have indications of erosion, breakdown, shearing, or trampling that exposes plant roots. Change in streambank stability may reflect incision, healing, or accumulated damage from use impacts such as streambank alteration. Failure to improve may also reflect nonfunctional conditions such as concentrated stream energy after channel incision.

Stream Channel Attributes – Because channel morphology provides habitat features important to fish for hiding or foraging, and because stream morphology also affects channel stability and water quality, land managers often target stream channels (e.g., width/depth ratio) for improvement through management.

Stream Survey – The General Aquatic Wildlife Survey (GAWS) (USFS 1985) and BLM Stream Survey (BLM 2001b) provide valuable baseline information (since the late 1970s) and have often guided management changes. These surveys contain photographs in addition to stream and fish habitat measurements and riparian observations related to optimal conditions for cold-water fish (but not in relation to site potential). Stream survey scores generally do not make useful management objectives because they combine numerous variables representing a variety of driving factors into one index. Index improvement is only partially tied to specific management actions or plans. An index may not change while the components of it change measurably, some increasing and others declining. Combining the understanding of process developed through riparian proper functioning condition assessment with the quantification from stream surveys leads to greater utility from both data sets.

Water Quality – BLM and the Forest Service comply with the Clean Water Act, the Safe Drinking Water Act, and other federal laws and Executive Orders, that require attainment and maintenance of water quality standards. Protocols for monitoring water quality attributes such as various plant nutrients, temperature, fecal coliform, etc. have been developed and are used by the Nevada Division of Environmental Protection (NDEP) and other agencies. The NDEP has signed a memorandum of understanding with the Bureau of Land Management and Forest Service, addressing authorities and protocols for water quality monitoring. Care should be used in interpreting water quality data because it often does not reflect current management, but rather a combination of watershed and upstream factors such as geology, climate, channel geomorphology and dynamics, etc.

Where there are water quality problems, it is usually best to determine the underlying causes and to manage and monitor accordingly. For example, streams that are not functioning properly may have poor water quality. Managing and monitoring for appropriate riparian vegetation is usually the most effective way to address water quality problems. Riparian vegetation improvements occur much sooner than improvements to stream channels, which occur more quickly than changes in water quality but which drive those changes (Wyman et al., 2006).

DETECTING PATTERNS OF VEGETATION CHANGE ACROSS A LANDSCAPE

Some vegetation changes occur on a landscape scale, such as an expanding plant community (e.g., advancing pinyon/juniper or invasive weeds) or as cumulative effects (e.g., increased acreage of dominance by annuals). Monitoring these changes helps to identify transitions across thresholds, from one state to another. (See information on state and transition models in Appendix B.) Although such changes can be detected or tracked with many individual plots, it is much more efficient to track landscape patterns with photos or other remote sensing, maps, or transects across the edges of community types. While some landscape-scale issues or changes are easy to observe, others can be detected through the use of pattern analysis techniques. Suitable data are needed for these analyses. It is imperative to include location markers for georeferencing.

Photos or Other Remote Sensing -- Vegetation changes visible at the landscape scale can be tracked with remote sensing when images are interpreted correctly. Stereo coverage is desirable (Appendix G).

Weed Maps – Maps of weed inventories can show patterns of dispersal. They help identify vectors and track the long-term eradication of individual populations. Maps can also be used with sampling for tracking weed density or weed control treatments. The value of these maps depends on the accuracy and completeness of the weed inventory data used to create them. Weed maps, vector use areas, maps of disturbance, and remote sensing can help stratify the landscape and prioritize areas for coordinated weed surveillance and mapping. Because weed management and monitoring are so important, continued development of monitoring protocols are expected and needed. One critical activity is consistently recording into a permanent record the random observations of agency personnel, ranchers, and other land users. Continued skill building in weed identification will add value to these efforts.

Plant Community Boundaries – Vegetation measurements across an edge of a plant community are better for noting changes over a smaller distance or where greater precision is warranted, (e.g., the expansion or contraction of a weed patch or riparian meadow). This can be accomplished through a variety of vegetation measurements with species noted by location along transects.

SUPPLEMENTAL TECHNIQUES AND INFORMATION

Supplemental information and techniques are helpful and often essential for the interpretation and proper use of short- and long-term monitoring data in making decisions on management changes. Any special conditions or events should be documented. Some of the more useful supplemental information includes identifying forage use by different species, using plant phenology for documentation of animal location, monitoring fire-related phenomenon, using exclosures and comparison areas, analyzing grazing use and utilization data with the grazing response index, and apparent trend.

Wildlife, Wild Horse and Burro, and Livestock Interactions – Wildlife use can have a measurable impact on Nevada rangelands and sometimes should be monitored. There is a vast diversity of wildlife species on Nevada rangelands; however, this section primarily focuses on large ungulates, wild horses, and burros. Furthermore, this monitoring emphasis recognizes that all species require and impact habitats.

Large herbivore (wild and domestic) interactions in a rangeland setting are complex. They depend upon habitat conditions and the age and physiological status of the animals. Therefore, whether the interactions are benign, negative, or positive depends in part upon how the animals are managed. In managing for habitat, the focus on interactions among wildlife, wild horses and burros, and livestock is similar. Monitoring of all large herbivore use requires similar information regarding effects of use (utilization, bank alteration, etc.) and numbers of animals by season, duration, and area of use in relation to offsetting recovery processes.

Wildlife are often very difficult to monitor because they are highly mobile and their use of forage may change with season, ecological site, etc. It is often easier to monitor habitat. When monitoring habitat, first consideration should be given to ecological capability and processes and the ability of a site or landscape to provide various seasonal habitat needs. The key to determining what to monitor in the short-term and long-term is to focus on the objectives in the management plan. For guidance on habitat-effects monitoring, refer to previous sections on short- and long-term monitoring. Monitoring wildlife numbers, season, duration, and area of use provides information analogous to livestock use records. The Nevada Department of Wildlife (NDOW) uses population data to set hunting seasons, evaluate attainment of population objectives, and evaluate population stability.

Where overlap among herbivores occurs, monitoring utilization and other habitat interactions should be based on documentation of spatial and temporal overlap among species and documentation of dietary overlap. When seasons of use do not overlap, utilization monitoring at the end of each season-of-use is possible and utilization can be clearly assigned to one herbivore (so long as subsequent growth and loss are also considered). <u>Properly timed movement of utilization cages is necessary to calibrate measurements at different times of the year.</u> If seasons of use partially overlap and it is important to estimate utilization levels for each herbivore, utilization measurements must be taken at multiple times. This is more complicated and requires multiple sampling periods.

Phenology – Plant phenology is the study of the plant's life cycle, e.g., leaf emergence, flowering, seed ripening, etc. in relation to seasonal weather factors. Because the time of occurrence of phenological events is to a large degree controlled by the weather, plants can be used as indicators of differences in growing conditions.

Phenological data (Appendix I) are helpful for understanding monitoring observations and measurements. Observations of forage species growth stages (especially critical growth stages such as the 3-4 leaf stage and flowering of grasses) relative to the timing of livestock movements are very useful because the effect of grazing differs in response to mechanisms of plant response that vary by growth stage.

Fire-Related Monitoring – When fire occurs on rangelands, management should be adjusted accordingly. Monitoring should recognize this influence and document where, when, and the effects of fire for planning and implementing needed changes. Information on pre-fire conditions (e.g., fuel load, species composition, transitions to other states (Appendix B)) is often critical for making treatment and management decisions. Such information may be available from permanent transects, aerial photos, soil surveys, ecological site descriptions, etc.

Post-fire monitoring includes fire effects, treatment, and follow-up management. Burned areas often attract use by wildlife, wild horses and burros, and/or livestock if allowed. Mapping this use can help explain patterns of recovery or lack thereof. One of the most important burned area observations to map is the viability of the remaining vegetation, especially the herbaceous perennials and important shrubs. Treatments should be well documented including actual location, seed mixes, effective seeding rate, methods used, weather, etc. Post-fire monitoring measures vegetation response and movement toward desired plant communities. Adaptive management is crucial to achieve desired results.

Exclosures and Comparison Areas – Exclosures are customarily used for visual observation and studies to compare vegetation change under grazed and ungrazed conditions. Comparison areas are locations (without livestock grazing) where the natural plant community has been protected from livestock grazing but exposed to natural disturbances such as drought, wildfire, insects, and grazing by native fauna. Comparison areas are used, along with other methods, to determine the composition and production that a particular ecological site is capable of producing with different historical management. They are helpful as a gauge or comparison for measurement when considering management objectives or monitoring species composition and trend. The history and location of these areas should be documented. Examples of comparison areas may include:

1. Areas protected from domestic livestock grazing because of inaccessibility or lack of water.
2. Sites with high ecological status, resilience, and resistance to transitioning across a threshold.
3. Large exclosures, highway or railroad rights-of-way, old cemeteries, or other areas that have been protected from livestock grazing for several years. (These areas can give useful information, but they can also be misleading because of the effects of local micro-environment, weather conditions, past disturbances, or vegetation stagnation.)

Grazing Response Index (GRI) – This tool combines several components of a grazing strategy – frequency of defoliation, intensity of use on green leaves, and opportunity for growth or regrowth – to estimate the impact of grazing on plants. Frequency is the number of times plants were grazed during of the grazing season. Intensity of use is utilization during the growing period. Opportunity is the time available to plants for active growth or regrowth before or after grazing. Opportunity is perhaps the most important factor for allowing plant growth over the long term. The grazing response index in the Ranchers' Monitoring Guide (Perryman et al., 2006) may be very useful as a planning tool or as an evaluation tool for understanding actual use records, growing season or phenology notes, and utilization or residual vegetation data. It must be stressed at this time that the grazing response index is most applicable and useful to the livestock and land managers as a planning tool. GRI is not, and never should be, used as an objective or a standard.

Apparent Trend – Trend is the direction of change in an attribute as observed over time (Bedell 1998 NRCS 2003). Apparent trend refers to one-time observations of soil and vegetation conditions on rangelands in the absence of or to supplement measured trend data. It relies on soil and vegetation indicators and in this way is very similar to the more modern concept of rangeland health assessment described in the Inventory and Assessment of Base Resources section above. It should only be done by an experienced observer and should always be clearly identified as apparent trend. Apparent trend indicators can be recorded when taking data at key areas. These observations should only be used to identify or focus on areas where additional monitoring and management may be necessary.

DEVELOPING A COOPERATIVE MONITORING PLAN

A monitoring plan specifies who is going to do what (short-term monitoring, as well as long-term monitoring), where, and when, to provide a basis for adjusting management according to monitoring results. An adequate management plan contains a monitoring plan related to objectives and relevant to actions. Appendix M, Table 1 provides a monitoring plan template. Appendix M, Table 2 provides a space for recording specific decisions about monitoring that will happen at each of the study sites, key areas, critical areas, photo points, or designated monitoring areas. If the tables are not used as forms, all the same information should be thought about and recorded in a narrative monitoring plan.

The Public Lands Council (PLC) and Bureau of Land Management (BLM) entered into a national memorandum of understanding (MOU) in 2004 to encourage and support cooperative rangeland monitoring between BLM and permittees. The MOU was transmitted to BLM offices by IM WO-2004-179. The MOU and subsequent BLM Washington Office materials provided guidance for implementing cooperative monitoring. Participation in cooperative monitoring in compliance with the MOU and guidance is also Nevada BLM policy. In 2005, the U.S. Forest Service (USFS) and the PLC entered into a similar national memorandum of understanding. The USFS did not provide guidance at the Washington Office level, but participation in cooperative monitoring in compliance with the MOU is also Humboldt-Toiyabe National Forest policy.

Monitoring of federally managed rangelands by a livestock producer necessitates a Cooperative Monitoring Plan if the rancher's monitoring data are to be accepted, used by the agency, and become part of the official record for the allotment or use area. To be most useful in ongoing management and legal protection, monitoring data must become part of the official record.

A Cooperative Monitoring Plan is a Monitoring Plan (described above) developed jointly with the agency(ies), rancher(s), and possibly others. Typically, a cooperative monitoring plan will outline the sites, resource issues (if any), resource objectives, monitoring methods, and who is responsible for collecting the data, when, and where. Usually, the livestock operator will focus on and collect short-term monitoring information (livestock actual use, photos, some type of utilization data, etc.) on an annual basis and agency range staff will collect long-term trend data (progress toward objectives). However, some ranchers will also want to collect long-term data (repeat photographs coupled with quantitative data tied to objectives collected over a period of five or more years). And, agencies may want to validate short-term data.

Appendix A provides specific and detailed information on how to set up and initiate a Cooperative Monitoring plan based largely on the Nevada State BLM Director's Information Bulletin on Cooperative Monitoring with modifications to meet Forest Service needs.

INTERPRETATION AND USE OF MONITORING DATA

Monitoring data must be interpreted and used to track progress toward achievement of land use plan and/or activity plan objectives (See Appendix N). Monitoring data can help identify linkages among conditions, objectives, and management within the setting. It can be used as evidence supporting decisions to continue or modify existing management. Monitoring data can also be used to validate goals and objectives. To summarize, monitoring data are used to:

1. Determine the affects of management actions on resource production, and economic conditions and values;
2. Determine the effectiveness of management actions in achieving objectives within the planned timeframes;
3. Support management actions and their modification; and
4. Periodically review the validity of resource condition and value objectives.

Monitoring is a key integral component of management, not an end in itself. If monitoring data are not used for these purposes, rangeland managers are not managing.

APPENDIX A – COOPERATIVE MONITORING

If you are a permittee, contact your BLM or Forest Service range conservationist and tell them you want to start a cooperative monitoring program. If you are an agency rangeland manager and want one of your permittees to begin monitoring, contact them about the idea. Implementing a cooperative monitoring program is relatively easy, though it will take some time, effort, and thought to get a useful monitoring plan in place. On March 1, 2006, Nevada State BLM Director Ron Wenker released Information Bulletin No. NV-2006-0023 regarding Cooperative Monitoring. He referred to this *Nevada Rangeland Monitoring Handbook* and ongoing Nevada educational programs about rangeland management and monitoring. A portion of that Bulletin is included or adapted below for reference because it provides useful insight for setting up a cooperative monitoring program and plan.

While use of these Nevada educational resources is recommended, it is not required for participation in BLM/permittee cooperative monitoring. All BLM authorized monitoring methods are acceptable. Three Technical References identify most of the BLM accepted vegetation monitoring methods; TR-1730-1, "Measuring and Monitoring Plant Populations," 1998; TR-1734-4, "Sampling Vegetation Attributes," 1996; and TR-1734-3, "Utilization Studies and Residual Measurements," 1996. (All three are available at www.blm.gov/nstc/library/techref.htm.) Resource, management, and economic objectives can arise from many sources. Resource objectives for BLM lands can be found in land use plans, multiple use decisions (MUDs), allotment management plans (AMPs), habitat management plans, herd management area plans, and biological opinions, to name a few. Information about resource objectives for the Forest Service can be found in AMPs, other implementation plans, grazing project plans, and Land and Resource Management Plans (Forest Plans). Ultimately, to be successful, the management must address the objectives, and the monitoring must measure indicators or components of the objectives that are affected by the management.

