3rd edition | EB-17-00 |

Nevada Rangeland Monitoring Handbook

In the pursuit of better rangeland management

We have designed the Nevada Rangeland Monitoring Handbook to provide you a clear overview of the complex and often confusing world of rangeland monitoring. Included are a suite of short- and long-term monitoring methods.

Successful rangeland management is more likely to occur when you identify clear and achievable management goals and objectives. Attaining your management goals and objectives is best demonstrated through a focused and well-structured monitoring program. Furthermore, a focused and structured monitoring program will help you, as a primary steward of that landscape, identify current management actions that are not achieving your management objectives.

Even the most knowledgeable manager makes mistakes and has good ideas that result in unintended consequences. Focused and structured monitoring identifies these outcomes quicker than when no monitoring occurs. Quick changes in management, based upon sound monitoring data, can get you back on track toward attaining your management goals and objectives. Also it may reduce the potential of conflict among the many users and varied interests focused on Nevada's rangelands.

We welcome your suggestions to improve this Handbook.

University of Nevada Cooperative Extension

A partnership of Nevada counties; University of Nevada, Reno; and U.S. Department of Agriculture

NEVADA RANGELAND MONITORING HANDBOOK | Third Edition

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PREFACE

The purpose of the Nevada Rangeland Monitoring Handbooks has been to provide a commonly agreed upon foundation of accepted rationale and practices for monitoring in the pursuit of better rangeland management. We expect this to guide the thinking of ranchers and agency personnel and others as they cooperate, prioritize and align the short- and long-term monitoring they commit to in monitoring agreements, contracts, plans, and other documents. We expect that monitoring that uses these principles will be more useful, efficient, effective, and trusted.

In 1980-1984, Nevada rangeland managers, recognizing the importance of monitoring for managing livestock grazing, came together to create the *Nevada Rangeland Monitoring Handbook* (Handbook or NRMH). 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 important, progress in the management of Nevada rangelands led to better rangeland conditions in many areas.

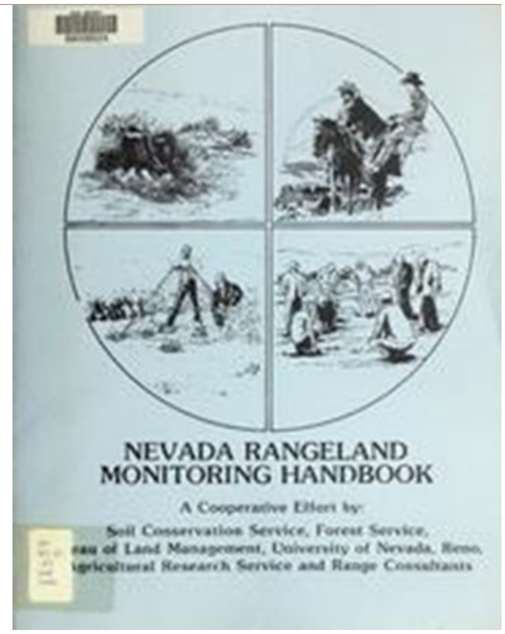
The 1984 *Nevada Rangeland Monitoring Handbook* recommended long-term and short-term monitoring and the following studies to be conducted at key areas: 1) Production – The Natural Resources Conservation Service (NRCS) double sampling method and the Bureau of Land Management (BLM) weight estimate vegetation inventory method, 2) Quadrat frequency, and 3) The modified key forage plant utilization transect method. Production data were compared with NRCS ecological site descriptions to determine ecological status. Frequency was recommended to indicate changes in plant composition. These methods are still valid. The modified key forage plant method has been replaced by the key species method.

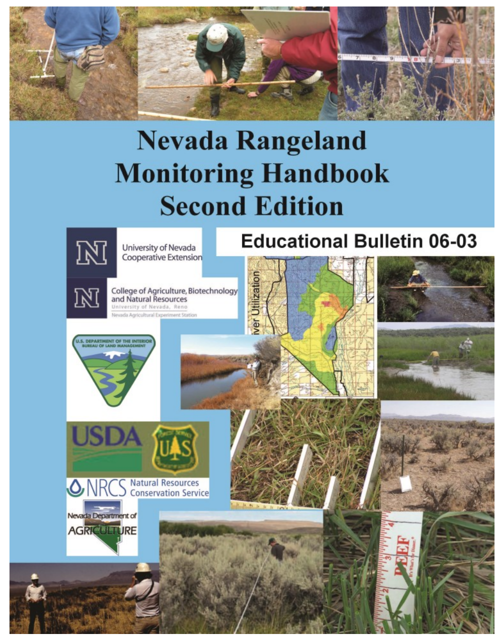
While the first Handbook proved useful, it was more than 20 years old when rewritten in 2006 to emphasize goals and objectives set in a planning process that considers the best available science and society's mix of values and expectations. Monitoring in the 1980s focused almost exclusively on livestock grazing management. By 2006 we recognized that, as important as this is, herbivory is only one aspect of rangeland management. Monitoring of vegetation change is also needed to track and manage problems such as modified fire regimes and invasive weeds that may not be resolved with changes in livestock management alone. Riparian issues were not addressed in the first handbook. We also had learned the importance of riparian assessment and monitoring for adjusting management.

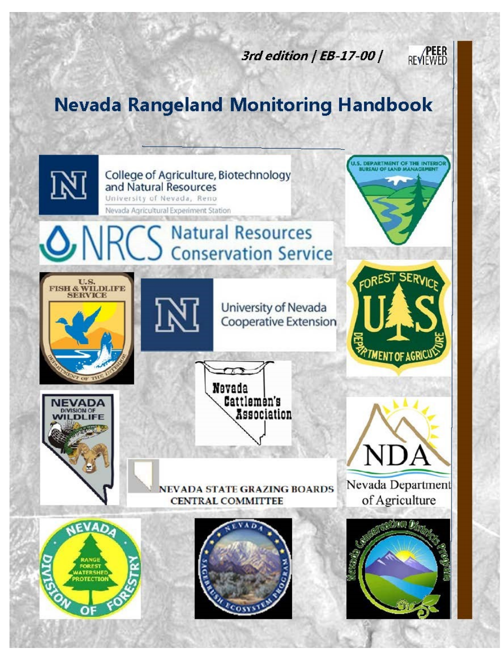
At that time, production data were often interpreted differently as ecological site descriptions were being revised to reflect evolving ecological concepts. Production data (with functional group composition) compared with ecological site descriptions help determine ecological state and phase. This identifies pathways for management among phases to reduce risk and increase resiliency and resistance while avoiding expensive and risky challenges for restoration after transitioning across ecological thresholds. Species composition may be compared with desired plant community (DPC) objectives. Frequency studies emphasized nested plots to make data more useable through time as communities change. More commonly cover has become the measurement of choice.

The Nevada Sagebrush Ecosystem Council Monitoring Committee recognized the need for the *third edition* of this Monitoring Handbook to reconcile issues of scale from a focus on sage-grouse. Land management agencies have now committed to monitoring at various scales. The BLM Assessment, Inventory, and Monitoring (AIM) Strategy and the BLM-Forest Service (FS) Sage-grouse Monitoring Framework (USDI-BLM & USDA-USFS 2014) included commitments to use the broad-, mid-, fine-, and site-scale indicators of habitat suitability provided within the Sage-Grouse Habitat Assessment Framework (Stiver et al. 2015).

This NRMH addresses resource management and monitoring issues at the allotment scale, or smaller. The AIM strategy addresses resource issues and questions at scales larger than the individual allotment. Data collected for one strategy (NRMH or AIM) cannot stand alone to answer questions related to the other strategy. Data collected at specific locations for one approach however, may add value to data from the other approach. A random sampling of monitoring plots called for in AIM, may display the overall effects of a management paradigm, but random plots across a landscape may only occasionally occur in key areas tied to specific resource objectives. Plots will often occur in low priority areas that are unlikely to change in response to management in a timely manner. The addition of random plots can eventually cause one to land on a key area. Managers must still choose the plot(s) suitable to inform adaptive management for specific objectives, and collect suitable short-term data to supplement long-term monitoring. Simply adding random plots may be too costly to sustain and adding key area plots to a random array requires separate analysis.







Monitoring is a critical component of proper rangeland management. It is often required to ensure that management activities are being implemented and to document that the effects of management activities are achieving or moving resource conditions towards desired objectives and goals. However, funding and staffing to achieve this critical task are far too often insufficient and inadequate. This is true for governmental agencies and ranchers alike, and yet both must adequately fund, staff, and consistently complete essential monitoring. It is also necessary that monitoring be well planned to be efficient and effective.

Appropriate use of the NRMH 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) among 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 the NRMH and the *Ranchers' Monitoring Guide* meet and inform agency requirements.

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BLM Photo

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 in various phases of dominance and may appear to be pinyon-juniper forest but are actually rangeland based on site potential as described in Ecological Site Descriptions. 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 land users, governmental entities, and other organizations. Family and agency missions and a wide variety of knowledge helps prioritize what can and/or must be accomplished on rangeland. This revised handbook is designed to provide guidance for tracking change relative to prioritized resource objectives (hereinafter referred to as objectives in this handbook), and making management 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 is to establish goals and the first step in monitoring is to set objectives. Goals are broad written statements, or categories of desired accomplishments. Objectives are clear quantifiable statements of planned results to be achieved within a stated time period at a specific

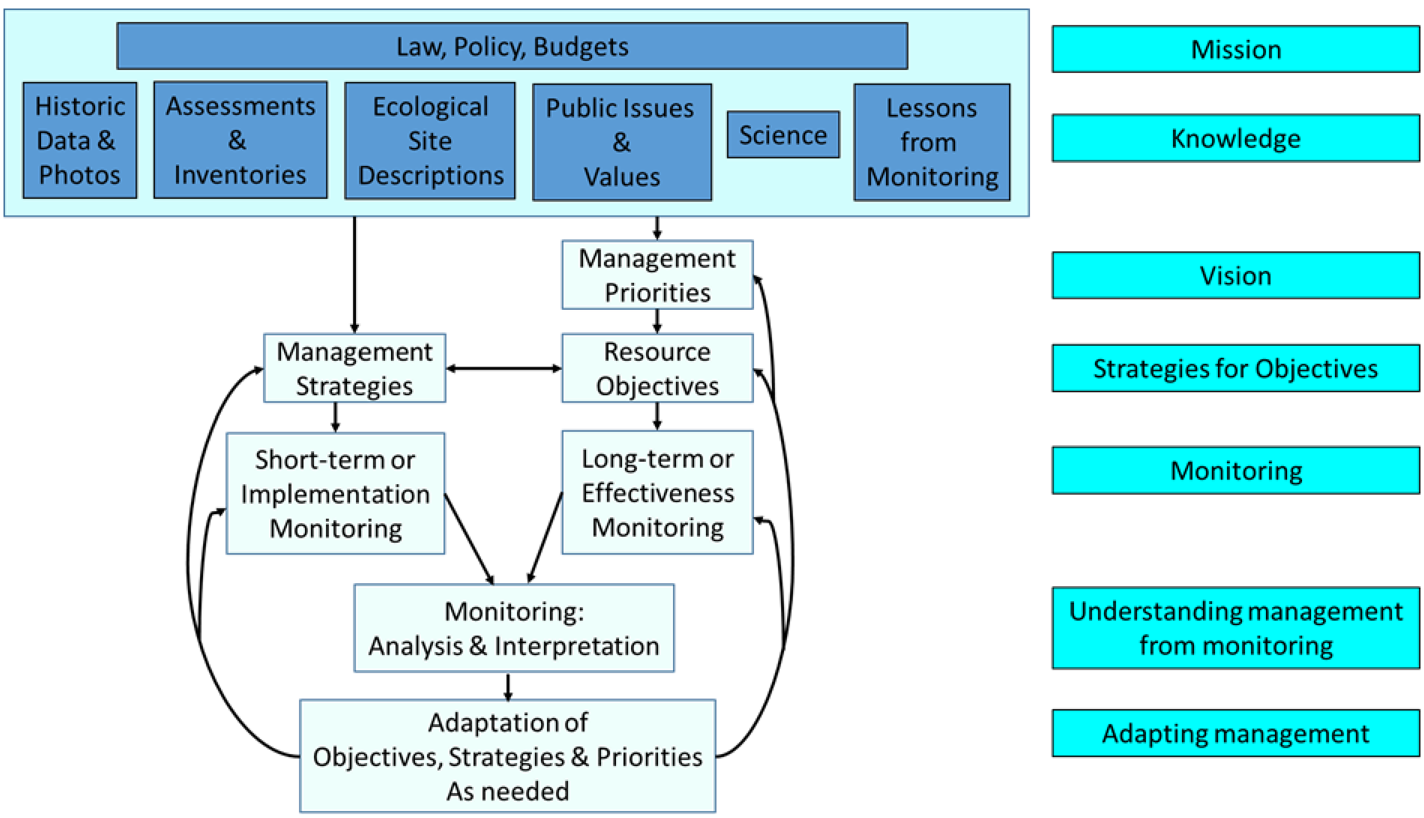

Figure 1. A Framework for Monitoring shows that law, policy (agency or family) and budgets as well as knowledge from many sources (top row of boxes) informs land managers about priorities for what is needed and what can be accomplished with various strategies on rangelands. Priorities about vision lead to setting important resource objectives that focus long-term (effectiveness) monitoring questions, methods, and locations. The strategies that will be used to meet them are chosen in planning that checks to make sure the strategies should reach objectives. Chosen strategies focus short-term (implementation) monitoring questions, methods, and locations. Also monitoring is to adapt management based on analysis of the monitoring information. Needed adaptation would cause adjustment to priorities, objectives, strategies or monitoring methods or locations.

site. Objectives describe a vision of desired future conditions based on ecological site potential and the response to natural disturbance and 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. An objective is specific, achievable, quantifiable, and relevant to management. This handbook guides objective setting as well as monitoring.

After monitoring information has been collected, it must be analyzed and used to make management 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 objectives. Monitoring activity therefore flows directly from the objectives. Adequate monitoring helps to justify continuing current management or making appropriate changes. Long-term, or effectiveness, monitoring focused on the objectives can be interpreted with strategic short-term, or implementation, monitoring that tracks the management applied and the effects of that management. Strategies for achieving objectives focus short-term monitoring. Practitioners should clarify linkages between strategies, objectives and short-term and long-term monitoring methods.

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 and 2006 Handbooks. 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 rangeland monitoring techniques is large. 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. This 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 and others would consider important. **Appendix A- Cooperative Monitoring** provides a process and template for cooperative monitoring.

"Monitoring is the orderly collection, analysis, and interpretation of resource data to evaluate progress toward meeting objectives. This process must be conducted over time to determine if 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 objectives are realistic and achievable;
7. Evaluate whether present uses of money and time produce an acceptable benefit;
8. Assist rangeland managers with herbivory management or management of other uses.

To start a monitoring program, identify objectives for the rangeland to be accomplished with management. Because of the importance of objectives for rangeland monitoring, the following sections address tools and criteria for setting objectives.

TOOLS FOR OBJECTIVES

Ecological Sites - Ecological sites have been adopted by the BLM, FS, and NRCS (Caudel et al. 2013). An ecological site (ES) is a conceptual division of the landscape that is defined as a distinctive kind of land based on recurring soil, landform, geological, and climate characteristics that differs from other kinds of land in its ability to produce distinctive kinds and amounts of vegetation and in its ability to respond similarly to management actions and natural disturbances (Caudle et al. 2013). Rangeland landscapes are divided into ecological sites for the purposes of inventory, evaluation, and management. Ecological sites may be lumped into disturbance response groups for practical management purposes (Stringham et al. 2016).

Ecological site descriptions are a continuing endeavor to collect, interpret, and categorize knowledge of the physical and biological relationships and dynamic nature of natural plant communities. A state and transition model is used to describe vegetation dynamics and management interactions for 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 1000 different ecological sites have been described in Nevada (see ecological site descriptions for each Major Land Resource Area available from the NRCS and UNR http://naes.unr.edu/resources/mlra.aspx). For a detailed description of ecological sites and their use for management, planning, and monitoring refer to Appendix B – Ecological Sites. Where ecological sites are not yet described, the concept could be applied to identify units of the landscape with repeating soil and vegetation characteristics.

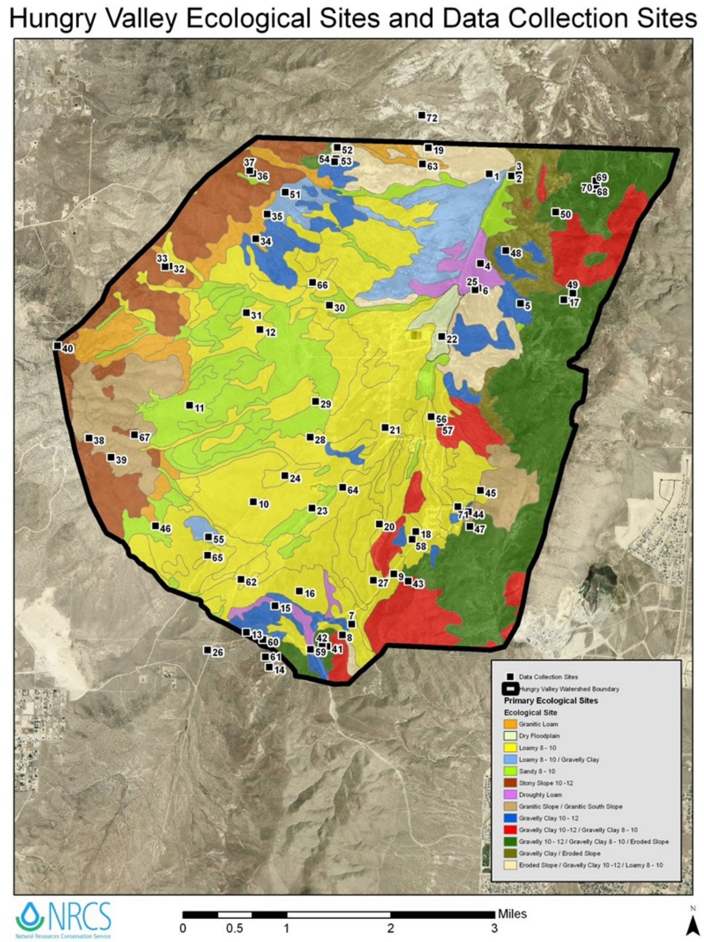

Figure 3 Ecological site map of Hungry Valley, NV

Figure 2. Phase 1 of pinyon juniper encroachment on a transitional pathway. toward phase 2

Riparian Areas - Riparian areas are as a transition to adjacent uplands 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 and Dickard et al. 2015) keep water on the land longer, improve water quality, produce important fish and wildlife habitats, produce lush green vegetation, and retain their beauty for recreation and stability during recurring flow events (5-25 year recurrence interval). 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 water flows after precipitation or snowmelt events and excessively low flows and warm water in summer. Whereas proper functioning condition riparian areas withstand most floods and droughts (Appendix C – Weather Variability), they often improve through these events. However, some very large infrequent floods (e.g.100 year events) may cause some properly functioning riparian areas to degrade and become non-functional or functional-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 some ecological site descriptions with state and transition models are available for Utah, or California and a draft NRCS manual on the development of ecological site descriptions for lotic systems is in development (Stringham and Repp 2010). The FS 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 Elko BLM 2002). They combine estimations with measurements and have been used to help set management goals and objectives, and track progress. Stream classification (e.g. Rosgen 1996) has also been used to make management interpretations and will inform riparian ecological site descriptions. 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 assessment for lotic or lentic riparian PFC (Prichard 1993, 1994, 1998, and 2003 and Dickard et al. 2015) or Stream Visual Assessment Protocol II (NRCS 2004) helps identify impaired functions or values that managers could address to promote riparian restoration through management. Dickard et al. (2015) and (Swanson 2016) describe a seven-step process for integrated riparian management that is very parallel to adaptive management (Appendix D – Adaptive Management) and the framework for monitoring above. Focusing on the at-risk areas and negative attributes identified in PFC assessment helps identify management priorities to set objectives. Objectives for riparian areas could focus on species composition of riparian meadows (Weixelman et al. 1996 and 1999), on the streambank (Winward 2000, Burton et al. 2011), or on structural features of vegetation that drive channel form and stability (Winward 2000; Burton et al. 2011). Objectives for lentic riparian areas could similarly focus on risks to function such as erosion, deposition, adequacy and composition of vegetation, etc. as well as values-based objectives such as forb diversity for sage-grouse brood rearing habitat. Objectives address factors that are directly influenced by management activities including livestock grazing, roads, upland watershed vegetation treatments, water storage and use, or others.

Understanding how similar streams or wetland areas have responded to or changed with specific management helps managers prescribe management and set 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 an 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 Objectives Appendix E – Characteristics of Good Objectives).

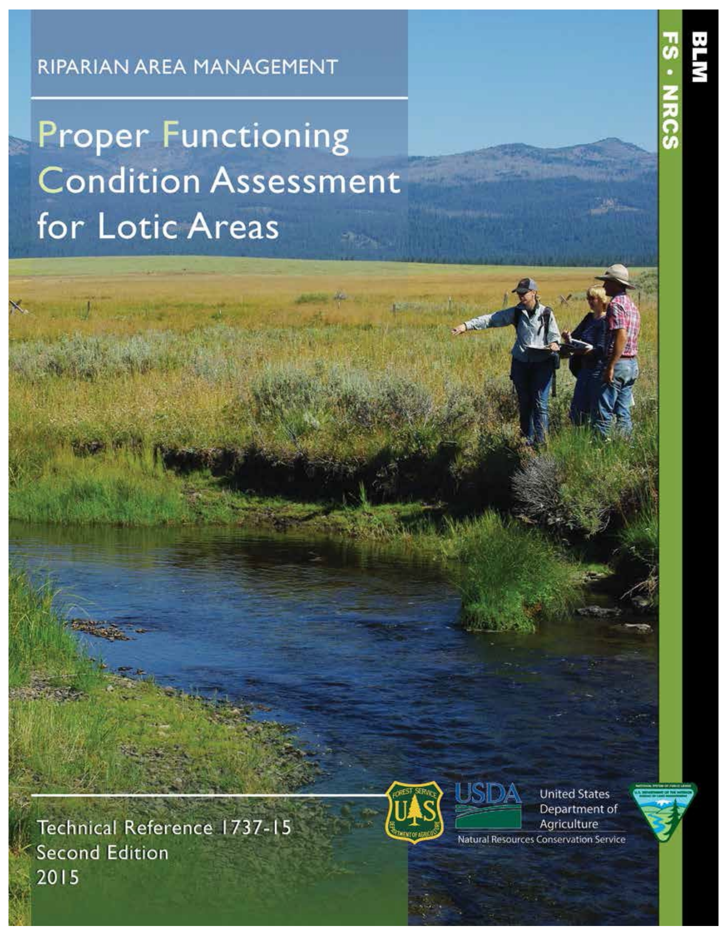

Figure 4. Cover of Dickard et al. (2015).

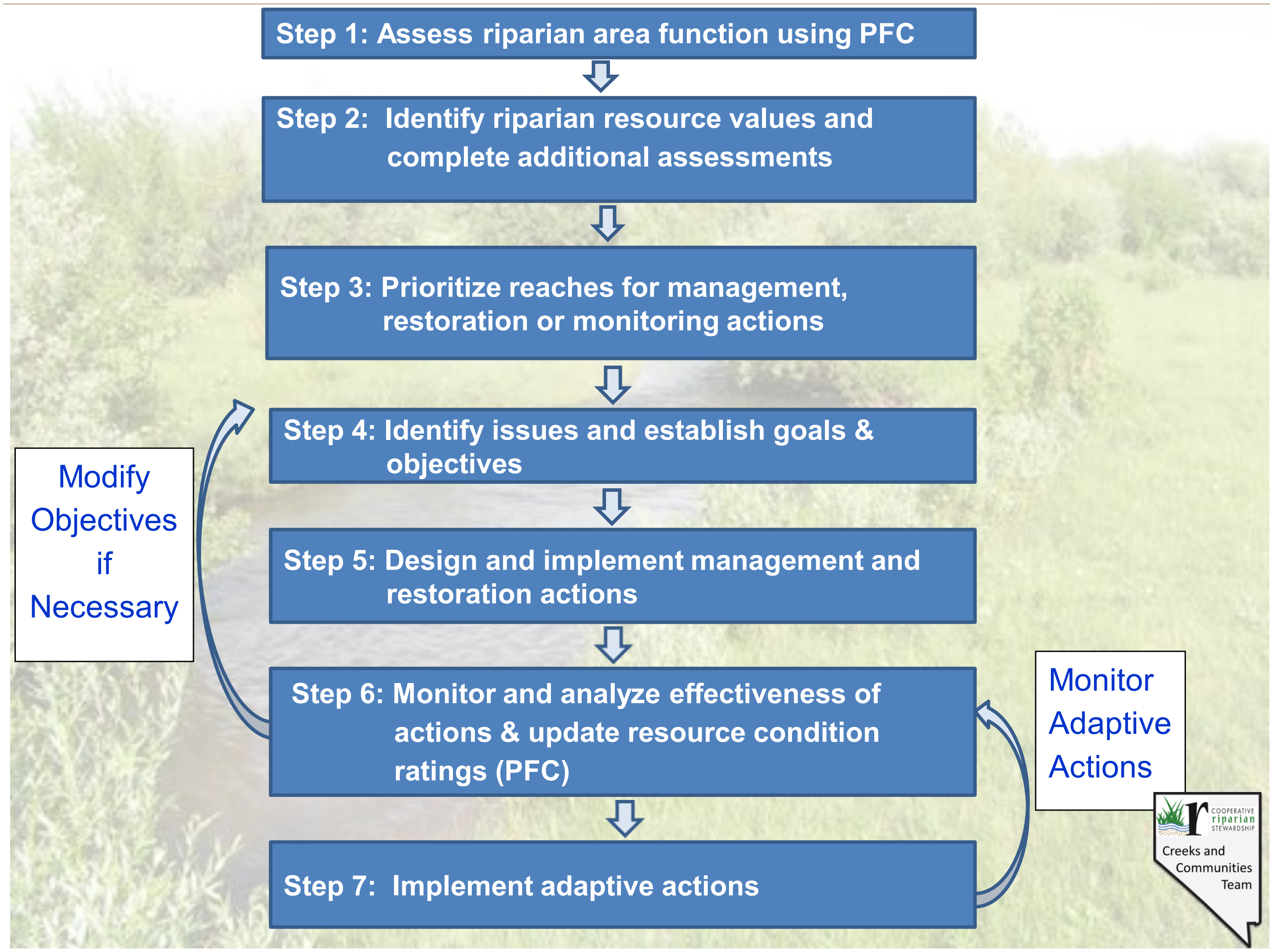

Figure 5. Integrated Riparian Management after Dickard et al. 2015.

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 sequence of landform, vegetation, and hydrology adjustments defines management and 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 (MIM) of Burton et al. (2011). Objectives should 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. Because changes in recovering riparian areas are sometimes obvious, photographs have often been quite useful for documenting change.

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 site specific baseline data points. Modern assessment methods such as riparian PFC (Prichard et al. 1998, and 2003 and Dickard et al. 2015) and interpreting indicators of rangeland health (Pellant et al. 2005) evaluate the current status of a number of indicators that address basic system functionality. The Assessment, Inventory, and Monitoring (AIM) Strategy (See Appendix F - Scales in Monitoring) provides data on the status, condition, trend, amount, location, and spatial pattern of vegetation, soil, and water resources. AIM relies on standard core indicator metrics also useful to assess rangeland health (Pellant et al. 2005) from thousands of plots annually located to statistically sample the diversity of BLM lands. These data are also used in the Habitat Assessment Framework (Stiver et al. 2015).

Evaluating several indicators allows the manager to more precisely identify problems and their causes. This helps develop priorities, objectives, and

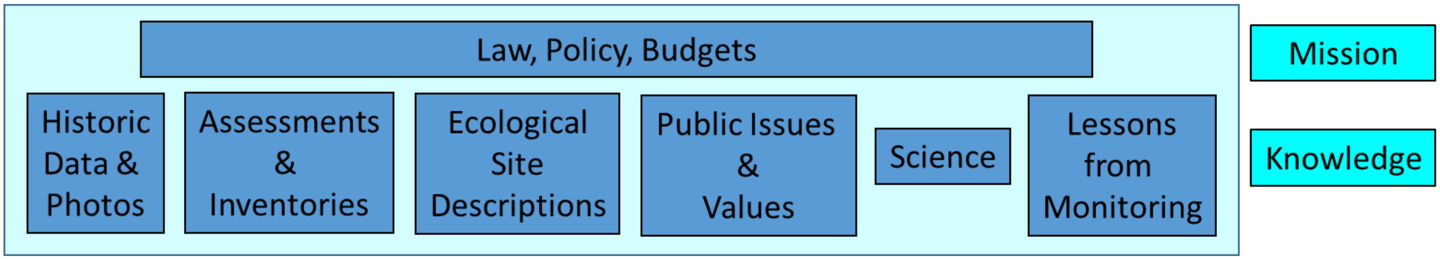

Figure 6. A variety of kinds of information informs agency priorities for rangeland management.

strategies for management actions designed to fix specific problems, rather than having to try and address the whole system without focus. Although not trend monitoring, when inventories and assessments are repeated through time they may help identify changes in issues, opportunities, and priorities. Burton et al. (2011) provide quantitative methods for measuring riparian trend, just as Herrick et al. (2005a and b) provide methods for measuring indicators of rangeland health. Such data help identify issues, states, and transitions, set objectives, determine limitations, and select key areas. The FS has developed a protocol for collecting riparian vegetation and channel data from wadeable stream locations (Merritt et al. 2017) and another for inventorying groundwater dependent ecosystems (USDA-FS 2012). A largely BLM effort is underway to develop a quantitative inventory and monitoring protocol for lentic areas (Dickard et al. in preparation).

Most Nevada BLM offices have Ecological Site Inventory (ESI) and/or Soil Vegetation Inventory Method (SVIM) inventories. The FS too has collected soils and plant community type data that may remain in their files. 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. Many areas have existing monitoring data from established key areas and various forms of data such as photos in reports and files within agency and ranch or other files. These can shed light on baseline conditions for trend, old issues that may have been resolved, or ongoing foci for improving management. Summarizing existing data is useful for context in setting objectives.

Broad-scale assessments or inventories and historic data about specific locations 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 systematic stream classification and/or proper functioning condition assessment. A series of publications sponsored by the Western Association of Fish and Wildlife Agencies focuses on sagebrush ecosystem resilience and resistance (Chambers et al. 2014 and 2017) to suggest priorities and management tools across large land areas. Research on sage-grouse by many Department of Interior agencies and personnel is summarized by Hanser et al. (2018) Concepts from these publications could be refined through application of ecological site descriptions. And, ecological site descriptions and other science based knowledge is continually updated with new science.