- *Monitoring gives us a limited view of the complex interactions among physical and biological processes, resource, social, and economic conditions, and management. Overly simplistic or unrealistic monitoring plans can lead to disappointment. Here are some basic ideas to keep in mind.*
- *Honest and continuing communications are essential to successful cooperative monitoring. Gaps in communications and differences in expectations or interpretations need to be continuously addressed. Such differences between agencies and permittees occur, because our basic goals only partially overlap.*
- *Figuring out the site specific relationships among the objectives, management, indicators, and monitoring is an expected part of the monitoring process. Continually reevaluate and be open to adjusting the monitoring and the management.*
- *Monitoring that tells whether or not management is achieving the rangeland health standards or other objectives is usually long-term monitoring. This is especially true for uplands in arid climates like Nevada.*
- *Not all monitoring results are as expected. This can be due to many factors other than non-compliance, including:*
  - *The action didn't really address the problem or the objective.*
  - *The monitoring didn't adequately measure the effects of management on the objectives.*
  - *Expect it to take some time for all parties to adjust to changes in how things are done. Or change causes wrecks, so it*

may take awhile for a change to actually be implemented as planned. Three years is a commonly used time frame for a permittee to train their cattle to different management.

- *Keep each year's monitoring in perspective. Generally, look at the big picture. Maintain a positive outlook.*

Crucial elements of a joint cooperative monitoring program:

1) Coordination requires frequent communication between permittee and the agency rangeland manager. A valuable benefit of honest and frequent communication is that both parties gain an understanding of each others' values, needs, abilities, etc. and will most likely develop a better working relationship over time. Frequent coordination and communication is the key to avoiding misunderstanding, ensuring both parties know what monitoring is being done and why. The results of monitoring that is developed by both parties will be more acceptable and defensible if there are challenges, and on-the-ground improvement will be achieved.

2) The cooperative monitoring program should be voluntary and both parties need to want success and to achieve great stewardship objectives.

3) Both parties need to confirm their sincere interest in securing the long-term health of the resources. This is often assumed as a given, however, it is important that both parties hear each other affirm this goal. This could be the first point of agreement, but if you cannot both agree on this point, there is no need to proceed further in a joint monitoring program.

4) Make the effort to get support of the administrative hierarchy in the agency and the ranch operation (and other operators on the allotment, if you are operating on a shared common allotment). At a minimum those people responsible for livestock's movement on your rangelands, private and public, need to be on board and participating from the onset.

5) Do not be afraid to ask for help. State office staffs of the federal land management agencies are aware and supportive of the Joint Cooperative Monitoring program and can provide assistance. These individuals can assist you and the District office to clarify the agency policy regarding joint cooperative monitoring; and how to set up and get a monitoring program started. Your local Extension Educator will also be willing to assist you in this endeavor and can get assistance from Cooperative Extension state specialists or other faculty at the University. The Nevada Department of Agriculture can also assist in initiating a cooperative monitoring program and plan. If you prefer to obtain the assistance of a private range consultant, they can also assist you.

Stepwise procedure for establishing and continuing a joint Cooperative Monitoring Program – Permittee participation in cooperative monitoring is often voluntary. It can be tailored to the specific permittee's issues, background, and available resources. Ideally, permittees and agencies will make cooperative monitoring a high priority. To the extent that a permittee is interested in participating in cooperative monitoring, but feels that the following is more than he/she is interested in, cooperative monitoring can be developed to address specific issues or the complete picture at a level that is feasible and comfortable.

1) To begin, the permittee and agency range specialist might discuss what each hopes to accomplish through cooperative monitoring, why they want to participate in cooperative monitoring, and the issues or concerns they would like to address. They might also identify the level of commitment each can make to cooperative monitoring and the importance of this allotment to the permittee's and agency's operation. They might discuss how the subsequent monitoring data are going to be used and how responsive either can be to making different kinds of changes. For example, adding several troughs to an existing pipeline can be done in about one year, but significant changes in livestock numbers will take at least three years, especially increases. What is most important is that they get started. Most of the above issues will become apparent as cooperative monitoring unfolds.
2) Make copies of all pertinent allotment information from the agency official allotment file. Make copies of the agency management and monitoring plan for your allotments. The livestock operator should have a copy of this information to understand the history and future direction of management of the allotment.
3) The permittee and agency range staff should review the allotment management and monitoring plans as an initial starting point. If no plans are available, it may be very beneficial to develop both of these plans in conjunction with establishing a cooperative monitoring plan. During the review process, discuss any points of concern, i.e., incorrect information, missing data, permit administration, etc. The Monitoring Plan Form and Monitoring Area Form in Appendix M can be useful in organizing your thoughts and assuring that you have covered all necessary topics during this process, as well as in the field.
4) The second meeting should be in the field at your monitoring site(s). The tour should be constructive and not confrontational. The purpose is to help everyone fully understand the resource, associated concerns, and important operational issues, i.e., livestock movement, infrastructure requirements, livestock water locations, wildlife habitat needs, fire or potential fire impacts, etc. Be sure to have a copy of your completed Monitoring Plan form and the *Ranchers' Monitoring Guide* (Perryman et al., 2006) with blank forms on hand for reference during the tour. On this tour you should:
    a) **Identify the Objective/s for the Allotment** -- This is an extremely important and critical step. (See, Resource Objectives, Pages 2-6 (especially pages 5-6) and Appendix D.) Objectives identify data requirements and determine what monitoring methods are required and how often measurements need to be taken. This will ultimately guide livestock movement. Objective/s and monitoring methods must be developed that can be measured, accomplished, and agreed to by all principal parties. Do not skimp on this task. If objectives have been set, discuss why they were selected and if they are correct. Remember resource objectives are SMART (see pages 5-6).
    b) **Identify the Key Area or Designated Monitoring Area –** Key areas should be selected and agreed to jointly. (See, Procedures for Selecting Key Areas and Key Species, Appendix F.) If key areas have already been selected, they each need to be reconfirmed jointly as

correct and at an appropriate site for the objective that is representative of the allotment. If a site is not reconfirmed as the appropriate monitoring site, consideration must be given to the historical data associated with the site and a determination should be made whether or not to continue monitoring this site to retain trend information. A Designated Monitoring Area (DMA) or Critical Area may be jointly chosen that is not a key area (Appendix F). The DMA will focus on an important and specific issue unique to that particular site. The DMA will usually not be representative of management of the whole allotment and only represent a site specific issue. If a DMA is chosen, a key area representative of the remainder of the allotment must also be chosen.

c) **Clarify the Resource Objectives –** Describe how objectives will look at each study site. Identify key species (Appendix F) and describe how they will change (if any) and vary through time if management is successful. Often an increase or decrease will be called for. However, this cannot go on forever and eventually species composition will change in new directions because of plant succession, fire, etc. Check to be sure that objectives for each study area are meaningful, realistic, and related to management.

d) **Affirm, Modify, or Develop Your Allotment Monitoring Plan as Necessary** -- Do not be afraid to request other specialists, both from within the agency or from other agencies, and University staff. Take the time and make the effort to establish a plan and set monitoring protocols that you can perform that provide the data requirements necessary to track livestock or other managements' impacts, positive or negative, over time. Make sure that the monitoring plan is achievable and not unnecessarily complicated or time consuming. If you are not confident in your ability to carry out the monitoring program, get help.

5) **<u>Follow Through</u> –** See the *Ranchers' Monitoring Guide (Perryman et al., 2006)*. Once a cooperative monitoring plan is developed everyone must be diligent in carrying out their respective roles. Whenever possible, both agency and permittee should collect short- and long-term data together. When together, collecting data is a great time to ask questions, discuss management ideas, and develop a common understanding for collaboration given the realities of response potentials, timelines, work loads, budgets, and outside funding. This does not mean that both parties must be together every time that monitoring data is collected, but advance communication of when data will be collected must be shared and the option to attend left open. The *Ranchers' Monitoring Guide (Perryman et al., 2006)* provides a selection of monitoring methods that are agency approved, generally easy to use, require a limited amount of time, and tend to produce consistently reliable results. Not all methods in the *Ranchers' Monitoring Guide* should be used at a monitoring site. The method or methods selected will depend upon the resource objective, ability and time of the data collector, etc. **Keep it simple**, effective, and correct to assure the best data possible. With the enthusiasm to start a new project, do not commit to more monitoring than needed nor more than both parties will make time for in their busy schedules.

6) **<u>Interpretation and Use of data</u>** – See "Interpretation and Use of Monitoring Data", Pages 21 in the *Nevada Rangeland Monitoring Handbook,* and Appendix N, Interpretation and Use of Monitoring Information. Once data are collected, copies of the data must be shared and maintained by both parties. In order to be of use, the data must also be analyzed to determine what, if any, effects management had upon the objectives; if the objective/s, triggers, and /or indicators are correct; if the monitoring site is correct; or if management should be modified. Once the analysis and interpretation is made, then a determination of action for the subsequent grazing season must be made. This must be done collaboratively between the permittee(s) and agency rangeland manager(s), at a minimum. A collaborative and adaptive management approach provides the best format and process for this type of management to succeed.

APPENDIX B – ECOLOGICAL SITES

Ecological Sites are interpretive units into which landscapes of native vegetation are separated for study, evaluation, and management. An ecological site, as defined for rangeland, is a distinctive kind of land with specific physical characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation (NRCS 1997).

Historical Climax Plant Community – The ecological site is a product of all the environmental factors responsible for its development including soils, climate, topography, and natural disturbances. The natural plant community of an ecological site in the absence of abnormal disturbances and physical site deterioration is referred to as the *historic climax plant community* for that site. The historic climax plant community (as defined by the NRCS) is that assemblage of plants presumed to be in place on an ecological site at the time of European immigration and settlement in North America.

The historic climax plant community is the plant community that was best adapted to the unique combination of environmental factors associated with the site. It is the plant community that was able to avoid displacement by the mix of disturbances and disturbance patterns (magnitude and frequency) that naturally occurred within the landscapes occupied by the site. Natural disturbances, such as drought, fire, grazing of native fauna, and insects, were inherent in the development and maintenance of these plant communities. Fluctuations in plant community structure and function caused by the effects of these natural disturbances establish the boundaries of dynamic equilibrium for a site. These fluctuations are accounted for as part of the range of characteristics for an ecological site as presented in the ecological site description.

The historic climax plant community for an ecological site is not a precise assembly of species for which the proportions are the same from place to place or even in the same place from year to year. In all plant communities, variability is apparent in productivity and occurrence of individual species. Variability (within reasonable limits) is the rule rather than the exception. Boundaries of plant communities, however, can be recognized by characteristic patterns of species or groups of species that dominate a site. Because of their stability in the historic climax plant community, these dominant (or co-dominant) species can be used to identify sites and to help differentiate one site from another. Generally, non-dominant plant species (including invasive species), fluctuate greatly according to local differences in microenvironment or weather conditions.

Ecological Sites – Each ecological site is recognized and described based on characteristics that differentiate it from other sites in the ability to produce and support a characteristic plant community.

Plant communities change along environmental gradients. Where changes in soil, topography, or moisture conditions are abrupt, plant community boundaries are distinct and easily observed. Boundaries are broader and less distinct where plant communities change gradually along wide environmental gradients of relatively uniform soils and topography. The important consideration is that, even though plant communities tend to be aligned along a continuum, distinctive plant communities can be identified and described. Where native plant communities occur with *predictable* regularity and are associated with concurrent differences in soil, climate, hydrology, or landscape position that can also be identified, an ecological site is recognized and a site description is developed. Of necessity, boundaries between ecological sites along a continuum of closely related soils and a gradually changing climate are somewhat arbitrary.

The criteria used to differentiate one ecological site from another are:

1) When there are significant changes in the plant species or groups of species that are ecological dominants in the historic climax plant community. A dominant species is one that makes up more than 10 percent of the total annual production (air-dry weight) in the historic climax plant community.

2) When there are significant differences in the proportions of species or species groups (i.e., grasses, forbs, shrubs), that are the ecological dominants of the historic climax plant community. More than a 20-percent departure (air-dry weight) in a given species or species group occurrence within the historic climax plant community is considered significant.

3) Where there are significant differences in the total annual production of the historic climax plant community. For plant communities capable of annual production less than about 500 pounds/acre, a 50-percent difference in total production is significant. For plant communities capable of annual production between 500 and 1,000 pounds/acre, a 30-percent difference in total production is significant. A 20-percent difference in total annual production for plant communities producing more than 1,000 pounds/acre is significant.

Any differences in the above criteria, either singly or in combination, great enough to indicate a different use potential or to require different management, provide a basis for recognizing a different ecological site. However, ecological sites are NOT differentiated on factors that have no direct affect on the character of the historic climax plant community (*i.e.,* livestock distribution, accessibility, or other management considerations). Site differentiation is based solely on those soil characteristics, response to disturbance, and environmental factors that directly affect the nature of the historic climax plant community composition and production.

Ecological site descriptions developed for use in Nevada reference the "typifying" environmental factors and disturbance regimes that have been correlated to the occurrence of a given historic climax plant community.

In assessing the characteristic vegetation best adapted to a site, such natural disturbances as drought, wildfire, grazing by native fauna and insects are recognized as inherent in the development and maintenance of the original plant community. Plant communities that are subjected to abnormal disturbances and physical site deterioration or that are protected from natural influences, such as fire and grazing, for long periods seldom typify the historic climax plant community.

Severe physical deterioration can permanently alter an ecological site’s potential to support the original or historic climax plant community. Examples include a permanently lowered water table caused by gullying or severe soil erosion by water or wind. When an ecological site's potential to produce a characteristic plant community has been permanently altered, a different ecological site is recognized based on the new/altered site potential.

Naturally occurring wildfire is thought to have crossed sagebrush-grass communities within Nevada’s northern desert shrublands on an average of every 15 to 100 years, depending on site productivity and topographic position. Mountain big sagebrush (Artemisia tridentata *ssp.* vasyana) communities are assumed to have been maintained under a natural fire regime where the period between burns was about

20-25 years (15 to 30 years). For high elevation, relatively productive, low sagebrush (Artemisia arbuscula) and black sagebrush (Artemisia nova) communities and mid-elevation Wyoming big sagebrush (Artemisia tridentata ssp. Wyomingensis), a fire frequency of about 40 years (35 to 50 years) is assumed. In the driest sagebrush communities (i.e., dwarf sagebrush on wind swept mountain ridges, low-elevation Wyoming big sagebrush, Lahontan sagebrush, and less productive dwarf sagebrush communities), fire frequencies of more than 50 years (50 to 75+ years) are assumed. Return intervals for wildfire in pinyon-juniper communities is assumed to be much greater than for the associated/adjacent rangeland (sagebrush-bunchgrass) communities. With the exception of very productive, perennial grass-dominant plant communities, natural fire is not considered to have been a major influence in the maintenance of most salt desert shrub and Mojave Desert communities of Nevada.

Succession and Retrogression – Succession is the process of soil and plant community development on an ecological site. Retrogression is the change in species composition away from the historic climax plant community due to management or severe natural climatic events.

Succession occurs over time and is a result of interactions of climate, soil development, plant growth, and natural disturbances. Plant succession (as defined by NRCS) is the progressive replacement of plant communities on an ecological site that leads to development of the historic climax plant community.

Primary succession is the formation process that begins on substrates having never previously supported any vegetation (lava flows, volcanic ash deposits, ancient lake beds, etc.). Secondary succession occurs on previously formed soil from which the vegetation has been partially or completely removed.

Vegetation dynamics on an ecological site include succession and retrogression. The pathway of secondary succession is often not simply a reversal of disturbances responsible for retrogression and may not follow the same pathway as primary succession.

State and Transition Models – Plant community state and transition models are being developed to describe vegetation dynamics and management interactions associated with each ecological site. These models provide a method to organize and communicate complex information about vegetation response to disturbances (fire, lack of fire, drought, insects, disease, etc.) and management.

A State is a recognizable complex of the soil resource and associated above-ground vegetation occurring within a characteristic climate. Phases within a State describe different plant communities with characteristics that cycle, or vary, back and forth through time, or in response to natural disturbances, management, or weather. Ecological processes connect the soil and vegetation within a State to sustain a "dynamic equilibrium" within a specified range in variation for plant species composition (or the set of associated Phases). Primary ecological processes for an ecological site include the reproduction of important plant species, energy and nutrient cycling; and the capture, storage, and safe release of water from precipitation.

Resilience and resistance determine the stability of a State and of the various Phases within a State. Resistance refers to the capability of a State to absorb disturbance and stresses and to retain ecological process functions. A resistant State tends to stay near equilibrium conditions with less variation in ecological processes. Resilience refers to the amount of disturbance or stress a state can endure and still regain its original function after the disturbances and stresses are removed. A resilient State can vary widely following disturbance and then return to the equilibrium condition. Resilient plant communities require only adjustments to management, if any, before the functioning of ecological processes returns the system to equilibrium following a disturbance.

Transitions are directions, or trajectories, of vegetation and soil change that will result in an altered functioning of one or more of a State's primary ecological processes. Transitional pathways reflect changes within a State that are reversible so long as they do not exceed the resistance or resilience thresholds of the State. A transition can be triggered by natural events, management actions, or both. Some transitions may occur very quickly and others over a long period. Two aspects of a transition are recognized: reversible and irreversible. Prior to crossing a threshold, a transition is reversible and represents an opportunity to reverse or arrest the change. Conventional management practices are used to reverse the transition. Once a threshold is crossed, however, the transition is irreversible without significant inputs of management, dollars, and energy.

States are relatively stable and resistant to change caused by disturbances up to a threshold point. A threshold is the boundary between two States such that one or more of the primary ecological processes has been irreversibly changed. Irreversible implies that restoration cannot be accomplished through natural events or a simple change in management. Active restoration (brush management, range planting, prescribed burning, etc.) must be accomplished before a return to a previous State is possible. Once a threshold is crossed, a disequilibrium among one or more of the primary ecological processes exists and will be expressed through changes in the vegetative community and eventually the soil resource. A new stable State is formed when the system reestablishes equilibrium among the altered primary ecological processes.

Movement across a threshold to a new State often represents a loss of, or at least a change in, resource values such as wildlife habitat, livestock forage, watershed functions, and/or soil protection. Some transitions and new States also reflect an increase in wildfire hazard, increased risk of spreading invasive weed seeds, or an increased risk of accelerated soil loss.

Each State reflects a different set of management possibilities and management methods. The vegetation within each State changes with the seral stages in plant succession (or Phases) recognized for the State. The role of managers is to work with ecological processes to facilitate change along desired pathways and to prevent transitions to less desirable states. Within each State certain management strategies work better for keeping a plant community resilient or resistant and keeping vegetation productive.

In general, keeping a desired plant community from irreversibly transitioning across a threshold is much less expensive than returning an undesirable, degraded, State to a more desirable State. Restoring ecological processes and returning a site it to its original State often requires more drastic actions that are expensive and risky. However, some potential States provide such vastly better products and services than their current State, that people invest much time and money in restoration, attempting to reverse an undesired transition. The top priority for large land areas is to implement management actions that maintain a landscape's (multiple plant communities) resilience, so less of it crosses a threshold, becoming less productive with fewer management options. This strategy is especially true for areas where a change in management could address the responsible stress or stresses and reverse a transition before it is too late.

The Ecological Site description represents a continuing endeavor to collect and categorize knowledge about the nature of native plant communities. A State and Transition model can be used to describe vegetation dynamics and management interactions associated with each ecological site. Ecological Site descriptions and State and Transition models help evaluate management, guide further study, and provide for proper use opportunities. More than 900 different ecological sites have been described in Nevada. Ecological site descriptions for each Major Land Resource Area in Nevada are available from the NRCS).

Wayne Burkhardt, Professor of Range Science at the University of Nevada, Reno (retired), aptly defined the development of ecological site descriptions as simply, "…a continuing process of approximation…" Each site description is an approximation of a characteristic vegetation and the environmental factors that are reasoned to support this plant community. The initial description of a historic climax plant community for an ecological site and the State and Transition Pathways (especially Thresholds) should be considered as an approximation, subject to modification as additional knowledge is obtained.

APPENDIX C – DROUGHT

Climate and weather must be considered for the interpretation of monitoring. In arid regions especially, drought is an important climatic factor that must be considered as changes are evaluated. Drought along with fires and unusually wet conditions of flooding are common reasons why flexibility in management is so important. Drought is defined in a number of ways, but is often described as a series of years when low rainfall and moderate to high temperatures exceed some average. Drought may be considered as "a period of abnormally dry weather sufficiently prolonged for the lack of water to cause serious hydrologic imbalance in the affected area." The Society for Range Management (Bedell 1998) defines drought as: (1) a prolonged, chronic shortage of water, as compared to the norm, often associated with high temperatures and winds during spring, summer, and fall; and (2) a period of reduced precipitation during which the soil water content is reduced to such an extent that plants suffer. Drought modifies the structure of rangelands by changing vegetation composition. The management of these plants before, during, and after drought influences the impact of the drought and rate of plant recovery following relief from drought conditions. Drought modifies the function of rangelands by influencing species composition, biomass production, nutrient cycling, and soil properties. Understanding how individual plants respond to drought and how ecological processes on rangelands are affected by drought allow us to interpret drought effects on monitoring data.

Monitoring helps managers detect, record, and understand drought impacts for appropriate management. Plants that normally have time to recover after grazing may not have soil moisture to do so. Appendix I provides a form for recording growing conditions and recommendations for management actions. Observations may lead to altered management within the season to minimize impact to range plants.

Furthermore, the level of use often increases during drought unless management changes are implemented. This may be especially evident near riparian areas where use is concentrated because intermittent streams have dried up early. Conversely, upstream or downstream areas without water may receive less or shorter use. Careful management in post drought years may be especially important for recovery after the stress of drought. Hence there is a need to track where drought induced management stress is or will be located so that managers can avoid or mitigate it. Maintaining short-term monitoring records through droughts helps interpret long-term monitoring data.

APPENDIX D – ESTABLISHING GOOD OBJECTIVES

Generally, objectives are developed from opportunities or concerns recognized at the beginning of the planning process. They can be resource or economic conditions or trends that need to be addressed (reduced, improved, or maintained) in the plan. Focusing on an opportunity or an issue creates a shared vision and helps stimulate thought.

Setting objectives is at the beginning of the nine-step planning process used by NRCS for developing conservation plans. (NRCS 1999 (National Planning Procedures Handbook and NRCS 2003 National Range and Pasture Handbook)) Landowners set goals and objectives for private land. Generally, these address the need to make an income through the intended land use(s) and may encompass a wide range of other values.

Once objectives are established, managers must refer to them to ensure movement toward the desired conditions or outcomes. Monitoring specifically related to the objectives indicates whether progress is being made or may indicate that management or objectives need revision.

Objectives In The Ecosystem Management Context – Rangelands are complex and dynamic. Establishment of appropriate management objectives must consider this complexity as well as societal values. Objectives must be achievable within a useful timeframe, measurable, and worthy of the management needed to meet them and the monitoring needed to assess them. (See section on Setting Objectives, Page 4.) Management often causes a chain reaction, leading to questions about how to identify the best resource management objective.

Riparian example:

- Spring *grazing for three weeks* may lead to:
- at least a *four-inch stubble height along the greenline of the stream*. Over a period of years this could lead to
- a ***measurable increase in colonizers on the streambank and on pointbars.*** Then, in a moderate flood this leads to
- *deposition of fine sediments* among the colonizers. Improved growing conditions then lead to
- an ***increase in greenline stabilizers*** through a period of years. More stable riparian vegetation leads to
- ***narrowing a stream*** by some measurable amount after a drought and flood cycle. With
- *increased floodplain access*, the aquifer recharges during peak flows. Stored water leads to
- *improved base flow*. More water in the stream leads to
- ***improved water quality*** and better fish habitat. Better habitat leads to
- *fish population increases*. With more fish to catch,
- *recreationists have more fun*.

In this example, each of the italicized changes could be measured (although some not easily) but only a few, the bold ones, would drive reasonable resource management objectives. Spring grazing and the four-inch stubble height are easily monitored. They are management tools or indicators of plan implementation, not objectives[1] (Clary and Leininger 2000; University of Idaho Stubble Height Review Team 2004).

The increase in colonizers, stabilizers, and narrowing of the stream are easily measured objectives that indicate changes in resource conditions. While water quality

[1] In some existing plans, utilization objectives are stated. These should be considered as indicators in the context of this publication. Presumably they are aimed at achieving some objective.

can be monitored, water quality measures vary greatly on a daily or even hourly basis and monitoring them is less informative than monitoring the other resource attributes. All of these changes occur over a series of years (possibly decades) and flow events. As indicated by the chain reaction, improvement in average water quality depends on the prior changes in riparian vegetation and channel conditions and, therefore, it takes longer. Which attribute is best to choose as a monitoring objective depends in part on the time frame for the management plan.

The described management uses ecologic and hydrologic processes that cause the riparian system to function properly and spiral upward toward other goals, e.g., more fish and recreational satisfaction. These goals would not make effective resource management objectives because they depend on a number of factors that are outside of the control of management, are too far removed from the management action, or are difficult or expensive to measure. Riparian functionality is often a standard that is assessed. Although not quantifiable, the assessment procedure, Assessing Proper Functioning Condition (PFC) in Prichard et.al. (1993, 1994, 1998 and 2003), is an extremely useful tool for recognizing riparian areas at risk, understanding the need for management, and setting resource objectives.

In general, riparian objectives address the composition of streambank (greenline) vegetation, streambank stability, and/or woody species regeneration (University of Idaho Stubble Height Review Team 2004; Cowley and Burton 2005). Because riparian vegetation and bank stability drive channel form changes (e.g., width), they are resource attributes suitable as long-term objectives. The closer the linkage between management treatment (e.g., grazing management) and resource attribute change (e.g., vegetation composition), the more useful the objective is in the adaptive management process.

Upland example:

- A rotation grazing system may lead to
- an *opportunity for plants* to grow when not grazed, grazing during *use periods* short enough to avoid numerous repeat defoliations, and *moderate utilization* on key species at the end of the growing season. With decreased plant stress this leads to
- increased vigor of the palatable perennial herbaceous community, slowing the *rate of sagebrush domination, and slowing the decline of herbaceous production*. This management could then lead to
- ***maintaining at least a certain percentage of decreasers in the herbaceous community***. This maintains at least some of the conditions for fire use which leads to
- Occasional wildfire and fire use. This leads to a mosaic of fire effects which leads to
- keeping ***a landscape in the herbaceous state with variable amounts of sagebrush cover in different places at different times***, which leads to
- regaining or retaining rangeland health which leads to
- maintaining *high quality habitats* for sage grouse and other sagebrush-dependent wildlife as well as habitats for grassland-dependent species. Maintaining *viable populations of wildlife* and *economically viable ranches* across a landscape leads to
- maintaining a socially and economically viable community of people.

In this example, each of the italicized changes could be measured but only a few, the bold ones, would drive reasonable resource management objectives. Rotation grazing, with its opportunity for plant growth, low frequency of use, and moderate utilization, are easily monitored. They are management tools or indicators of plan implementation (short-term monitoring), not objectives for long-term monitoring.

The percentage of decreasers in the herbaceous community, maintenance of the herbaceous state, variable amounts of sagebrush cover, and certain other attributes of habitats are easily measured objectives that indicate changes in resource conditions. Rangeland health and high quality habitat must be defined in such measurable terms to be monitored. While populations of wildlife and the economic viability of ranches and communities can be monitored, populations and economic variables vary greatly on a monthly and yearly basis and monitoring them is less informative than monitoring the other resource attributes. All of these changes occur over a series of years (possibly decades) and with differing weather. As indicated by the chain reaction, goals, such as the improvement in wildlife populations, depend on the prior changes in habitat (or upon preventing certain changes) and, therefore, the effects of management accumulate over many years. Which attribute is best to choose as a monitoring objective depends in part on the timeframe for the management.

The described management uses ecological processes that cause the system to regain or retain rangeland health and spiral upward toward other goals, e.g., more wildlife and economic viability. These goals would not make effective resource management objectives because they depend on a number of factors that are outside the control of management, are too far removed from the management action, or are difficult or expensive to measure. Rangeland health is often a standard that is assessed. The assessment procedure, Interpreting Indicators of Rangeland Health (Pellant et al., 2005) is a useful tool for recognizing areas at risk, understanding the need for management, and focusing resource objectives.

In recent decades, many rangeland management objectives have used range condition classes or seral stages for describing objectives. Unfortunately, many desired changes in species composition are not well described by this approach. Ecological thinking has moved away from this thought process. An alternative to condition classes or seral stages is to clearly describe the changes that are desired from a particular management plan or action by describing the desired plant communities (DPC). In doing so, it remains necessary to ensure:

1) DPCs are within the potential of the ecological site and soil. Describing desired vegetation from the same ecological site in a nearby area under different management is one way to ensure that changes are possible. Monitoring records from successful management are extremely useful for describing what's possible.
2) DPCs address the most important concern(s) of rangeland health. Often the most important changes to describe in objectives are those that will lead the community away from the risk of crossing an ecological threshold (see Appendix B).
3) DPCs do not create conflicts with rangeland health. Some plant communities might be desirable for some resource value, but are not sustainable and should not be the objective for management if there are sustainable alternatives. (The desire to achieve useful vegetation characteristics may lead to a plant community that is unable to provide these values after a threshold is crossed and the community is no longer resilient to disturbances such as fire (e. g., a shrub state sagebrush-dominated plant community without a resilient understory).
4) DPCs are described in a manner that recognizes they will naturally change through time. Describing any plant

community objective should recognize the changing nature of rangeland vegetation due to plant succession, natural disturbance regimes, and the vagaries of year-to-year weather, insect infestations, etc.

Combining goals, management actions, and objectives – Rangelands comprise many different types of land, different ecological sites, different historical uses and management (e.g., native and seeded rangeland), and goals that vary across the landscape and through time. The goals for an allotment could include regaining and then retaining rangeland health across the land and proper functioning condition in the riparian areas. Management of these large areas often integrates livestock, wild horse, and wildlife management, as well as direct vegetation management such as weed control, vegetation treatments, and fire management. It may also involve recreation management and other activities. Because it is impossible to micromanage large areas and impossible to not manage, it is critical for managers to focus on measurable objectives that lead to identified goals. Some management objectives should apply to specific areas, such as key areas that represent important goals. Other objectives should address the mix of vegetation across a landscape to address goals requiring the integration of resource conditions. (See Karl 2005.)

Examples of good objectives: (Assuming these objectives are achievable and worthy of the management and monitoring cost.)