Land Use Planning – Large Scale - As required by law, both the FS and BLM develop land use plans

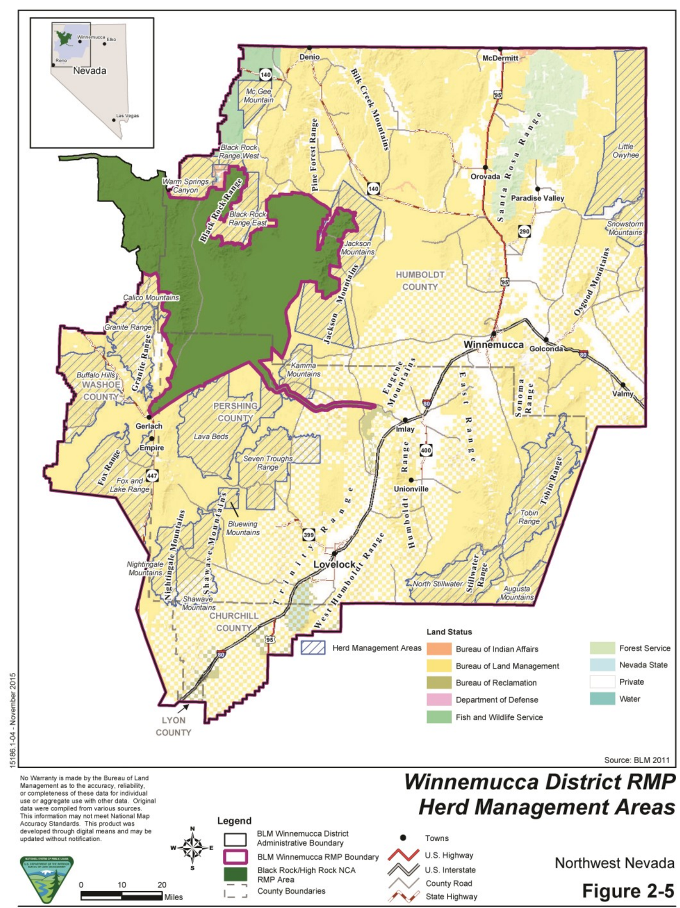

Figure 7. Land use plans as illustrated by this map of herd management areas from the Winnemucca District BLM Resource Management Plan (2015) provide broad direction for rangeland management.

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 develops Resource Management Plans (RMPs) which are periodically updated or amended (e.g. Sage-grouse FEIS-ROD (USDI-BLM/USDA-FS 2015)). The FS similarly uses 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.

Because more than 70% of the land in Nevada is managed by the BLM or FS and most of these lands are used for livestock grazing and other uses, the source of agency objectives is important. Land use planning objectives become or lead to objectives for management of individual grazing allotments. The relationship of these land-use plan objectives to monitoring is that land use plans, agency activity plans, agency standards, and the Standards for Rangeland Health can directly provide (if and where appropriate), or can inform, objectives applicable to individual allotments and specific areas.

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 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 proceeds under guidance in the Land Use Planning Handbook (H-1601-1). Recent RMPs and amendments incorporate the applicable RAC standards, and specific actions for sage-grouse, vegetation and fuels management, drought, etc.

FS standards and guidelines were developed for both the Humboldt and Toiyabe National Forests (now combined into the Humboldt-Toiyabe National Forest) in forest plans written in the mid-1980s and amended several times. These Forest Plan standards and guidelines include direction specifically for management of livestock such as forage utilization and stream bank disturbance levels. More recent thinking (e.g. Wyman et al. 2006; Swanson et al. 2015) suggests these tools should be used for short-term monitoring only where they effectively address the strategy used for success at the local level and then they should be set within the context of that local management. Perhaps this will be reflected in future forest plan revisions.

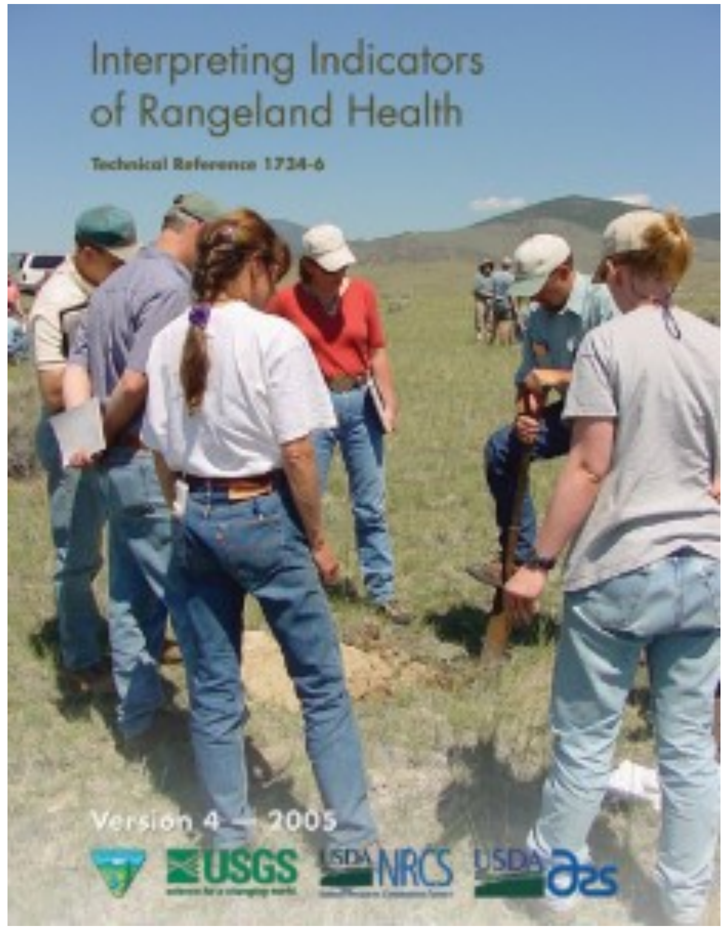

Figure 8. Cover of Pellant et al 2009.

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 or wild horse territory 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 Nevada, the BLM multiple use decisions (MUDs) or grazing permit renewal environmental assessments (EAs) are often used as surrogates for AMPs. Often the process of developing plans is collaborative, using processes of or like Coordinated Resource Management (Phillippi and Cleary 1993). Currently, not all livestock grazing allotments on either the FS or BLM have an AMP (or surrogate); therefore, management of these allotments is guided by the objectives and standards in the higher level land use plans. There are many advantages from developing a plan through Coordinated Resource Management, for all parties concerned.

On private rangeland, planning is at the discretion of the landowner. However, others such as NRCS, Conservation Districts, University of Nevada Cooperative Extension, Nevada Departments of Agriculture and Wildlife and Division of Forestry, Sagebrush Ecosystem Technical Team, US Fish and Wildlife Service, and others may help with information, technical assistance, financial assistance, mitigation funding or conservation credits, and/or collaboration. Publications such as the National Range and Pasture Handbook (NRCS 2003) help with planning. The conservation benefits of NRCS rangeland practices were assessed by Briske (2011; Briske et al. 2016). The Nevada Conservation Credit System (CCS) is a market-based opportunity in the Nevada Sage Grouse Conservation Plan (Nevada Sagebrush Ecosystem Technical Team. 2014) is an important mechanism for avoidance, minimization, and mitigation of impacts from anthropogenic disturbances such as roads, mines, and powerlines. The best private and public land management plans are developed in collaboration with land owners, managers, scientists, and other knowledgeable and interested parties. When a use occurs on both public and private lands, it makes sense to plan and monitor across ownerships.

ACTIVITY PLANS

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

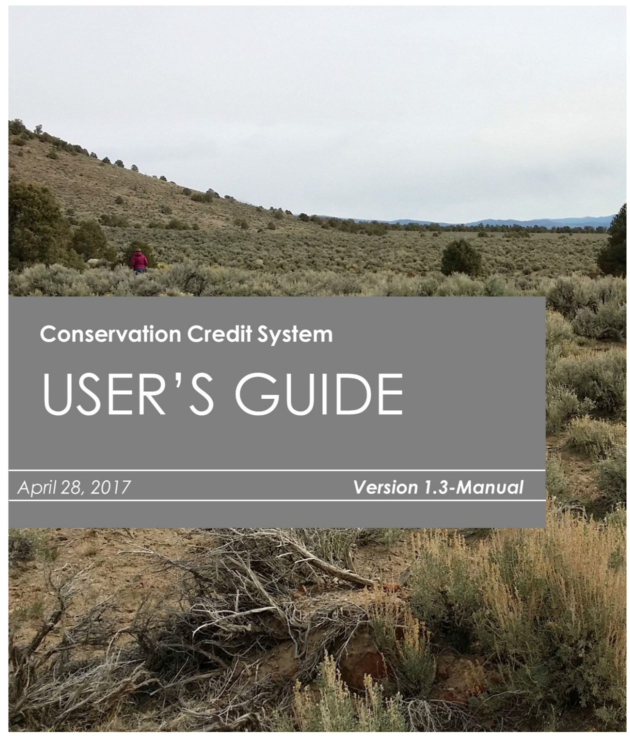

Figure 9. Cover of the Nevada Sagebrush Ecosystem Program Conservation Credit System Manual.

Figure 10. Improvement with spring and fall (cool season) use. Occurred on Susie Creek, NV, which was grazed until 1991 with annual hot-season use by cow-calf pairs. By 1999, spring and fall (cool season) grazing by cow-calf pairs allowed willow recovery. By 2007, beaver occupied the reach and by 2012 recovery is

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 or planned 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 or Time-specific – 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 E – Characteristics of Good Objectives.

The scale for objectives should match the scale and focus of the planned management and the timeline for making management decisions. Some objectives should reflect landscape-scale questions such as: Are pinyon and/or juniper trees encroaching? Is distribution of invasive weeds expanding? Is the landscape becoming more homogeneous? Other objectives should focus on important critical areas or key areas such as important species on a large or important ecological site (See Appendix F - Scales in Monitoring). 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 adaptive management is determined by tracking changes in resources over time, objectives must be measurable attributes of the resources that are directly affected by the management actions. 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 and amount of streambanks dominated by stabilizing species on a specific stream reach are resource

transitioning the area to cattails and by 2014, a meadow. While the changes here were not all predicted, Objectives about increase of riparian stabilizers would have focused management for return of riparian functions.

attributes that can be directly affected by livestock use and respond to management changes in many settings. It is paramount that the selected resource objectives be site-specific, within the site and state's capabilities, and clearly predicted from planned livestock grazing or other management. After crossing an ecological or geomorphic threshold, it is not reasonable to base an objective on the previous state without significant investment (and often risk) associated with active restoration; that is, not just a change in 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 phase (DPCP) 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 DPCP must be within the site's current state unless active restoration is applied. Usually the DPCP will be achieved and maintained through reasonably applied management actions. 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 DPCP 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 DPCPs 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 DPCPs at an appropriate spatial and temporal scale. DFC is analogous to DPCP 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.).

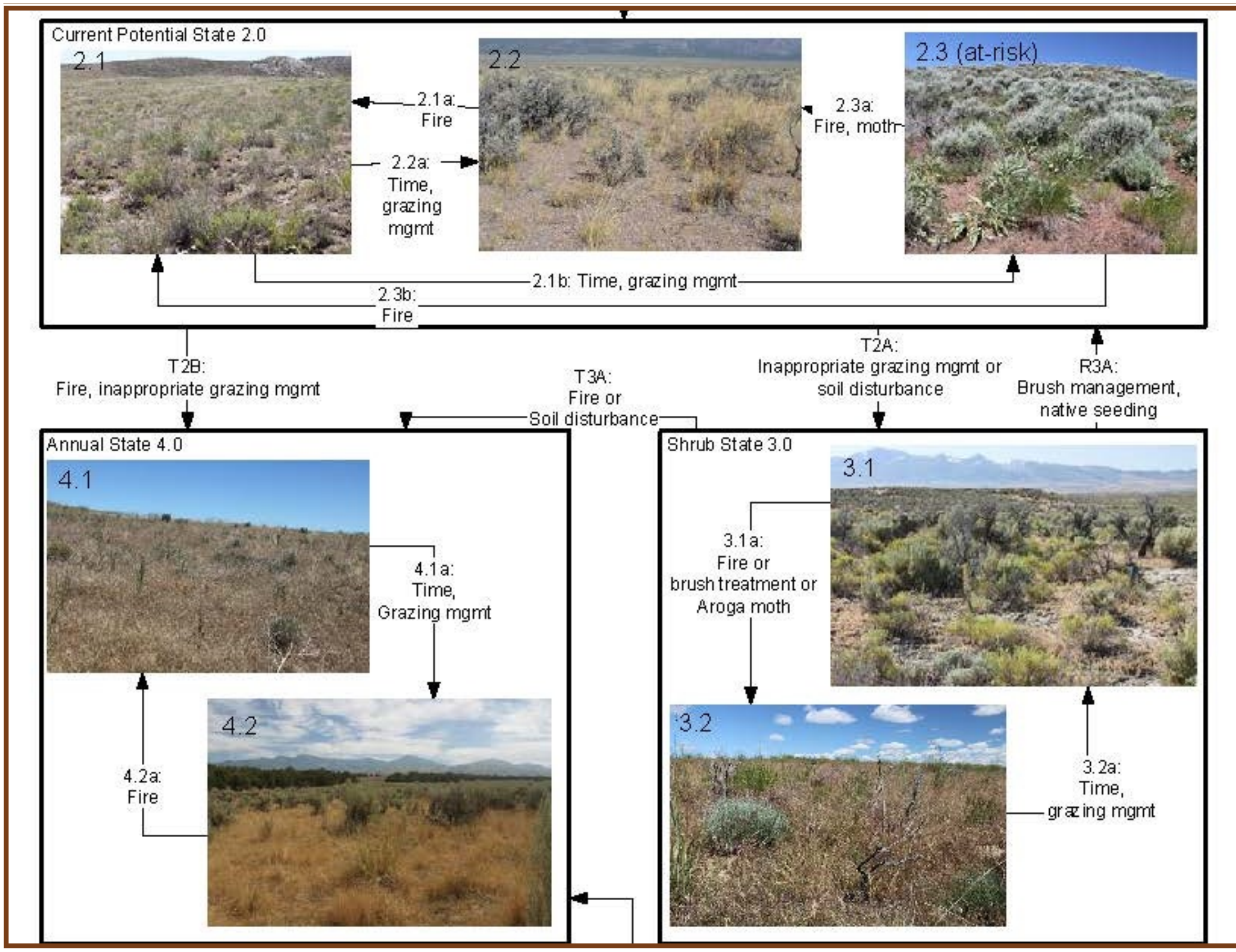

Figure 11. A STM describes alternative states (black boxes), processes and mechanisms (e.g. 2.1a) that cause plant community changes (pathways) to phases within states (photos), maintenance of a current state (e.g.2.3b), transitions between states (e.g.T2A), and restoration toward a previous state (e.g. R3A). For more information, see Appendix B — Ecological Sites.

ADAPTIVE MANAGEMENT

Adaptive management (Appendix D – Adaptive Management) is the essential and continual process of learning from our experiences and managing based on what we have learned. An activity plan must 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 (USDI Technical Guide (Williams et al. 2009) and adaptive management (Williams and Brown 2012). Adaptive management depends on flexibility and repeated iterations. Management plans and monitoring methods flow from objectives. Cooperative monitoring (Appendix A) builds on the same principles as cooperative and adaptive management. People who depend on public land must take particular interest in monitoring. It is the responsibility of the managing agency and landowner to analyze and modify the plan as needed as new information is gathered through monitoring.

Monitoring methods are selected to determine whether progress is being made toward achieving objectives. Also, monitoring helps to determine why or why not progress is being made toward objectives. 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 added significance. Keeping existing data, and periodically reanalyzing and interpreting all data using established methods and plots, is extremely valuable for developing an understanding for rangeland management.

Once the monitoring data are collected, they must be analyzed along with other useful data and information. Analysis includes organizing, summarizing, analyzing, and evaluating the validity and utility of information. Because it is often preferable in planning and monitoring to use a collaborative approach, analysis of monitoring data should also be collaborative. 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 increases and shares understanding. The permittee should be included in discussions and development of conclusions to better understand management practices and conditions for particular sites and seasons of use. Conclusions about progress toward objectives and causes of meeting or not meeting the objectives are both essential and must be thoroughly reasoned based on all available information. For application to public lands, the rationale for management changes (or not) must be documented.

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 strategies for new goals. For example, grazing intensity and duration may be increased in order to reduce fuel loads of invasive annual grasses as a tool to meet an objective for vegetation structure on a fuel break.

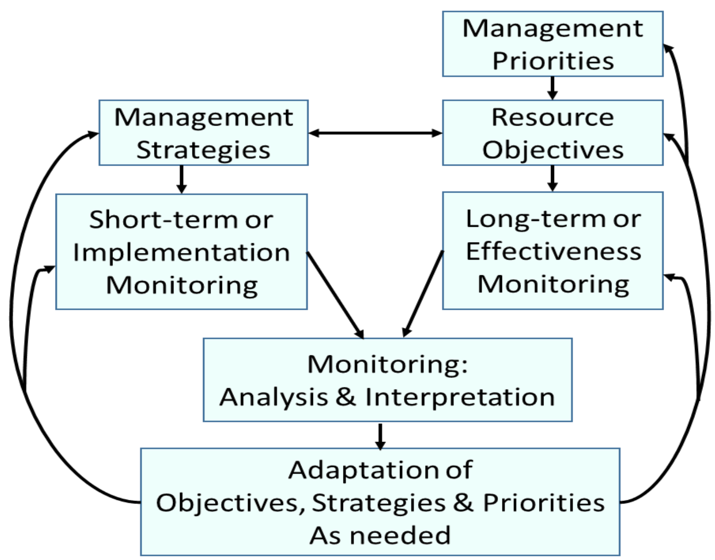

Figure 12. Adaptive management requires using long-term monitoring to evaluate progress toward objectives and short-term monitoring to understand what management has been implemented.

TRIGGERS AND INDICATORS

Triggers are within-season guides for livestock managers to make changes or move livestock, ensuring that end-point indicators (described below) are met (not to be confused with state and transition model triggers). For instance, animal movements may be triggered by use levels. The University of Idaho Stubble Height Review Team (2004) described proper use of triggers for riparian management. Triggers must be location and management plan specific. Also, recording use level at the end of grazing, when this occurs within the growing season, 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; Wyman et al. 2006)).

Triggers may be 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 desired grazing intensity or strategy is too much, too little, or is inconsistent with achieving the desired resource objectives, then the agency and the permittee should implement corrections. This is part of the adaptive management process.

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 helps 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 (BLM 1999b). This is especially true of a single year's values (Smith et al. 2005).

Across broad and diverse areas, different values of a given indicator or different indicators would be selected for different vegetation types and objectives. For example, crested wheatgrass, with its resilience to grazing pressure and tendency toward wolf plants (plants that have grown large and accumulated unpalatable thatch through lack of use), might have a higher utilization level than would be suitable for bluebunch wheatgrass, a species more susceptible to defoliation impacts. A pasture might have a higher acceptable 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.

REMEMBER,

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. Does the monitoring method directly flow from the management strategy, and is it consistent with the season, duration, and rotation of use ?

MONITORING METHODS— GENERAL CONSIDERATIONS

Stratifying Landscapes for Analysis and Monitoring --

Data from individual monitoring sites can be more reliably extrapolated to represent larger areas if the area of interest is stratified. Stratification can improve the ability to detect change by minimizing variability within, and maximizing variability between, strata. Landscape stratification is a three-step process. This greatly reduces the number of study areas needed in comparison to using random locations.

3 STEP PROCESS

1. Assemble background information.
2. Define criteria to stratify the landscape into functionally similar monitoring units.
3. Divide the soil-landscape units into possible monitoring units.

Step 1 – Assemble background information: remotely sensed data including aerial photos, topographic maps, ecological site descriptions, soil surveys and maps, allotment/management unit maps, fire history, treatment area maps, use maps, habitat maps, herd management areas or wild horse and burro territories, etc. (BLM 1999a; Herrick et al. 2005).

Step 2 – Define the stratification criteria in order to stratify the landscape into functionally similar monitoring units. Criteria include soil-landscape units (soil map units), current vegetation, management units, or Disturbance Response Groups. Disturbance Response Groups (DRGs) are groupings of similar ecological sites that respond similarly to disturbances (fire, grazing, drought, insects, flooding, etc.). DRGs capture a broader range of ecological similarity than ecological sites and can be used to plan management or reduce the amount of monitoring sites needed (Stringham et al. 2016).

Step 3 – Complete the stratification by dividing the soil-landscape units into possible monitoring units. Soil-landscape units (soil map units) are areas that are relatively homogenous with respect to slope, aspect and parent material. These units are further divided into ecological sites. Ecological sites repeat across the landscape and are expected to be a relatively stable means of stratification. Ecological site maps can be created through the use of Web Soil Survey or ArcGIS. Further stratification can be done by the use of State and Transition models (STM). The states and phases in an STM are described in terms of their vegetation composition and sometimes dynamic soil and soil-surface properties. STM transition narratives explain the mechanisms by which transitions to alternative states occur. Ecological state maps of an allotment or management unit can be created by the use of ArcGIS and field verification. The current state determines what is realistic, and the community phase within a state conveys the current conditions and the likelihood of future transitions. State maps can be used to locate areas dominated by invasive species or habitat types for a particular animal.

Further subdivisions based on management units may also be necessary – for example, pasture units, distance from water, wildfire areas, treatment areas, and recreation use can also be used to delineate possible monitoring units Aerial photographs or other images are helpful 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 – Remote Sensing to Monitor Rangelands for a list,See Appendix H-Procedures for Selecting Key Areas and Key Species, and Appendix F - Scales in Monitoring). Understanding these possible monitoring units helps in strategically planning management and monitoring by focusing attention on those that are more important, likely to change, and representative of management goals.

Sampling 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 important differences. Generally, more sampling increases the ability to detect significant differences. It is possible to detect differences that are so small that they are not important. However, with budget constraints for land management and monitoring, the more common problem is collecting enough data to gain confidence that the samples represent reality rather than simply random variation. Further adequate sample size is necessary to ensure that real and important change is not hidden by random variation.

In monitoring, there is always a tradeoff 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 one plot at each of a dozen different locations would tell more than the same amount of information from a dozen different plots at one location. If all the data are from one location the question remains, "How representative was this location?"

"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 are the data to collect, and how important is it to know. It also depends on the resource objective(s). When setting 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. More information on statistical and sampling considerations is in Appendix I - Statistical Considerations.

To avoid having to sample an excessive number of locations, monitoring often reduces the variability by focusing on key areas where change across time should reflect the response from planned management action. That is, they focus on areas that are getting the prescribed treatment and where the objectives would show a change if the management works. Monitoring sites are not located in areas that do not have and represent management concerns, nor in areas where management actions are expected to not affect conditions. Key areas are discussed in the following section and in Appendix H - Procedures for Selecting Key Areas and Key Species. Key areas have thus been used to replace multiple random sampling locations. Monitoring random locations without using key areas selected by managers to be representative of important objectives requires many sampling locations within the unit (e.g. allotment) sampled.

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, sensitivity to management, 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 phase, a specific ecological site or disturbance response group, or some other significant portion of a management unit.

Key areas in a unit may change if management, plant communities, and/or objectives change. Therefore, key areas should be periodically re-evaluated to assure that the overall monitoring results reflect the situation in the unit and current objectives. However, the value of long-term data sets

Figure 13. Measuring progress toward objectives in carefully selected key areas enables data to be used strategically for adapting management.

should be considered as well, prior to abandonment of past key areas.

Critical Areas -- Where needed, an area may be selected for monitoring where a special management concern warrants additional 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 (Burton et al. 2011) are similar. (See Appendix H - Procedures for Selecting Key Areas and Key Species)

Key Species -- Key species are the forage species whose use serves as an indicator to the degree of use of associated species, or those species which must, because of their importance, be considered in the management program (Bedell 1998). More than one key species may be selected, depending on objectives and data needs. Allotment objectives are often based on improving or maintaining the amount or distribution of key species. Plants may be selected for monitoring wildlife habitat, watershed, or other attributes if they tie land management to ecosystem processes targeted by objectives.

Observation of key forage species can indicate the general degree of grazing use on a key area and may indicate grazing use of closely related species. 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

Figure 14. Because cattle are central place foragers, Key areas are often placed after consideration of use patterns across the landscape.

APPENDIX H – PROCEDURES FOR SELECTING KEY AREAS AND KEY

Key Areas – Rangeland managers, livestock operators, and others who know the range should cooperatively select key areas based on issues, opportunities, and goals. Once selected, key area baseline data becomes the foundation for a site-specific objective. (See Appendix B Ecological Sites and the Handbook section “Stratifying Landscapes for Analysis and Monitoring”). 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 are used where random sampling locations would be prohibitively expensive for accurately (Appendix I – Statistical Considerations) monitoring grazing (most pastures or allotments (Appendix F -- Scales in Monitoring). Key areas for long-term, effectiveness, monitoring should also be used for short-term, implementation, monitoring.

To select a key area:

1. Consult Standards and Guidelines, land use and activity plan goals and 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, disturbance response groups, 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 components must be confirmed in the field because soil inclusions lead to differing potentials within the same soil map unit (e.g., sandy surface textures produce more perennial grass than finer soil surface textures). The attributes of the objectives(s) monitored must be present on the area selected.

2. Refine objectives for each key area at the time they are set up in the field based on baseline data and potential to reach objectives. Consider the management plan, including primary management strategies (and possibly triggers and end-of-season indicators).
3. Overlay use pattern map, water locations (noting timing of water availability), 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. Avoid areas of concentrated use (such as near a water trough) and areas of slight to light use (such as steep slopes). These do not provide much information 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 ecological site and utilization maps, together with an on-site assessment.
4. Choose area(s) representative of the 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, where the pasture is grazed at different seasons or where multiple seasonal wildlife habitats are important.
5. The key area must have the potential to improve or decline in response to planned management. There must be sufficient plants of the key species (those plants identified in 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.
6. Do not establish a key area in a small or atypical location or close to fences, or other infrastructure. Avoid water sources, trails, corrals, historic salt grounds, bedding grounds, dusting areas, shade, and other concentration areas. And, stay away from roadsides or other disturbances.
7. Where multiple herbivore (wild and domestic) use is significant, select key areas as needed.
8. Confine monitoring studies on a key area within the boundary of a single soil, single land form, and single plant community and ecological site. The Key Area Location Form included in this appendix is an example for recording the location and specific selection criteria.
9. Consider the season(s) of use and class of animal because diet preferences change by season, kind, and class of animal.
10. Establish new key area(s) and discontinue reading old key areas if they do not address objectives. This can happen when the pattern of grazing use is significantly modified because of a difference in season(s) of use, kinds or classes of grazing animals, pasture size, watering locations, or other factors affecting grazing distribution or the management plan.

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:

Critical wildlife habitat;

Areas of species of concern or special status species;

Highly erodible areas;

Isolated aspen patches; or

Riparian areas.

Designated Monitoring Areas – In riparian zones, areas selected for short- and long-term monitoring may be called designated monitoring areas (DMAs) (Burton et al. 2011). In riparian areas, representative designated monitoring areas should:

1. Represent management concerns within the riparian area as reflected by riparian PFC assessments, management plans, resource values, and especially objectives (e.g., a functional-at-risk reach 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 much opportunity 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 species present that will respond to management and meet objectives.
4. Represent similar reaches in use and response, 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, or inaccessible locations surrounded by willow thickets.
5. Be characterized by existing stream survey or PFC assessment locations where available (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.

Key Species – Key species should represent objectives and be a significant component of the potential desired plant community. For example, in a riparian area, key species are normally riparian stabilizers adapted for the soil redox conditions (often sedges or bulrushes on fine soils and willows or aspen on rocky soils or steeper gradients). The species selected should:

1. Be those that respond to management. Species selected remain consistent until or unless objectives change.
2. Key forage species should be palatable to the grazing animals during the planned season of use and respond to grazing management. Very palatable plants that have low production potential should not be selected as key forage species. Species with low palatability or lower palatability than other abundant species should not be selected. Very palatable or very unpalatable species give a falsely high or low use reading, leading to under or over-use of the important more or less palatable forage species.
3. Key species should be perennial except on annual rangelands, and be selected after:

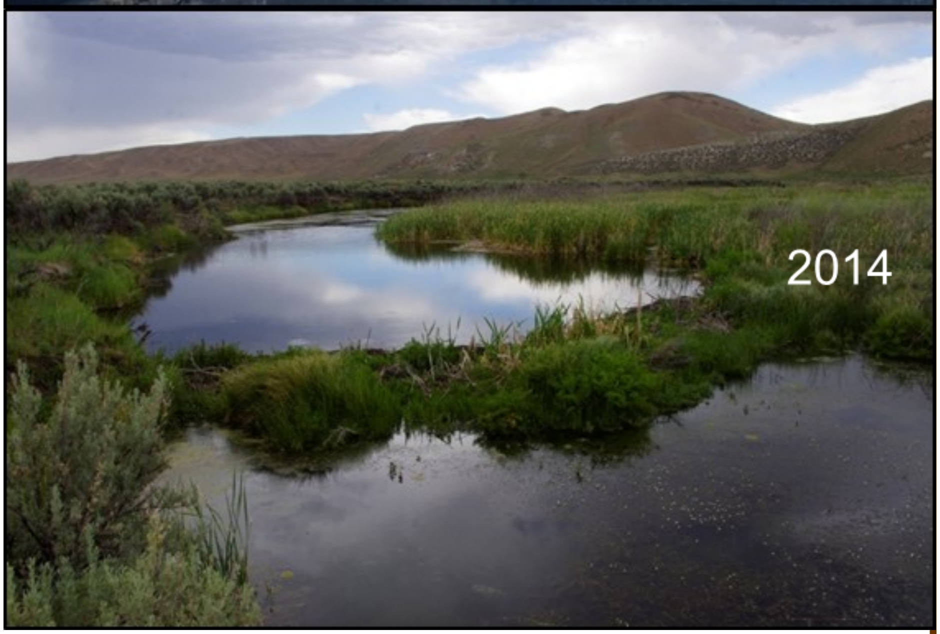

Figure 15. Riparian areas that provide habitat for listed species such as Lahontan cutthroat trout may be considered critical areas.

a. Choosing the key area and evaluating the present plant community.
b. Deciding the plant community or important plant(s) 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 in plant communities with low diversity.

are highly palatable “ice-cream” species with low composition in the forage base (<15%) make inappropriate key species. (See Appendix H Procedures for Selecting Key Areas and Key Species)

Short-term Monitoring -- Short term, or implementation, monitoring addresses four topics:

1. Conformance with management plans (the actions applied – e.g. actual use dates by pasture or use area),
2. Current, annual, or short-term impacts of the implemented management on resources of interest,
3. Weather, and
4. Other unplanned events (e.g. fire).

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. 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 gathering data and keeping records of observations on actual use (See form for this in Perryman et al. 2006), distribution patterns and utilization (Appendix J - Use Mapping, Key Species Method, and Proper Use), streambank alteration (Burton et al. 2011), growing conditions, and documentation of wildlife use, insect infestations, fire, and adequacy of range improvements. Short-term monitoring may also include notes recorded in a pocket calendar or herd book (red 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 or removal date is too early or too late. Within-season triggers could include changes in livestock behavior such as a shift in use areas or preferred forage species or reaching planned seasonal utilization on specific plants or plant groups. Weather events 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 future management. Management changes that are based on multiple years of monitoring are usually more reliable than changes based on just one or two because of variability in environmental conditions and associated use patterns. Furthermore, strict adherence to triggers can cause sudden changes throughout a management system (Smith et al. 2005).

Before making an adjustment in the timing, duration, and intensity of grazing, utilization and other short-term monitoring data from several years prior must be considered. However, if the use of triggers is the management strategy, then animal movements may be based on annual use levels. Prompt implementation of management changes may keep rangeland more productive. The need for triggers and the strictness of their application should vary on a case-by-case basis, depending on the current status of the resource in relation to the objectives and the degree to which an action prohibits or enables achieving those objectives. For example, movement at a utilization trigger is usually not important in the dormant season, or if the principle strategy is short duration grazing with recovery.

Long-term Monitoring -- Long-term, or effectiveness, monitoring measures changes over time in resource attributes. It periodically measures progress toward meeting long-term objectives. It also helps determine the applicability and effectiveness of annual indicators or triggers. Long-term monitoring

Figure 16. Nebraska sedge or other stabilizing riparian species are considered key species in many riparian areas.