1. Increase by 15 percent the proportion of the greenline that is dominated by deep/densely rooted riparian species or late seral community types (Winward 2000) within 10 years (by 2016*) on Rose Creek in Big Meadow (designated monitoring area (DMA)1).
2. Facilitate willow establishment on the point bars of Fish Creek in south pasture (DMA 2) so that by 2015* at least 65 % of the greenline has a willow overstory or a willow plant within 1 meter of the greenline.
3. Increase bank stability along Sand Creek so that by 2010 at least 80% of the banks are stable within DMA 3.
4. Reduce greenline-to-greenline width along 80% of Gray Gulch Gully in DMA 4 within 15 years.
5. Within the West Canyon above the riparian pasture, increase the length of valley bottom covered by willow canopies or other riparian shrubs from 60% (2005) to 80% by 2015*.
6. By 2015* (assuming that the years between 2005 and 2015 experience at least two years with below 75% snow pack followed by at least one year with above 125% snow pack) the bankfull channel width at riparian monitoring station 2 (GPS Location___) along Deer Creek in South Allotment Riparian Pasture will narrow from 12 to < 10 feet. (This objective requires more than just livestock management and time to be met and, therefore, the flow regime caveat is stated.)
7. At monitoring station 3 in the South Pasture, a loamy 8-10 ecological site, achieve by 2011* and maintain thereafter an herbaceous community composed of at least 60% by weight of decreaser species (e.g., thurbers needlegrass, needleandthread, or Indian ricegrass) or a ratio of 2:1 between decreaser and increaser species (e.g., sandberg's bluegrass, squirreltail, phlox, or prickley gilia), with no plants on the State noxious weed list.
8. The landscape scale objective for mountain big sagebrush sites in the Purple Mountains is to retain at least 90 percent of the acreage with sufficient perennial herbaceous vegetation to fully occupy most areas within one year after the event of a wildfire.

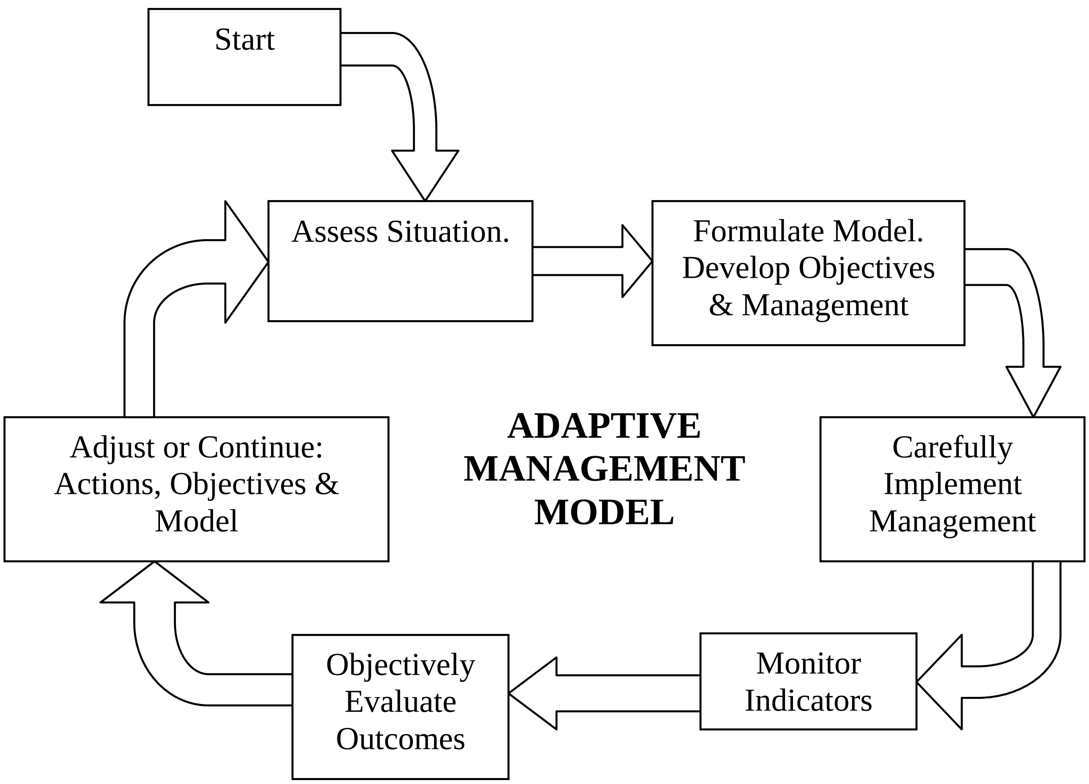
9. The landscape scale objective for all sagebrush sites in the Purple Mountains is to maintain a shrub cover of 5-25 percent on at least 50 percent of the area and to have no areas exceeding the maximum shrub cover identified within the historic climax plant community for that ecological site. (Note, this objective could be accomplished with livestock grazing management, including careful management of the understory and occasional treatments to use livestock to diminish sagebrush. However, it would normally be accompanied by livestock management and other means, such as mechanical or chemical shrub control or the use of prescribed fire.)
10. Eradicate the five known populations of perennial pepperweed in the Elderberry Creek watershed by 2010,* while continuing surveillance to detect and eradicate new populations.
11. Remove pinyon and juniper trees from 20 percent of Phase II encroachment areas inventoried on Sage Grouse Mountain by 2015*. (Phase II encroachment is the period after pinyon or juniper trees have become established throughout a sagebrush area, during which their continued growth, and some continued recruitment, leads to reduction (through competition) of most of the herbaceous and shrub understory on many ecological sites.)
12. At key area one, attain and retain a frequency (16" frame) of Indian ricegrass of 20 percent or more.
13. Allow aspen regeneration to exceed the height of browsing at or near Rock Spring resulting in at least a 10% increase in the young age class (1-5-inch diameter at breast height) by 2011*.
14. Maintain aspen at Rock Spring for diverse age classes, with at least 10 percent of the stems in the young age class.

Objectives should be based on the current and potential condition of the site, be connected through cause and effect to the management plan, be measurable, and allow for adjustments due to unusual weather or other conditions.

[*] **Often the timeline for meeting objectives provides an indication of expected results given our present understanding and assuming a normal range of variation of the factors that drive the changes, such as weather. When not stated explicitly in an objective, this assumption should be made clear in the management plan so that failure to meet (or early attainment of) an objective does not suggest any arbitrary standards.**

APPENDIX E - ADAPTIVE MANAGEMENT

At its most simplistic level, adaptive management is "learning by doing." Continuous feedback and revision can make management increasingly effective, efficient, and accountable. Management and monitoring are designed in concert to achieve the objectives and optimize the information gained. Management is evaluated in light of this information and continued or revised based on progress toward the objectives. The following is a basic model of adaptive management. While there may be a beginning to successful adaptive management, there is not an end.



This model of adaptive management includes six steps.

- Assess the existing condition of the resources or values of interest.
- Formulate a model of the situation, develop objectives and management to achieve them. This is an important and potentially difficult step. The model is a conceptual description of the existing situation that identifies stressors or impacts and how they affect the goals and objectives and explains how management actions will influence the stressors and modify the status of the objectives. To manage successfully we must ferret out these relationships. Just knowing that conditions are not meeting our expectations does not determine the causes, or identify what (if anything) can be changed to meet the objectives.

Almost without exception, every activity has the potential for positive and negative affects. Therefore, we must seek out the causes and effects. Not understanding these relationships often leads to a default solution of limiting some suspected activities.

- Carefully implement the management actions.
- Monitor indicators. The ecosystems, landscapes, and allotments we manage are complex. We cannot possibly monitor all attributes. The conceptual model helps identify indicators. Effective indicators respond in a manner that mirrors ecosystem dynamics, and responds to the applied management. Responses to management are measurable and can be differentiated from natural variability.
- Objectively evaluate the outcomes. The model is used to help evaluate the monitoring information. Typically by this step much time, effort, and thought has been invested. Participants tend to have ownership in the decisions. As a result, it can be difficult to accept, or even recognize, results that suggest the management actions are not working, the objectives should be adjusted, or the model needs to be modified. The participants need to be continuously vigilant of such factors. Positive outcomes reinforce the model and objectives and provide data to support continuation of the management.
- Adjust or continue.
- Continue adaptive management.

A fundamental observation of successful adaptive management is that, not only do resource conditions improve, but the participants evolve and in unpredictable ways. This process often begins with the realization that our perceived understanding of the situation was imperfect and, as a result, we are not able to completely predict the outcomes of management. On-going monitoring, evaluating, and adapting brings increased knowledge and surprises. We have to expect and accept both.

APPENDIX F – PROCEDURES FOR SELECTING KEY AREAS AND KEY SPECIES

Key Areas – A key area is a relatively small portion of a unit selected as a representative monitoring point for measuring change in vegetation or soil and the impacts of management. It is chosen because of its location, use, and value. It is assumed that key areas, if properly located, will reflect the current management over similar important areas in the unit. They should serve as representative samples for long- and/or short-term monitoring (e.g., range conditions, trends, seasonal degrees of use, resource production, etc.). Key areas may be selected to represent a particular plant community, a specific ecological site, or some other significant portion of a management unit. Rangeland managers, livestock operators, and others who know the range should cooperatively select key areas based on management objectives. Key areas for long-term monitoring should also be used for short-term monitoring. To select a key area:

1. Consult standards and guides and land use and activity plan objectives. Use a vegetation map, aerial photo, soil survey, ecological site inventory, and whatever other useful information is available for the allotment. Use these to determine soils, ecological sites, ecological status, and/or state and risk of transition, if possible. Map vegetation types in the allotment or pasture, if possible. Key management areas should be located where the ecological situation is well understood. They should not bridge two or more ecological sites. Soil taxonomy must be confirmed in the field because soil inclusions lead to differing potentials within the same ecological site (e.g., sandy surface textures produce more perennial grass than finer soil surface textures).
2. Relate key area locations to allotment specific objectives. To do this, gather the Standards and Guidelines; Land Use plan goals and objectives; and any allotment specific goals and objectives from allotment management plans or other pertinent documents. The attributes of the objectives(s) monitored must be present on the area selected.
3. Refine objectives for each key area at the time they are set up in the field based on potential to represent management objectives. Consider the management plan, including triggers and end-of-season indicators.
4. Overlay use pattern map, water locations, and vegetation map together on a base map. Look for the most productive soils and sites with the highest use. Heavy or moderate use areas targeted for improvement in the plan and that are no farther than a mile from water are good places to put a key area (closer than 1 mile in a small pasture). Slight to light use areas do not tell much unless they are used to compare trend or production between heavy or moderate and slight use areas. A key area should represent an area that provides a significant amount, but not necessarily the greatest amount, of available forage in the pasture. This can be ascertained from an evaluation of the utilization and ecological site maps, together with an on-site examination.
5. Choose area(s) representative of the suitable seasonal range or use area. Two or more key areas may be needed for large pastures, pastures that have very rough topography or widely spaced water, various areas where animals tend to locate, areas where different kinds of animals graze, or where the pasture is grazed at different seasons. One key area may represent more than one pasture only if they are in the same grazing system with similar ecological sites, conditions, topography, water,

treatments, etc. Large, unfenced allotments may require many more key areas than implied above.

6. Determine the plant community potential. The site must have the potential to improve or decline. That is, there must be sufficient plants of the key species (those plants identified in management objectives) that an increase is predicted from the management plan and enough that they could decline if management does not achieve objectives or does not work or get implemented correctly. Within an ecological site, the area between abundant and sparse vegetation of the key species is often the best place to establish studies. For example, between abundant and sparse fourwing saltbush in the Sandy Loam 5–8" p.z., Ecological Site of MLRA 29-A change in abundance of key species will show up quickly. Whereas, sparsely populated areas that may have crossed a threshold have little or no potential to improve vegetation and may only go downward in trend. A study placed in the center of a patch of abundant or very little fourwing will take years to show change. It may be necessary to establish a study in such areas if a new water source is to be developed in it or if livestock management changes and this will influence the plant community. Studies in healthy rangeland can also be used for comparison areas.
7. Do not establish a key area in a small, atypical location.
8. Establish key areas in sites that herbivores prefer.
9. Ensure that key areas are accessible to grazing animals because of favorable factors influencing livestock distribution. Areas remote from water or having limited accessibility may be suitable for comparison areas but should not be selected as key areas.
10. Avoid water sources, trails, corrals, historic salt grounds, shade, and other concentration areas. And, stay away from roadsides or other disturbances.
11. Where multiple herbivore (wild and domestic) use is significant, select key areas as needed.
12. Confine monitoring studies on a key area within the boundary of a single soil, single land form, and single plant community or ecological site. The Key Area Location Form included in this appendix is an example for recording the location and specific selection criteria.
13. Consider the season of use and class of animal because diet preferences change by season, kind, and class of animal.
14. Establish new key area(s) and discontinue reading old key areas if they do not address management objectives. This can happen when the pattern of grazing use is significantly modified because of a difference in season of use, kinds or classes of grazing animals, pasture size, water supplies, or other factors affecting grazing distribution or the management plan.

Designated Monitoring Areas – In riparian zones, areas selected for short- and long-term monitoring may be called designated monitoring areas (DMAs) (Cowley and Burton 2005). In riparian areas, key, critical, or designated monitoring areas should:

1. Represent management concerns within the riparian area as reflected by riparian PFC assessments, management plans, and especially management objectives (e.g., be associated with spawning areas for listed fish, if spawning habitat is targeted by recovery plans).
2. Have the potential to respond to the planned management. For example, a recent gully or recently incised stream is not suitable because it no longer has the ability for vegetation to influence channel stability and riparian functions. This will eventually return as the channel widens and develops the area

needed for a new floodplain and riparian vegetation inside the gully. Functional-at-risk reaches are often a higher priority for management and monitoring than are nonfunctional or properly functioning reaches.

3. Have the species present that will be needed to respond to management objectives and have suitable places for them to grow.
4. Respond similarly to similar reaches, if there are similar reaches in the unit. They should not be located on isolated atypical areas such as where trails enter or cross a riparian area, water gaps, "postage stamp" locations surrounded by willow thickets, etc.
5. Be characterized by existing stream survey or PFC assessment locations (if they meet the above criteria) because of the existence of historic photos and data. Other historic photo sites may also be suitable, if they meet the criteria.

Critical Management Areas – Critical management areas must be treated with special consideration because of inherent site factors, size, location, conditions, values, or significant potential conflicts among uses. It may be important to designate and monitor critical areas as key areas because they have a significant resource value or concern. However, critical areas may not be extensive in area and do not reflect the management of the entire grazing unit. Critical management areas may include:

1. Critical habitat for wildlife;
2. Areas having threatened or endangered species;
3. Highly erodible areas;
4. Isolated aspen patches; or
5. Riparian areas.

Key Species – These are often key forage species that indicate the degree of use of associated species or species which must, because of their importance, be considered in the management program. Generally:

1. Key species should represent objectives and be a significant component of the potential desired plant community. The species selected should be those that respond to management. Key forage species should be ones that respond to grazing management
2. Key forage species should be palatable to the grazing animals during the planned season of use. (Very palatable plants that have low production potential should not be selected as key species. Species with low palatability or lower palatability than the preferred species should not be selected. These give a falsely high or low use reading, leading to under use or excessive use on the more palatable forage species.)
3. Key species should be perennial except on annual rangelands, and be selected after:
    a) Choosing the key area and evaluating the present plant community.
    b) Deciding the plant community or important plants that will reflect the objectives.
    c) Giving due consideration to planned management, such as kinds and classes of grazing animals and season of use.
    d) Thoroughly evaluating the factors affecting grazing distribution. If only one kind of animal grazes the pastures, a single plant species generally may suffice as the key species.