(Continued on page 27)

usually occurs at permanent sampling locations. Techniques used or types of data collected periodically for long-term monitoring may include frequency, percent composition by weight of the vegetation (See Production and Plant Community Objectives side bar.), resource value ratings, remote sensing - including ground and aerial photography (Appendix G- Remote Sensing to Monitor Rangelands), and photo plots (Perryman et al. 2006)).

Because objectives vary by location, long-term monitoring methods must also vary (BLM 1999a; Herrick et al. 2005a and b; Elzinga et al. 1998). However, because long-term monitoring is intended to detect trend, it is very important that methods be used consistently over time at specified locations. Locations should be periodically re-evaluated to ensure they continue to provide information that is useful for management.

Vegetation attributes are monitored most often because vegetation is an integral part of most ecological processes and responds directly to management. Measurements of species composition by weight were the gold standard for determining range condition (Dyksterhuis 1949). Quadrat frequency data have been collected on many BLM lands since the early 1980s (Nevada Range Studies Task Group 1984). Vegetation cover and line-point intercept were selected for the BLM Assessment Inventory and Monitoring method (Toevs et al. 2011). However, cover techniques are not all equivalent (e.g. foliar vs. canopy (BLM 1999a) and caution is needed for comparisons of cover data. Recently, dynamic soil properties (Herrick et al. 2005a&b) and multiple indicator riparian monitoring (MIM) (Burton et al. 2011) are receiving increased attention. Use of the appropriate monitoring method is vital to assessment of the effectiveness of management.

Figure 17. Where changes to streambank stability or channel pattern focus riparian objectives, the Greenline is a logical place to measure progress.

Traditionally, vegetation monitoring methods were designed with the idea that vegetation changes at the monitoring site (key area) should reflect progress toward or away from objectives. MIM uses a designated monitoring area that is selected to randomly sample a reach of interest (Prichart et al. 1998; Dickard et al. 2015).

References describe the methods for many accepted monitoring techniques. With developing technologies, tools are increasingly available to electronically capture and store field data. The use of these tools should not preclude the use of paper data forms when needed or preferred.

Some objectives refer to spatial problems like the expansion of trees onto adjacent rangeland 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. In the absence of quantitative data, or in the presence of conflicting or confusing quantitative data, many people rely on what is observable in photographs. Photography can be fast and, with proper labeling and storage, provides a record that can be used in many different ways. Furthermore, photographs may address issues that were not important when earlier pictures were taken (e.g. Photos in Gruell and Swanson 2012). Not all photographic media however, is equally durable. Backup copies and their durability should be considered for photo archives.

Roles and Responsibilities -- Ideally, monitoring would occur across ownership boundaries in pursuit of the agreed upon 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 depend on monitoring information to adjust management that impacts resource productivity and may influence future opportunities to graze. All parties should review the information together on an annual basis and use it to plan management adjustments or affirm strategies for the following grazing season. Land users other than livestock producers may also take an active part in monitoring their own use(s) and the achievement of objectives in which they are a stakeholder.

Grazing management aims in part to maintain the quality and quantity of forage needed for a successful livestock operation. Agencies and their managers seek to balance many competing and complementary interests expressed in policy, law, regulation, and plans. The ideal relationship between the producer and the land management agencies results in the identification of monitoring tools and management practices that meet the needs of each. The idea of cooperative monitoring is embraced by the Public Lands Council in memoranda with the BLM and FS. 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, the more influence they may have in improving management. Furthermore, cooperative permittee monitoring may encourage agencies to become more effective as partners in monitoring and management. A template for a cooperative monitoring agreement is in Appendix A- Cooperative Monitoring.

Weather is an important environmental attribute and a key element of a rangeland monitoring program. Producers should track such things as weather, growing conditions, the results of management, etc. to help make appropriate grazing management decisions (See Appendix C –Weather Variability). The Ranchers' Monitoring Guide (Perryman et al. 2006; 2017) provides additional information and forms for collecting and recording weather information.

Management agencies have regulatory responsibilities for short- and long-term monitoring to ensure that permitted or leased activities are conducted to meet goals, objectives, and standards., To provide guidance for this, the BLM has the 4180 Handbook, Rangeland Health Standards (BLM 2005) and a 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. Furthermore, good things happen when ranchers and agencies monitor and adapt their management when needed.

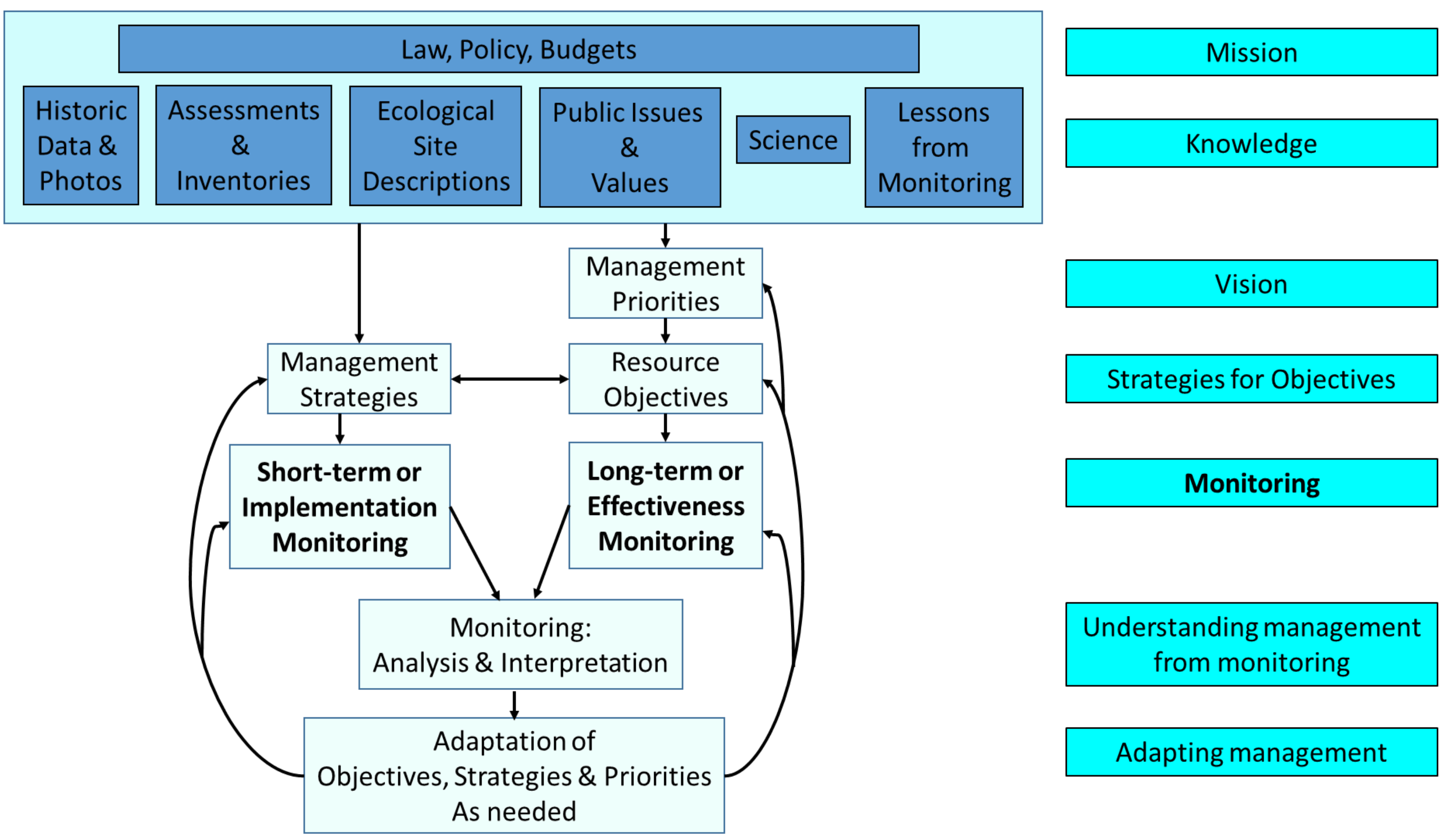

Figure 18. Within the monitoring framework, All parties should review the information together to adapt management.

PRODUCTION AND PLANT COMMUNITY OBJECTIVES

Ecological sites (Appendix B) are production-based. For an indication of the degree of similarity and feasibility or achievability of an objective for a key area, compare existing species composition to the ecological site description. The procedure can vary depending on the issues and 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 objectives dictate the need for production type data. The double weight sampling technique (BLM 1999a; Elzinga et al. 1998; Herrick et al. 2005b) 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 species present 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 H - Procedures for Selecting Key Areas and Key Species.)

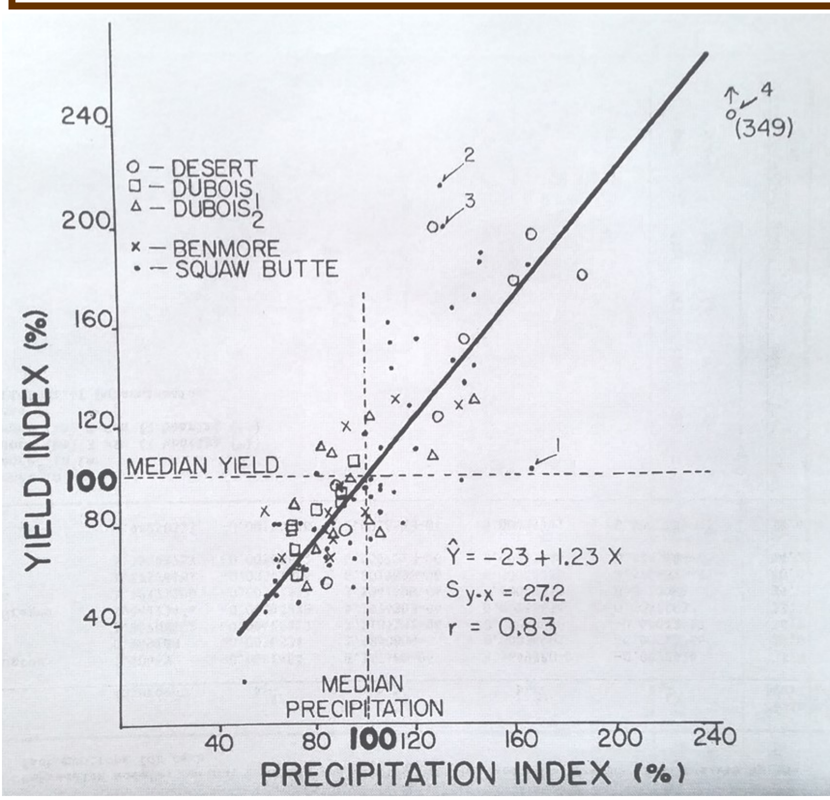

Figure 19. Rangeland forage production can vary from less than 50% to nearly 200% of the median among dry to wet years (Sneva and Britton 1983). Variation in production of annuals like cheatgrass can be much greater.

DID YOU KNOW?

Probably the single most used, long-term monitoring method is repeat photography. In the absence of quantitative data, or in the presence of conflicting or confusing quantitative data, many people rely on what is observable in photographs. Photography can be fast and, with proper labeling and storage, provides a record that can be used in many different ways.

APPENDIX C — WEATHER VARIABILITY

Climate and weather must be considered for the interpretation of monitoring. In arid regions especially, timing and effectiveness of precipitation, which can vary by season and size of each precipitation event, is an important climatic factor that must be considered as changes are evaluated. The bottom line for plants is the soil moisture (and soil temperature) during their thermal growing season. Drought along with fires and unusually wet conditions of flooding or prolonged rapid plant growth are common reasons why flexibility in management is so important.

Drought -- is defined in a number of ways (NOAA 2008), 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 a significand reduction in plant growing conditions and productivity or a serious hydrologic imbalance in the affected area. These two effects can happen simultaneously or, either can happen in the absence of the effects of the other; and each has different management implications. Extreme drought may or may not modify the structure of rangelands by changing vegetation composition. However, in a summer-dry climate such as most of Nevada, moisture limitations end the growing season for most rangeland plants every year. Plants express growth and phenology to reflect the limited amount and duration of soil moisture. No two droughts are the same, so the management response to drought should vary to reflect the unique conditions of the current drought.

The management of plants before, during, and after drought influences the impact of drought and rate of plant recovery following relief from drought. Drought may or may not modify ecological processes by influencing species composition, biomass production, nutrient cycling, and soil properties. Understanding how individual plant species respond to drought, and how ecological processes are affected by drought, informs flexibility in management and interpretation of monitoring data.

Monitoring helps managers detect, record, and understand drought effects and separate the respective influences of drought and management. Plants that may have had time to recover after grazing may not have soil moisture to do so. Observations on growing conditions 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 or stream reaches have dried up early. Conversely, upstream or downstream areas without water may receive less or shorter use. Also, the physiological effect of grazing on dormant plants after soil dehydration is much reduced from grazing effects while plants are still growing.

Careful management in a post drought growing season 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.

Very Wet Years -- may represent an even more significant challenge than drought. In the past four decades, Nevada has had six cycles of many large fires in the year(s) following very wet conditions that allowed abundant fine fuels production. Residual fuels as well as the abundance of litter that facilitates cheatgrass production perpetuate the risk of fire. Then expansive dry lightning caused more fire starts than could be successfully controlled. Abundant highly flammable fine fuels (often combined with accumulated woody fuels) across a landscape allow the uncontrolled fires to get very large (mega-fires) before eventual containment. Where the fine fuels cause connectivity among woody fuels, the resulting hot fire may cause excess perennial plant mortality. Sagebrush, is not fire tolerant, and these large fires after wet years is perhaps the biggest issue for sagebrush ecosystems and associated wildlife, as well as multiple other land uses.

To address the abundance of fine fuel after wet years, it is helpful to recognize the abundant plant growth early to enable flexibility in management such as temporary nonrenewable (TNR) grazing and targeted grazing to create linear fuel breaks. Plans should be developed before the wet years to monitor the abundance of plant growth in the wet springs for the purpose of triggering criteria-based follow-up management. Monitoring of fuel breaks is also important. See Monitoring Fuel Breaks side bar.

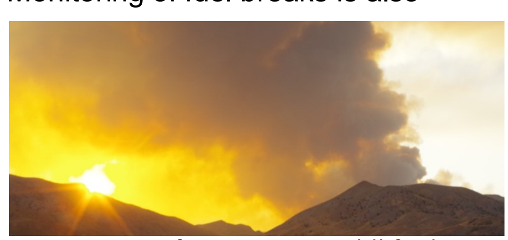

Figure 20. Fires, Including 100,000+ acre mega-fires, impact wildlife depending on sagebrush ecosystems.

MONITORING METHODS— SHORT-TERM OR IMPLEMENTATION MONITORING

In selecting short-term monitoring methods, consider the goals, objectives and strategies being used for management. For example, if the strategy is rotation of short periods of growing season use after recovery, utilization measurements may be less important than dates of use, including use by stragglers. If use periods are longer than a week or two in the upland growing season where deep rooted perennial grasses are the goal, or hot season for riparian areas, both duration and intensity of use are important.

Grazing Use Records – Accurate recording of actual grazing use by livestock, wild horses and burros, and wildlife should occur 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/supplementation, forage conditions, or other important matters. A pocket herd-book, diary (red book), or Nevada Department of Agriculture Rangeland Monitoring App is recommended (http://agri.nv.gov/Plant/Rangeland_Health/Rangeland_Health_Program/). These data provide information on the season and duration of use and the number, kind, and class of grazing animals that used pastures or use areas within 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; 2017) and each agency has a form for this. However, when these forms are used for the whole pasture and not for specific use areas, much information is missing. Many large pastures are grazed for long seasons, but specific use areas within the pasture are grazed for short periods. The movement of livestock to provide opportunities for growth or regrowth of plants is critical during the growing season. Failure to capture the grazing period for each specific use area makes actual use information much less useful.

Photography – Photographs capture a variety of useful information, especially when they include an object that indicates scale such as a ruler or hat. Every photograph of an area should be labeled and dated. Location should be easy to re-locate and re-photograph in the future by including obvious permanent landmarks or using GPS coordinates. Hall (2001) provides other useful information in his photo point monitoring handbook. See photography in the Ranchers' Monitoring Guide (Perryman et al. 2006; 2017) (and see Appendix G – Remote Sensing to Monitor Rangelands).

Project Implementation Records – Many resource management plans call for projects of various types, including range seedings, fences, water developments, etc. Records of implementation should document what was done by whom where, when, and how to help managers learn from experience about projects, especially those that

Unit/Pasture Use Information			
Animal (Kind & Class):	Cattle (steers)	**Season of Use:**	1-Jun **to** 1-Jul
Number:	175	**Grazing System:**	rest rotation
Current Year Grazing Management:	Baldy to Iron Creek - rest Willow Creek		
Other Notes (optional e.g., growth stage of plants at time of use):	Counted 22 head of elk		
in pasture when cattle went on. Use levels in riparian areas were light to moderate.			

Figure 21. Actual use records are extremely valuable for interpreting why progress was made toward objectives or not.

involve many variables such as range 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 must be considered when making changes in grazing use. Monitoring plans should include gathering information on weather (temperature and precipitation) and growing conditions (soil moisture). Recording and preserving weather observations should be a routine activity for ranchers (Clements and McLain 2015.) and land managers. Weather records can be maintained in physical form as well as by electronic means. Ranch weather stations can be extremely useful for interpreting pasture specific monitoring information. Weather patterns can vary between widely spaced agency-operated weather monitoring stations that are generally used to make drought and other environmental condition determinations for very large areas.

The Western Regional Climate Center provides weather data for many locations in Nevada at http://www.wrcc.dri.edu/summary/climsmnv.html. The Great Basin Climate and Weather dashboard is at http://gbdash.dri.edu/ . The National Weather Service's Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS) is a platform conveniently availble to all (see https://www.cocorahs.org/). The precipitation-oriented information in CoCoRaHS combined with temperature records can provide important weather and extreme event information useful in understanding changes on rangelands.

Other sources are the FS and BLM remote area weather stations (RAWS), other agencies such as the Nevada Department of Transportation, and any ranchers or others who maintain records. Relationships between seasonal precipitation patterns and temperatures can be used to interpret production and vegetation dynamics and make determinations about whether a regionally declared drought is applicable to any, all, or portions of allotments.

Declaring drought based solely on the USDA Drought Monitor data (which is not recommended by the National Drought Mitigation Center) misses the ecological principle that shallow rooted plants, such as grasses, depend on soil moisture. Soil moisture depends on precipitation that came in the months immediately before and during the effective growing season, not in the years and months prior to that. Aboveground biomass production of herbaceous species is strongly affected by the amount and periodicity of precipitation that occurs during the thermal growing season. The crop year (Sept 1-June 30), water year (starting October 1) or spring (April + May + June) precipitation can all serve as more accurate predictors of plant growth or forage production (Sneva and Hyder, 1962; Mosley 2001; Mosley 2015). These have been utilized successfully (Daubenmire 1956; Sneva and Hyder 1962), and take into account the effective growing season conditions.

Insects, Disease, Wild Herbivores, etc. – Monitoring records should also include notes on the location of significant occurrences and impacts other

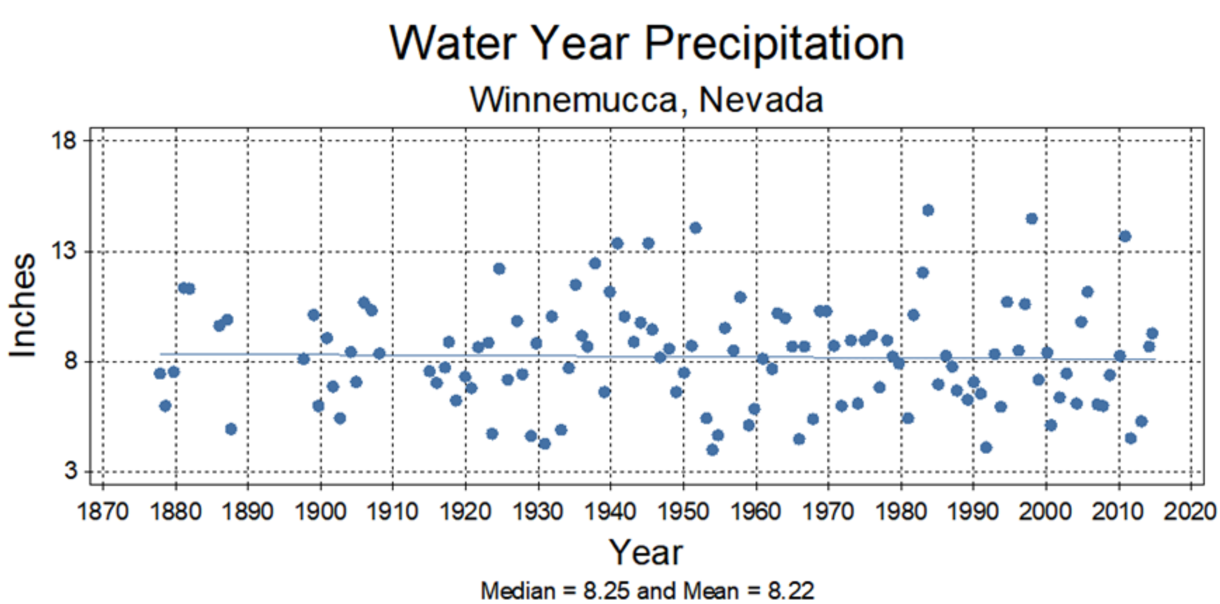

Figure 22. Weather data like other data show natural variability and precipitation is the most importance influence on plant growth.

than livestock. All rangeland vegetation is subject to disease, insect, and rodent impacts. Most ranges also provide forage for other ungulates, rabbits, etc. Notes or records can augment other short-term studies to help interpret long-term studies following such impacts.

Use Mapping – Mapping of areas for proportions of the annual production that has been consumed or trampled by animals is one of the most important tools in grazing management for short-term monitoring. Use mapping can help determine locations 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 (over and under use) are more likely in large pastures with many plant communities over a rough topography. They can be identified with a use map for closer study to determine causal factors and potential solutions. Photographs and/or Global Positioning System (GPS) points at specific use areas may be taken to display observed or measured utilization levels at certain locations. However, utilization records that are based on a limited number of utilization transects, cannot be used to create a use-pattern map and provide almost no useful information about livestock distribution.

Developing utilization maps is a joint responsibility of rangeland managers and livestock operators and is essential for adaptive management. Use mapping helps managers become and stay familiar with the allotment. Comparing periodic use maps help identify chronic patterns and patterns that vary among years in response to weather, season of use and other management factors. This helps identify where adjustments may be needed in a grazing plan. Adjustments might be in the form of new or relocated water developments, fences or salt/supplement grounds, or changing the intensity of grazing by modifying the season or length of use period or the stocking rate. It may also be appropriate to complete more than one use map per year for an area if there are different species using the same area at different times of the year (e.g. wild horse winter use and spring livestock use). An approach to use mapping is discussed in Appendix J (Use Mapping, Key Species Method, and Proper Use) and in Utilization Studies and Residual Measurements (BLM 1999b).

Utilization – Utilization is the estimation of the proportion of annual production consumed or trampled by animals. The proper time to measure utilization depends on the purpose for which the data

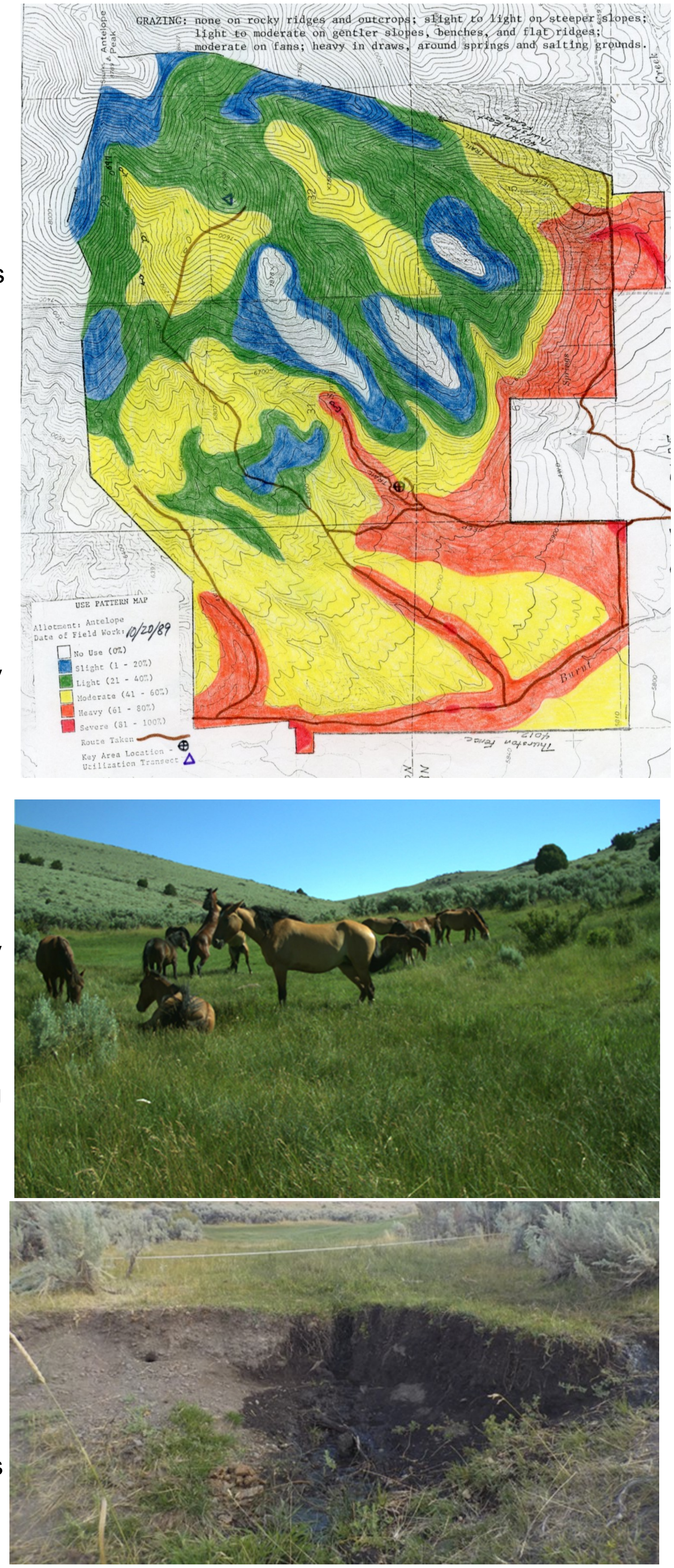

Figure 23. Ungulates select favorite places to graze and understanding distribution is fundamental to recognizing opportunities or needs for management to address issues before they create lasting degradation.

will be used. Seasonal use is useful for recording or using triggers. It may be estimated during the growing season at the end of grazing to understand physiological effects that vary by plant phenology. 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, especially where the focus was on stocking rate or the duration of use was season-long. Both types of utilization measurements help with adaptive management. To help observers, utilizations cages are sometimes used to show the growth that year of plants protected from grazing. To be effective, the cages must be placed where the plants to be protected and unprotected plants that will be evaluated for their utilization are similar before placing the cage. They must be of the same species, size, and health (similar in appearance) and they must have the same soil (landform, slope, aspect, elevation, etc.). For utilization cages to remain useful, they must be moved every year, preferably immediately before the grazing period. If left in one place, they show accumulating effects from protection, thatch, attracted rodent activity or bird droppings, and altered microclimate (snow drifts etc.). These effects can increase or decrease caged plant growth and make them useless for evaluating utilization of uncaged plants.

The Key Species Method (formerly the Modified Key Forage Plant Method) has been widely recommended (Nevada Range Studies Task Group 1984) and used to monitor utilization on upland key areas. See Appendix J (Use Mapping, Key Species Method, and Proper Use) for a description of this method. Utilization may be more effective than stubble height for tall bunchgrass rangelands because of the uneven use by grazers. The key is to choose methods that best measure effects of management to understand application of strategies for objectives. Note that utilization and residual vegetation are management tools for plant health, fuels management, or watershed protection, not long-term resource objectives.

Residual Dry Matter It is easier to see the amount remaining than to estimate the portion removed. Residual dry matter, or the amount of dead plant material and litter remaining after grazing, has been used effectively to help managers achieve soil and vegetation objectives on California annual grasslands and for rangeland areas supporting annual grasses and forbs (Bartolome et al. 2002; Guenther and Hayes 2008). Litter, or residual dry matter is a factor in soil protection and the reproduction of annual grasses such as cheatgrass (Evans and Young 1972 and Trowbridge et al. 2013) and hence in the management of this fine fuel (Schmelzer et al. 2014 and Monitoring Fuel Breaks side bar). For guidance on measuring residual dry matter, see Guenther and Hayes (2008).

Stubble Height - has been used to monitor the remaining parts of herbaceous plants after grazing, usually on

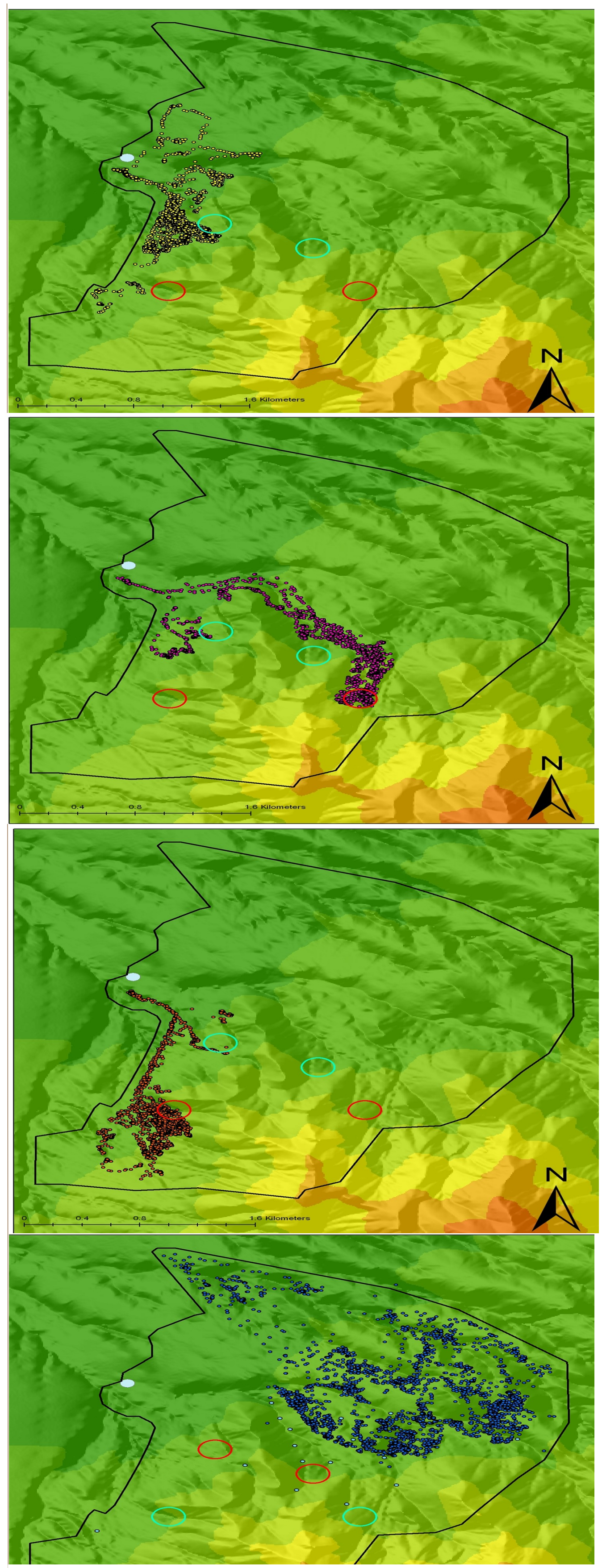

Figure 24. No herding/no supplement top, herding to supplement sites 1 & 4 in middle frames, With wet year & ephemeral springs bottom. (Howery et al. 2010).

meadows or greenlines. Perennial herbaceous stubble can provide greenline roughness that slows water and encourages sediment deposition and retention. Stubble height is often used as an indicator of the effects of riparian grazing management. Intensity of use versus leaf area for ongoing photosynthesis during the growing season has important implications for plant physiological responses to grazing and regrowth. Therefore, seasonal use (measured within the growing season) is often used as a trigger for livestock movement. For guidance on measuring stubble height, see Perryman et al. (2006; 2017), BLM (1999b), and Burton et al. (2011). The proper use of stubble height is discussed in Clary and Leininger (2000), University of Idaho Stubble Height Review Team (2004), Hall and Bryant (1995), and Appendix J - Use Mapping, Key Species Method, and Proper Use.