Study Site Location					
Key Area Name and/or Number					
District/Ranch		Observer			
Allotment Name and Number (if any)					
Pasture Name and Number					
Wild Horse or Burro Herd Management Area					
Habitat Management Plan Area					
Wildlife Season of Use					
Soil Series or Map ID		Ecological Site/Soil Taxonomic Unit			
Key species					
Location	Township	Range	Section	1/4	1/4
GPS Lat.	Long./UTM	Elevation	Slope	Aspect	
Current Plant Community Dominants					
Key species					
Types of Studies Established					
Site location selection criteria narrative:					
Site Location Map and Narrative: Show witness post location and bearing from known landmark, also approximate scale. Indicate easiest access.					

APPENDIX G – REMOTE SENSING TO MONITOR RANGELANDS

Aerial Remote Sensing – Aerial remote sensing has strong potential to assist in the monitoring of rangelands. However, this technology has not yet been successfully used to monitor rangeland vegetation except for some specific applications. The practice and science of remote sensing is changing very rapidly. For many years the National Aeronautics and Space Administration (NASA) suggested using remote sensing to evaluate rangeland characteristics. This potential has not been realized because of several factors: 1) cost – the acquisition, analysis, and interpretation of remotely sensed data is not yet feasible to evaluate large areas of rangeland; 2) since it is expensive, sub-sampling expansive areas is necessary; 3) trained interpreters that understand both rangeland ecology and the capabilities of various remote sensing and image-analysis systems are essential.

A brief discussion of costs and some types of available imagery follows. In the future, those who wish to monitor using remote sensing technology will have to constantly determine what new applications have been developed and how they might be used to monitor rangelands. Prices are likely to change through time.

To obtain single meter and, in some cases, sub-meter resolution, panchromatic satellite data are available from the IKONOS satellite (1m grid size dimension(GSD) go to http://www.spaceimaging.com/products/ikonos/. The cost for digital color data is about $7.50 per square kilometer with a minimum order of 100 square kilometers. For the Quick Bird (60 cm GSD), go to http://www.digitalglobe.com/ satellites. The costs are $46 per square mile with a minimum order of $450.

For most states, high quality 1m-resolution color infrared imagery is available and obtained via the National Air Photo Program (NAPP), http://edc.usgs.gov/products/aerial/napp.html. These photographs were acquired from an altitude of 20,000 feet and are available in black & white (B/W) or color infrared (CIR), depending on location and date. Each photo is centered on one-quarter section of a 7.5-minute USGS quadrangle, and covers approximately a 5.5 x 5.5-mile area. Data are obtained on five- to seven-year intervals, which is an appropriate timeframe for rangeland monitoring. Cost for these excellent images (1m GSD) is $100 for a twenty-square-mile area.

LANDSAT7 data (15m GSD) can be acquired from MapMart at http://www.mapmart.com/ for $600 per scene. You can also evaluate LANDSAT directly by accessing http://landsat.gsfc.nasa.gov/. Each scene covers about 100 square miles. These costs seem somewhat reasonable, but as the acreage increases, the costs can become prohibitive.

Other potential applications are light detection and ranging (LIDAR) and Inferometric Synthetic Aperture Radar (IFSAR), which offer potential for rangelands involving radar (e.g., tree height or erosion/deposition along rivers) including rapid terrain visualization http://www.ghcc.msfc.nasa.gov/sparcle/sparcle_tutorial.html.

The Moderate Resolution Imaging Spectroradiometer system (MODIS) is the replacement for Advanced Very High Resolution Radiometer (AVHRR) data and now gives up to 200m resolution over large land areas.

The Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) is a multispectral system with 224 spectral channels in the 400 to 2500 nanometer range and, while the value of many of the bands has not been proven for rangeland applications, the importance of such systems may be realized in the future.

SPOT (Systeme Pour l'Observation de la Terre) (http://www.spotimage.fr/html/_167_.php) offers multiresolution imagery to meet multiscale needs from 2.5 m to 20 m.

To make remote sensing work and to realize its great potential will take considerable effort by managers to actually use this medium. It will require multiscale sampling procedures. The LANDSAT7 ETM may be used as part of this extrapolation process, along with other satellite data and the NAPP data. Software for batch processing photographic samples by automatic analysis needs improvement for greater accuracy, consistency, precision, and calibration.

Remote sampling and automated image analysis apply at various scales for rangeland monitoring efforts. Some current generation programs are capable of processing hundreds of digital color images in less than five minutes providing bare ground measurement accuracies of around 70 percent (Booth et al., unpublished data). For large areas, this may be considerably more accurate than single site "representative" sampling. Preliminary work with more sophisticated software (Feature Analyst) showed accuracy approaching 90percent, but this software cannot yet batch process images at the same rate as VegMeasure.

Work is currently underway to develop and implement a protocol for sub-sampling of allotments or watershed rangeland areas. Very Large Scale Aerial imagery (VLSA) will provide procedures to solve what is bound to be a somewhat difficult sub-sampling problem. Dr. Terry Booth, Agricultural Research Service, Cheyenne, Wyoming, in his research on Wyoming, Nevada, and other rangelands, has been able to use flight transects to obtain reasonable measurements of average bare ground percentages by allotment and average bare ground by watershed at a cost (for the one watershed for which figures are available) of $0.03 per acre (although this is not full coverage, as are Landsat, Quickbird, IKONOS, and NAPP images). Perhaps this digital color data (1 mm ground sample distance) can be extrapolated upward to even larger areas with proper interpretation. Riparian areas were flown separately, and at a lower resolution and larger field of view, because of their different vegetation structure and relative importance.

The VLSA example represents monitoring at only the watershed/allotment level and the extrapolation to the regional or national level has not been attempted. However, as methods for automated range vegetation measurement are improved, sampling protocols refined, and data storage and utilization in GIS mapping are implemented, the potential for using these data in the application of remotely sensed data to measure bare ground as part of regional and national rangeland monitoring programs will become reality.

A land manager's strategy should be to follow the research and development of remote sensing systems and determine when and how they can be used for rangeland monitoring. As part of this effort, the marriage of remote sensing data to GIS (Geographic Information System) and GPS (Global Positioning System) data will become commonplace. Recently, efforts supported by the U.S. Department of Homeland Security has led to a program called ARIES (Airborne Rapid Imaging for Emergency Response) (see EarthData at http://www.earthdata.com/about.html), which describes how ARIES can collect color digital imagery, LIDAR terrain profiles, and thermal data. ARIES also downloads the data from the aircraft to a transportable ground processing center using a direct wireless downlink, processes the data, and disseminates the data through a wireless internet connection to users in the field. While we do not require data with such speed, except for fire control and fire use, to achieve resource management objectives, the development of these protocols will certainly lead to timely accession of high quality, remotely sensed data of high resolution for rangeland monitoring applications. Then all that remains is the training and use of quality people with good rangeland ecology and management skills to provide the interpretation.

Ground Photography – In both riparian and upland range areas, photography is an excellent tool for capturing short-term monitoring information. Photos taken before and after use periods can indicate use by various herbivores in areas where multiple grazers share the forage base. Photos taken after the use period show seasonal use, and photos at the end of the grazing and growing season show utilization or residual vegetation or other end of season indicators. Photos may focus on streambank alteration or other management concerns that would show up well in a photo. Photos must periodically be taken at key areas or designated monitoring areas.

Suggestions for taking better photographs include:

1. Identify the date and exact location within the picture, using a field slate or form (See the Ranchers' Monitoring Guide by Perryman et al., (2006)).
2. Take the picture during the same stage of plant growth each year, if possible.
3. Include the same skyline in the landscape photos. If possible, include a distinctive landmark in the background of the photo.
4. Carefully relocate the photo points each time. This might be done using GPS technology, stakes in the foreground and a post to set the camera on, and/or taking previous photos into the field.
5. Use the same lens or focal length lens and proper settings for light each time.
6. Obtain one landscape photo and one or two close-up photos of the vegetation along each transect.
7. For the close-up photos, use a specific plot size and have some scale marker in the photo such as a foot ruler or pole with 6-inch color changes (e.g., red and white). Use a similar procedure each time you take photos for the site. These photos will be taken vertically over the plot or at a low oblique angle. You should try to be consistent in how you obtain the photos.

Photos can be taken with several different types of cameras. However, a digital camera is very useful since the images can be stored on the hard drive of your computer or placed on a CD for storage and future reference. They can also be printed out for storage in hard copy. Place data and photos in file folders. Record notes in a notebook or individual paper for filing. It is good to record as much of what you can see as practical while you are in the field. It has been the experience of many that it is not possible to remember all of the salient features of the site. **Save and backup the data**.

Photos also make an excellent record of riparian conditions to accompany any long-term or short-term monitoring data. Photos are taken at times of stream survey and riparian PFC assessment. File photos identify suitable permanent photo points where they address management objectives. Generally, riparian photo sets include an upstream, downstream, and across the stream shot. Because riparian trends often lead to an abundance of willows or other riparian vegetation, later photos often show only a mass of vegetation hiding the stream. Therefore, it is often useful to take a photo from a station some distance from the riparian area such as an overlook. In riparian areas, it is more important and more difficult to capture a part of the horizon or some unique feature like a tree or rock outcrop to help with photo-point relocation.

APPENDIX H – USE MAPPING, KEY SPECIES METHOD, AND PROPER USE

Use Mapping -- Use pattern mapping is an excellent way to understand how livestock management connects to the rangeland resource in larger pastures. Across the West, livestock distribution is commonly the biggest management problem and opportunity. It will vary according to slope, aspect, location of waters, palatability of forages, patterns of residual forage, season of use, etc.

The best kind of base map for delineation of use zones is an aerial photo or orthophotoquad showing ecological sites and physical features such as fences, water, and roads. Other kinds of maps commonly used include 1:24,000 topographic maps, 1:000,000 maps or even rough sketches (see sample). The mapping procedure involves traversing the pasture to obtain a general concept of how the vegetation has been utilized and the pattern of this utilization. Features such as topography, rockiness, ecological sites, vegetative types, and distance from water affect grazing patterns. They are helpful in denoting the extent of use zones and mapping their boundaries.

The currently used groupings are: 0-5%, 6-20%, 21-40%, 41-60%, 61-80%, 80-94, and 95-100%. Other classes can be used to maintain continuity with an existing management plan or monitoring data set. Use classes and an approach to judging the degree of utilization are discussed under *Key Species Method Utilization* on page 23 of the Interagency Technical Reference "Utilization Studies and Residual Measurements"(BLM 1999b).

Mapping proceeds as the pasture is traversed. When another use zone is observed, the name of the new use class and approximate boundary of the zone is recorded on the map together with the other information. Other information that should be recorded for each traversed use zone includes name(s) or symbol(s) of the key species and other common species that were routinely grazed, and other allotment or site-specific observations or indicators that relate to the level and pattern of grazing use. Further traversing extends boundaries of use zones until the entire pasture has been observed, then the approximate number of acres within each use zone is recorded on the map as illustrated in the *Ranchers' Monitoring Guide* ((Perryman et al., 2006)).

The timing for utilization mapping depends on objectives. Commonly, use mapping and utilization measurement occurs at the end of the growing season or the end of the grazing season, whichever occurs later. It is important to observe utilization during the grazing period to observe use zones as they develop. Such data or even observations would be very useful for applying the grazing response index (in the Ranchers' Monitoring Guide by Perryman et al., (2006)). A seasonal use map would give early indications of livestock distribution problems. It may be advantageous to map use by wildlife or wild horses and burros just prior to livestock turn-in to determine use by different kinds of grazing animals.

Lumping or averaging species for utilization monitoring may miss key information. The exception is an area with several forage species of approximately equal palatability, production, and grazing accessibility at the same time of year. Such circumstances are most likely to occur in wet meadows, riparian areas, or seedings. Under these conditions, utilization may be judged for a community rather than for a key species. For example, degree-of-use of mountain meadow sites could be represented by an average use recorded on the part of the plant community that produces the bulk of the forage. On rangelands not meeting the above criteria, do not average use of different species together. In a situation where vegetation is needed for riparian functions, monitor the vegetation that relates to these functions such as at the water's edge, the greenline.

Use patterns often remain similar from year to year due to grazed plants' regrowth having enhanced palatability in comparison to ungrazed plants with residual leaves and stems, habits of grazing animals, topography, and other factors. However, utilization pattern also changes because of management actions, development of water, herding, season of use, culling, changing kind or class of livestock, etc. The number of years of data needed for interpretation varies depending on the variation from year to year. Once use patterns are understood, they may suggest management changes that should be considered to adjust the use pattern. These changes should also be tied to objectives and opportunities for enhancing plant health and vigor. Remember that use pattern mapping shows distribution patterns. As a result management changes that effect livestock distribution should be the first ones tried to correct problems based on use pattern mapping. Management changes that effect distribution include water locations, season of use, and use of supplements. Other changes that may also effect distribution include changing the pastures size or shape, animal numbers, duration of grazing period, vegetation (type conversions), etc.

Key Species Method – The Key Species Method (formerly the Modified Key Forage Plant Method) is based on an ocular estimate of the amount of forage removed by weight on individual key species. This method is well described in the interagency technical reference on utilization studies and residual measurements (BLM 1999b). This method is also described in the *Ranchers' Monitoring Guide* (Perryman et al., 2006).

Training for this utilization method requires technicians to compare their ocular observations of use with the clipped and weighed amount using ungrazed plants. Observations are recorded in one of seven utilization classes, as in use mapping. Utilization cages should be employed in conjunction with this method on key areas to provide ungrazed plants to observe while reading a study or to clip while training. Utilization cages must be relocated annually to protect randomly chosen but representative plant(s) of the key species in similar growing conditions. The utilization determined on key areas is used with actual use data, trend in species composition, use patterns, (key species utilization can be used as a component of use pattern mapping) weather, and/or supplementary information to evaluate whether or not management changes are needed.

While key species utilization is broadly applicable, compare this method with other utilization/residual forage methods to choose one that the best addresses the site-specific conditions and objectives. For example, residual vegetation is preferred in areas where vegetation is relatively evenly dispersed, such as meadows and annual grasslands, and where remaining vegetation provides especially important functions in the dormant season, such as protection from erosion or sediment trapping. For guidance related to monitoring the use of woody plants, also see the Interagency Technical Reference "Utilization Studies and Residual Measurements" (BLM 1999b).

Proper Use – Proper use is a degree of utilization of current year's growth that, if continued, will achieve objectives and maintain or improve the long-term productivity of the site (Bedell 1998). Proper use is species specific. It may also be affected by the ecological site, and varies to a great degree with the season of use and, therefore, the opportunity for the plant to grow or regrow, as well as the duration of use, which influences the number of times the plant is likely to be grazed during the growing season.

Determination of proper use is part of the planning process. Local specifications for acceptable degree of use should be based upon research data and on the experience of the manager and range user. Considerations of proper use often drive targets for end-of-season indicators in allotment management or multiple-use management plans. Proper use, based on existing grazing management and setting should be checked against trend data to determine if the current proper use is appropriate or may need to be adjusted.