Woody Species Use – The utilization level on woody plants is often estimated as the proportion of available leaders that have been browsed. 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. However, observing when cattle shift their grazing from herbaceous to woody species may provide a more timely indicator of the need to move livestock where shrub density is low. 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 Burton et al. (2011) and the Ranchers' Monitoring Guide (Perryman et al. 2006; 2017).

Streambank Alteration – Streambank alteration is often measured as the percent of the line at the edge of the streambank that has been broken or deformed, although there are a number of different methods that have specific rules and the methods produce different results. In addition to the effects of grazing and browsing of vegetation, large herbivore and recreation use can cause physical disturbance to stream systems. Similar to stubble height, streambank alteration is an annual or short-term indicator of the effect of impacts on long-term stream condition. When streambanks are excessively trampled or altered, stream function is impaired. Excessive streambank alteration may result in decreased streambank stability, increased erosion, channel widening, decreased water storage capacity of the streambank, a decrease in deeper rooted hydrophilic (water loving) plant species and an increase in more shallow rooted upland plants, and a degradation of water quality and aquatic habitat (Bengeyfield 2006). Streambank alteration can be used as a tool to assess impacts, e.g. large herbivore and recreation, and to determine when these impacts may be excessive. It may be used during the grazing season to trigger a need to move livestock out of the pasture. It can also be used to help determine cause-and-effect relationships between livestock grazing and stream-riparian conditions and whether livestock grazing management changes may be needed the following year (Burton et al. 2011).

Short- term annual indicators like streambank alteration are useful, however, it is inappropriate to use single indicators to manage streams – managers should use a suite of indicators to assess impacts as streams respond differently among sites. The University of Idaho Stubble Height Report (2004) suggested that it is inappropriate to use short-term indicators (e.g. streambank alteration and stubble height) as the metrics for whether or not long-term objectives are being met. Long-term resource condition data are needed to determine whether or not objectives (e.g. streambank stability or greenline stability rating) are being met. Short-term indicators are metrics for how well strategies are followed, but only if the metrics are aligned with chosen strategies. Long and short-term data can also be used to evaluate if the strategies or indicators are useful.

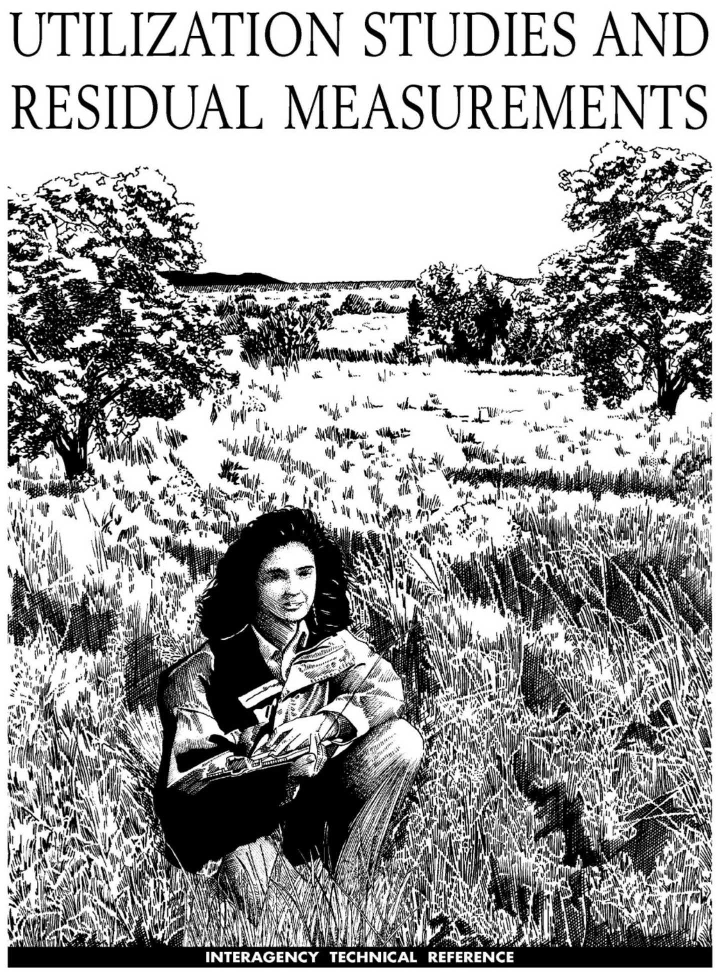

Figure 25. Cover of USDI-BLM (1999b).

Several factors influence how a stream is impacted by alteration and how it will recover from physical disturbance. Stream gradient, streambed material composition, streambank soil composition, vegetation cover and type, channel geometry, and flow rate and timing all influence how a stream responds to alteration (Burton et al. 2011; Dickard et al. 2015). These site specific factors need to be taken into consideration when determining appropriate levels of annual alteration for a particular stream. Stabilizing vegetation, rock armoring or embedded large wood provide streambank stability. Streambanks lacking needed vegetation cover generally are those most affected by streambank alteration; in these cases, management should be designed to promote an increase of stabilizing plant species, and bank alteration may not be an effective measure of chosen strategies to effect this outcome.

When streambank alteration is being used as an annual indicator for livestock grazing impacts it is measured annually after grazing. When other large herbivores or recreationists are contributing to streambank alteration, it is appropriate to measure streambank alteration pre and post livestock use to help understand the causative factor. It is most effective if measured as soon as possible after livestock have been moved from the area so that alteration by livestock can easily be distinguished from natural disturbances by wild ungulates (Burton et al. 2011) and because precipitation events and/or high flows can "wash out" livestock alterations and make them less visible. Although the alteration may not be visible after a precipitation or high flow event, the effect of trampling and/or destabilizing the bank still exists until riparian recovery exceeds bank alteration.

As with all monitoring techniques, in order for data to be valid and useful, practitioners must be adequately trained to collect streambank alteration data. Burton et al. (2011) provide guidance for monitoring streambank alteration and other indicators. Other methods will produce different results.

MONITORING FUEL BREAKS

The creation of fuel breaks can employ a variety of strategies for altering the amount, moisture content, height, and continuity of both herbaceous and woody fuels (The Rangeland Fire Task Force 2015) (Trowbridge et al. 2013; Schmelzer et al. 2014; Bates and Davies 2015; Davies et al. 2015a; Davies et al. 2015b). Fuel breaks may be distinct and obvious such as a mowed or chained strip, or they may be more diffusely located (e.g., an area of targeted, intensive grazing) (Strand et al. 2014).

As with the management of all rangelands, the methodology used to monitor fuel breaks must be able to inform whether or not the implemented strategies are meeting objectives. Short-term monitoring tracks and records the implementation of maintenance treatments and their annual effects on plant community (fuel break) attributes. For example, measuring residual aboveground biomass and fuel height can determine if fuel reduction targets were achieved. Long-term monitoring addresses changes in vegetation composition, that in turn provides insight into resistance, resilience, and wildfire risk. Long-term monitoring can also identify known instances where strategies have been effective in reducing or halting fire spread, or the burning conditions that allowed a fire to cross a fuel break. Tracking efficacy (and fire conditions) can inform managers about future strategies regarding such things as break width, fuel removal, species composition, resistance to flammable species, and other fuel break characteristics.

Section Summary

All of the aforementioned short-term monitoring tools are used to indicate effects from the management applied in that year. These data address conformance with the grazing plan. To adjust management, consider all the grazing management tools, season, duration, rotation, and intensity of use to meet objectives. Adjustments in stocking rate alone seldom resolve grazing management issues. Short term monitoring data should not ordinarily be used as long-term goals or objectives. However, residual or total vegetation height or cover may be a guide for management in specific seasons for specific situations tied to objectives.

MONITORING METHODS— LONG-TERM OR EFFECTIVE-

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. Hall (2001) provides other useful information in his photo point monitoring handbook. These techniques are also discussed in the photography section of the Ranchers' Monitoring Guide, (Perryman et al. 2006; 2017) and in Appendix G - Remote Sensing to Monitor Rangelands.

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 - Remote Sensing to Monitor Rangelands.

Frequency – Frequency measurements, recording the percentage of plots or quadrats that contain each species, often indicate changes in species composition, density, or dispersion. This quantitative method can be used to assess trend in long-term monitoring. Nested frequency is recommended (BLM 1999a; Elzinga 1998) because of the importance of quadrat size and the need to have frequency data in the mid-range (10-90%) for proper statistical 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).

All vegetation monitoring requires high quality data with no or few errors including correct species identification; taxonomy is especially important for frequency. Failure to differentiate a similar species causes missing and wrong data when using frequency methods, whereas with other measurements (e.g. cover or production), a missed difference between two plant species leads to permanently lumped data (and a lower record of species diversity).

Production – production is the weight of this growing season's plant growth by each species and there are several different methods for measuring or estimating it. Methods include harvest, volumetric, comparative yield, dry weight rank, double sampling, and other 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 – Ecological Sites). Production has been used to describe ecological sites and is often used to describe and assess plant community objectives.

Cover – The cover of plants is the amount of ground surface beneath plant materials (basal, foliar, live, dead, and/or total) or other objects (litter, rocks etc.). Because different methods and decision rules can lead to very different cover numbers for the same vegetation, it is critical to be clear which cover technique is used and to carefully follow the measurement rules (canopy cover, foliar cover, ground cover, and basal cover are defined in the glossary, Appendix M). Species can later be grouped by life form or functional groups.

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

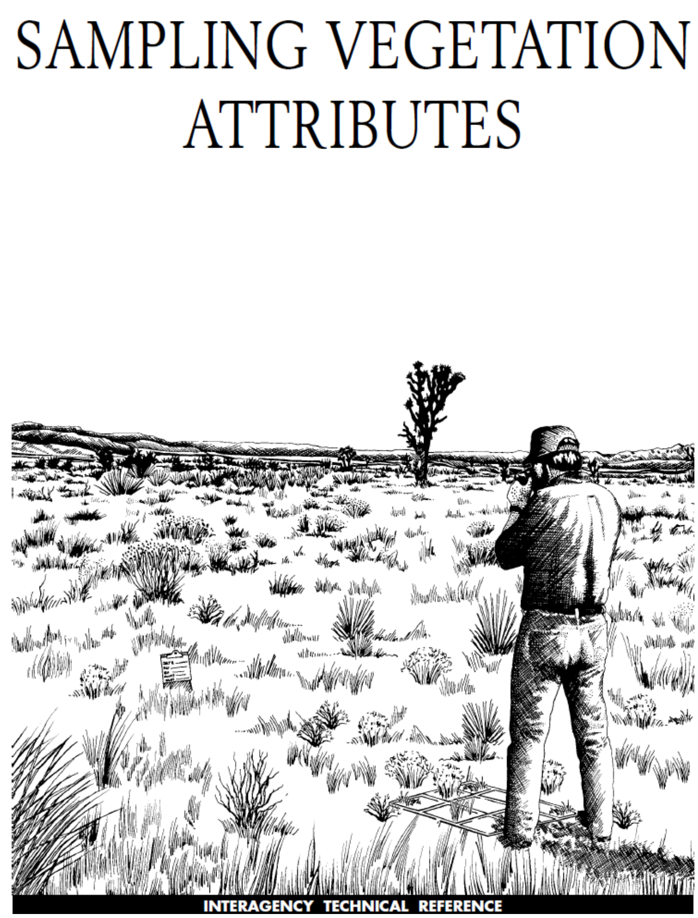

Figure 26. Cover of USDI-BLM (1999a).

conclusions about basal cover should not be made without a large enough sample size to make the sampling statistically valid. The Ground Cover and Canopy Cover Measurements side bar further describes a procedure for obtaining cover data.

Canopy Cover – Canopy cover is the percent of ground covered by a vertical projection of the outermost perimeter of the natural spread of foliage, including small openings. Because of overlapping canopies, it may exceed 100% for the community if data are collected by plant species or functional group. 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, especially for shrubs (e.g., sagebrush line intercept cover has often been used to describe habitat values and make management recommendations (e.g., Rassmussen et al. 2001)). Canopy cover of herbaceous species varies greatly among seasons and years, much more than basal ground cover.

Foliar Cover – Foliar cover is the amount of leaves and stems that could intercept raindrops or provide shade from a vertical sun. Foliar cover is less than canopy cover because it does not include gaps within the canopy. This is measured with line point intercept or any dimensionless point tool such as a pin drop, laser pointer, or other sighting tool. It is being used extensively by the BLM in Assessment, Inventory, and Monitoring (AIM) and by NRCS in National Resources Inventory (NRI).

Basal Cover – Basal cover is the area of the ground surface covered by the basal part of plants. For trend comparisons in herbaceous plant communities, perennial grass basal cover is generally considered to be the most stable. It does not vary as much due to climatic fluctuations or current year grazing (BLM 1999a).

Ground Cover -- is most often referred to as the percentage of ground surface covered by plants, litter, microbiotic crust, rocks, and gravel. Ground cover is an important soil-surface attribute (BLM 1999a and Herrick et al. 2005a&b). It and foliar cover have been most often correlated to rangeland hydrologic function. 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.

Figure 27. Canopy cover is often measured with a stretched measuring tape using either line intercept or line point intercept which is often used for foliar, basal, or ground cover.

Community-Type Transects – The proportion of the area occupied by various community types can be used as the unit of measure (e.g. Winward 2000) in riparian areas, where the number of species is often greater than on uplands, and where many plant species are rhizomatous.. 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 objectives relate to vegetation away from the stream edge.

More commonly, community types or dominance types are monitored along the greenline (Winward 2000; Burton et al. 2011; Perryman et al. 2017) or streamside (Perryman et al. 2006). Stabilizing plants are needed where they can buffer the forces of flowing water and influence erosion and 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 Burton et al. (2011). 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) or greenline (Perryman et al. 2018).

Winward (2000) presents guidelines for setting long-term 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. Rosgen (1996) stream classification or a geomorphic analysis and PFC assessment (Prichard et al. 1998; Dickard et al. 2015) can help locate stream reaches responsive to management and help in setting objectives. 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 (e.g. MIM Burton et al. 2011).

Greenline transects sometimes measure revegetation on pointbars, but will not where the greenline is well above the revegetating pointbar. To capture vegetation trends early in the recovery process, the pointbar may be a place of focus. 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 be misleading if not interpreted in light of intervening flow records.

Greenline-to-Greenline Width – The distance across a creek from the greenline on one side to the greenline on the other side is another way to assess pointbar revegetation and the narrowing of streams (Burton et al. 2011). Very often, problematic riparian

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 exclude small voids, or it 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 or point intercept, it is important to observe enough line length or points to get a reliable estimate. 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 into functional groups. The applicability of grouping by life form depends on the objectives. Also, species data can always be lumped for analysis, but lumped field data cannot later be split. For an additional discussion of cover monitoring see Sampling Vegetation Attributes (BLM 1999a).

Figure 28. Many streams recovering after a change in riparian grazing management narrow in their greenline to greenline width. (Burton et al. 2011).

grazing management weakens streambanks and leads to or perpetuates over-wide channels that reflect poor fish habitat and water quality. When grazing management that enables riparian recovery of functions and values (Wyman et al. 2006; Swanson et al. 2015) is implemented, greenline to greenline width is often the most notable indicator of recovery.

Riparian Shrubs – Winward (2000) and Burton et al. (2011) also describe methods for monitoring woody species abundance, regeneration, and height. Both methods may require some practice in order to collect consistent data (Coles-Ritchie et al. 2004). Riparian shrubs can also be monitored with line intersect or air photos for canopy cover, which can be augmented with height for measurements for canopy volume. Doing this requires careful consideration to match methods with site potential and objectives. Where wildlife habitat considerations warrant, a robel pole can be used to measure visual obstruction at various heights (BLM 1999a).

Streambank Stability – Burton et al. (2011) describe streambank stability for non-depositional streambanks as a combination of cover and stability, versus uncovered and 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 otherwise reflect nonfunctional conditions such as concentrated stream energy after channel incision or other impacts that are not related to grazing management (e.g. altered flow regime, OHV use, etc.).

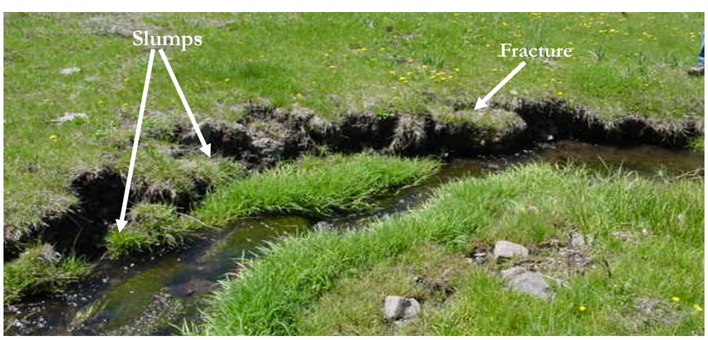

Figure 29. On some streams the instability of banks with slumping or fractures indicate recent incision or weakened riparian root systems (Burton et al. 2011).

Stream Channel Attributes – Stream channel morphology provides habitat features important to fish for hiding or foraging, and also affects channel stability and water quality. Land managers, sometimes monitor stream channel characteristics (e.g., width/depth ratio, depth, or pool quality) for improvement or degradation from management actions. However, the driver of channel attributes is usually riparian functionality (Dickard et al. 2015) especially greenline vegetation. Monitoring vegetation with MIM (Burton et al. 2011) provides more timely and sensitive data for detecting change in relation to management. Also, it is important to recognize that desired channel attributes differ among species needing habitat. Some desert spring fish and amphibians evolved with high levels of disturbance and may require different habitat characteristics than commonly associated with good habitat for others (Kodric-Brown and Brown (2007).

Stream Survey – The General Aquatic Wildlife Survey (GAWS) (USFS 1985) and BLM Stream Survey (Elko BLM 2002) 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 objectives because they combine numerous variables representing a variety of factors into one index. Index improvement is only partially tied to specific management actions or plans. An index may not change while two or more of the index's components change measurably, some increasing and others declining. Combining understanding of process, developed through riparian proper functioning condition assessment with the quantification from stream surveys leads to greater utility from both data sets. Multiple indicator monitoring (MIM) uses many more independent plots and provides a much more sensitive measure of change through time at a location (Burton et al. 2011).

Water Quality – BLM and the FS comply with the Clean Water Act (and in places, 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 BLM and FS, addressing authorities and protocols for water quality monitoring. Water quality data should be interpreted carefully because it often does not reflect current or on-site management, but rather a combination of uncontrollable watershed and upstream factors such as geology, climate, channel geomorphology and stream dynamics, etc.

Where there are water quality problems, it is best to determine the underlying causes and to manage and monitor accordingly. For example, streams that have poor water quality are often not functioning properly. Managing and monitoring for stabilizing riparian vegetation is usually the most effective way to address rangeland water quality problems unless they are caused by a discrete source of contaminants (Kozlowski et al. 2013; Swanson et al. 2017). Riparian vegetation improvements occur faster than improvements to stream channels, which occur quicker than changes in water quality but which also drive desired changes in water quality (Wyman et al. 2006).

The Nonpoint Source Management Program of the NDEP has worked with the Nevada Creeks and Communities Team to support the use of PFC (Dickard et al. 2015) grazing management practices and riparian habitat restoration (NDEP 2015). Riparian concepts are embraced throughout the 2015 -2019 Nevada Nonpoint Source Management Plan.

Canopy Gap Intercept -- Canopy gap intercept measurements provide information about the proportion of soil surface in large intercanopy gaps. Large gaps between plant canopies have the potential to facilitate wind erosion and invasive species establishment. As vegetation height increases, the gap size that allows wind erosion also increases. Canopy gap is measured along a line-intercept transect. For the National Resources Inventory Protocol – canopy occurs any time >50 percent of any 0.1 ft. tape edge intercepts live or dead perennial or annual plant material based on a vertical projection from canopy to ground. Canopy gap is an area along the tape edge that is absent of any plant canopy if the gap is 1.0 foot (30 cm) or greater in width (MacKinnon et al. 2011) . Perennial gaps can also be measured - all annuals are excluded as a gap disrupter. The length of each gap is calculated, and the sum of the lengths is divided by the transect length to obtain the proportion of soil surface in large intercanopy gaps. Number of gaps in various gap-size-length groups and distances between gaps are also useful. Appropriate gap size varies by ecological site, state, and phase. The management interpretations differ widely among areas. Therefore, gap size should not be used independently of other vegetation measurements.

Plant Density -- Plant density is the number of individuals of a species, or of each species, per unit area. Density measurements can be used to track population response to treatments such as weed control, seeding establishment (or success through time), or enhancement strategies for key species. Density measurements may address an entire population with a total count, if small in size and area. Usually, density measurements track an area with a

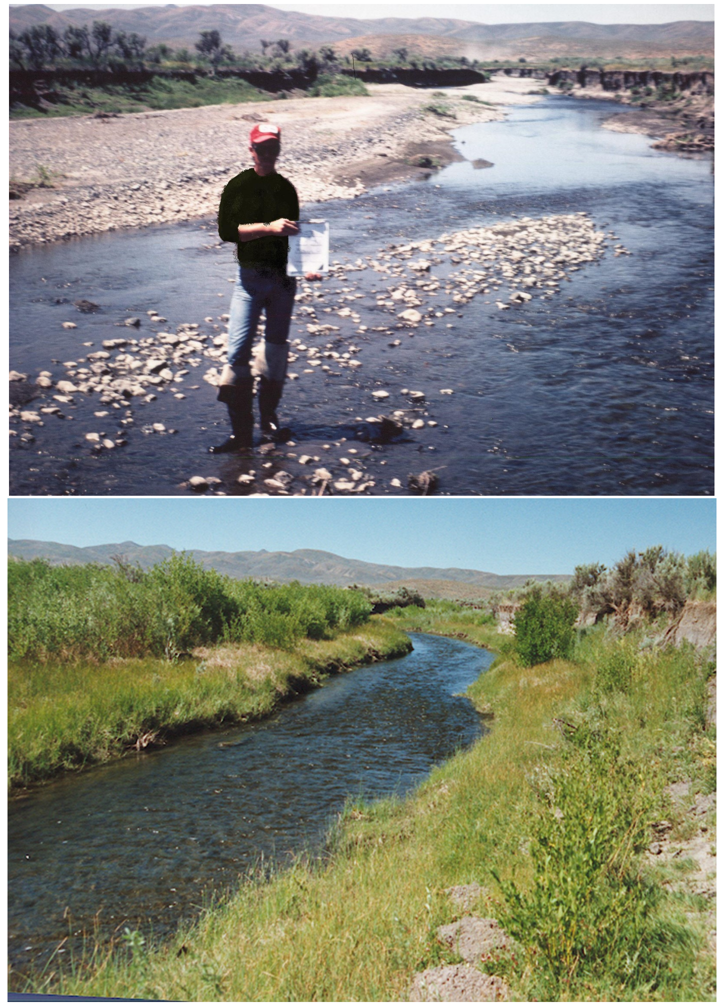

Figure 30. Many streams that do not meet water quality standards or that could meet water quality goals at a higher level have been impacted by loss of riparian functions and regaining functions can recover water and aquatic habitat quality such as happened on Maggie Creek (Kozlowski et al. 2013).

Figure 31. Canopy gap measurements provide indications of susceptibility to wind erosion and invasive species.

sampling protocol, using multiple quadrats or one or more belt transects. Population dynamics can be tracked by noting or counting by age or size classes of woody plants or perennials (Elzinga 1998, BLM 1999a, Winward 2000; Burton 2011). Density varies by ecological site, state, phase, plant size, and population size structure. The management interpretations differ widely among areas. Therefore, density should not be used independently of other vegetation measurements.

Vegetation Height -- Vegetation height describes the vertical structure of vegetation, which can be used to characterize wildlife habitat, model fuels, and estimate wind erosion. This method is a fast and unbiased way to measure vertical structure of vegetation. When used together with the proportion of the soil surface in large intercanopy gaps, it can be used to create three-dimensional models of vegetation structure. For the NRCS NRI and BLM AIM protocols, the height of a leaf, stem or seed head (non-stretched and living or dead) of woody and herbaceous plants within a 6-inch radius is recorded at selected points at fixed intervals along a transect. If vegetation is taller than 10 feet, a standard tape and clinometer method is used to estimate vegetation height.

Forb Abundance and Diversity – Forbs are valuable in the diets of many herbivores and often support pollinators. Forb diversity, or any species diversity, can be evaluated with a variety of species composition metrics (species list, cover, density, production, frequency) and evaluated using various diversity indices. However, all diversity is not equally useful (e.g. noxious weeds). Sage-grouse chicks depend on select protein-rich forbs for growth and development until fall when they switch to a diet of mostly sagebrush. The Habitat Assessment Framework (HAF) (Stiver et al. 2015) provides specific methods for monitoring forb abundance and diversity in sage-grouse habitats.

Figure 32. Measurements of forb density, species diversity, or forb cover often are taken in sage-grouse late brood rearing habitat where riparian soil moisture keeps protein rich forbs green after upland forbs have dried out in the normally dry summers of the western and northern Great Basin.

Figure 33. A diversity of riparian forbs provides a choice to cage-grouse chicks.

SECTION SUMMARY

Long term monitoring tracks accomplishment of objectives to understand the appropriateness of management; therefore, there must be strong connection between the methods chosen and the SMART objectives. These objectives must be measured in appropriately selected key areas that reflect the opportunity for management to achieve the desired outcome. Long-term monitoring information is supported by, but not replaced by short-term monitoring.

DETECTING PATTERS 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 – Ecological Sites.) Although such changes can be detected or tracked with many individual plots, it is often more efficient to track landscape patterns with photos, or other remotely sensed imagery, or maps. 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. GIS software can be used in concert with remotely sensed data to capture, analyze and produce raster data sets that contain metrics of change across landscapes. Stereo coverage is desirable (Appendix G – Remotes Sensing to Monitor Rangelands).

Weed Maps – Maps of weed inventories can show patterns of dispersal. They help identify vectors and track the long-term control or expansion of individual populations. Maps can also be used with sampling to document weed density or weed control treatments. The value of these maps depends on the accuracy and completeness of the weed inventory data. Weed maps, (point locations or patch polygons), 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 and readily accessible database the structured and random observations of agency personnel, ranchers, cooperative weed management group employees or volunteers, the public, and other land users. To accomplish this, the Nevada Department of Agriculture encourages all users to enter observations of noxious and invasive weeds into a smart phone application named EDDMaps (https://www.eddmaps.org/). The EDDMaps application has an integrated photo library.

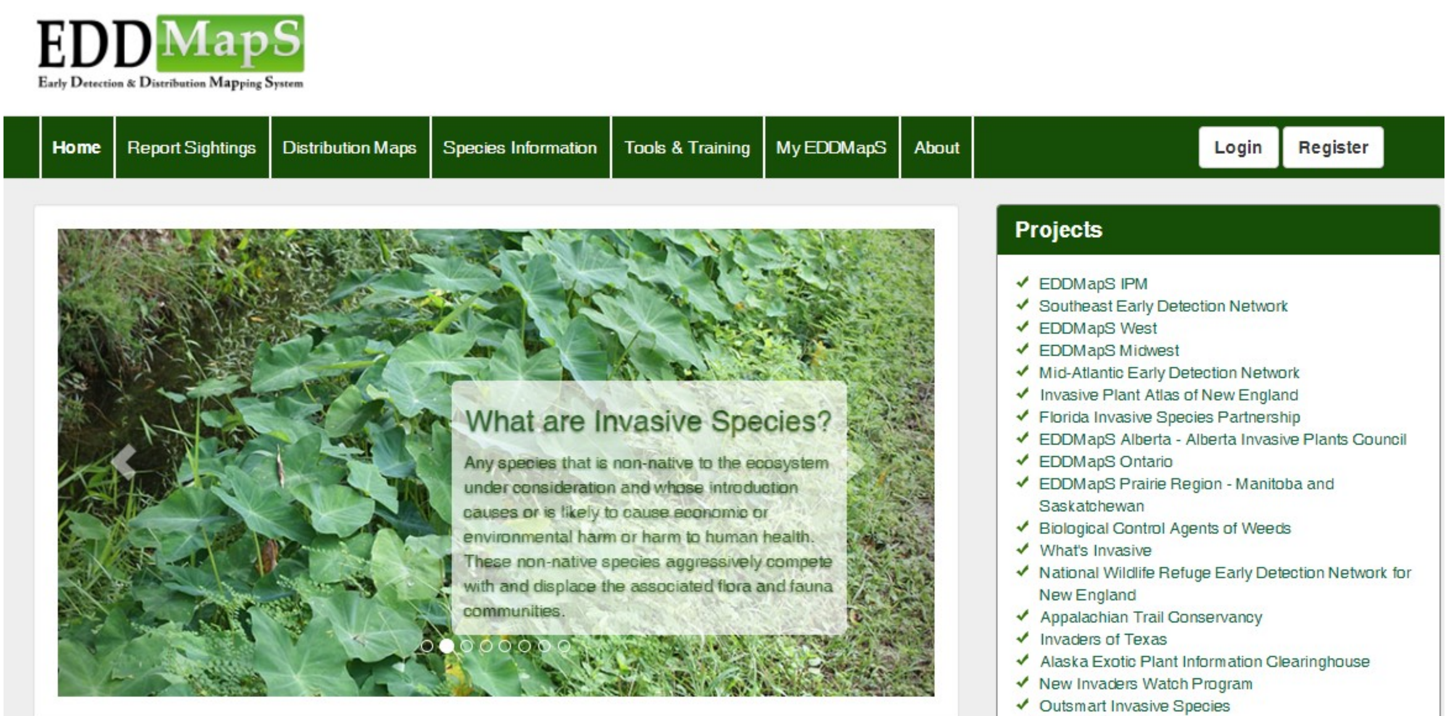

Figure 34. The Eddmaps App. Supported by Nevada Department of Agriculture has been used across Nevada to map weed distributions.