APPENDIX I - GROWING CONDITION INDICATOR CHECKLIST

This form identifies information that rangeland managers will want to consider at various times when they make decisions that exercise the flexibility in their management plan. The form can be filled out at the beginning and end of grazing in a pasture or use area, as well as on specific dates for representative locations such as study sites. It can be used when planning the sequence of moves through the growing season, before entering a particular pasture, and during pasture use when contemplating a move or other management action. Filled out forms show reasons for management actions and become part of the short-term monitoring record for interpreting long-term monitoring data.

Growing Condition Indicator Checklist	
Name of the Allotment/Ranch	
Use Area/Pasture/Rangeland Area	
Name of Observer	Date
INDICATOR	**OBSERVATION**
Forage vigor (Does plant height, leaf length/width, and color indicate strong vigor?)	Below avg.___ average___ above avg. ___
Does leader growth of shrubs indicate strong vigor?	Below avg.___ average___ above avg. ___
What is the average height of current year's growth on a key species?	Species_____________________ Inches _____________________
Are leaves of deciduous shrubs lost or dead?	Below avg.___ average___ above avg. ___
Phenological stage of key species in plant community? (refer to plant phenology stages table)	Trees and shrubs __________________________ Grasses___________________________________ Forbs_____________________________________
Utilization of previous year's growth (if observable)	
Soil moisture depth	_________ Inches
Rainfall for current year	Below normal ___ normal ___ above norm ___
Last date of effective precipitation	
Physical condition of wild horses, wildlife, livestock	Below normal ___ normal ___ above norm ___
Water source availability	Below normal ___ normal ___ above norm ___
Other comments:	
Management recommendations:	

Plant Phenology Stages		
Trees and Shrubs	**Grasses**	**Forbs**
Dormant	Dormant	Dormant
Leaf growth starts	Growth Starts	Growth Starts
Twig growth	3+ leaves per tiller	Flower stalks appear
Flower buds first visible	Flower stalks appear	First bloom
Leaves full grown	Heads out fully	Full bloom (3/4 blossom)
First bloom	Anthesis	Bloom over (3/4 blossoms dry)
Full bloom (3/4 blossom)	Dough seed set	Seeds ripe (3/4 dry)
Bloom over	Hard seeds	Dissemination
Seed ripe	Dissemination	Plants begin to dry
Dissemination	Plants Begin To Dry	Plants Dry - Summer, Fall
Leaves Turn Yellow or Brown	Plants Dry, Summer, Fall	
Leaves dry & begin to drop		

APPENDIX J – FREQUENCY SAMPLING PROCEDURES

Frequency sampling is a rapid, objective means of evaluating the trend of range vegetation.[2] It has two important advantages over other methods: 1) It is highly objective with a minimum amount of human decision involved, and 2) It is relatively simple and easy to perform. Once a frequency transect design is laid out, human decision is limited to species identification and to whether the plant is rooted within the frame or not.

The following method was described (with some modifications) in the 1984 *Nevada Rangeland Monitoring Handbook.* It was originally based on the work in Tueller et al., (1972). This method has been used extensively by the BLM for uplands. The Forest Service uses a slightly different nested frequency procedure (FS 2003). Whatever methods have been used to provide useful data, the same procedure and frame size (s) should be used to continue providing useful consistent data.

1. **Selecting the representative site –** follow the guidance in Appendix F – Key Areas.
2. **Sampling procedures –** A set of frequency frames of various sizes is required. In the 1984 *Nevada Rangeland Monitoring Handbook*, emphasis was given to individual frame sizes for specific plant communities. In this handbook, emphasis is given to nested frequency (BLM 1999a). The nested approach requires listing the presence of all species within the smallest nested plot. Then, the additional species present in the next largest plot are recorded, and so on. All plots within the smaller frame are also within the larger frame. Plant size and abundance will dictate the appropriate frame size for data analysis.

   Appropriate frame sizes for adequate sampling of typical Great Basin plant communities using a single frame size are found in Table K-1. The objective of the nested frequency approach is to further assure that all species, especially any key species, will have frequency percentages between 10 and 90 percent, and hopefully between 20 and 80 percent, thus allowing potential for detecting both upward and downward trend for all species when initial frequencies are relatively high (60-80%). Smaller vegetation changes can be measurable with statistical significance. For appropriate sampling, a procedure for laying out the presence/absence quadrats must be used. For example, a 100-foot or 30-meter steel tape may be used to establish a permanently placed baseline. A spring with a swivel on it is useful for keeping this tape tight and straight while it is in use. Surveying pins are useful for securing the baseline tape. Stakes for permanently marking the study area can be made from reinforcement bar (rebar). They should be painted a brilliant color to ensure their relocation from year to year. A stake-driving hammer is also necessary. To record the data, a clipboard or digital recording device is useful.
3. **Plot Layout –** The example described here is the one used in the 1984 version of the handbook and is repeated with only a few modifications to maintain consistency with the considerable data gathered over the past 20 plus years, particularly on BLM managed Nevada rangelands. In this example, the **first step** is laying out the baseline (Figure 1). Such a line constitutes a permanent part of the frequency trend plot and may be established by stretching a measuring

[2] [1]Tueller, P.T., et al., 1972. Methods for measuring vegetation changes on Nevada rangelands. Nev. Agr. Exp. Sta. Tech. Bull. 16.

tape in a representative part of the area to be evaluated. The tape is stretched as close to the ground as possible and affixed to the ground with two surveying pins. A second tape, stretched perpendicular to the baseline, greatly facilitates easy placement of the plots, keeps the transect perpendicular, and defines the remaining side of the plot frame. A painted rebar or angle iron or angle aluminum stake placed at a given distance from a known point will be helpful in relocation. This stake will then be used to measure out to find one end of the baseline. Relocation of the baseline ensures repeated sampling in the same setting.

The **second step** is to photograph the vegetation and soil surface at the transect location. A panoramic and a close up photograph should be taken after the baseline is established for a given transect. This constitutes an historical record for the site and helps in later interpretation of the data. Take the panoramic or landscape photo of the vegetation from the reference stake facing in the direction of the baseline. The close-up photograph should be of the vegetation in a frame off one of the belt transects. This frame should be relatively close to the baseline. It is important that the frame selected contains vegetation representative of the site and its location is documented. This allows the picture to be repeated each time the trend is sampled so the vegetation changes observed represent temporal rather than spatial changes.

The **third step** consists of selecting the appropriate frame sizes and the recommended sampling plans. The sample plan refers to the number of transects and number of frames per transect. Recommended sampling plans and frame sizes for representative Nevada range types are found in Table K-1. These guides have been developed to give the best sample for the greatest number of species on a given ecological site. Efficiency was evaluated in terms of data variance and cost (time spent in sampling). Transects consist of groups of quadrats (frames within which presence or absence is determined) placed contiguously in a belt or at given intervals along the tape. Each transect is originated at a random footmark (metermark) along the baseline. The randomization is restricted so that half of the transects are randomized on each side of the 50-foot or 15-meter mark (midpoint of the baseline). When the frequency frame is placed on the ground, it forms one quadrat. Continuation of this procedure through 10 to 20 quadrats will constitute a transect. Once a transect is complete, the worker moves to the next random foot mark and starts again.

The presence or absence of a species depends upon its root location—rooted frequency. If any part of the plant is rooted inside the frame, it is counted as being present. A plant rooted on the line between two contiguous plots (in two plots) is recorded as present in both plots.

4. **Reading the quadrats –** This consists of two very simple decisions. If a plant is rooted in the quadrat and the worker can recognize the species, then its presence should be recorded. A form for nested frequency is on page 46 of Sampling Vegetation Attributes – Interagency Technical Reference (BLM 1999a). Ecological site, location, plot number, examiner, recorder, date, sample plan, frame size, interval (when appropriate), sheet number, all species, notes, etc. should be recorded. Plants which are unknown should be marked with a symbol for later identification. Careful observation of the quadrat will show the species rooted within. Only one hit per species is recorded regardless

of the number of individuals occurring within the quadrat, i.e., presence or absence. Depending on the allotment and key area objectives, it may be useful to collect size, age, or form class for the key species (however, it considerably complicates and prolongs data collection). The intensity or number of species and types of data collected for them should be determined during the planning process.

The percent frequency can be computed very simply by dividing the number of hits per species (quadrats containing the species) by the number of quadrats per transect. For nested frequency, the percentage is for each given frame size. The sampling procedures preclude the need to place the quadrats in the exact same location.

5. **Statistical analysis of frequency trend data –** To assure statistical reliability, it is recommended that 200 presence or absence frames constitute a minimum, if several species are of concern. The Range Inventory Standardization Committee (1983) suggested that a precision of 20 percent of the mean at a probability of 80 percent should be the minimum acceptable level of statistical reliability. It is likely that 100 frames will do this for a few species on many ecological sites. The greater number of transects, at least 20, will give more statistical strength.

   The question that is addressed -- Is the frequency of occurrence of a plant species in year one significantly different from year five, etc.? It is a yes or no answer. The cause or reason for any differences must be determined, and thus interpreted, after careful analysis of all available information, i.e., utilization, actual use, climate, production, resemblance to the desired plant community, ecological status, grazing plan, etc.

   A number of statistical analyses may be used with frequency data. These may include simple t-tests, analysis of variance, etc. To prepare frequency data for these analyses, calculate the percent value for each nested frame size based upon the number of frames per belt transect. If there are a number of values above 80 or below 20 percent, then a transformation calculation on all the percentage data for a plant species or cover class can be applied to stabilize the variance and approximate a normal distribution. Transforming the percentage data validates statistical procedure assumptions and increases the sensitivity of the statistical analysis for detecting change. If the results of all the frequency or cover data fall between 30 and 70 percent, chances are a transformation calculation is not required. This is because the data approximates a normal distribution within that range. An appropriate transformation equation may be of this form:

   Arcsin $\sqrt{X}$ = transformed value
   Where X = percent frequency

6. **Special areas requiring trend determinations –** The frequency technique can be adapted for use on small areas and in dense vegetation. When the area to be sampled is small, the sampling plan must be adapted to fit the area. This can be accomplished in several ways. The length of the baseline can be reduced from 100 feet to 50 feet, or even 25 feet. The number of quadrats per transect can be reduced from 20 to 10. A reduction in the number of quadrats per transect may be offset by an increase in the number of transects to produce an adequate sample size. In practice, it may be possible to select two similar sites in close proximity and sample half of the transects on each area.

   In dense vegetation, the quadrat size should be reduced to keep the percent occurrence in the proper limits. Experience has shown, for example, that a 10 X 10-inch quadrat with 5 X 5-inch, and 2.5 X 2.5-inch or smaller subdivisions is an appropriate size to use for the various species in a wet meadow range site. In a few instances, however, the frequencies of Kentucky bluegrass, redtop, and sedge were greater than 80%, even in 2.5 X 2.5-inch sample. The individual conducting the study will have to make the decision on which quadrat size to use for each species sampled. When the observer is undecided, frequency can be determined on two different sized quadrats for several transects, then the proper size selected. In situations with great plant abundance or very sparse vegetation, frequency may not be the best measurement method.

Trend procedure summary:

1. Place the baseline in a representative stand of an important ecological site. Make provisions for its relocation.
2. Select the appropriate frame size (or nested set of frames) and recommended sample plan for the ecological site in question.
3. Read and record quadrat data for each randomly located transect.
4. Hits are recorded only when the species is rooted within the quadrat.
5. Only one hit is recorded per species and per quadrat regardless of the number of individuals occurring within the frame.
6. Record frequency percentages by species and place the values in a PDA or similar device for rapid computation and summary.
7. Photograph the landscape along the baseline and one or more representative or repeat photograph quadrats close to the baseline.
8. Statistically analyze data for significant species changes through time.
9. Summarize short-term monitoring information over the time span of the long-term trend data.
10. Interpret the change or lack of change in relation to possible or probable causes.
11. Determine whether management is leading toward objectives or if additional or alternative management is needed to meet objectives
12. Determine whether trend monitoring and management objectives are still appropriate for planned management.

Table K-1: Appropriate frame sizes and sample plans (transect-quadrat allocations) for efficient sampling of certain range plant communities in Nevada.

Plant Community	Frame Size* Recommendation	Transect/Quadrat Allocation***
Artemisia tridentata / Stipa hymenoides (Big sagebrush /Indian ricegrass)	30”	20/20
Artemisia tridentata (Seral) (Big sagebrush)	16”	10/20
Artemisia nova / Poa secunda (Black sagebrush / Sandberg bluegrass)	20” (10”)**	20/10
Artemisia arbuscula / Poa secunda / Elymus spicatus (Low sagebrush / Sandberg bluegrass / Bluebunch wheatgrass)	10”	20/10
Krascheninnikovia lanata (Winterfat)	3”	20/10
Sarcobatus baileyi / Stipa hymenoides (Bailey’s greasewood / Indian ricegrass)	12”	20/10
Chrysothamnus viscidiflorus (Green rabbitbrush)	6”	20/10
Picrothamnus desertorum / Artriplex confertifolia (Bud sagebrush / shadscale saltbush)	10”	20/10
Artemisia arbuscula / Bromus tectorum (Low sagebrush / Cheatgrass)	24” (3”)	20/10
Artemisia longiloba / Poa secunda / Festuca idahoensis (Early or Alkali sagebrush / Sandberg bluegrass / Idaho fescue)	24” or 30” (15”)	20/20
Southern Great Basin and Mojave Desert communities	30”	10/20