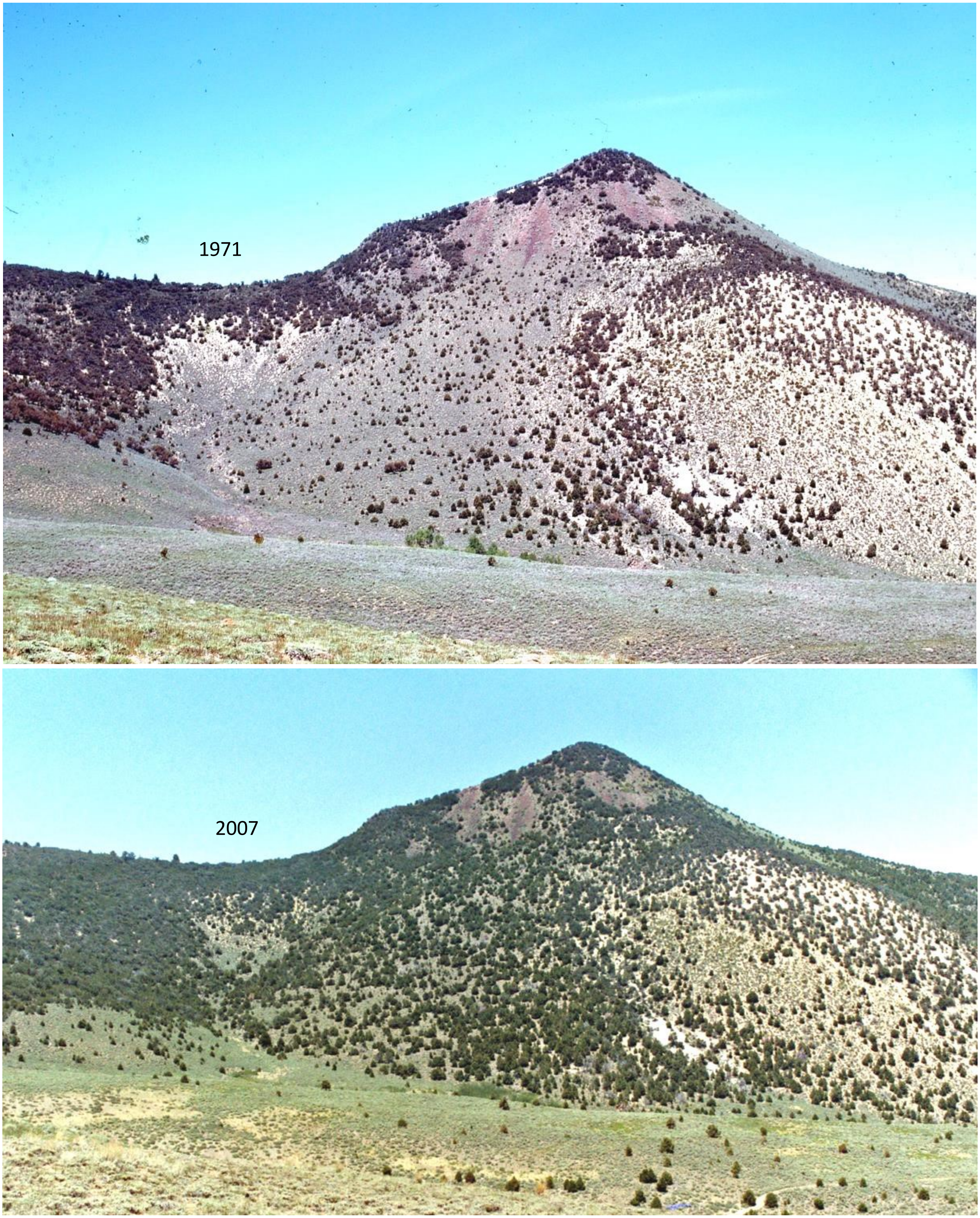

Figure 35. This photo pair taken by Robin Tausch in 1971 and 2007 in the Shoshone Range has helped many people understand the consequences of altered fire regimes and pinyon Juniper encroachment.

SUPPLEMENTAL TECHNIQUES AND INFORMATION

Supplemental information and techniques can be used to help interpret short- and long-term monitoring data and benefit decision making and management outcomes. Supplemental information may include anything needed to explain or interpret short or long-term data. Examples include identifying forage use by different species, recording plant phenology during the period animals graze a management unit, monitoring fire and insect-outbreak phenomenon, examining 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 (elk, mule deer, bighorn sheep, pronghorn antelope, wild horses, and burros). Population outbreaks of lagomorphs (rabbits and hares) and ground squirrels can be significant and can have substantial effects that should be documented when they occur.

Large herbivore (wild, feral, and domestic) interactions in a rangeland setting are complex. They vary depending upon ecological site, 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.

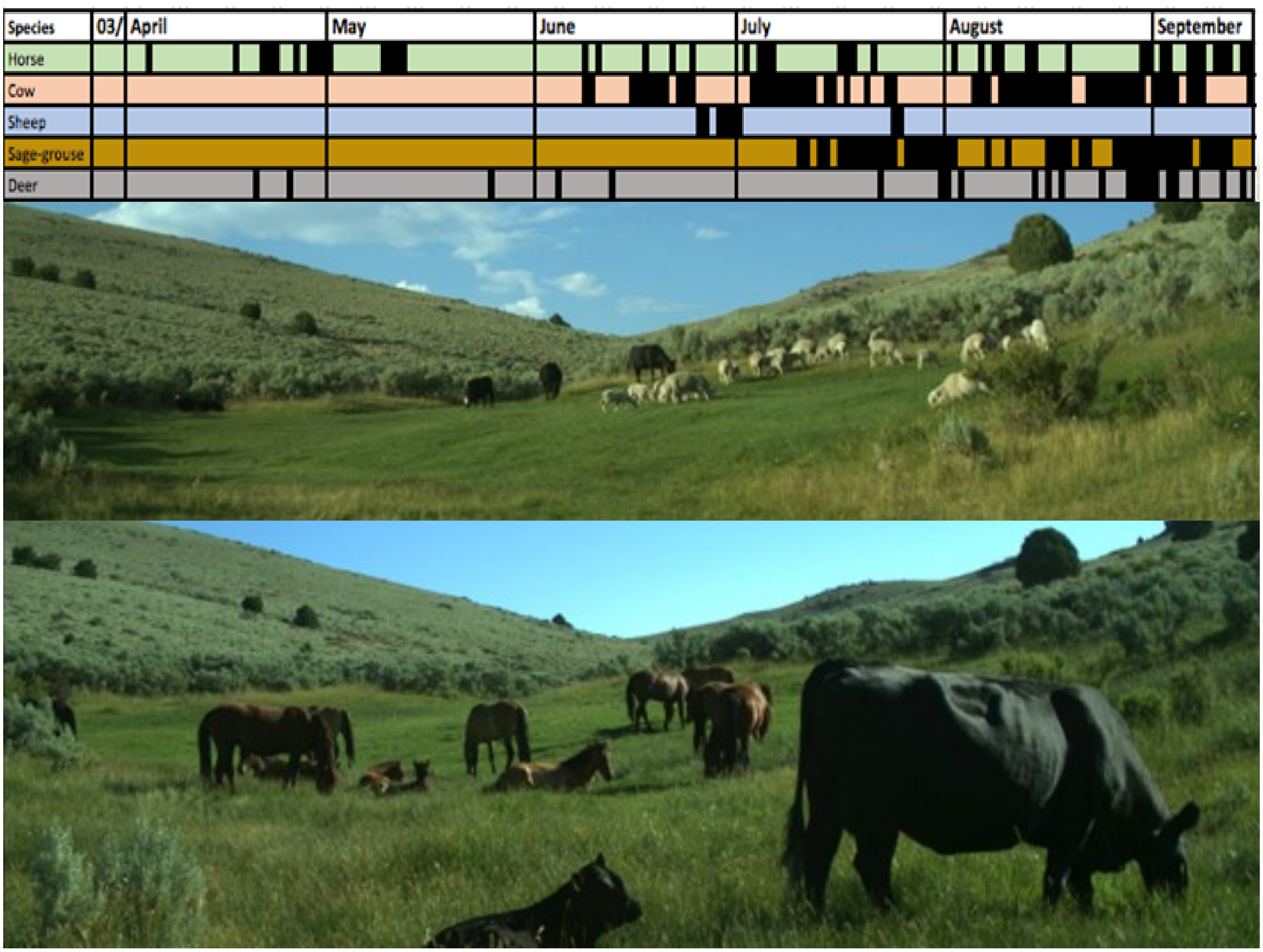

Figure 36. Riparian meadows attract many species of ungulates and finding a way to sort out use by different grazers is important for identifying management needs and tracking management strategies.

Monitoring of all large herbivore use requires similar information regarding effects of use (utilization, streambank 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 (or much shorter periods), 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 (e.g. sage-grouse seasonal habitat requirements). Objectives in the management plan determine the attributes to monitor over the short-term and long-term. 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 animal 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). Properly timed movement of utilization cages is necessary to calibrate measurements within each year and at different times of the year. 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. Because of the importance of moving utilization cages at correct times, discuss cage placement for cooperative permittee monitoring and consider having the rancher be responsible for the moving. Many ranchers may want to build their own utilization cages and take care to place them at times and in places (key areas) where they will be most useful for future utilization monitoring and management discussions.

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 controlled to a large degree by precipitation (seasonal distribution and event size and frequency) and temperature, plants can be used as indicators of differences in growing conditions. Phenological data are helpful for understanding monitoring observations and measurements. Observations of the growth stage(s) when forage species are defoliated (especially critical growth stages such as the boot stage and flowering of grasses) can help explain or predict the response of the key and non-key species in a management unit. Plants respond to grazing quite differently when defoliated at different growth stages.

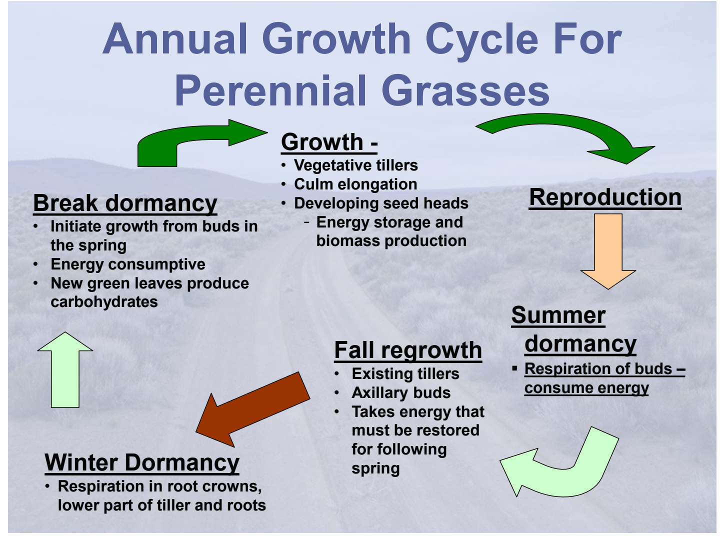

Figure 37. Each phenological stage of plant growth has different physiological needs that must be met to ensure the plant and its individual units survive and are capable of producing new parts the following spring or growth period.

Fire-Related Monitoring – When fire occurs on rangelands, management should be adjusted accordingly. Monitoring programs 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 – Ecological Sites)) 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.

Figure 38. Rangeland fires have been recognized as a very significant threat to sagebrush and sage-grouse habitats.

Post-fire monitoring includes fire effects, treatments, and follow-up management. Burned areas, especially small ones, often attract use by wildlife, wild horses and burros, and/or livestock. Mapping this use can help explain patterns of recovery or lack thereof. One of the most important burned area observations to record/map is the location of unburned islands and/or the survival of herbaceous perennials and important shrubs. Post fire rehabilitation and stabilization treatments should be well documented including actual location, seed mixes, effective seeding rate, methods used, weather and other data/information that may help explain a post-fire management actions success or failure. Post-fire monitoring measures vegetation response and movement toward desired plant communities. Adaptive management is crucial to achieve desired results.

<u>Exclosures and Comparison Areas</u> – Exclosures are customarily used for visual observation and studies to compare vegetation change under adjacent grazed and ungrazed conditions. Exclosures protect the plant community from livestock (and sometimes wildlife) grazing but permit exposure to other processes (drought, wildfire, insects, and some herbivory, etc.) experienced by the grazed area. These are very different from utilization cages that must be moved to accurately represent un-grazed current year's plant growth in the embedded grazed plant community. Exclosures and comparison areas are each placed in a fixed location.

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 objectives or monitoring species composition and trend. The history and location of these areas should be documented. Examples of comparison areas may include: Areas protected from domestic livestock grazing because of inaccessibility or lack of water; Sites with high ecological status, resilience, and resistance to transitioning across a threshold.

Large exclosures, old cemeteries, or other areas that have been protected from livestock grazing for several years or decades. (These areas can give useful information, but they can also be misleading because of the effects of local micro-environment, weather conditions, past disturbances, vegetation stagnation or altered fire regime or fire effects (Davies et al. 2016).

Figure 39. Vast expanses of annual vegetation may represent having crossed an ecological threshold that forces refocusing management strat-egies and rewriting objectives.

Figure 40. the edge of riparian or other exclosures may represent areas of concentrated use that are not representative or areas farther away.

Figure 41. When areas out side exclosures are managed well, they may not look much different, or exclosures may show an abundance of thatch, fuel, or other indicators of their lack of use.

Grazing Response Index (GRI) – This tool combines several components of a grazing strategy, frequency of defoliation, intensity of use (utilization), and opportunity for growth or regrowth. The grazing response index in the Ranchers' Monitoring Guide (Reed et al. 1999; Perryman et al. 2006; 2017: Wyman et al. 2006) may be very useful as a planning tool or to help interpret multiple data sources such as actual use records, notes about phenological stage or the time of the growing season when grazing occurred, and utilization or residual vegetation data.

It must be stressed that the grazing response index is most applicable and useful to both livestock and land managers as a planning tool, providing valuable information for adaptive management. GRI is not, and should not be, used as an objective or a standard. It may provide confidence that grazing within an existing permit is providing the management needed to enable plant growth and riparian or upland range recovery or health.

The grazing response index could easily be augmented with an additional planning tool considering variation in use period between or among years (Swanson et al. 2015). An area grazed in a different season from last year could be rated +1. Use in the same period could be rated -1, and use in a similar season but different phenology stage could be rated as 0 or neutral in affect. Also, some other index could be developed to evaluate the application of important strategies for management to encourage plant growth or to reach objectives.

Grazing Response Index

Frequency —The number of times a preferred plant is defoliated during active growth, based on duration of grazing during a growing period

One Defoliation	+1
Two defoliations	0
Three or more	-1

Intensity — Leaf material remaining for growth

Light intensity > 65% remaining	+1
Moderate 50-64% remaining	0
Heavy intensity <50% of leaf remaining	-1

Opportunity — For growth or regrowth

Full season to grow	+2
Most of the season	+1
Some chance	0
Little chance	-1
No chance	-2

Total provides a positive, neutral, or negative rating of grazing impacts for the year.

Apparent Trend – Trend is the direction of change in an attribute over time (Bedell 1998; NRCS 2003). Apparent trend refers to one-time observations of soil and vegetation conditions on rangelands. Apparent trend is determined for areas that lack measured trend data or it can be used to supplement measured trend data. It relies on soil and vegetation indicators which make it very similar to the more modern concept of rangeland health assessment (Pellant et al. 2005) described in the Inventory and Assessment of Base Resources section above. Recording apparent trend 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 monitor which attributes (short- and long-term (implementation and effectiveness) monitoring), where, and when, to monitor, and the techniques to be used. Interpretation of the monitoring information provides a basis for adjusting management. An adequate management plan contains a monitoring plan related to objectives and relevant to actions. Appendix K, Form1 provides a monitoring plan template. Appendix K, Form 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. This is similar to the information recorded in the Cooperative Monitoring Agreement template in Appendix A - Cooperative Monitoring.

The Public Lands Council (PLC) and Forest Service (FS) entered into a national memorandum of understanding (MOU) in 2014 (Appendix A- Cooperative Monitoring). The Public Lands Council (PLC) and Bureau of Land Management (BLM) entered into a national memorandum of understanding (MOU) in 2004 and in 2017 to encourage and support cooperative rangeland monitoring between BLM and permittees. The MOU and subsequent BLM Washington Office materials provided guidance for implementing cooperative monitoring. Participation in cooperative monitoring is voluntary for the permittee in compliance with the MOU and guidance in Nevada BLM policy. The USFS did not provide guidance at the Washington Office level, but participation in cooperative monitoring in compliance with the MOU is Humboldt-Toiyabe National Forest policy. Both MOUs are in Appendix-A Cooperative Monitoring.

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. This is where cooperation becomes essential.

A cooperative monitoring plan should be developed jointly with the agency(ies), rancher(s), and possibly others. Typically, a cooperative monitoring plan will outline the resource issues (if any) resource objectives, monitoring methods, and who is responsible for collecting the data, and when, and where data are to be collected. 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 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.

A complete suite of monitoring methods and data would be ideal; however, there are personnel, time, and budget limitations. These limitations require focus on the essential information needed for adaptive management. The focus on efficiency and effectiveness requires the participation of key people with a shared commitment to the objectives and monitoring plan, including interpretation.

Appendix A- Cooperative Monitoring 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 Memorandum on Cooperative Monitoring with modifications to meet FS needs

Figure 42. Agee Smith and the Shoesole Holistic Management Team tours the Cottonwood Ranch and two other ranches each year to discuss their goals strategies and results.

INTERPRETATION AND USE OF MONITORING DATA

Monitoring data must be interpreted and used to track progress toward objectives. This interpretation should be conducted by those directly involved in planning and implementing management. This includes the landowner or management agency and the on-the-ground people doing the management. For livestock grazing management this includes the permittee or the cow-boss. Monitoring data can help identify linkages among conditions, objectives, and management within the management unit. It can be used as evidence to support 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. Consider the effects of management actions on resource and economic conditions and values;
2. Consider the effectiveness of management actions in achieving objectives within the planned timeframes;
3. Support management actions, or if necessary their modification; and
4. Periodically review the validity of objectives;
5. Informs and educates resource managers for ongoing adaptive management.

Monitoring is an integral component of adaptive resource management, and is not an end in itself. If monitoring data are not used for these purposes, rangeland managers are not managing properly. Successful management requires collection of high quality monitoring data and appropriate interpretation of all data including ancillary information (notes, photos, observations, etc.) within the context of the management unit.

Monitoring is an integral component of adaptive resource management

Figure 43. For adaptive management to work, long-term monitoring must address risks, opportunities, and objectives while short-term monitoring must address strategies for management.

APPENDIX A - COOPERATIVE MONITORING

If you are a permittee, contact your BLM or FS 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. In October of 2014, Tom Tidwell, the Forest Service Chief, and Brenda Richards, President of the Public Lands Council signed a Memorandum of Understanding (below) to "document the cooperation between parties to encourage, promote, and increase allotment level monitoring on National Forest System (NFS) lands." On September 22, 2017, John Ruhs, Acting BLM Deputy Director and Dave Eliason, President of the Public Lands Council, signed a Memorandum of Understanding (below) to "establish an updated framework for cooperative monitoring and the exchange of information on rangelands administered by the BLM." Instruction memoranda may be developed to help implement the cooperative monitoring MOUs.

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," 1999a; and TR-1734-3, "Utilization Studies and Residual Measurements," 1999b. (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 FS 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 a while 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 other's 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 must desire success and achievement of 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.

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 issues will become apparent as cooperative monitoring unfolds.

2. **Make copies** -- Copy 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 for management of the allotment.

3. **Review management and monitoring plans** -- 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 1 and Monitoring Area Form 2 in Appendix K or the Cooperative Monitoring Agreement Template (below) 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. **Tour the allotment** -- The second meeting should be in the field at the monitoring site(s).

Figure 44. In much of Nevada, there is no better way to see management issues, opportunities, and results than from the back of a horse.

SEEK ASSISTANCE

Do not be afraid to ask for help. State office personnel 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.

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 or Cooperative Monitoring Agreement Template and the *Ranchers' Monitoring Guide* (Perryman et al. 2006; 2017) 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 E – Characteristics of Good Objectives.) Objectives identify data requirements, 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(s) or Designated Monitoring Area(s)** – Key areas should be selected and agreed to jointly. (See, Appendix H - Procedures for Selecting Key Areas and Key Species) 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 pertinent areas in 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 H – Procedures for Selecting Key Areas and Key Species). The DMA will focus on an important and specific issue unique to that particular riparian area. 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 H – Procedures for Selecting Key Areas and Key Species) 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 faculty. Take the time and make the effort to establish a plan and set monitoring protocols that you can perform that provide the data required 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: 2017). 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, workloads, budgets, and outside funding. This does not mean that both parties must be together every time that monitoring data are 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; 2017) 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 XX in the *Nevada Rangeland Monitoring Handbook*. Once data are collected, copies of the data must be shared and maintained by all parties of a cooperative monitoring agreement. 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 sites are correct; or if management or monitoring should be modified. Once the analysis and interpretation is made, then a determination of action for the subsequent grazing season must be made. **Analysis and interpretation must be done collaboratively among 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.

BY THE NUMBERS

1. Identify the objective(s) for the allotment.
2. Identify the key area(s) or designated monitoring area(s).
3. Clarify the resource objectives.
4. Affirm, modify, or develop your allotment monitoring plan.

COOPERATIVE MONITORING AGREEMENT TEMPLATE

This Template is based on the Nevada Rangeland Monitoring Handbook, including Appendix A - Cooperative Monitoring and the *Ranchers' Monitoring Guide* (Perryman et al. 2017) which encourages the use of the Nevada Department of Agriculture rangeland monitoring application (___).

1. The permittee_________________ would like to accomplish the following (to address issues and concerns) for the ____________ allotment: ____
   ____
   ____
2. The agency ________________ would like to accomplish the following (to address issues and concerns) for this allotment: ____
   ____
   ____
3. The permittee has copies of the agency files pertinent to this allotment (circle one). **Yes** or **No**
4. The agency has permittee information related to this allotment (photos, history, actual use data by pasture, etc.) (circle one). **Yes** or **No**
5. Both parties have reviewed the existing documents relevant to this allotment (e.g. Allotment Management Plan, monitoring plan, allotment evaluations, land use plan, past agreements. Etc.) (circle one). **Yes** or **No**

   Documents relevant to this allotment: ____
   ____
   ____
6. The most important elements from these documents that must be considered to establish this cooperative monitoring agreement are:____
   ____
   ____
7. Are there elements on these documents that need to be updated? Is so list these elements: ___________
   ____
   ____
8. The (SMART) objectives for this allotment are: ____
   ____
9. The locations for the key areas or designated riparian monitoring areas on this allotment and the key species and how do we expect them to change or not over what time period are: (use ecological site descriptions with their available state and transition models , base line data, field tour discussions, and other pertinent information) (Or attach tables from Appendix K – Monitoring Plan Tables):

   Key Area (name or GPS location) ____

Key species	Baseline	Expectation	Year expected

10. Long-term, effectiveness, monitoring to determine if management is succeeding or not will be conducted as shown below (consider budget, personnel, technical expertise, time commitments, outside help needed, etc.):

Who	Method	Frequency	Location

____

11. The following crucial elements of the management strategy need short-term monitoring (management applied and effects of that management):

____

____

12. Short-term, implementation, monitoring will be used to determine how the management strategy is implemented and its pertinent effects. Methods, where, how often, and when are:

Who What Methods Where When Frequency

____

____

13. We agree to strive for joint monitoring, to at least keep each other informed about dates and locations for monitoring, and to meet at least annually to discuss results and how to use the information to maintain or adjust ongoing management or monitoring.

Authorized permittee name ____

Authorized permittee signature____

Date____________________________________

Authorized agency officer name ____

Authorized agency officer position ____

Authorized agency officer signature ____

Date ____________________________________

Perryman, B., B. Bruce, P. Tueller, S. Swanson B. Schultz, G. McCuin, D. Voth, P. Novak-Echenique. 2017. Rancher's Monitoring Guide 2nd Edition. UNCE Educational Bulletin, 18-XX.

Swanson, S., B. Schultz, P. Novak-Echenique, K. Dyer, G. McCuin, J. Linebaugh, B. Perryman, P. Tueller, R. Jenkins, B. Scherrer, T. Vogel, D. Voth, L. Turner, R. Shane, K. McGowan, 2017. Nevada Rangeland Monitoring Handbook 3rd Edition. UNCE Educational Bulletin, 18-XX .

Insert citations pertinent to this agreement as needed for other specific documents cited above such as RMPs, AMPs, FMUDs, etc.:

USDA, Forest Service | OMB 0596-0217 FS-1500-15

FS Agreement No. 15-SU-11132421-001
Cooperator Agreement No. ____________

MEMORANDUM OF UNDERSTANDING
Between The
PUBLIC LANDS COUNCIL
And The
USDA, FOREST SERVICE
WASHINGTON OFFICE

This MEMORANDUM OF UNDERSTANDING (MOU) is hereby made and entered into by and between the Public Lands Council, hereinafter referred to as "PLC," and the USDA, Forest Service, Washington Office, hereinafter referred to as the "U.S. Forest Service."

Title: Service-wide Memorandum of Understanding on the Cooperative Monitoring Program

I. **PURPOSE:** The purpose of this MOU is to document the cooperation between the parties to encourage, promote, and increase allotment level monitoring on National Forest System (NFS) lands. With this MOU the PLC members that are recognized as livestock grazing permittees on NFS lands would assist to develop and implement a cooperative monitoring program for their assigned livestock grazing allotment(s) on national forests and national grasslands, in accordance with the following provisions.

II. STATEMENT OF MUTUAL BENEFIT AND INTERESTS:

Both the PLC and the U.S. FOREST SERVICE have responsibilities and interests in rangelands management. Monitoring of rangelands is essential to the sustainability of livestock grazing activities on national forests and grasslands. However, cooperative monitoring enhances the working relationship of the parties at the local level when the parties cooperatively acquire, analyze, and approve data collections to assist with creating rangeland management programs that enhance and improve the condition of rangelands. Furthermore, cooperative monitoring would also reduce impacts associated with livestock grazing activities.

The U.S. Forest Service is a natural resource agency dedicated to sustained management of the nation's natural resources with service to people, through its laws and regulations set forth by the Secretary of Agriculture. The U.S. Forest Service strives to restore, maintain, and enhance the condition of rangelands with livestock grazing activities that would sustain, protect, and improve the type and amount of forage plant species. Their opportunity to initiate, promote, and implement cooperative monitoring programs with consenting livestock grazing permittees would contribute immensely towards effectively addressing and resolving rangeland management issues associated with livestock grazing activities through cooperative relationships with PLC membership. At the present time, livestock grazing activities are permitted on NFS lands in approximately 30 states for a variety of permit holders. These are single individuals to several types of legal entities.

The Public Lands Council (PLC) was established in 1968, and represents both cattle and sheep producers. The PLC membership consists of state and national cattle, sheep and grassland associations. Many of their membership hold grazing permits or agreements to graze domestic livestock on public lands. These public lands also include NFS lands that are classified as national forests or national grasslands. The PLC works to advocate for western ranchers who use public lands as a means to provide food and fiber to the nation and the world. Their focus is to preserve natural resources and the unique heritage of the West.

In consideration of the above premises, the parties agree as follows:

III. THE PUBLIC LANDS COUNCIL SHALL:

A. Publicize and support the cooperative rangeland monitoring program among its membership, particularly those authorized to graze livestock on national forests and/or national grasslands.

B. Serve as a liaison to address issues of concern for livestock grazing permittees that arise during the administration of this MOU.

C. Prior to the annual PLC meeting, discuss and provide an update to the U.S. Forest Service for any cooperative activities by their membership that are also recognized as livestock grazing permittees on NFS lands and who voluntarily decided to participate in the cooperative rangeland monitoring program.

D. At the annual PLC meeting, provide an Agenda item to discuss any cooperative monitoring activities that are in progress for their membership with Forest Service livestock grazing allotments.

IV. THE U.S. FOREST SERVICE SHALL:

A. Identify grazing allotments where cooperative monitoring data is currently collected and analyzed with consenting livestock grazing permittees for their assigned allotment(s) on national forests and grasslands.

B. Contact livestock grazing permittees and invite them to participate in the cooperative monitoring program and establish a cooperative rangeland monitoring program for their assigned grazing allotment(s).

C. Encourage, and increase grazing allotments participating in the monitoring program each year, to the maximum extent feasible with available resources.

D. Prior to the annual PLC meeting, discuss and provide an update to the PLC for any cooperative monitoring activities in place with livestock grazing permittees that are also recognized as PLC members and who voluntarily decided to participate in the cooperative rangeland monitoring program.

E. At the annual PLC meeting, participate in the Agenda item discussion that addresses cooperative monitoring activities on National Forest System lands.

F. Work cooperatively with livestock grazing permittees participating in the cooperative monitoring program to develop allotment monitoring plans for their assigned grazing allotment(s). APPENDIX A displays information that was developed to address the cooperative rangeland monitoring program and allotment monitoring plan that would be developed between local Forest Officers and PLC members for their assigned livestock grazing allotment(s).

G. Provide information and updates of rangelands condition changes as it becomes available to the livestock grazing permittees for their assigned livestock grazing allotment(s).

H. Work with other Federal agencies to improve consistency of rangelands management associated with monitoring protocols, data standards, and data management.

I. Reserve the management flexibility to establish priorities that would continue cooperative monitoring activities with livestock grazing permittees.

J. As needed, coordinate with USDA-Natural Resources Conservation Service staff to inquire and provide soil surveys and/or vegetation correlation information for sites involved in cooperative monitoring.

K. Ensure conformance with U.S. Forest Service protocols. The planning, collection and interpretation of monitoring data will be jointly conducted by livestock grazing permittees and local Forest Officers pursuant to the agency's protocols developed to measure forage use and/or indicators of rangeland condition. The Forest Officers may check data collected and presented by the permittee or permittee's representative prior to adopting it. The Forest Officers shall adopt data that meets its Agency standards. In the absence of monitoring by the livestock grazing permittee or a permittee's representative, the Forest Officers will monitor independently using established protocols. The local Forest Officers will decide how to use or interpret monitoring data when there are differences between the data collection entities.

L. Ensure agreement between the livestock grazing permittees and Forest Officers on methods for collecting cooperative monitoring data, which must occur prior to implementing the allotment monitoring plan. The methods to be considered will be based on approved U.S. Forest Service protocols. When differences occur between the data collection entities in the methods to be used, the local Forest Officers will make the decision.

M. Ensure that livestock grazing permittees have the option to seek assistance from other individuals or institutions such as the Cooperative Extension Service and/or consultants for monitoring data collection. Ensure the permittee(s) designate one individual to work with the local Forest Officers. As needed, Forest Officers or Cooperative Extension Service, operating under Interagency Agreements with the U.S. Forest Service, will provide training to the permittees or their representatives for agency approved methods.

N. Ensure this MOU only addresses the interaction between the U.S. Forest Service and PLC, which represents its membership that is also recognized as livestock grazing permittees on National Forest System lands. Further assure, this MOU in no way precludes the involvement of other federal land users or interested publics from participating in the cooperative rangeland monitoring program.

V. IT IS MUTUALLY UNDERSTOOD AND AGREED BY AND BETWEEN THE PARTIES THAT:

A. PRINCIPAL CONTACTS. Individuals listed below are authorized to act in their respective areas for matters related to this agreement.

Principal Cooperator Contacts:

Cooperator Program Contact	Cooperator Administrative Contact
Name: Dustin Van Liew Address: 1301 Pennsylvania Avenue, NW City, State, Zip: Washington, DC 20004 Telephone: 202-347-0228 FAX: 202-638-0607 Email: dvanliew@beef.org	Name: Marci Schlup Address: 1301 Pennsylvania Avenue, NW City, State, Zip: Washington, DC 20004 Telephone: 202-347-0228 FAX: 202-638-0607 Email: mschlup@beef.org

Principal U.S. Forest Service (USFS) Contacts:

USFS Program Manager Contact	USFS Administrative Contact
Name: Annette Joseph Address: USDA Forest Service 1400 Independence Ave, SW Range Mgmt., Mailstop 1153 City, State, Zip: Washington, DC 20250 Telephone: 202-205-1454 FAX: 703-235-0428 Email: ajoseph@fs.fed.us	Name: Altonia Matthews Address: USDA Forest Service 1400 Independence Ave, SW Range Mgmt., Mailstop 1153 City, State, Zip: Washington, DC 20250 Telephone: 202-205-0982 FAX: 703-235-0428 Email: altoniamatthews@fs.fed.us

B. ASSURANCE REGARDING FELONY CONVICTION OR TAX DELINQUENT STATUS FOR CORPORATE ENTITIES. This agreement is subject to the provisions contained in the Department of Interior, Environment, and Related Agencies Appropriations Act, 2012, P.L. No. 112-74, Division E, Section 433 and 434 regarding corporate felony convictions and corporate federal tax delinquencies. Accordingly, by entering into this agreement the cooperator acknowledges that it: 1) does not have a tax delinquency, meaning that it is not subject to any unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or have lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability, and (2) has not been convicted (or had an officer or agent acting on its behalf convicted) of a felony criminal violation under any Federal law within 24 months preceding the agreement, unless a suspending and debarring official of the United States Department of Agriculture has considered suspension or debarment is not necessary to protect the interests of the Government. If cooperator fails to comply with these provisions, the U.S. Forest Service will annul this agreement and may recover any funds cooperator has expended in violation of sections 433 and 434.

C. NOTICES. Any communications affecting the operations covered by this agreement given by the U.S. Forest Service or the PLC is sufficient only if in writing and delivered in person, mailed, or transmitted electronically by e-mail or fax, as follows:

To the U.S. Forest Service Program Manager, at the address specified in the MOU.

To the PLC, at the PLC's address shown in the MOU or such other address designated within the MOU.

Notices are effective when delivered in accordance with this provision, or on the effective date of the notice, whichever is later.

D. PARTICIPATION IN SIMILAR ACTIVITIES. This MOU in no way restricts the U.S. Forest Service or the PLC from participating in similar activities with other public or private agencies, organizations, and individuals. Further, nothing in this MOU requires the U.S. Forest Service or Public Lands Council to notify or include interested public when cooperative monitoring is initiated by the livestock grazing permittee.

E. ENDORSEMENT. Any of the PLC's contributions made under this MOU do not by direct reference or implication convey U.S. Forest Service endorsement of cooperator's products or activities, and does not by direct reference or implication convey the cooperator's endorsement of the FS products or activities.

F. NONBINDING AGREEMENT. This MOU creates no right, benefit, or trust responsibility, substantive or procedural, enforceable by law or equity. The parties shall manage their respective resources and activities in a separate, coordinated and mutually beneficial manner to meet the purpose(s) of this MOU. Nothing in this MOU authorizes any of the parties to obligate or transfer anything of value.

Specific, prospective projects or activities that involve the transfer of funds, services, property, and/or anything of value to a party requires the execution of separate agreements and are contingent upon numerous factors, including, as applicable, but not limited to: agency availability of appropriated funds and other resources; cooperator availability of funds and other resources; agency and cooperator administrative and legal requirements (including agency authorization by statute); etc. This MOU neither provides, nor meets these criteria. If the parties elect to enter into an obligation agreement that involves the transfer of funds, services, property, and/or anything of value to a party, then the applicable criteria must be met. Additionally, under a prospective agreement, each party operates under its own laws, regulations, and/or policies, and any Forest Service obligation is subject to the availability of appropriated funds and other resources. The negotiation, execution, and administration of these prospective agreements must comply with all applicable laws

Nothing in this MOU is intended to alter, limit, or expand the agencies' statutory and regulatory authority.

G. USE OF U.S. FOREST SERVICE INSIGNIA. In order for the PLC to use the U.S. Forest Service insignia on any published media, such as a Web page, printed publication, or audiovisual production, permission must be granted from the U.S. Forest Service's Office of Communications. A written request must be submitted and approval granted in writing by the Office of Communications (Washington Office) prior to use of the insignia.

H. MEMBERS OF U.S. CONGRESS. Pursuant to 41 U.S.C. 22, no U.S. member of, or U.S. delegate to, Congress shall be admitted to any share or part of this agreement, or benefits that may arise therefrom, either directly or indirectly.

I. FREEDOM OF INFORMATION ACT (FOIA). Public access to MOU or agreement records must not be limited, except when such records must be kept confidential and would have been exempted from disclosure pursuant to Freedom of Information regulations (5 U.S.C. 552).

J. TEXT MESSAGING WHILE DRIVING. In accordance with Executive Order (EO) 13513, "Federal Leadership on Reducing Text Messaging While Driving," any and all text messaging by Federal employees is banned: a) while driving a Government owned vehicle (GOV) or driving a privately owned vehicle (POV) while on official Government business; or b) using any electronic equipment supplied by the Government when driving any vehicle at any time. All cooperators, their employees, volunteers, and contractors are encouraged to adopt and enforce policies that ban text messaging when driving company owned, leased or rented vehicles, POVs or GOVs when driving while on official Government business or when performing any work for or on behalf of the Government.

K. PUBLIC NOTICES. It is the U.S. Forest Service's policy to inform the public as fully as possible of its programs and activities. The PLC is encouraged to give public notice of the receipt of this agreement and, from time to time, to announce progress and accomplishments. Press releases or other public notices should include a statement substantially as follows:

> "Rangelands Management and Vegetation Ecology of the U.S. Forest Service, Department of Agriculture, Washington Office, concurs to encourage, promote, and increase allotment level monitoring on National Forest System (NFS) lands for both national forests and grasslands."

The PLC may call on the U.S. Forest Service's Office of Communication for advice regarding public notices. The PLC is requested to provide copies of notices or announcements to the U.S. Forest Service Program Manager and to The U.S. Forest Service's Office of Communications as far in advance of release as possible.

L. U.S. FOREST SERVICE ACKNOWLEDGED IN PUBLICATIONS, AUDIOVISUALS AND ELECTRONIC MEDIA. The PLC shall acknowledge U.S. Forest Service support in any publications, audiovisuals, and electronic media developed as a result of this MOU.

M. NONDISCRIMINATION STATEMENT – PRINTED, ELECTRONIC, OR AUDIOVISUAL MATERIAL. The PLC shall include the following statement, in full, in any printed, audiovisual material, or electronic media for public distribution developed or printed with any Federal funding.

> ***In accordance with Federal law and U.S. Department of Agriculture policy, this institution is prohibited from discriminating on the basis of race, color, national origin, sex, age, or disability. (Not all prohibited bases apply to all programs.)***
>
> **To file a complaint of discrimination, write USDA, Director, Office of Civil Rights, Room 326-W, Whitten Building, 1400 Independence Avenue, SW, Washington, DC 20250-9410 or call (202) 720-5964 (voice and TDD). USDA is an equal opportunity provider and employer.**

If the material is too small to permit the full statement to be included, the material must, at minimum, include the following statement, in print size no smaller than the text:

> ***"This institution is an equal opportunity provider."***

N. TERMINATION. Any of the parties, in writing, may terminate this MOU in whole, or in part, at any time before the date of expiration.

O. DEBARMENT AND SUSPENSION. The PLC shall immediately inform the U.S. Forest Service if they or any of their principals are presently excluded, debarred, or suspended from entering into covered transactions with the federal government according to the terms of 2 CFR Part 180. Additionally, should the PLC or any of their principals receive a transmittal letter or other official Federal notice of debarment or suspension, then they shall notify the U.S. Forest Service without undue delay. This applies whether the exclusion, debarment, or suspension is voluntary or involuntary.

P. MODIFICATIONS. Modifications within the scope of this MOU must be made by mutual consent of the parties, by the issuance of a written modification signed and dated by all properly authorized, signatory officials, prior to any changes being performed. Requests for modification should be made, in writing, at least 30 days prior to implementation of the requested change.

Q. COMMENCEMENT/EXPIRATION DATE. This MOU is executed as of the date of the last signature and is effective through September 30, 2019 at which time it will expire.

R. AUTHORIZED REPRESENTATIVES. By signature below, each party certifies that the individuals listed in this document as representatives of the individual parties are authorized to act in their respective areas for matters related to this

MOU. In witness whereof, the parties hereto have executed this MOU as of the last date written below.

Brenda Richards — 10-21-14

BRENDA RICHARDS, President — Date
Public Lands Council

Thomas L. Tidwell — 11/20/14

THOMAS L. TIDWELL, Chief — Date
U.S. Forest Service

The authority and format of this agreement have been reviewed and approved for signature.

W S Mitchell Jr — 10/8/14

WILLIS S. MITCHELL, JR. — Date
U.S. Forest Service Grants & Agreements Specialist

APPENDIX A

Cooperative Rangeland Monitoring Program
{Service-wide Memorandum of Understanding}

Allotment Monitoring Plan

The following items should be considered when developing an allotment monitoring plan with livestock grazing permittee(s) on National Forest System lands that are also recognized as Public Lands Council members and who voluntarily decided to participate in the cooperative rangeland monitoring program.

It is not intended for this list to be inclusive or absolute. Local considerations must be factored when jointly preparing the allotment monitoring plan with the permittee(s). The monitoring plan will be considered a dynamic document. The monitoring plan must also be reviewed and modified as necessary when new information becomes available. Consideration will be given to incorporating the allotment monitoring plan into the Allotment Management Plan. As such, the allotment monitoring plan should then be reviewed each year, during annual permittee meetings and prior to development of the Annual Operating Instructions.

Monitoring Plan Elements:

1. State clearly the resource objectives that will serve as the basis for selecting the attributes to be monitored. Resource objectives should be similar to those objectives in the Forest's Land and Resource Management Plan, Biological Opinions, and Allotment Management Plan, etc.

2. Describe and agree upon the locations, timing, attributes to be measured, and protocols to be used for short-term (implementation) and long-term (effectiveness) monitoring. Items to consider are as follows:

    a. Utilization or residual measurement
    b. Vegetation production
    c. Erosion indicators
    d. Ground cover
    e. Species composition
    f. Livestock use patterns
    g. If available, incorporate information from Ecological Site descriptions.

3. State the grazing and other resource standards that are required to be met and make clear which monitoring protocols will be used to measure the standards.

4. If available, include a summary of prior inventories, monitoring data, stocking records, climatic records, photographs, livestock use patterns, etc.

5. Allotment monitoring data collection should be collected in a manner that is repeatable, and as quantitative as practical.

MEMORANDUM OF UNDERSTANDING

Between

The U.S. Department of the Interior, Bureau of Land Management

And

The Public Lands Council

This Memorandum of Understanding (MOU) replaces the 2004 MOU, as previously extended, between the Public Lands Council (PLC) and the Department of the Interior (DOI), Bureau of Land Management (BLM) that established a framework for cooperative rangeland monitoring.

STATEMENT OF PURPOSE

The purpose of this MOU is to establish an updated framework for cooperative monitoring and the exchange of information on rangelands administered by the BLM. The MOU strives to create opportunities for consultation and coordination of rangeland stewardship, through joint, cooperative monitoring at the pasture, allotment, watershed or landscape levels.

The signatories to this MOU agree that cooperative monitoring on BLM-administered public rangelands provides mutual understanding, exchange of information, and collaboration for the inter-dependent goals and interests of the private sector served by PLC, while assisting the BLM to make integrated rangeland management decisions.

SHARED VISION

Both the BLM and the PLC have a common objective of utilizing science-based monitoring to evaluate, achieve, and sustain desired rangeland conditions. In addition, the BLM and grazing permittees, lessees, and cooperators benefit from the exchange of information when monitoring data is collected, analyzed, and interpreted in a transparent and candid setting. This MOU creates resource management efficiencies that benefit the BLM by using the current, historic, operational, and practical experience of grazing operators while simultaneously benefitting PLC members by creating a straightforward setting for sharing data analysis results, biological concepts, and professional judgements made by BLM rangeland resource professionals.

ESTABLISHMENT OF RESPONSIBILITY

This MOU is not intended to, and does not create any right, benefit or trust responsibility, substantive or procedural, enforceable by law or equity, by a party against the United States, its agencies, its officers, or any person.

The BLM, PLC, and all cooperative monitoring parties under this MOU will comply with the Federal Advisory Committee Act (FACA), to the extent it applies.

AUTHORITY

Section 307(b) of the Federal Land Policy and Management Act of 1976, 43 U.S.C. 1737(b), authorizes the Secretary, subject to the provision of applicable law, to enter into contracts and cooperative agreements involving the management, protection, development, and sale of public lands.

Section 4 of the Public Rangelands Improvement Act of 1978, U.S.C. 1903(a), authorizes "*...the Secretary of Interior and Secretary of Agriculture [to] update, develop (where necessary) and maintain on a continuing basis thereafter, an inventory of range conditions and record of trends of range conditions on the public rangelands, and shall categorize or identify such lands on the basis of the range conditions and trends thereof as they deem appropriate.*"

GENERAL RESPONSIBILITIES

The PLC and the BLM will jointly:

1. Work together to inform public land permittees/lessees and BLM employees of the content and purpose of this MOU.

2. Encourage respective local members (permittees and lessees) and BLM employees to share monitoring information and data between livestock permittees/lessees and the BLM. Emphasis will be on short-term monitoring to guide season-of-use, stocking, compliance and annual allotment decisions in a collaborative setting, but actions taken under this MOU may also include long-term monitoring.

3. Work together to seek to promote, achieve, and maintain healthy rangelands in accordance with the BLM's Rangeland Health Standards.

The Public Lands Council will, as appropriate:

1. Publicize and otherwise support joint, cooperative monitoring among its members, including emphasis of monitoring across landownership boundaries, and in the context of the larger landscape, where practical.

2. Encourage livestock permittees and lessees to work cooperatively with the BLM to develop a monitoring plan which, at a minimum, addresses those items outlined in Appendix A (attached).

3. Work with the BLM to emphasize and implement consistent use of monitoring protocols or methodologies between PLC members and cooperators and the BLM.

4. Include a discussion between the PLC and the BLM on cooperative monitoring as an agenda item at each annual PLC meeting.

5. Provide participation information by members and cooperators. This information will be made available to BLM employees and PLC members to evaluate the level of cooperation achieved between the parties, as provided for under this MOU.

The Bureau of Land Management will:

1. Continue working with livestock permittees and lessees who have actively participated with the BLM in collecting and/or analyzing monitoring data. The BLM will survey previously active monitoring partners to assess their ongoing interest in conducting joint, cooperative monitoring.

2. Work with all interested parties, including permittees and lessees new to cooperative monitoring, to collaborate on cooperative monitoring to the maximum extent feasible within limits of available funds and BLM priorities.

3. Work cooperatively with the livestock permittees and lessees to develop monitoring plans. The plans should address those items outlined in the Appendix A for the public land portion of their operation, at minimum.

4. Involve permittees and lessees in data collection and evaluation processes, and provide copies of evaluation(s), and or results to collaborating permittees and lessees.

5. Continue to coordinate with the Natural Resources Conservation Service to perform soil surveys and develop Ecological Site Descriptions where joint, cooperative monitoring occurs and as agency budgets and personnel allow.

6. Maintain the final decision authority concerning the planning, collection and interpretation of the monitoring data collected under this MOU. The BLM retains its responsibility to make decisions relating to public land management, including livestock grazing, and compliance with public involvement requirements in the grazing regulations.

7. Provide a rangeland specialist knowledgeable about the cooperative monitoring program to attend the PLC annual meeting to discuss cooperative monitoring with permittees and lessees, contingent upon agency personnel availability and travel funding.

ADMINISTRATIVE PROVISIONS

A. Use of Data: Data used to make decisions on public lands will be available to the interested public, including permittees and lessees, except in cases where data have restrictions, such as personally identifiable information or cultural site data. The BLM shall accept for consideration monitoring data collected using BLM-approved techniques when the data meets the BLM's data quality requirements. Monitoring data not collected as referenced above or found not to accurately reflect on-the-ground conditions may be subject to limited use.

B. Prior to implementing joint cooperative monitoring both parties shall agree to the methods for collecting data in accordance with Appendix A. Priority should be given to methods found in the current version of the interagency Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems, Herrick, J., *et al.*, and those techniques found in statewide Rangeland Monitoring

Guides. Additional resources found in Technical Reference 1730-1, Measuring and Monitoring Plant Populations, 1734-3, Utilization Studies and Residual Measurements, 1734-4, Sampling Vegetation Attributes, 1734-7, and Ecological Site Inventory may also be considered.

C. Nothing in this agreement may be construed to obligate either the DOI or the United States to any current or future expenditure of resources in advance of the availability of appropriations from Congress. This agreement does not obligate the DOI or the United States to expend funds, property or services.

D. The BLM has a responsibility to coordinate, consult, and communicate with many different entities concerning management of the public lands. This MOU addresses interaction between the BLM and the PLC which represents members of the livestock industry operating on public lands. This MOU does not preclude or restrict the involvement of other public land users, interested public, or other public or private agencies, organizations or individuals from participating in cooperative monitoring.

E. This MOU does not require the BLM to notify or include interested public when cooperative monitoring is initiated by the permittee or lessee.

F. Nothing in this agreement shall be construed to conflict with any existing statute, regulation or policy of the United States or any policy or procedures of the BLM or the DOI.

G. This agreement shall be effective upon the date of the last signature, for a period of five years.

H. This agreement may be re-negotiated, amended, extended, or modified by a written amendment through an exchange of correspondence between authorized officials of PLC and BLM.

I. Either party may terminate this agreement by written notice to the other party. Each party will obtain prior approval from the other prior to releasing all press releases, published advertisements, or other statements intended for the public that refer to this MOU or to the parties, the DOI, the name or title of any employee of the DOI, or other cooperating individuals in connection with this MOU.

J. Nothing in this MOU may be interpreted to imply that the United States, the DOI, or the BLM endorses any product, service, or policy of PLC. The PLC will not take any action or make any statement that suggests or implies such an endorsement.

APPROVED:

John F. Ruhs Acting Deputy Director Bureau of Land Management	Dave Eliason President Public Lands Council
Date: 22 September 2017	Date: 9, 22, 2017

Cooperative Monitoring Planning

The following examples should be considered when developing a monitoring plan with the grazing permittee or lessee. Cooperative monitoring plans should be considered dynamic documents, and should be reviewed and modified as necessary, when new information is available, or data needs change. (Caution should be considered when modifying long-term monitoring planning when legacy data exist and trend data value is reliant on re-reading existing monitoring sites.) Where Allotment Management Plans (AMPs), or other landscape-level management plans are used, consider augmenting these documents with joint cooperative monitoring planning.

A. Management Objectives

Clearly identify environmental assessment decisions, land use plans and/or other management plans, watershed or landscape management objectives and desired plant or animal habitat objectives to be used as a basis for selecting which rangeland attributes to be monitored. Updated sagebrush species' habitat objectives should also be identified. Allotments may be used or aggregated if size approximates a watershed level.

For grazing units with fully processed term permits, the environmental assessment and Records of Decision(s) will list or reference applicant-committed measures, special rangeland monitoring requirements, vegetation objectives, wildlife monitoring requirements, riparian and stream objectives, archaeological site livestock protection monitoring, and other resources involved with livestock grazing.

Agree on the appropriate interpretation and use of cooperative monitoring data and results, and review applicable BLM quality, and data standards ahead of time with all cooperators and agencies. Review and agree on joint calibration of estimated data and qualitative data definitions, adjusted for local conditions and species.

B. Background Monitoring Compilation

1. Compile and review data and summaries available from prior inventories and monitoring. Review of Ecological Site Descriptions (ESDs), state and transition models, county soil survey descriptions, and other local GIS base-layer vegetation information (The following examples should not be considered all-inclusive).

    A. For short-term monitoring, consider utilizing data sources such as local climate-related records, actual-use/season of use stocking records, utilization surveys, previous photo-point records, ocular estimate stubble height data and other sources of information collected from methods using state Rangeland Monitoring Guides and/or livestock association Resource Monitoring Guides. Additional resources include, but are not limited to BLM Technical Reference 4400-22 Actual Use Studies, and Interagency Technical Reference 1734-3 Utilization Studies and Residual Measurements.

indicators within the area of interest, and whether they are at or trending toward the desired condition given the potential of the area, e.g., the trend of perennial bunchgrasses, forb diversity, or annual grass cover. Long term monitoring can also inform departure from the desired condition based on the ecological site potential if sufficient monitoring sites are present for the area being assessed and these are supplemented with professional judgement and other information provided through cooperative monitoring with the permittees or other stakeholders.

Data Evaluation

1. All parties involved in cooperative monitoring should receive copies of field data, results and summaries. Consider follow-up sessions to further monitor, evaluate and discuss data findings, as appropriate.

2. No single attribute or point-in-time measurements are adequate to be used as stand-alone information for trend monitoring or consideration of obtainment/non-obtainment of rangeland objectives.

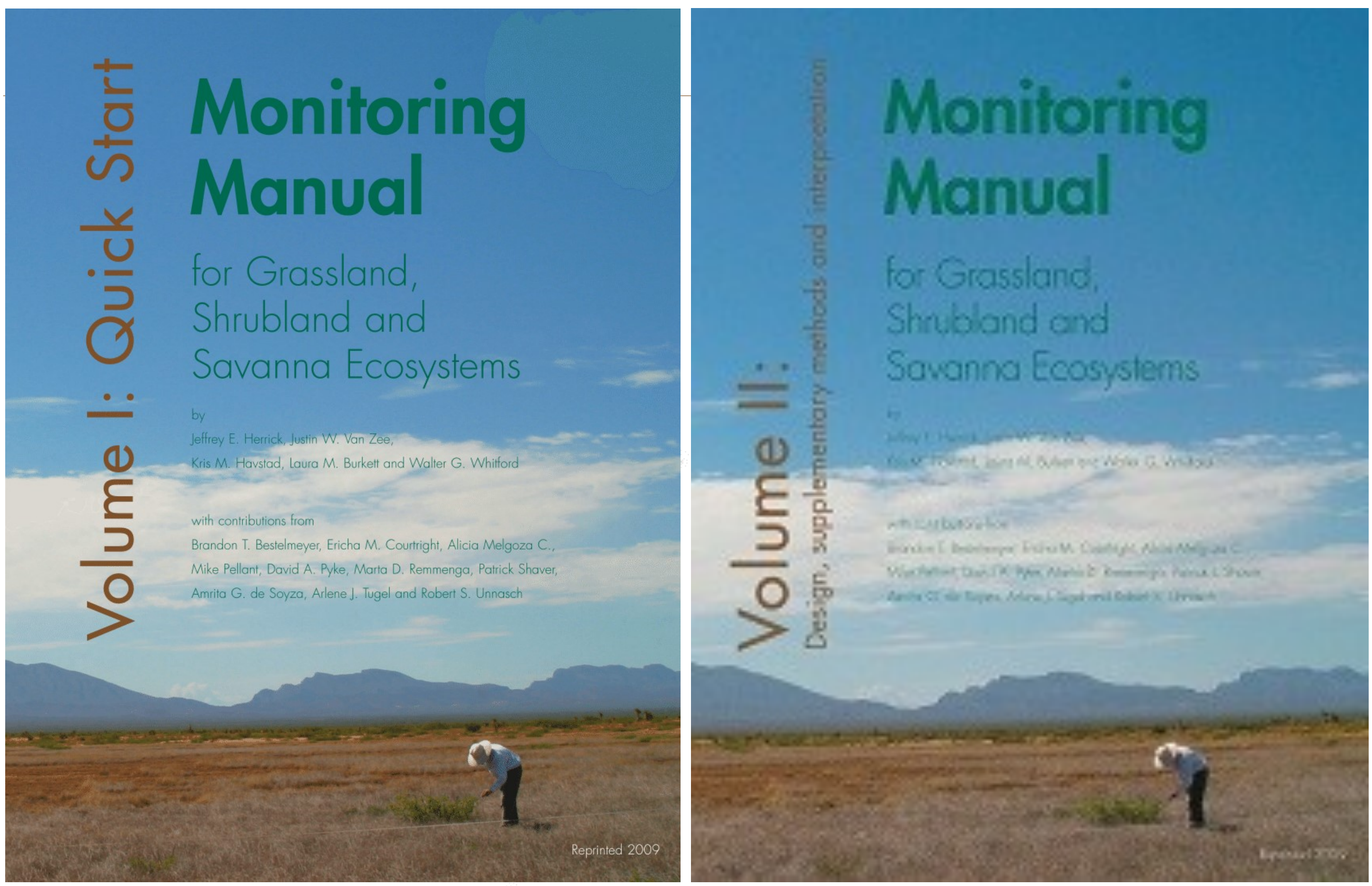

Figure 45 Many published monitoring manuals provide standard methods for rangeland monitoring such as Volume I (Herrick et al. 2009a) providing guidance for long-term (photo points, line point intercept, canopy gap, soil stability, and belt transect) and short-term (annual use record) methods. Volume II (Herrick et al. 2009b) provides guidance for design, supplementary methods, and interpretation.

APPENDIX B - ECOLOGICAL SITES

An ecological site is a conceptual area of the landscape that is defined as “a distinctive kind of land based on repeating soil, landform, geological, and climate characteristics that differs from other areas in its ability to produce distinctive kinds, amounts and proportions of vegetation and its ability to respond similarly to management actions and disturbances”. An ecological site incorporates abiotic and biotic environmental factors such as climate, soils, landform, hydrology, vegetation and natural disturbance regimes that together define the site (Caudle et al. 2013). Ecological sites are not determined by current or historic management, but by the inherent soils and climate and their influence on potential plant communities.

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.

Defining the Ecological Site Concept -- The ecological site concept is based on reference conditions representing natural states, with state changes and transitions determined by our understanding of thresholds of change (see State and Transition Models below). The reference condition is based on an understanding of pre-settlement vegetation, disturbance regimes, climatic variability, and existing vegetation. Disturbances, such as drought, disease, fire (human and non-human ignitions), 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 and succession 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.

Ecological Site Descriptions -- Ecological site descriptions are used to organize the information on the known plant community types, soil properties and vegetation characteristics associated with that site. Ecological site descriptions integrate soil development, hydrologic and ecosystem functions, and other ecological knowledge about plant communities. The ecological site description also outlines the processes of change that may occur on a site as well as showing change as a deviation from the reference condition. Because of the more thorough evaluation of ecological factors at work on an area of rangeland, the ecological site description provides information needed for management of rangelands for many uses and values.

State and Transition Models -- State and transition models (STMs) are a component of the ecological site description, and are developed to describe changes in soils, vegetation dynamics, and management interactions. 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 STM describes alternative states, range of variability within states, processes and mechanisms that cause plant community changes (pathways) within states, maintenance of a current state, transitions between states, and restoration toward a previous state. A STM diagram provides a general graphical overview and the accompanying narrative describes the states and transitions in detail.

A state is a recognizable complex of the soil resource and associated 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, plant uptake and timely release of water from precipitation.

Resilience and resistance concepts describe the stability of a state and the various phases within a state. “Resistance is defined as the ability of the system to remain the same while external conditions change, whereas resilience is the ability of the system to recover after it has been disturbed” (Stringham et al. 2003). 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 result in an altered functioning of one or more of a state's primary ecological processes. Pathways reflect phase changes within a state. Transitional pathways reflect changes within a state that are only reversible if they do not exceed the resistance or resilience thresholds between states. A transition can be triggered by natural events and/or management actions (or inaction). 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 and when crossed results in one or more of the primary ecological attributes or processes having been irreversibly altered. 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 in order to return to a previous state. Once a threshold is crossed, 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 resultant chaos ends and the system establishes a new equilibrium among the primary ecological processes.

Transition across a threshold to a new state often represents 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 manage ecological processes to facilitate change along desired pathways and to prevent transitions to less desirable states. Within each state certain management strategies facilitate community resilience or resistance and maintain desired plant communities.

In general, preventing a desired plant community from transitioning across a threshold is much less expensive than returning a site that has crossed a threshold. Restoring ecological processes and returning a site it to its original state often requires drastic actions that are expensive and risky. However, some potential states provide better products and services than the current state, and 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.

References and Products -- Ecological sites represent 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 1000 different ecological sites have been described in Nevada.

Disturbance response groups (Stringham et al. 2016) are groups of ecological sites that respond to management similarly and have the same basic structure to their state and transition models. Among their ecological sites, response rates and the amount of vegetation required to achieve resilience may differ although the management outcomes are similar. Similarities in response allow managers to apply some concepts across broader areas.

Ecological site descriptions for each major land resource area in Nevada are available from the Ecological Site Information System online at: https://esis.sc.egov.usda.gov/Welcome/pgESDWelcome.aspx or from UNR http://naes.unr.edu/resources/mlra.aspx . Detail soil series descriptions are available from the NRCS Soils website at: http://www.nrcs.usda.gov/wps/portal/nrcs/site/soils/home/ . The Web Soil Survey can be used to generate soil maps, ecological sites, and associated information and is available at: http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

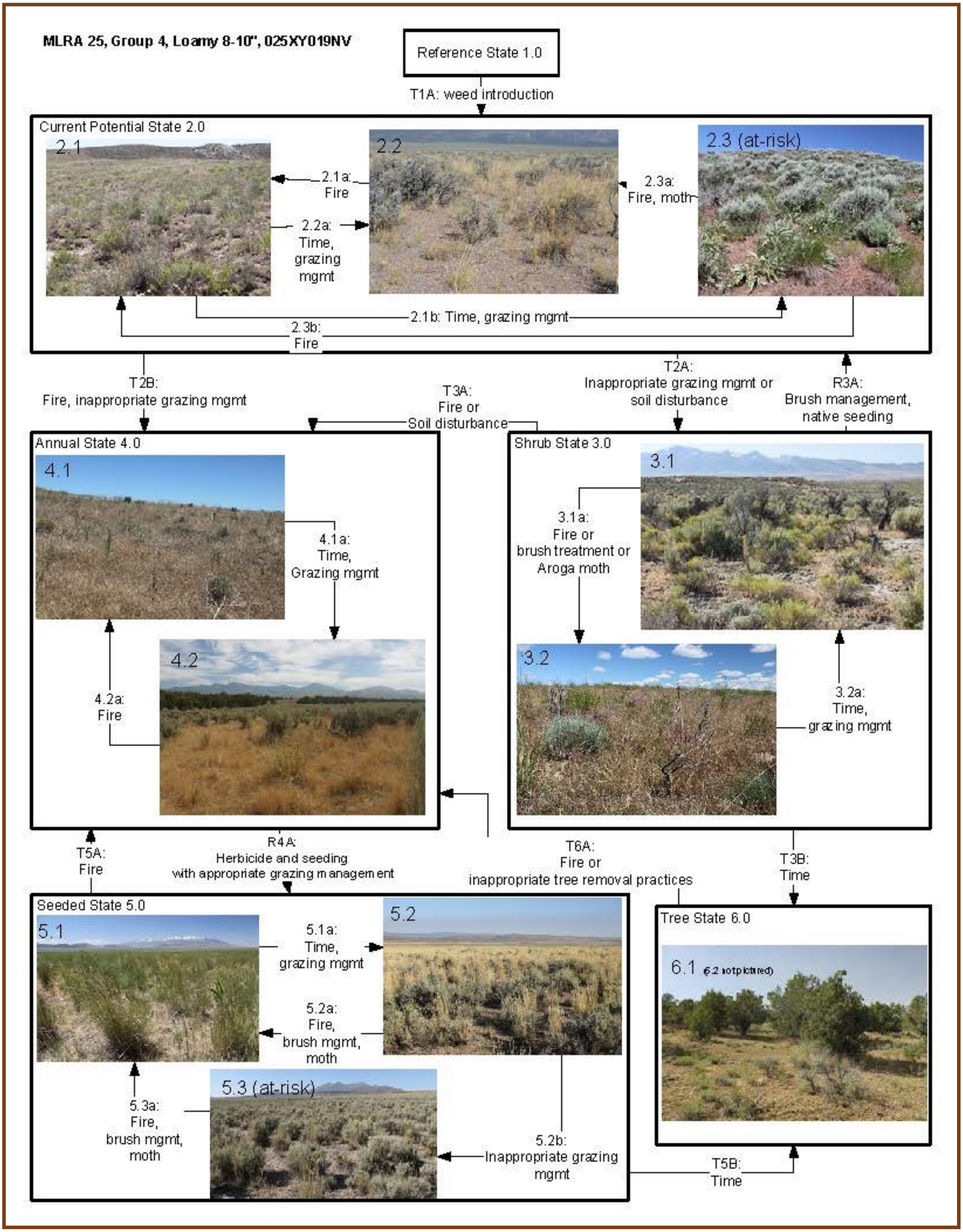

Figure 46. Each of the boxes in the state and transition model represent observed conditions, phases within a state. The arrows represent drivers of change and indicate the need or opportunity for management.