*The length of one side of a square quadrat

**Artemisia nova only

***The most efficient ratio of transects to quadrats

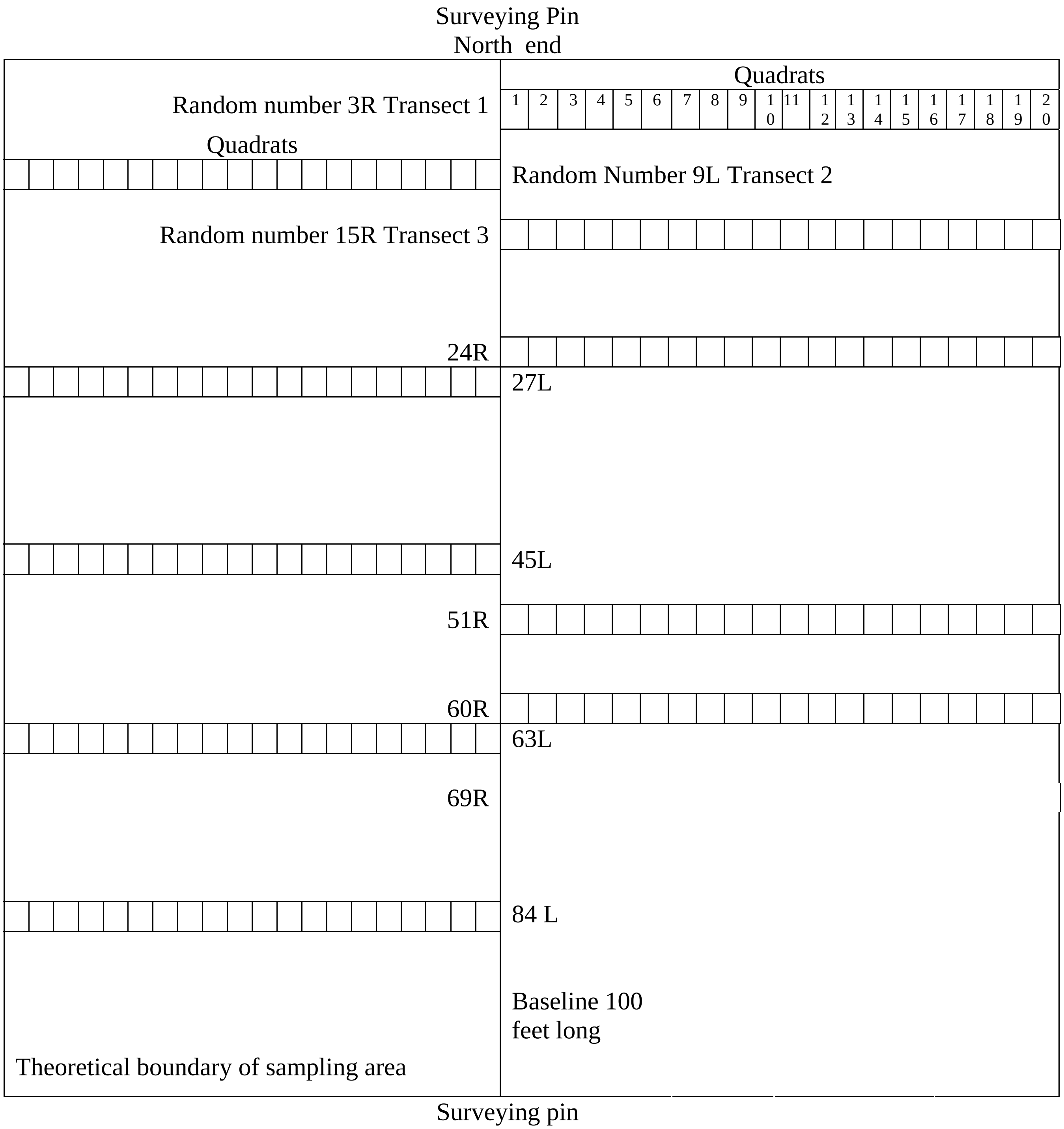


Figure 1. Schematic outline of a frequency macroplot. (A sample plan with ten transects and twenty quadrats (10/20), using 36-inch frame, would be approximately to scale.)

APPENDIX K – PRODUCTION AND PLANT COMMUNITY OBJECTIVES

Ecological sites (Appendix B) are production-based. First compare existing species composition to the ecological site description for an indication of the degree of similarity and feasibility or achievability of an objective for a key area. The procedure can vary depending on the issues and management objectives for the area being monitored. Required data can range from directly estimating the species composition by weight to conducting a 10-30 plot weight estimate transect. The dry weight rank, comparative yield, or weight-estimate-transect method for determining the species composition of an ecological site would be employed in areas where the issues and management objectives dictate the need for production type data. The double weight sampling technique (BLM 1999a) is a suitable technique if followed correctly.

Where a quantitative ecological comparison to a reference plant community or Desired Plant Community (DPC) is warranted, the present species and their percent composition by weight are compared to the reference plant community or DPC.

When selecting and using a particular technique, it is necessary to:

1. Document the method used so it can be repeated at a later date.
2. Confine the weight estimate transects within the boundaries of an ecological site and key area.
3. Document the transect location on an aerial photo, map, GPS, and/or by narrative. (See the Study Site Location form in Appendix F.)

APPENDIX L – GROUND COVER AND CANOPY COVER MEASUREMENTS

Foliar cover is the area of ground covered by the vertical projection of the aerial parts of the plants. Canopy cover is similar but does not separate out small voids or estimates a polygon around the outer parts of the canopy. Ground cover is the area or percent of ground surface occupied by the basal portion of individual plants or by bare ground, rock, litter, and soil biotic crusts (where identifiable). See glossary for precise definitions. Basal cover or ground cover of live vegetation can quickly be obtained, along with frequency information, by observing cover at specific points along the transect and/or quadrat frame.

Common methods used to measure cover are line intercept (canopy or basal cover) and point intercept (foliar or ground cover). When using line intercept, at least three, 100-ft. (or 50-meter) lines per site should be used. Five transects usually reduces the standard deviation. It is important to strictly follow the set of rules used among individuals from monitoring period to monitoring period (Elzinga et al., 1998). Foliar or canopy cover is often less useful for herbaceous plants (especially bunch grasses) than basal cover because the aerial parts of the plants vary with season, year, and grazing use.

In some instances, species groups, e.g., grasses, forbs, or shrubs, can be lumped. The applicability of grouping by life form depends on the objectives. Also, species data can always be lumped for analysis, but lumped data cannot later be split. For an additional discussion of cover monitoring see Sampling Vegetation Attributes (BLM 1999a).

APPENDIX M - MONITORING PLAN TABLES

The following two tables can either be copied and filled out as forms or used as a content guide for writing a narrative monitoring plan. They are intended to address the major decisions faced by rangeland managers as they determine what to monitor, where, when, and how, and who will take responsibility for which tasks. The first form (Table 1) focuses on one objective for the rangeland and it would be used as often as needed to address the many objectives in the management plan. The second form (Table 2) focuses on an individual study site. It too would be used as many times as needed to address all the study sites and all the short and/or long term monitoring that will take place at each key area, critical area, photo point, or designated monitoring area.

Table 1. Monitoring plan. (Copy table 1 and fill it out for each management objective.)

Monitoring plan for the ___________________________ land or management unit Date_______
What is the issue being addressed ____
____
Management objective #____: (including the component or indicator, what will change in what manner, by how much, where, by when) ____
____
____
____
Brief description of the management to meet this objective (e.g., actual use, season of use, etc.) and how is this management likely to accomplish this objective: (who) __________________ will do: ____
____
____
What is the expected relationship between management and the objective? __________________
____
____
How this objective will be monitored each year to track the management that will be applied?
(who)__________________ will track: ____
____
(where)____
(when) ____
How this objective will be monitored each year to track the effects of management?
(who)__________________ will observe and record (what): ________________________________
____
(where)____
(when) ____
How will weather and growing conditions be recorded?
(who) _________________ (will keep (get) records of) ______________________________________
____
(where)____
How will other events (fire, etc.) be recorded?
(who) __________________ will keep records of ______________________________________
____
____
Over the long term, how will progress toward meeting this objective be measured?
(who) __________________ will measure ____
____
____
(where) ____
(by when or how often) ____
(Relevant Photo points)____

Table 2. Monitoring Area Plan. (Copy table 2 for each study site (KA), critical area (CA), photo point (PP), or designated monitoring area (DMA).) (Or use this form to guide for filling out a narrative monitoring plan.)

Name of this study site, etc. ______________________________KA CA PP DMA (circle one)
GPS or narrative location ____
Date established _____________________ By whom ____________________________________
What short-term triggers will be monitored here? _______How will it be monitored?
____
Target value ____
When will it be monitored? ____
By whom? ____
What will it trigger? ____
What end-point indicators will be monitored at this location?
How will it be measured? ____
Target value _______________________When will it be measured? ________________________
By whom? ____
How will these data and observations be used and interpreted? ______________________________
____
____
____
Who will use and interpret the data and observations? ___________________________________
How often? ____
For objective #_____, what long-term monitoring will occur here?
What will change?____
____
Will change in what manner? ____
By how much? ____
By when? ____
What data or observations will be collected at this location? _______________________________
____
By what method? ____
Who will collect the data? ____
When and how often? ____
How will these data and observations be analyzed? _______________________________________
____
____
(Who will analyze and interpret the data and observations?) _______________________________
When or how often?) (refer to form 1) ____

APPENDIX N – INTERPRETATION AND USE OF MONITORING INFORMATION

The following are two examples of using monitoring data:

Example one -- A Proper Functioning Condition assessment was performed on a creek-side riparian area and the interdisciplinary team concluded that the stream was too wide and that a wider vegetated floodplain was needed to dissipate flood energy. The management team's evaluation concluded that by allowing the existing desirable herbaceous riparian plants to increase sediment trapping, the floodplain would widen and stabilize the riparian area with a narrower, deeper active channel. The team decided to change livestock management by placing mineral/protein supplement in the uplands at least a mile from the creek in lightly utilized areas and using low-stress herding to move cattle out of the riparian area five or more days each week. To monitor the effects of this management and progress toward the objective, stubble height (with a trigger set to achieve an appropriate end-point indicator by fall) was selected for short-term monitoring and greenline-to-greenline width was selected for long-term monitoring of stream width. It was agreed that, if in any two years in a row the actual stubble height is/was less than 80 percent of the target, management would be modified for the next year.

For several years, the stubble height target was met and the first greenline-to-greenline was slightly (not significantly) narrower than the baseline reading. The planned management continued. The next year the fall stubble height was 70 percent of the target. The team met, discussed why the target wasn't achieved, its significance, and what to do. They decided that for the next two years the supplementation and riding would be dropped and the livestock season of use would be changed to early spring use in the pasture with the wide creek. For the rest of the grazing period, the cattle would be moved to two pastures that had been planned for rest, one in each of the years, but could easily accommodate short periods of summer use for the two years. This change would continue to address the objective by providing the riparian vegetation with much of the growing season to regrow following grazing use and would produce adequate stubble to trap sediment during the normal runoff season (lower trigger or trigger replaced by an off date – same end-point indicator). By building flexibility into the grazing plan, alternative use areas and the flexibility to use them were available to make this modification.

During each of the two years with the modified management the stubble height target is met. At the end of this period the greenline-to-greenline measurement is reread and found to have made a big jump toward the objective. At this point the team can decide to keep the modified management, which monitoring shows is meeting the objective; go back to the original management, which also was making progress toward the objective of a narrower creek; or develop other management that would continue progress toward meeting an appropriate objective. They might now focus less on stubble height and more on bank trampling (short-term monitoring) and bank stability (long-term monitoring). They might also agree to measure multiple indicators using the method developed by Cowley and Burton (2005).

Example two -- When a reduction or increase in AUMs for livestock or wild horses or burros is needed, there are many ways to estimate the appropriate adjustments. The following formula could be a **starting place** for making adjustments:

$$\frac{\text{Existing Actual Use}^{1} \times \text{Desired Average Utilization}^{3}}{\text{Weighted Average Utilization}^{2}} = \text{Calculated Capacity}^{4}$$

[1] Existing actual use is the number of livestock and/or wild horses or burros actually grazing on an area expressed as AUMs.
[2] Weighted average utilization is the average utilization of the forage in the area (allowable use levels and above).
[3] The desired average utilization is the degree of utilization that will meet the short and long-term vegetative objectives for the area.
[4] Calculated capacity is the level of use, or number of animals expressed as AUMs, which could graze the area and achieve the desired average utilization.

Example:

$$\frac{\text{1,200 AUMs (1,200 cows or horses for one month) x .50}^{3}}{\text{.40 (weighted average use)}} = \text{1500 AUMs}$$

The ultimate effect of a change in management will depend largely on animal behaviors related to the use pattern. Usually a variety of things change from a change in management. Often, change in stocking rate does not produce a linear effect on vegetation use in key areas. Furthermore, it may not be the most effective tool for reaching some objectives. It would be much more effective to change the season or duration of use and maintain or even increase stocking rate. Therefore, this formula is only a starting point for considering a management change. It is more useful in small or homogenous pastures and when other management remains similar.

[3] Fifty-percent utilization is an example, not a recommendation. Prescribed utilization will depend on type of vegetation, season of use, duration of use, rotation of use, management objectives, other resource concerns, etc.

APPENDIX O - RANGELAND MANAGEMENT AGENCY OFFICES IN NEVADA

Nevada Agencies

Nevada Department of Agriculture
State Office
350 Capitol Hill Avenue
Reno, Nevada 89502-2923
Telephone: (775) 688-1180

Weed Districts or Cooperative Weed Management Groups – see Nev. Department of Agriculture

Nevada Department of Conservation and Natural Resources
Office of the Director
123 West Nye Lane, Room 230
Carson City, Nevada 89706-0818
Telephone: (775) 687-4360

Nevada Division of Environmental Protection
333 West Nye Lane
Carson City, Nevada 89706-0866
Telephone: (775) 687-4670

Nevada Division of Forestry
2525 South Carson Street
Carson City, Nevada 89701-5502
Telephone: (775) 684-2500

Nevada Natural Heritage Program
1550 East College Parkway, Suite 145
Carson City, Nevada 89706-7921
Telephone: (775) 687-4245

Nevada Division of Water Resources
123 West Nye Lane
Carson City, Nevada 89706-0896
Telephone: (775) 687-4380

Nevada Indian Commission
5366 Snyder Avenue
Carson City, Nevada 89701-6743
Telephone: (775) 687-8333

Nevada Department of Wildlife
1100 Valley Road
Reno, Nevada 89512-2861
Telephone: (775) 688-1500

University Of Nevada Agricultural Experiment Station
College of Agriculture, Biotechnology, and Natural Resources
Reno Office (775) 784-6237

University of Nevada Cooperative Extension
Administrative office (775) 784-7070

UNR - Animal Biotechnology and Univ. Of Nevada Cooperative Extension
State Livestock Specialists
Fleischman Agriculture Building
9th and Evans St.
Reno, NV 89557
Beef (775) 784-1624 or
Sheep (775) 784-6135

UNR - Natural Resources and Environmental Science
and Univ. Of Nevada Cooperative Extension
State Range Specialist
Knudtsen Resources Center
1000 Valley Rd.
Reno, NV 89512
(775) 784-4057

Federal Agencies

U.S. Department of Agriculture
Agricultural Research Service
920 Valley Rd.
Reno, NV 89512
(775) 784-6057

Natural Resources Conservation Service (NRCS)
Nevada State Office
1365 Corporate Blvd
Reno, Nevada 89502
(775) 857-8500

Forest Service - Humboldt-Toiyabe National Forest
Supervisor's Office
1200 Franklin Way
Sparks, NV 89431
(775) 331-6444

Forest Service - Rocky Mountain Research Station
920 Valley Rd
Reno, NV 89512
(775) 784-5329

U.S. Department of Interior

Bureau of Land Management
State Office
1340 Financial Blvd.
Reno, NV 89502
(775) 861-6475

Bureau of Indian Affairs
311 E. Washington
Carson City, NV
(775) 887-3500

Fish and Wildlife Service
Nevada Fish and Wildlife Office
1340 Financial Blvd.
Reno, NV 89502
(775) 861-6300

National Park Service - GBNP
100 Great Basin National Park
Baker, NV 89311
775-234-7331

Lake Mead National Recreation Area
601 Nevada Hwy.
Bouder City, NV 89005
(702) 293-8990

U.S. Department of Defense

U. S. Navy
Fallon Naval Air station
4755 Pasture Rd.
Fallon, NV 89496-5000
(775) 426-5161

U. S. Air Force
Nellis Air Force Base LMR
702-652-7351

Rangeland Management/monitoring Consultants: Society for Range Management
http://www.rangelands.org/srm.shtml
maintains a list of rangeland consultants

APPENDIX P – GLOSSARY

Actual Use – Documentation of livestock use and management in a pasture through each year and through the years. It contains dates; and numbers of livestock put into each pasture, gathered, or moved; notes about partial removals, and death losses. It may also include information about grazing problems involving water or livestock distribution, salting records, forage conditions or other important matters.