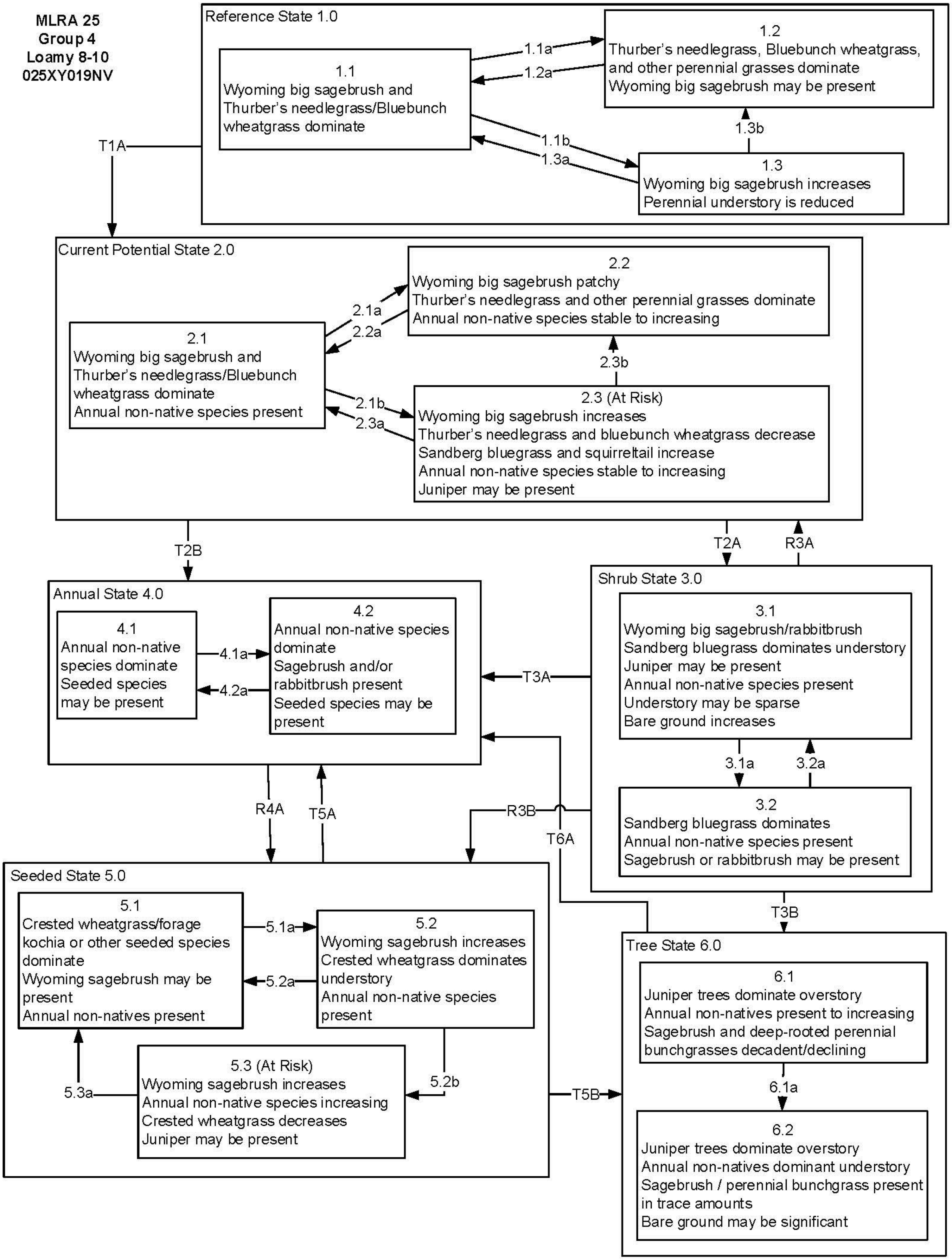

Figure 46 cont. State and Transition Model for Loamy 8-10" (an example)

Reference State 1.0 Community Phase Pathways

1.1a: Low severity fire creates grass/sagebrush mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community, dominated by grasses and forbs

1.1b: Time and lack of disturbance such as fire or drought. Excessive herbivory may also decrease perennial understory.

1.2a: Time and lack of disturbance allows for shrub regeneration.1.3a: Low severity fire or Aroga moth infestation resulting in a mosaic pattern.

1.3b: High severity fire or Aroga moth significantly reduces sagebrush cover leading to early/mid-seral community.

Transition T1A: Introduction of non-native species.

Current Potential State 2.0 Community Phase Pathways

2.1a: Low severity fire creates grass/sagebrush mosaic; high severity fire significantly reduces sagebrush cover and leads to early/ mid-seral community dominated by grasses and forbs; non-native annual species present.

2.1b: Time & lack of disturbance such as fire or drought. Inappropriate grazing management may also reduce perennial understory.

2.2a: Time and lack of disturbance allows for regeneration of sagebrush.

2.3a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Brush treatment with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.

2.3b: High severity fire or Aroga moth significantly reduces sagebrush cover leading to a early/mid-seral community.

Transition T2A: Inappropriate grazing management favoring shrub dominance and reducing perennial bunchgrasses will lead to phase 3.1. Soil disturbing treatments (such as tilling or intensive brush management) will lead to phase 3.2.

Transition T2B: Catastrophic fire (to 4.1); inappropriate grazing management that removes bunchgrasses, favors shrubs and promotes the presence of non-native annual species (to 4.2)

Shrub State 3.0 Community Phase Pathways

3.1a: Low severity fire or Aroga moth infestation creates sagebrush/grass mosaic. Brush treatment with minimal soil disturbance; late-fall/winter grazing causing mechanical damage to sagebrush.

3.2a: Time and lack of disturbance.

Restoration R3A: Brush management and seeding of native deep rooted bunchgrasses (probability of success is low).

Restoration R3B: Brush management and seeding of crested wheatgrass and/or other non-native desirable species.

Transition T3A: Fire and/or soil disturbing brush-removal treatments.

Transition T3B: (If site has neighboring trees) Time and lack of disturbance such as fire favors an increase in tree dominance (from phase 3.1.)

Annual State 4.0 Community Phase Pathways

4.1a: Time and lack of disturbance. Big sagebrush is unlikely to reestablish and may take many years.

4.2a: High-severity fire.

Restoration R4A: Application of herbicide and seeding of desired species (probability of success best immediately following fire).

Seeded State 5.0: Seeded wheatgrass species are the dominant grass. Community Phase Pathways

5.1a: Time without disturbance.

5.2a: Fire, brush management, or Aroga moth infestation reduces shrub component.

5.2b: Inappropriate grazing management decreases perennial bunchgrass understory.

5.3a: Fire, brush management, Aroga moth infestation.

Transition T5A: Catastrophic fire (coming from 5.3).

Transition T5B: (If site has neighboring trees) Time and lack of disturbance allows trees to dominate site resources.

Tree State 6.0 Community Phase Pathways

6.1a: Time without disturbance.

Transition T6A: Catastrophic fire that kills trees. Inappropriate tree removal practices may also lead to dominance by non-native annuals.

APPENDIX D - ADAPTIVE MANAGEMENT

Adaptive management is the essential and continual process of learning from our experiences and managing based on what we have learned. As defined by the 2007 USDI Technical Guide (Williams, Szaro, and Shapiro, 2007):

> "Adaptive Management is a decision process that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders".

Adaptive management hinges on flexibility and repeated iterations and must include a management program and a monitoring program to keep management on track, test assumptions, provide the information needed for future planning, and guide rangeland managers to achieve the desired objectives. Management plans and monitoring methods flow from objectives. Cooperative monitoring (Appendix A) builds on the same principles as cooperative management. "Adaptive management focuses on learning and adapting, through partnerships of managers, scientists, and other stakeholders who learn together how to create and maintain sustainable resource systems" (Williams, Szaro, & Shapiro, 2007).

Monitoring methods are selected to determine whether progress is being made toward achieving objectives. Also, monitoring helps to determine why or why not progress is being made toward objectives. 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 added significance. Keeping existing data, and periodically reanalyzing and interpreting data using established methods and plots, is extremely valuable for developing an understanding for rangeland management. Referencesdescribe 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, analyzing, and evaluating the validity and utility of information in order to make a decision. Because it is often preferable in planning and monitoring to use a collaborative approach, analysis of monitoring data should also be collaborative. 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 increases and shares understanding. The permittee (s) is (are) an integral part of the process of development of conclusions to better understand management practices and conditions for particular site(s) and season(s) of use. Conclusions about progress toward objectives and causes of meeting or not meeting objectives are both essential and must be thoroughly reasoned based on all available information. For application to public lands, the rationale for management changes (or not) must be documented.

Management involves not only predicting how ecological or physical systems are likely to respond to management actions, but also identifying what management options are available, what outcomes are desired, how much risk can be tolerated and how best to choose among a set of alternative actions. State and transition models in ecological site descriptions along with short-and long-term monitoring informed by the lessons from Nevada Range Management School (McAdoo et al. 2010) help managers choose to continue existing management, change management, or change objectives. In many areas, past objectives based on range condition or seral stage should be modified to reflect modern ecological and management thinking. The challenge confronting managers is to make "good" decisions in a complex situation. Therefore, the quality of decision making in the face of uncertainty should be judged as much by the decision making process as by the progress towards desired outcomes.

> "For many important problems now facing the resource management community, adaptive management holds great promise in reducing the uncertainties that limit the effective management of natural resource systems. For many

conservation and management problems, utilizing management itself in an experimental context may be the only feasible way to gain the system understanding needed to improve management. An adaptive approach actively engages stakeholders in all phases of a project over its timeframe, facilitating mutual learning and reinforcing the commitment to learning-based management" (Williams, Szaro, & Shapiro, 2007).

Adaptive management for riparian areas is described in Dickard et al. (2015), Swanson et al. (2015), and Swanson (2016) as "integrated riparian management." it includes 7 steps (See Appendix E – Characteristics of Good Objectives).

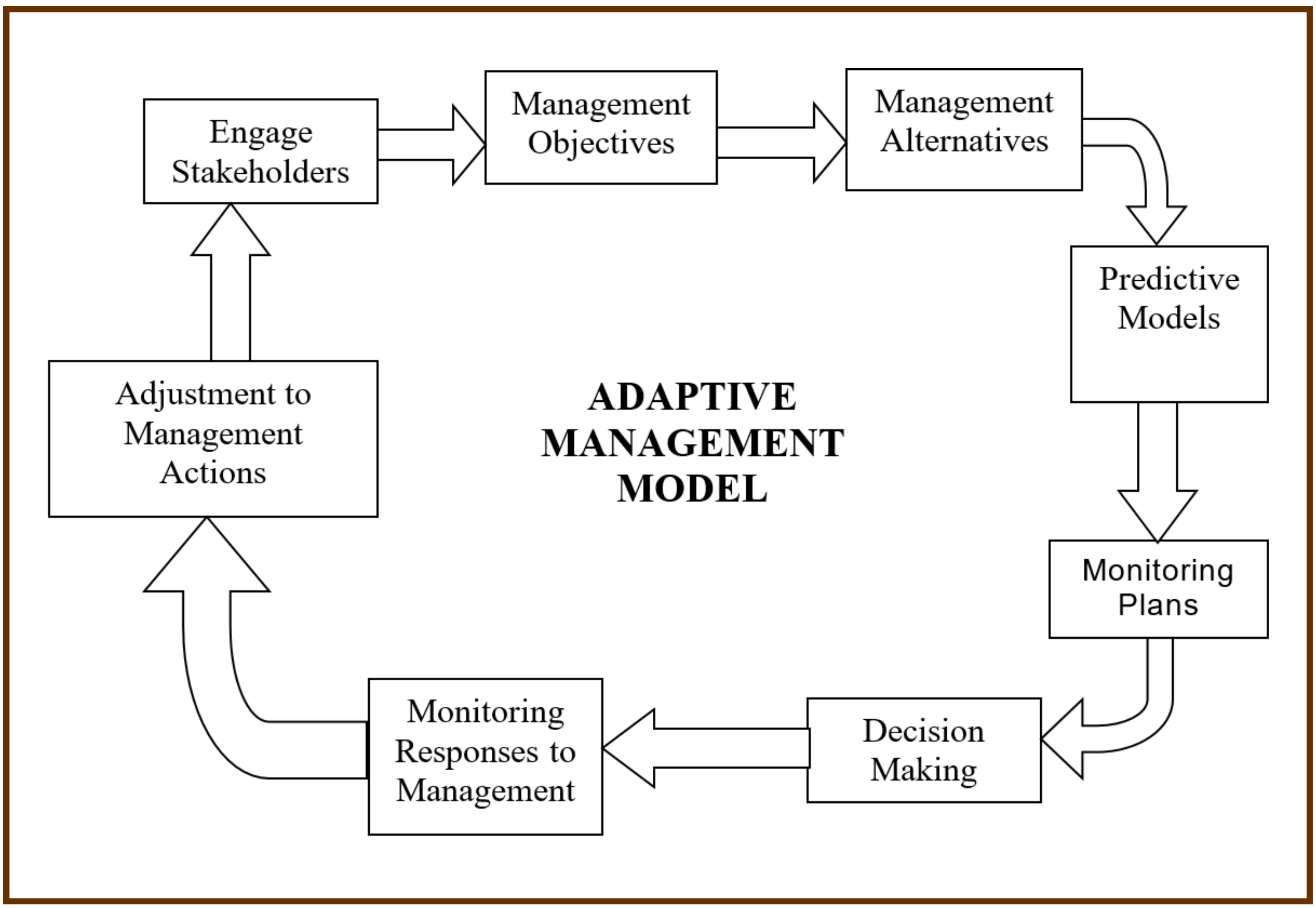

Figure 47. This adaptive management model includes some steps needed and implied in other flow charts: engaging stakeholders, considering alternatives, and predicting results to determine how the objectives and strategies should be monitored.

APPENDIX E - CHARACTERISTICS OF GOOD OBJECTIVES

Properly developed objectives need to consider that rangelands are complex and dynamic. Establishment of appropriate 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 evaluate management. (See section on Setting Objectives, Page 4.) Management often causes a chain reaction, leading to questions about what to identify as the best focus for resource objective.

Riparian example:

In this example, each of the *italicized* results could be measured (although some not easily or consistently) but only a few, **the bold ones*,** could be efficiently monitored in SMART objectives. Short grazing duration and long recovery periods are easily tracked (short-term monitoring) through actual use. The four-inch stubble height end point indicator is easily monitored, but not the driving strategy. Period of use and intensity are management tools or annual indicators of plan implementation, not objectives (Clary and Leininger 2000; University of Idaho Stubble Height Review Team 2004).

Riparian example:

- Rotation *grazing for three weeks* (or other strategy) leads to
- A *four inch stubble height* and 85% growing season recovery leads to
- An ***increase in colonizers*** leads to
- Deposition there of fine sediments leads to
- An ***increase in stabilizers*** leads to
- ***Narrowing the greenline to greenline width***
- *Narrowing a stream* leads to
- Increased floodplain access & aquifer recharge leads to
- *Improved base flow* leads to
- *Improved water and habitat quality* leads to
- *Increased fish populations* leads to
- Increased *recreationist satisfaction*

Objectives to **increase colonizers, stabilizers, and narrow the greenline to greenline width** are easily measured and indicate changes in resource conditions. These would be a suitable focus for objectives. Stabilizers on the greenline drive the process of recovery by preventing erosion, slowing average water velocity, and inducing both deposition and scour to form floodplains and pools. While water quality can be monitored, water quality measures vary greatly on a daily or even hourly basis and also vary annually and through hydrographs. Monitoring them is less informative and more costly than monitoring the other resource attributes that ultimately drive water quality processes Swanson et al. 2017). 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. It also takes longer to detect a significant trend because of the variability. Which attribute is best to choose as a monitoring objective depends in part on the time frame for the management plan and the steps and process in stream recovery.

Riparian functionality is often a standard that is assessed. Although not usually quantified in the assessment procedure, assessing proper functioning condition (PFC) assessment (Prichard et al. 2003; Dickard et.al. 2015), is an extremely useful tool for recognizing riparian areas at risk, understanding the need for management, and launching the integrated riparian management process described in (Dickard et al. 2015; Swanson 2016) as a seven-step process for managing riparian areas: (see page 13).

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; Burton et al. 2011). Because riparian vegetation and bank stability drive changes in channel form (e.g., width), they are resource attributes suitable as long-term objectives. They link management treatment (e.g., grazing management) and resource attribute change (e.g., vegetation composition), making the objective useful in the adaptive management process.

Upland example:

In this example, each of the italicized changes could be measured but only a few, **the bold ones***, would guide development of reasonable objectives. Rotation grazing, with its opportunity for plant growth or regrowth, low frequency of use, is easily monitored through actual use dates. Moderate utilization, could also be monitored, and it may or may not be important to the strategy. Season, duration, and intensity of use are management tools or annual indicators of plan implementation, not objectives for long-term monitoring.

The ***percentage of decreasers*** in the herbaceous community, maintenance of *the **herbaceous state, perennial recovery*** after fire or fire surrogate, ***A landscape in a mosaic of different plant communities**** across a landscape, and certain

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Upland example:

- Deferred rotation *grazing for a fraction of the growing season* leads to
- Moderate *end-point utilization* and leaf area for photosynthesis during the growing season leads to
- Plant vigor, growth, and health leads to
- Slowing plant community *domination by sagebrush* and enabling perennial herbaceous production leads to
- Maintaining at least a certain ***percentage of decreasers**** in the herbaceous community and maintaining the *herbaceous state** leads to
- Occasional wildfire and the opportunity for fire use or fire surrogates with ***perennial recovery**** leads to
- A ***landscape in a mosaic of different plant communities**** (phases of a current potential state (see Appendix B on ecological sites) *in different places at different times leads to*
- ***Certain vegetation attributes of habitats*** leads to
- *Maintaining viable populations of wildlife* and *economically viable ranches* leads to
- Socially and *economically viable community* of people

---

vegetation attributes of habitats are easily measured objectives that indicate changes in resource conditions with management, weather, and time. Rangeland health and high quality habitat must be defined in such measurable terms to be monitored. The specific objective appropriate for an area depends on where that local landscape fits in a longer term progression and the timeframe for the plan. 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 vegetation 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 rangeland health or 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 and how to describe the desired change depends in part on the timeframe for the management plan.

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 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 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 community phases. In doing so, it remains necessary to ensure:

1. Desired phases vary based upon the present vegetation, potential of the ecological site, and soil. Describing desired vegetation from the same ecological site in nearby areas 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. Desired phases provide the most important ecological components and functions of resistant and resilient rangelands. 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 – Ecological Sites).

3. Desired phases or plant communities reflect human desires for resource production or habitat quality. However, described communities or phases should not be ones that are at-risk of crossing an ecological threshold. Certain plant communities may be desirable for some resource value, but may not be 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. Desired phases are described in a manner that recognizes they will naturally change through time. Describing any plant community objective should recognize the dynamic nature of rangeland vegetation due to plant succession, non-human 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 reflect management that varies across the landscape and through time. The goals for an allotment generally include restoring and/or maintaining rangeland health across the land (and other considerations such as a dynamic mosaic of seasonal sage-grouse habitats) and proper functioning condition of riparian areas. Management of these large areas often integrates livestock, wild horse, recreation and wildlife management, as well as direct vegetation management such as invasive species control, vegetation treatments, and fire and fuels management. It is impossible to micromanage large areas, yet both action and inaction have substantial effects on the achievement of goals and objectives. It is critical for managers to focus on measurable objectives in order to achieve identified goals. Some objectives apply to specific areas, such as key areas that represent identified goals. Other objectives address the mix of plant communities across a landscape to address goals requiring the integration of resource conditions and values. (Karl 2005)

Examples of SMART Objectives -- (Assuming these objectives are achievable (e.g. within site potential and state) and contingent on the management/treatment and monitoring cost.) Each objective would be within the context of the management and/or treatment needed to accomplish it. The following are examples (Not suggested objectives):

1. Increase by 15 percent the proportion of the greenline that is dominated by deep/densely rooted (stabilizer) riparian species or late seral community types (Burton et al. 2011) within 10 years* 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 within 10 years* 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 2030 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 within 20 years*.
6. Within 20 years* (assuming that these years 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.
7. At Monitoring Station 3 in the South Pasture, within 20 years, increase the forb and/or grass component by 5% (specify cover or production) and decrease shrub cover and/or modify the age classes of shrubs.
8. In XYZ landscape unit, increase fire resistance and reduce fire risk, intensity, and size by modifying the fuel continuity of the Wyoming big sagebrush current shrub state (3).
9. 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 effectively re-establish perennials within two years after the event of a wildfire.
10. Eradicate the five known populations of perennial pepperweed in the Elderberry Creek watershed within 5 years,* while continuing surveillance to detect and eradicate new populations.
11. Remove 100% of pinyon and juniper trees from 70% of Phase I and II encroachment areas inventoried on Sage-grouse Mountain within 10 years*.
12. At Key Area 1, attain and retain a frequency (16-inch frame as used in past monitoring) of Indian ricegrass of 20 percent or more.
13. Obtain and retain an aspen stand at Rock Spring with diverse age classes and at least 10 percent of the stems in the young age class (1-5-inch diameter at 4.5 feet off the ground).

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.

Figure 48. The Greater and Bi-state subpopulation of sage-grouse are now perhaps the most well known examples of sagebrush ecosystem dependent species. By focusing on their year round needs we have become more acutely aware of the need for rangeland resilience, resistance to invasive weeds, and fire and fuels management as well as many other issues. By considering habitat needs and the needs of other stakeholders at multiple scales, we can focus management in specific locations with objectives and strategies.

APPENDIX F - SCALES IN MONITORING

Different types of information and measurements are used to answer different types of questions. The national AIM (Assessment, Inventory, and Monitoring) strategy is randomized in a way to provide large scale depiction of overall ecological conditions, and will rarely if ever answer site specific or management related questions on its own. The key area concept and the variety of long and short-term (effectiveness and implementation) monitoring protocols included in this handbook are necessary to answer site-specific and management related questions. Having both broad scale data and local site specific key area based data promotes optimal understanding. Neither replaces the need for the other.

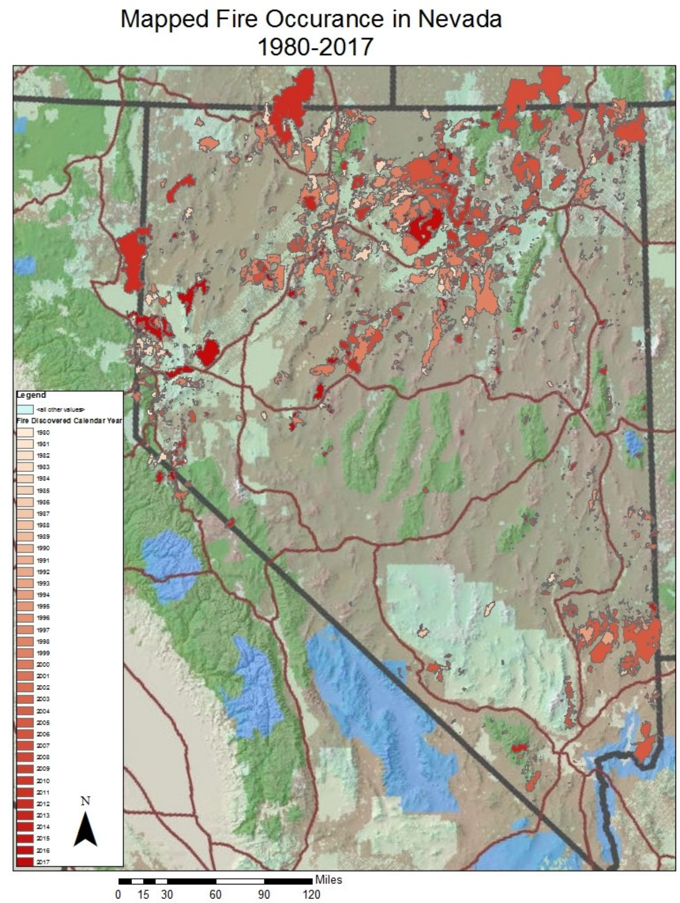

Figure 49. in recent decades fires in Nevada have become larger and with higher frequencynthis has changed many sagebrush habitats.

Demand for consistent data from across the Nation -- Mega-fires in 1999, 2000, 2001, (and later in 2006, 2012 and 2017) focused the attention of Nevada and national rangeland managers on the sagebrush ecosystem, sage-grouse and other sagebrush dependent wildlife and on rangeland health. These issues and the congressional thirst for a clear report with consistent data from across the nation about the condition of the public land stimulated the development of the BLM Assessment, Inventory, and Monitoring (AIM) strategy and principles (Toevs et al. 2011; MacKinnon et al. 2011; Taylor et al. 2014). The intent of AIM is to 1) document distribution and abundance of natural resources (inventory); 2) facilitate the description of resource conditions (assessment); and 3) identify natural resource trends or changes (monitoring). AIM provides statistically sampled data (from random locations) on the status, condition, trend, amount, location, and spatial pattern of renewable resources on the nation's public lands. This monitoring assumes a set of generic objectives (land health standards) and the statistical sampling provides reliable information at broad scales, such as monitoring of district or field office level resource management plans, across which sampling is adequate.

Land health standards are addressed by the Resource Advisory Council (RAC) standards and guidelines. These are based on the fundamentals of rangeland health (43CFR4180). Although worded differently by different RACs, they all, at a minimum, address A) watershed functionality (including upland, riparian, and aquatic wetland components, soil and plant conditions); B) Ecological processes (hydrologic cycle, nutrient cycle, and energy flow); C) Water quality that complies with state water quality standards; and D) Habitats are restored or maintained for federally threatened or endangered or special status species. Useful handbooks include interpreting indicators of rangeland health (Pellant et al. 2005) assessment of riparian proper functioning condition (Prichard et al. 2003 and Dickard et al. 2015), and for sage-grouse, the habitat assessment framework (Stiver et al. 2015)

The 2015 Record of Decision for greater sage-grouse conservation and Land Use Plan Amendments (BLM 2015; USFS 2015) and the BLM-FS Sage-grouse Monitoring Framework (USDI-BLM & USDA-USFS 2014) included requirements to use the broad-, mid-, fine-, and site-scale indicators of habitat suitability provided within the Sage-Grouse Habitat Assessment Framework (Stiver et al. 2015). The BLM accomplishes this with the help of AIM data and supplemental indicators. The FS also uses multi-level sampling (not AIM) related to sage-grouse habitat quality (protocol is in development at the time of publication).

Each AIM-Monitoring survey uses standardized field methods and a set of core indicators (amount of bare ground, vegetation composition, nonnative invasive plant species, plant species of management concern, vegetation height, and proportion of soil surface in large inter-canopy gaps), remote sensing, and a statistically valid study design to track changes at broad scales (MacKinnon et al. 2011). The core indicators and standard methods should also be used at the site-scale of management when they address the site specific objectives. If not, alternate methods should be used as needed.

Remote sensing informs connections among scales. It provided an essential platform for mapping soils and ecological sites (Caudle et al. 2013), documented the large scale issue with loss of sagebrush habitats (LANDFIRE 2013), was intended for extrapolation of AIM ground based data (Toevs et al. 2011), and helped identify and map sage-grouse seasonal habitats, habitat quality, and limiting factors (Coates et al. 2014; Nevada Sagebrush Ecosystem Technical Team 2014). It remains extremely useful in locating representative key areas for long-term monitoring and extrapolating ground-truthed data to larger landscape units (Appendix G - Remote Sensing to Monitor Rangelands).

Other Scale Tools and Considerations -- State and transition model based on ecological site descriptions provide the basis for all levels of rangeland management (Caudle et al. 2013). They facilitate awareness about risky transitional pathways as well as restoration or other pathways among states or phases. Disturbance response groups (DRG) help to link similar threats and ecological thresholds across landscapes by grouping similarly behaving ecological sites Stringham et al. 2016). This enables strategic landscape scale planning addressing parts of a mapped unit of a DRG in a similar state and phase contrasted with other areas in a different state or phase, or contrasted with different ecological sites in a different DRG.

The Nevada Greater Sage-Grouse Conservation Plan calls for monitoring at two scales, 1) "inventory monitoring" at a broad scale and 2) monitoring for tracking and adapting site specific management. The plan calls for integration of federal data such as discussed above with State data (including data from private land). State data includes fire numbers and sizes, sage-grouse population trends, extent of weeds and invasive species, weather (growing conditions etc.), functional acres lost or gained as tracked for the "Conservation Credit System", and other data (Sagebrush Ecosystem Council and Technical Team 2014).

Successful monitoring occurs at various scales, and the focus of most managers is at the scale of

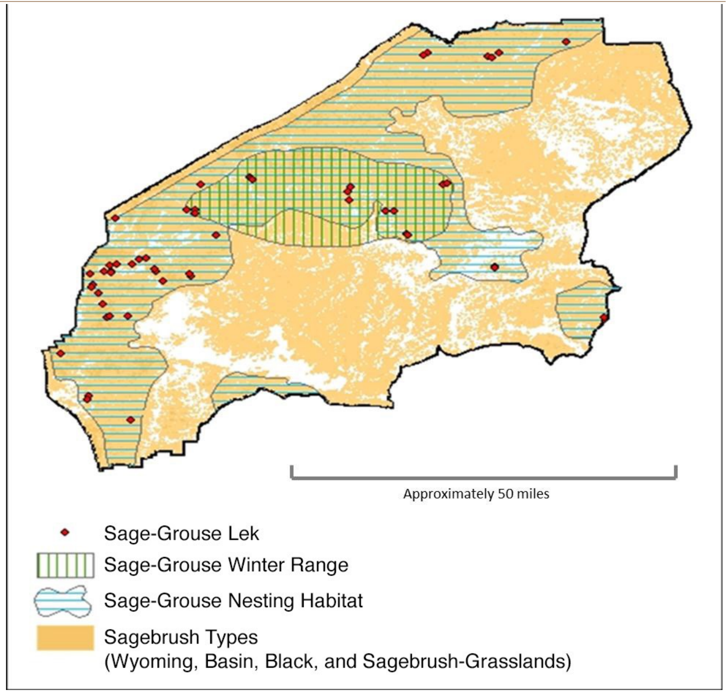

Figure 50. Sage-grouse management planning occurs at various scales.

their management responsibilities or of the plans and decisions they write, implement and adapt. National data sets, such as AIM, and identified issues may

Figure 51. Measuring progress toward objectives in carefully selected key areas enables data to be used strategically for adapting management.

influence goal setting, selection of treatments, and selection of key areas needed for adaptive management of local land uses or treatments. The national data sets rarely contain data from locations chosen with the criteria for key areas described in Appendix H – Procedures for Selecting Key areas and Key Species.

For sage-grouse issues, EIS objectives table 2-2 (BLM) and 1A and 1B (USFS) inform managers about the general characteristics of habitats desired by sage -grouse. AIM, remote sensing, or other broad scale data may suggest that for a population, a particular seasonal habitat is likely limiting. Then managers use transitional pathways in ESDs to consider opportunities and threats in a particular management unit, and select one or more key area(s) to monitor the site-scale (HAF (Stiver et al. 2015)) long-term effects of implemented management strategies. Range managers have been doing something similar for decades using a general understanding of what is important for rangeland management in a given management unit. We select key areas for measuring achievement of objectives driven by planned management, documented with short-term monitoring, and substantiated by long-term monitoring.