Adaptive management – The continual process of adjusting management based on a changing management situation as well as on learning from our experiences as tracked through monitoring and research. It often involves management for the purpose of learning to improve future management. (See Appendix E.)

Anthesis – The period of opening of a flower, e.g., when anthers are visible on some grasses.

Apparent trend – An interpretation of trend based on observation and professional judgment at a single point in time (Bedell 1998).

Assessment – The systematic collection of resource and condition data so that managers can learn about resource potentials, important problems, and the resource attributes in play for making changes to address issues (BLM H 4180-1).

Colonizer – A plant adapted to begin growth on recently deposited sediments or on recently disturbed areas (Winward 2000).

Community – A general term for an assemblage of plants and/or animals living together and interacting among themselves in a specified location; no particular successional status is implied (Bedell 1998).

Community type – A group of species that characteristically occur together and become recognizable as a known entity. A community type may represent any stage in succession.

Composition – The proportions (percentages) of various plant species in relation to the total on a given area. It may be expressed in terms of cover, density, weight, etc. Syn. *species composition*

Cover – (1) The plant or plant parts, living or dead, on the surface of the ground. Vegetative cover or herbage cover is composed of living plants and litter cover of dead parts of plants. (2) The area of ground covered by plants of one or more species. cf. basal area. (Bedell 1998)

Cover - basal – The area or percent of the ground surface occupied by the root crown part of live vegetation.

Cover - canopy or crown – The percentage of ground covered by a vertical projection of the outermost perimeter of the natural spread of foliage of plants. Small openings within the canopy are included. It may exceed 100% (because the canopies of different species may overlap). (Bedell 1998)

Cover - foliar – The percentage of ground covered by the vertical projection of the aerial part of plants. Small openings in the canopy and intra-specific overlap are excluded. Foliar cover is less than canopy cover and either may exceed 100% (Bedell 1998)

Cover - ground – The percentage of material, other than bare ground, covering the land surface. It may include live and standing dead vegetation, litter, cobble, gravel, stones, and bedrock. Ground cover plus bare ground would total 100%. Syn. *cover* (Bedell 1998)

Critical areas – Areas that must be treated with special consideration because of inherent site factors, size, location, conditions, values, or significant potential conflicts among uses (Bedell 1998). Critical areas represent only smaller parts of a management unit that are more important to managers, such as riparian areas or specific places in riparian areas where there is a need to focus management and monitoring.

Decreaser – For a given plant community, those species that decrease in amount as a result of a specific abiotic/biotic influence or management practice (Bedell 1998).

Density – Numbers of individuals or stems per unit area. Density does not equate to any cover measurement (Bedell 1998).

Designated Monitoring Area (DMA) – The location in riparian areas and along the streambanks of a livestock grazing management unit where monitoring takes place (Cowley and Burton 2005).

Desired Future Conditions (DFC) -- A quantitative expression of the resource attributes such as vegetation, soil, or water identified in management goals or objectives. It usually focuses on important and attainable differences from current conditions in an area or on important resource attributes that could be lost or altered through management. DFC is similar to DPC but has a broader perspective including other measurable resource attributes or features in addition to the vegetation resource (e.g., channel width, width-depth ratio, etc.).

Desired plant community (DPC) – Of the several plant communities that may occupy a site, the one that has been identified through a management plan to best meet the plan's objectives for the site. It must protect the site as a minimum (Bedell 1998). It may be described as dynamic, changing through time, or within a range of variability.

Drought – (1) A period of abnormally dry weather sufficiently prolonged for the lack of water to cause serious hydrologic imbalance in the affected area. (2) A prolonged chronic shortage of water, as compared to the norm, often associated with high temperatures and winds during spring, summer, and fall. (3) A period without precipitation during which the soil water content is reduced to such an extent that plants suffer from lack of water (Bedell 1998).

Ecological site – A distinctive kind of land with specific physical characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation (NRCS 1997).

Ecological Site Inventory (ESI) – A resource inventory that involves the use of soils information to map ecological sites and plant communities and the collection of natural resource and vegetation attributes. The sampling data from each of these soil-vegetation units, referred to as site write-up areas (SWAs), become the baseline data for natural resource management and planning (Habich 2001).

End-point indicators – Guides to assess resource use impacts at the end of the grazing and growing season, whichever comes last. They indicate whether grazing use left resources in an appropriate condition for moving toward objectives. Commonly, stubble height or utilization indicate the desired degree of use. **Syn.** End of season indicators

Evaluation – The systematic process for determining the effectiveness of management actions at making progress toward meeting management objectives.

Flexibility – The ability to adjust a plan or on-the-ground management to adapt to timely use of new information, unusual weather, or the spirit of innovation. Flexibility is fostered by adaptive management, preplanning, and relationship building which creates confidence that managers will have the responsibility to do what is right for the resources.

Frequency – The proportion of quadrats that contain the species in question. To make frequency comparable, the plot size must remain constant in each measurement time period.

Frequency of defoliation – (As used in GRI) The number of times forage plants are defoliated during the grazing period. It depends on plant growth rate and the length of time over which plants experience grazing within a growing season. Other factors include amount of forage present at the beginning of grazing, phenological stage of the plant, point in the growing season, ability of the plant to regrow after grazing, weather, etc.

Georeferencing – The process of connecting data to its precise geographic location. When two or more images or maps are georeferenced, they are effectively overlapped with the same scale and orientation.

Goals – General statements of the desired direction of change or the desired condition of resources in the future (BLM TR4400-1).

Grazing Intensity – (as used in the GRI) The amount of plant material removed during the grazing period. The primary concern is the amount of photosynthetically active leaf material remaining for the plant to recover from grazing. This is not an estimate of percent utilization which also includes utilization after plants are dormant and/or may be modified by growth. Syn. *intensity*.

Greenline – The first perennial vegetation that forms a lineal grouping of community types on or near the low water's edge. Most often occurs at or slightly below the bankfull stage (Winward 2000). It is found only along streams with defined channels (Cowley and Burton (2005).

Herbaceous – Vegetation growth with little or no woody component; non-woody vegetation such as graminoids and forbs.

Herbivore – An animal that subsists principally or entirely on plants or plant materials (Bedell 1998).

Historic Climax Plant Community -- (1) The natural plant community of an ecological site, in the absence of abnormal disturbances and physical site deterioration. (2) Is that assemblage of plants presumed to be in place on an ecological site at the time of European immigration and settlement in North America

Increaser – For a given plant community, those species that increase in amount as a result of a specific abiotic/biotic influence or management practice (Bedell 1998).

Inventory -- The systematic collection of quantitative data about a resource and its condition Often inventory data are used as a baseline for future comparisons.

Key Area – A relatively small portion of a range selected because of its location, use, or grazing value as a monitoring point for grazing use. It is assumed that key areas, if properly selected, will reflect the overall acceptability of current grazing management over the range (Bedell 1998).

Key species – (1) Forage species whose use serves as an indicator to the degree of use of associated species. (2) Those species which must, because of their importance, be considered in the management program (Bedell 1998).

Leader – The growing or most recently grown annual increment of the stem at the top of, or end of the branches of, a woody plant (tree or shrub).

Lentic – Referring to standing water, as in ponds, marshes, and seeps have lentic riparian areas.

Long-term monitoring - Measurement of changes in resource attributes such as plant composition of ground cover over time. It is used to periodically assess progress toward meeting long-term resource management objectives.

Lotic – Referring to running water, as in streams, rivers, and springs have lotic riparian areas.

Monitoring – The orderly collection, analysis, and interpretation of resource data to evaluate progress toward meeting management objectives. This process must be conducted over time in order to determine whether or not management objectives are being met (Bedell 1998).

Nested frequency – The same as frequency except that a change in species abundance is anticipated by collecting data in nested quadrats of different sizes during each time period; occurrence in one plot equals occurrence in all larger nested plots. This allows future comparisons by selecting the most appropriate quadrat size for analysis (USFS Handbook 2209.21).

Opportunity for growth and/or regrowth – (as used in GRI) The amount of time plants have to grow prior to grazing or regrow after grazing. This factor is related to time and duration of use. Syn., *opportunity*.

Pixel – Picture element or the smallest individual element of a digital picture or image over which reflectance characteristics are averaged.

Phenology – The study of periodic biological phenomena that are recurrent such as flowering, seeding, etc. especially as related to climate (Bedell 1998).

Point bar – The deposit of sediment on the inside edge of a bend in a low-gradient stream or river.

Proper use – A degree of utilization of current year's growth which, if continued, will achieve management objectives and maintain or improve the long-term productivity of the site. Proper use varies with time and systems of grazing. Syn., *Proper utilization, proper grazing use, cf. allowable use* (Bedell 1998).

Quadrat – Sampling frame within which vegetation information is gathered.

Quantitative ecology – Comparison of a species composition data set against a reference standard for that ecological site. Each native or desired species percentage is counted up to some maximum allowable limit, determined by that species maximum contribution to a historic climax plant community or a desired plant community.

Rangeland – Land on which indigenous vegetation (climax or natural potential) is predominantly grasses, grass-like plants, forbs, or shrubs and is managed as a natural ecosystem. If plants are introduced, they are managed similarly. Rangeland includes natural grasslands, savannas, shrublands; many deserts, tundras, alpine communities, marshes and meadows (Bedell 1998).

Rangeland Health – The degree to which the integrity of the soil, vegetation, water, and air as well as the ecological processes of the rangeland ecosystem are balanced and sustained. Integrity is defined as the maintenance of the structure and function attributes characteristic of a locale, including normal variability (Bedell 1998).

Remote sensing – Detecting information about the character of a resource from afar, such as through photography or other imagery, often obtained from planes or satellites.

Residual vegetation – The current year's above-ground plant material remaining after grazing. It may be recorded as weight per unit area, stubble height, or as the opposite of utilization, the percent remaining.

Resilience – The amount of disturbance or stress a state can endure and still regain its original function after the disturbance or stresses are removed.

Resistance – The capability of a state to absorb disturbance or stresses and to retain ecological process functions. Resistant plant communities tend to stay near equilibrium conditions with less variation in ecological processes.

Resource objectives – Specific attributes of natural resource conditions that management will strive to accomplish, the area or location where this will occur, and the time frame. Resource objectives must be site-specific, measurable, and attainable statements of the desired resource attributes.

Resource Value Rating – A measure of the value of vegetation present on an ecological site for a particular use or benefit. Resource value ratings may be established for each plant community capable of being produced on an ecological site, including exotic or cultivated species (Bedell 1998).

Rhizomatous – a group of plants that spread by rhizomes or underground stems.

Riparian – A form of wetland transition between permanently saturated wetland or aquatic and upland areas. Riparian areas can support vegetation that survives in or depends on moister or permanently saturated soils.

Riparian Proper Functioning Condition – Riparian-wetland areas are functioning properly when adequate vegetation, landform, or large woody debris is present to; dissipate stream energy associated with high flows, thereby reducing erosion and improving water quality; filter sediment, capture bed load, and aid floodplain development; improve flood water retention and groundwater recharge; develop root masses that stabilize streambanks against cutting action; develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses; and support greater biodiversity.

Short-term monitoring – Addresses three topics, (1) Conformance with the plan (2) Current, annual, or short-term impacts of the implemented management on resources of interest, and (3) Weather and other unplanned events. This information guides day-to-day and year-to-year management by monitoring within-season triggers and end-point indicators. It also helps interpret long-term monitoring data.

Shrub – A plant that has persistent woody stems and a relatively low growth habit, and that may produce several basal shoots instead of a single bole. It differs from a tree by its low stature, (generally less than 5 meters or 16 feet), and non-arborescent form (Bedell 1998).

Stabilizer – A plant that is noted for its deep and/or dense root systems and is particularly adept at holding soil against the forces of flowing water (Winward 2000).

State – A combination of vegetation and soil processes that perpetuate through time or cycle in response to disturbances.

State and transition model – A description of vegetation dynamics and management interactions associated with each ecological site. The model provides a method to organize and communicate complex information about vegetation response to disturbances (fire, lack of fire, drought, insects, disease, etc.) and management (NRCS 2003).

Streambank – The edge of a stream that contains the flow of water except the water that floods out of the channel in flood conditions that may occur less often that once in two to three years. The streambank should not be confused with a gully bank or other high bank that is only wetted during rare flood events, if ever.

Streambank alteration – The deformation (at least ½ inch) of shearing of a part of a streambank by the physical impact of livestock, recreationists, or wildlife during a season of use (Cowley and Burton 2005).

Streambank stability – A measure of the degree to which a streambank is covered by vegetation or anchored rock or logs versus the degree to which a streambank is showing signs of active erosion or vulnerability to erosion or slumping/breakage (Cowley and Burton 2005).

Stream channel morphology – The shape of a stream includes attributes such as average width and depth, slope, meandering, width/depth ratio, pool/riffle ratio, or other characteristics that may relate to energy dissipation, erosion, sediment transport, deposition, or fish habitats.

Stubble Height – The measure or height (in centimeters or inches) of herbage left ungrazed at any given time (BLM 1999b).

Succession – the progressive replacement of plant communities on a site which leads to the potential natural plant community, i.e., attaining stability. Primary succession entails simultaneous succession of soil from parent material and vegetation. Secondary succession occurs following disturbances on sites that previously supported vegetation, and entails plant succession on a more mature soil. *Cf. plant succession* (Bedell 1998).

Sustainable – Retaining a similar set of resource conditions and ecological processes or retaining a resilient nature so that changes are cyclic or dynamic, rather than permanent, or ones that would require significant restoration. This concept applies to human communities and economies as well as ecosystems and to the opportunity for future generations to choose among resource management options.

Threshold – A point of irreversible transition to a new state. After the transition, significant management effort (e.g., seeding, herbicide control, fire control, etc.) is needed to restore the ecological processes of the prior state.

Tiller – The asexual development of a new plant from a meristematic region of the parent plant (Bedell 1998).

Transition – The trajectory of system change between states that lead to the establishment of a new state. The transition may be reversible for a time and may become irreversible after the new state has been reached. A transition involves the loss or significant change of ecological processes such as soil capture of water, reproduction of key species or species groups, resilience after fire, etc. Lost or changed processes do not recover without intervention.

Trend – The direction of change in an attribute as observed over time (Bedell 1998).

Trigger – Within-season guide for livestock managers to make changes or move livestock, ensuring that end-point indicators are met.

Ungulate – A large herbivore with a cloven hoof and a particular type of digestive system. Cattle, sheep, deer, antelope and elk are ungulates.

Use map – A map depicting zones of utilization by livestock or some other herbivore within a pasture or other defined area. It is likely to show patterns of heavier and lighter use that can be used to help evaluate management.

Utilization –The proportion of the current year's growth that has been removed by herbivores.

Utilization cage –A small moveable exclosure to prohibit grazing within its boundary. By moving the utilization cage to new representative areas each year before the grazing period, it can be used to estimate the growth that would have occurred without grazing and, therefore, the amount of utilization of plants in similar outside locations.

Water quality – The combination of biological, chemical, and physical characteristics of water and aquatic environments. Some agencies and laws have specific definitions for water quality.

Woody – A term used in reference to trees, shrubs, or browse that characteristically contains persistent ligneous material (Bedell 1998).

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