Long-term monitoring at that key area could use methods identical to, similar to, or different from data collection methods in AIM, depending on the question. Methods selected would depend on site specific objectives and the data needed to determine if management in that area was meeting those objectives. If AIM methods were used, the data from the key area would usually not be analyzed with other AIM plot data, because the key area location was not randomly located at the right scale. For statistical reliability, plots for AIM data are randomly located across the district, state, and nation, with livestock management units having no bearing on the stratification. Plots should not be intentionally placed on an existing or new key area because that would not be a random location representing the district, state or nation. AIM data that happen to be from a plot in a pasture are not likely to be reliable for adaptive management of grazing in that pasture because the plot was not likely to be from a place sensitive to management or that reflects objectives (see Appendix H – Procedures for Selecting Key areas and Key Species). Instead of using a key area for monitoring, many random plots could be used to achieve statistical reliability (Appendix I – Statistical Considerations) within a pasture. However, that approach is not feasible for grazing management on a limited budget.

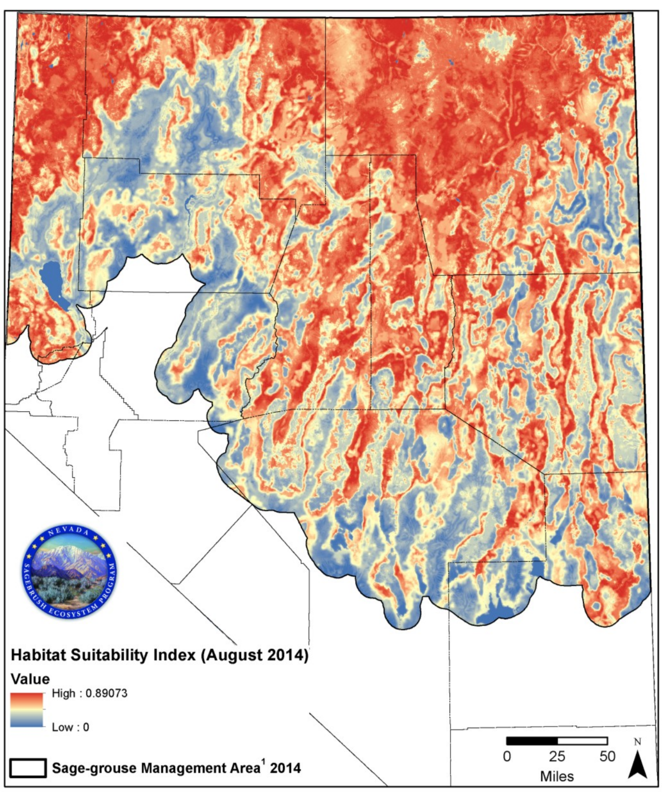

Figure 5. Habitat Suitability Index

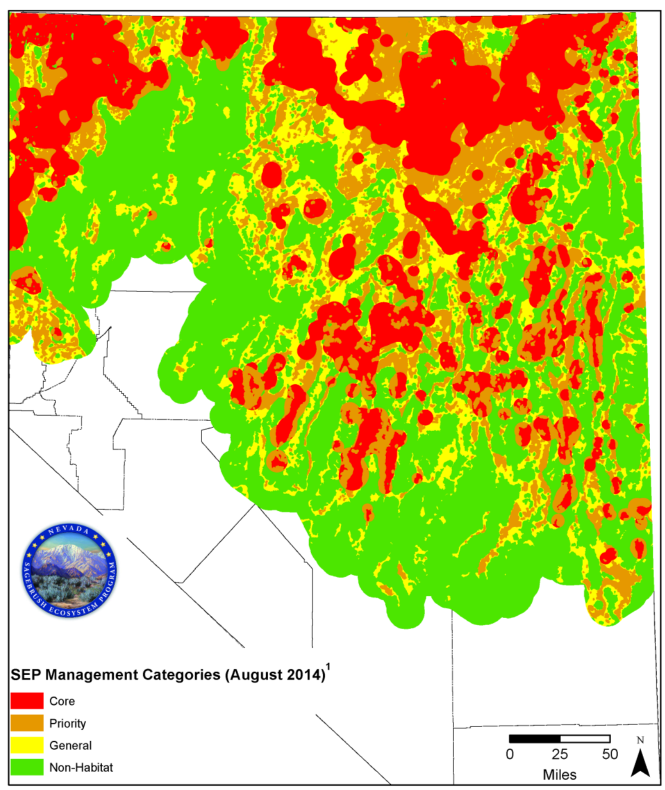

Figure 4. Management Category Map

1. The express purpose of the SGMA is to trigger consultation with the SETT; specific area or project habitat determinations must be conducted in accordance with established scientific protocol. This should not be used for any other purpose.

1. Coates et al. 2014

Figure 52. Habitat suitability mapping based on sage-grouse habitat use studies and remote sensing have been used to the management category map that helps managers focus on priority areas.

The precise location of a key area plot can be random within a representative landscape component. For example, a key area can represent an appropriate ecological site in an appropriate state and phase and at an appropriate distance from water or receiving representative levels of use, etc. (See H – Procedures for Selecting Key areas and Key Species)).

In land use plans (resource management plans (BLM) or land and resource management plans (USFS)) objectives or desired future conditions may be stated, as they are for sage-grouse in Habitat Objectives tables 2-2 (BLM) and 1a and 1b (USFS) in the greater sage-grouse Record of Decision and Land -use Plan Amendments (BLM 2015 and USFS 2015). The HAF (Stiver et al. 2015) contains similarly general criteria for suitable, marginal, and unsuitable habitat quality. Such criteria or objective tables are statements analogous to long-term objectives, but they are general in nature and don't adequately consider ecological site descriptions until locally applied. Stringham and Snyder (2017) determined that many of these criteria cannot or should not be achieved on many ecological sites, especially Wyoming big and low sagebrush sites, at least within Major Land Resource Area 25. In using them for site-scale monitoring, the preponderance of the evidence should guide SMART objectives tailored for local ecological sites and a carefully chosen key area. Each individual table attribute cannot be used as a make or break criterion. Criteria or table attributes should inform strategic management targeting areas and changes in conditions where there are important opportunities for improvement. Without a restoration pathway to another state, the current state is the potential. With a restoration pathway, the higher state is the potential. Pathways for accomplishing vegetation (state or phase) changes vary widely in their expense and likelihood for success.

Permit renewal, and the NEPA analysis that supports it, relies on data from many scales and sources. All of the data described here and additional information about past management and its effects from permittees and agency files (Appendix A - Cooperative Monitoring) informs the conversation about: 1.) Resource concerns; 2.) SMART objectives; 3.) Management tools and strategies; 4.) Short-term monitoring tied to the chosen tools strategies and objectives; 5.) Long-term monitoring at specific key areas using appropriate methods; 6.) Analysis of monitoring information and possibly extrapolation of key area data using remote sensing; and 7.) Flexibility, responsibility, and adaptive management.

There has been a great deal of discussion about the plant height and sagebrush cover objectives in tables 2-2 and 1a & 1b. With these (or any new version of a table addressing habitat objectives) considered as long-term objectives, or used to inform setting objectives, managers can apply a diverse set of targeted strategies in sites with the potential (site and state) to support taller plants or not (Stringham and Snyder 2017). Sampling plant height across space and time allows managers to use concentration of livestock with an annual rotation as a tool to provide shorter duration grazing periods with less stress to favored plants, as well as more recovery time to facilitate regrowth and success of taller grasses. This may be more strategic than attempting to limit utilization which often leads to uneven distribution or more fire risk from fine fuels.

Adaptive management should not be used to restrict available responses, but instead should be used to encourage flexibility by considering a variety of responses. It is the use of monitoring to track implementation of management strategies and results, and to select different strategies (response) if implementation is not feasible or effective (threshold) for accomplishing objectives. It is critically important to connect short-term monitoring to the strategies chosen for effective management to attain long-term objectives. There are many tools in the management toolbox. Adaptive management can also occur within a planning/permitting cycle, such as by using the grazing response index (GRI) or a similar index of management effect to adjust season (dates of use and growing season nonuse) and intensity of use next year based on the record of season, duration and intensity of use this year.

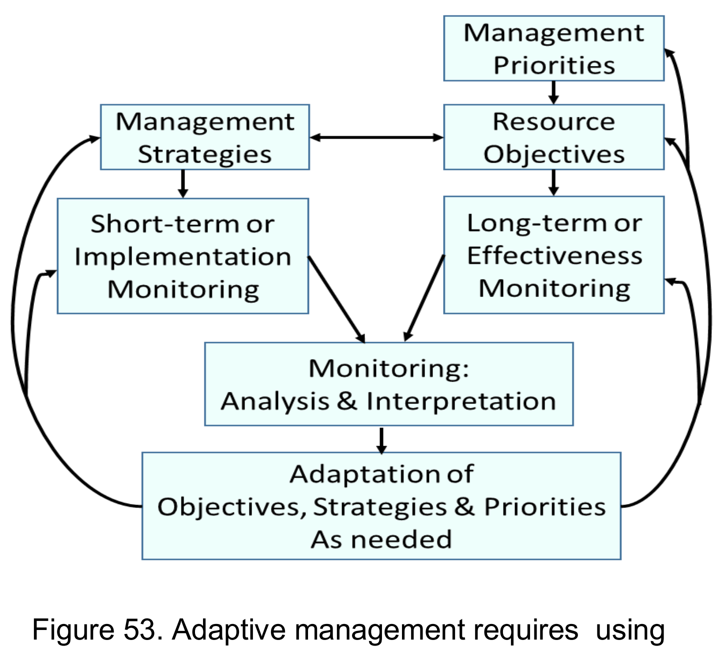

Figure 53. Adaptive management requires using long-term monitoring to evaluate progress toward objectives and short-term monitoring to understand what management has been implemented.

APPENDIX G - REMOTE SENSING TO MONITOR RANGELANDS

Remote Sensing – Aerial and satellite remote sensing systems have strong potential to assist in or accomplish landscape-scale inventory, assessment, and monitoring of rangelands. However, the technology has not yet been thoroughly applied on rangelands for the following reasons: 1) trained interpreters that understand both rangeland ecology and the capabilities of various remote sensing and image-analysis systems are essential but not always available; 2) the acquisition, analysis, and interpretation of remotely sensed data is increasingly available but has not been as much used and strongly developed for the most important issues of rangelands 3) sub-sampling expansive areas is necessary and computer procedures for interpretation are just now being developed.

The technology for analysis of remotely sensed data on rangelands is changing very rapidly. We are on the verge of being able to examine rangeland vegetation characteristics in real time with high resolution (sub-meter) data. Because prices change almost weekly it is not useful to provide much cost data. It appears that eventually the remotely sensed images and radar returns will be essentially free, although the data storage, retrieval, ground-truthing, and analysis will be the cost. Numerous new companies provide remote sensing information. Several are briefly reviewed here.

Satellite Systems -- To obtain few meter and, in some cases, sub-meter resolution, panchromatic, multispectral, Lidar and hyperspectral data are available from numerous satellites. Detailed information on satellites is available from various web sites. For the IKONOS satellite (1m grid size dimension (GSD) go to http://www.spaceimaging.com/products/ikonos or to http://www.digitalglobe.com. LANDSAT is a collection of space based moderate-resolution land remote sensing data available from the USGS and includes imagery from the last 40 years. LANDSAT 7 data (15m GSD) can be acquired from MapMart at http://www.mapmart.com/. To evaluate LANDSAT directly, access http://landsat.gsfc.nasa.gov/. Each Landsat scene covers about 100 square miles while other satellites provide other swath widths. Light detection and ranging (LIDAR) and Inferometric Synthetic Aperture Radar (IFSAR) can provide high-resolution three dimensional radar images useful for tree and shrub height or erosion/deposition along rivers with rapid terrain visualization (see Synthetic Aperture Radar on Google). The Moderate Resolution Imaging Spectroradiometer system (MODIS) is the replacement for Advanced Very High Resolution Radiometer (AVHRR) (http://noassis.noaa.gov/NOAASIS/ML/avhrr.html/) data and now gives up to 200m resolution over large land areas. Other low resolution systems such as Tempo with 30 mile pixels are available but are used for worldwide analysis of air pollution over large areas and have little use for rangeland applications (https://directory.eoportal.org/web/eoportal/satellite-missions/t/tempo). The Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) (see http://aviris.jpl.nasa.gov/) is a multispectral system with 224 spectral channels

Figure 54. Images from google Earth of a Nevada 2006 fire.

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. Another firm at www.pcigeomatics.com can provide high quality synthetic aperture radar data analysis. The RADARSAT-satellite (http://www.asc-csa.gc.ca/eng/satellites/radarsat2) flown by the Canadian Space Agency provides radar data from anywhere on the earth with 1 by 3m resolution. AIRBUS Defense & Space Pleiades-1A and 1B satellites provide resolutions of 70cm panchromatic and 2.8m multispectral data in 20km swaths throughout the world. (http://www.satimaging corp.com/satellite-sensors/pleiades-1) They also provide post processing and elevation models of potential use for rangelands analysis (see Apollo Mapping) for further information. Rapid Eye, Geoeye-2, Worldview-1, 2 and 3, Quick Bird, and other satellites provide remotely sensed data for the worlds rangelands. Each satellite has different sensors and sensor systems.

Several companies (Harris MapMart (www.mapmart.com), Apollo Mapping referred to as The Image Hunters (www.apollomapping.com), Planet labs (www. Planet.com) and Space Imaging Corporation (http://www.satimagingcorp.com/) provide imagery from a number of these satellites including a variety of image types, panchromatic, multispectral, Lidar, 3-D Lidar, hyperspectral and others. Most companies provide a variety of services with their products such as custom mosaics, elevation data, change monitoring, ortho images and other data sets. ESRI provides a web App (Earth Secrets demo App) using Landsat and ArcGIS at http://landsatappv1p3.s3-website-us-west-2.amazonaws.com/

Planet Labs is unique and symbolic of the newest in satellite remote sensing. They design and launch small imaging satellites to cover the earth every day. Their satellites, called Doves, have dimensions of 10 by 10 by 30cm and weigh 4 kg (Whereas a Landsat Space Craft weighs 6 tons with dimension of 4 by 4 by 6m and costs $855 million dollars to launch). They have launched over 100 doves and plan on about 150 with 30 ground stations. The data are primarily panchromatic but have as low as 10cm pixels although most data have 3-5m pixels. The satellites fly in low earth orbits (about 420 km). They are downloaded every day with three formats, unrectified imagery data intended for integration, preprocessed data intended for on-the-spot analysis or orthrectified analytic imagery data in bulk instantly available. Rapid eye is part of the Planet Labs system and provides 6.5m resolution at nadir and 5m when orthorectified.

UAV Systems -- While satellite systems will be used extensively, many groups, companies and individuals are using Unmanned Aerial Vehicles (UAVs) to provide remotely sensed data. Numerous universities have ongoing research projects developing applications for using UAVs for rangeland and agricultural applications. Most commercial systems provide vegetation analysis algorithms such as the Normalized Difference Vegetation Index (NDVI).

PrecisionHawk (http://www.precisionhawk.com/) can provide high resolution data in several formats including visual, thermal, multispectral, Lidar and hyperspectral. With 1.3 cm resolution and 2d and 3d pixels it is possible to measure and interpret details such as bare ground and many species. Imagery can be flown and then analyzed while in the field.

EagleEye (www.eagleeyedroneservice.com), and 3DR Mapping Drones (https//3dr.com/mapping-drones/) with high resolution, 3DR's Aero-M and X8-M are fully automated and intelligent drone mapping platforms for easy, fast and accurate aerial data acquisition and analysis.

Quiet Creek (**www.thequietcreek.com**) provides Unmanned Aerial Mapping including the eBee sensfly system with centimeter resolution, 2 and 3-d mapping, classification algorithms, and land management monitoring.

Another new system recently advertised is Parrot Disco. This system is a ready-to-fly fixed wing drone that can fly for up to 45 minutes. Embedded GPS provides way points. This drone can "loiter" around point with GPS coordinates and allows the operator to use immersive glasses to view the site in real time. See www.us.store.parrot.com.

Eagle Eye Company (www.eagleeyeimagery.com.au/) uses the 3DR Solo (see http://3dr.com/solo-drone/) and a Gopro camera linked to an Ipad. The dji phantom 4 (http://www.dji.com/product/phantom-4) is a similar product.

Many systems include both video and burst shooting where one to several frames can be captured and stored as high quality imagery with sub-centimeter resolution for use with analysis algorithms. Prices for these systems vary but are approximately around $2500 to $3,000 for a complete system. Many people are intrigued with the idea of flying their own drone, storing the data, and doing the analysis and interpretation often with the flight ongoing. Data can be stored in a cloud for comparison and monitoring landscape changes. The battery power of many of these new technology drones provide around 28 minutes of flight time. With extra batteries it is possible to examine 6 sites per day including driving time to new locations. The data sites can be documented by GPS capabilities within the drone system. The imagery is panchromatic and the resolution is as low as sub-centimeter. This allows interpretation of such things as bare ground, shrub species, perennial grasses and many forbs when sampled at the proper phenological stage. This along with daily free imagery from the Dove satellites mentioned earlier would provide a strong remotely sensed data set to monitor changes in upland and riparian vegetation. Also remember that the technology is changing very rapidly.

Aerial Photography -- Aerial photography is available from a number of sources. For example, 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 every five to seven years. The USDA Farm Service Agency annually provides National Agriculture Imagery Program (NAIP) imagery, http://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/. Many companies provide aerial photography services including aerial acquisition, processing and orthoimaging (rectified to map quality) and lidar (Light Detection and Ranging). Aerial photography will continue to be used on rangelands but the turnaround time will not be as useful as near real-time satellite data or rapid analysis using drone technology.

Ground Photography – Ground photography is an excellent tool for capturing short-term monitoring information. 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 also capture long-term monitoring information and improve the interpretation of other long-term monitoring data. Photos must periodically be taken at key areas or designated monitoring areas. Photos can also be used to extend the application of ground vegetation cover sampling by interpreting aerial photos or satellite imagery (Sant et al. 2014). All photos should be carefully labeled (date and location) and stored for easy retrieval.

Photos also make an excellent record of riparian conditions to accompany long-term or short-term monitoring data. Photos are taken at times of stream survey and riparian PFC assessment. File photos can be used to identify suitable permanent photo points where they address objectives. Generally, riparian photo sets include an upstream, downstream, and across the stream shots. 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.

Final comment —To make remote sensing useful and to realize its great potential will require considerable effort by managers and ranchers to actually use this medium. Multiscale sampling procedures and software for processing photographic samples by automatic analysis is rapidly improving and will lead to applications with greater accuracy, consistency, precision, and calibration. Remote sampling and automated image analysis apply at various scales for rangeland monitoring efforts. Those using remotely sensed data will have excellent sets of data in real time or near real time. For example, consider a heavy storm in which the question arises as to the damage to riparian sites that might have occurred. With real time satellite data or user obtained drone data the next day one could determine just what has happened to the stream and the stream side vegetation. No waiting, an instance of land management analysis gratification. For further gratification go to the numerous URL's mentioned above to visualize and be impressed by the variety of images useful for rangeland monitoring.

Providing the corporate or product names and URLs mentioned above does not constitute a recommendation or endorsement. They are simply examples of the kinds of products available. The right remote sensing tool (if any) depends on the needs and constraints of the user.

Figure 55. One of the many unmanned aerial vehicles in use for capturing aerial imagery.

SUGGESTIONS FOR TAKING BETTER PHOTOS

1. Within the picture, identify the date and exact location using a field slate or form (See the Ranchers' Monitoring Guide by Perryman et al. (2006; 2017)).
2. Take the picture during the same stage of plant growth (phenology) each year, if possible.
3. Include the same skyline in the landscape photos.
4. Consistently locate 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 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 close-up photos, use a specific plot size and have a scale marker in the photo such as a foot ruler or a pole with 6-inch color changes (e.g., red and white). Use similar procedures each time you retake each photo. These photos will be taken vertically over the plot or at a low oblique angle. Be consistent in how you obtain the photos. Digital cameras should be used since the images can be stored on the hard drive of your computer, a cloud or placed on a CD for storage and future reference. It is good to record as much of what you can see as practical while in the field since experience has shown that it is difficult to recall all of the salient features of the site.

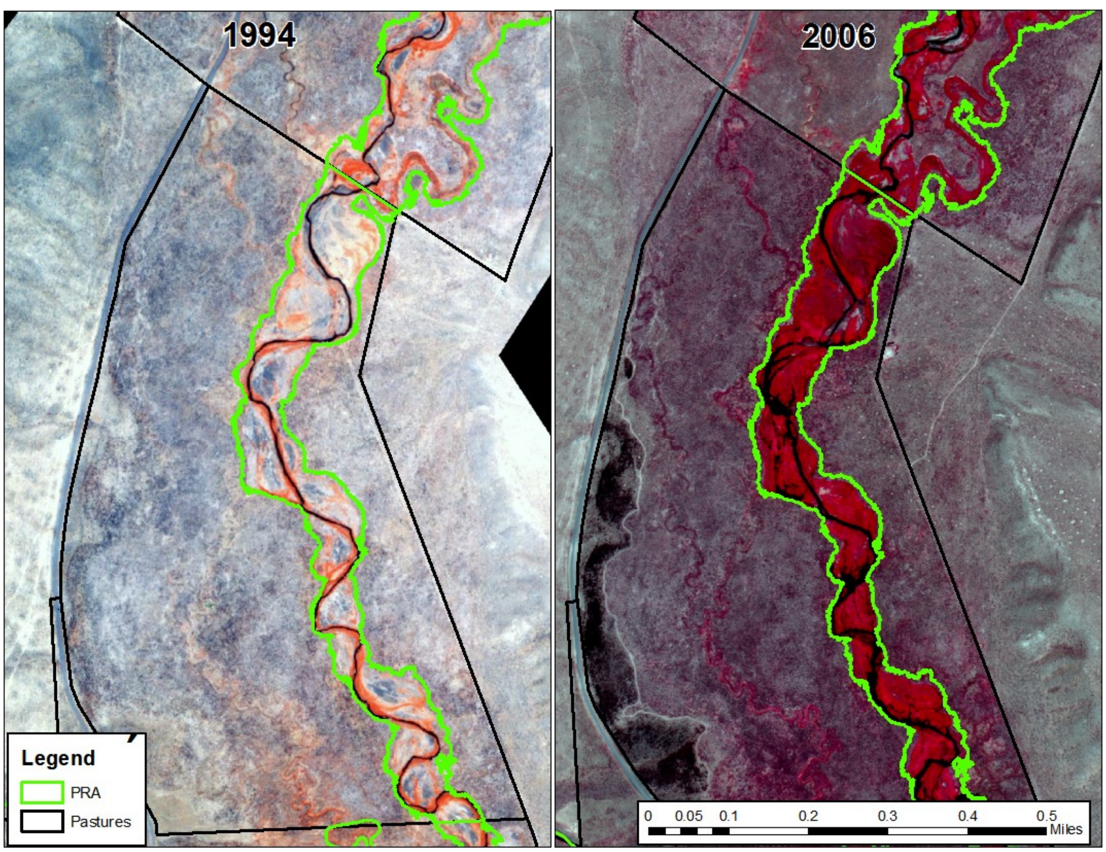

Figure 56. Riparian vegetation increased by 816 acres in the Maggie Creek Watershed Restoration area Open Range Consulting and Newmont Mining Company (2009).

APPENDIX H - PROCEDURES FOR SELECTING KEY AREAS AND KEY SPECIES (see page 22)

Study Site Location					
Key Area Name and/or Number					
District/Ranch					
Observer(s)					
Allotment Name and Number (if any)					
Pasture Name and Number					
Wild Horse or Burro Herd Management Area					
Habitat Management Plan Area etc.					
Wildlife season of preferred use					
Soil Series or Map ID		Ecological Site/			
Soil Taxonomic Unit		Disturbance response group			
State in ESD-STM		Phase in State in ESD-STM			
Location	Township	Range	Section	1/4	1/4
GPS Lat.		Elevation	Slope	Aspect	
Long./UTM		UTM			
Current Plant Community Dominants					
Key species					
Types of Studies Established					
When and by whom was this key area validated for its relationship to objectives and management?					
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. Attach labeled and dated photos here or provide location information to enable finding photos of the study site.

APPENDIX I - STATISTICAL CONSIDERATIONS

Introduction-- Virtually every measurement of nature shows variation. Scientists have developed procedures for sampling and replication to improve their confidence that the data they collect provides a reliable estimate of the population sampled, and any change (or lack thereof) for important attributes related to the implementation of management actions. Generally, more samples with additional data points increases the ability to detect important differences for one or more attributes among populations and/or communities, or for the same population/community attribute across time. With enough data once can detect differences so small that they are unimportant or trivial.

The land management agencies and producers generally have small budgets to implement monitoring programs, and too few people to collect adequate data, both spatially and temporally, to confidently conclude that the measurements represent conditions on the ground, not random variation. Managers, therefore, often look for a preponderance of evidence across a variety of data types to evaluate the probable effects and influences of management actions. They assemble monitoring information to interpret the effects of management in a manner that makes sense. When the information available includes samples from many locations and they generally tell the same story, managers can conclude with reasonable probability (i.e., high confidence) that the observed responses correctly inform their judgement. To help improve their decision making, managers often use statistical tools to analyze their data.

For all data collection (monitoring) efforts there is a trade-off between taking many samples (and data points per sample) at one to only a few locations, or obtaining fewer samples per location, but collecting data at many more sites. Often, the most informative approach is a compromise between either extreme. That is, collect adequate information about the important attributes to generate a reliable estimate, at enough locations, to ensure that the estimates tell a consistent story. That is, the population(s) being measured is (are) accurately characterized. Repeated collection of the same data on the same site across time allows for statistical comparison of change across time, which is known as trend. In general, management goals and objectives that address issues across large spatial areas require data collection at multiple locations, often with several samples per location.

Important questions are: 1.) How many data collection sites are needed to confidently address the spatial scale of the issue; and 2.) How many plots, transects or other sample units are needed for an accurate estimate at each sampling site. An adequate number of independent, accurate (i.e., the true value) and precise (repeatability of the measurement) data points are required to properly characterize the population every time it is sampled. This allows one to detect change across time, both within and among locations. The number of samples affects the level of confidence to state whether or not the change detected had a high or low probability. The answer to both questions depends on:

- The amount of variation. Typically, the greater the variation on a landscape the more sample sites (plots) needed, and the greater the variation at a location, the more samples needed to accurately characterize the variables measured.
- How precisely the attributes need to be measured to determine change. The detection of ever smaller change requires increasingly more data to be confident about finding differences.
- How important is the detection of a small degree of change, for determining if management goals and objectives are being achieved.
- The cost in both time and money for data collection, processing, and analysis.

For a level of variability in what is measured, there is an optimal match among the size of the change confidently detected, expense of detecting that amount of change, and the importance of any change detected. To justify an objective that targets a small change in an ecological attribute, that attribute should have high ecological or management importance. Detecting small changes with high confidence often requires a large number of samples per site, and/or many study sites. Conversely, a change that is very obvious may be recorded with only a photograph, inexpensive and easy to justify.

To focus monitoring investments, monitoring often reduces sampled landscape variability by focusing plots at key areas expected to respond positively (or negatively) to management actions. That is, monitoring locations are located where management objectives are expected to show a desired change, provided the management action(s) work as planned. There should be no required monitoring sites located in areas that do not represent management concerns (agency or producer) or plan objectives. Generally the amount of change expected from management should be large enough to detect with a reasonable investment in monitoring considering the amount of random variation expected in the measurements.

Monitoring data may be qualitative, quantitative or a combination. The goal of collecting monitoring data is to determine if important resources attributes are having an acceptable, unacceptable, or neutral change due to the management action(s) implemented. Raw data for each attribute being measured are summarized into manageable numbers that improve interpretation of the data. When appropriate, statistical tests can be used to help explain the reliability of measured differences. Data collection and analysis, however, are not the final products. To improve land use decisions rangeland managers may consider the following concepts.

Attributes Measured -- The purpose of data collection, summary and analysis is to improve the ability of rangeland managers (including producers) to decide whether or not management decisions and actions result in desired, undesired or neutral outcomes for important resource attributes. The attribute featured in the objective needs to be closely linked to the attribute actually measured and it should be reliable (not changing dramatically in response to things outside of the manager's control) and important (directly tied to issues of real concern about management).

Descriptive statistics -- describe important attributes, usually about a plant population and/or community. Multiple measurements (samples) of an attribute are reported as single value, typically the mean, median and mode that describe or characterizes the population or community. Measurements of variability include the standard deviation, variance, standard error of the mean, and the maximum and minimum. The variability of the data can also be shown by identifying quartiles or other clustered groups of equal size (range: e.g., 0-5, 6-10, 11-15) between the maximum and minimum values.

Descriptive or summary statistics "paint a picture" about the plant population(s), communities and/or management units and attributes being measured. The basic assumption about most descriptive quantitative data is that all data points are normally or evenly distributed around a central point. When graphed on an x-y axis, the data will represent a bell-shaped curve where the right and left sides are mirror images of one another. In figure 57, the mean (average), median (half are below and half above) and mode (most common values) are all the same value, 13.

These descriptive or summary statistics provide rangeland managers with an overview about the structure, composition, use, or response of a given population and/or community at a moment in time. That is if the data collection process has been carefully designed and an adequate number of samples collected.

Test Statistics -- allow a conclusion, with a degree of confidence, whether or not the differences between or among the sampled locations was real or the result of measurement error. Test statistics assume the attribute measured is sampled in two or more distinct (independent) populations or communities using the same methods and protocols.

Comparisons between populations can be made using inferential statistical tests, including t-tests and analysis of variance (ANOVA), to determine with some level of confidence if two (t-test) or more (ANOVA) populations are similar or different. The ANOVA can also be used to determine if an important attribute for a single population or community has changed across time, when data have been collected from three or more years.

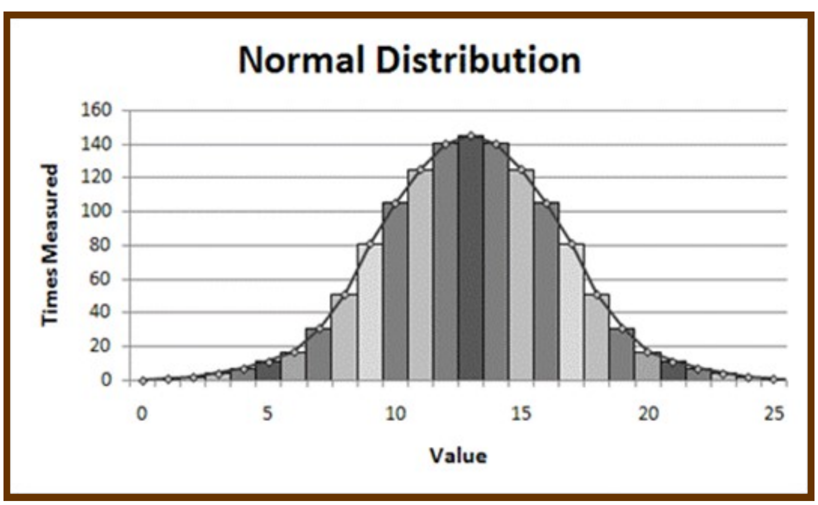

Figure 57. An example of a normal distribution.

Data Scales -- Data typically fit one of four scales: nominal, interval, ordinal or ratios. Of these data types, nominal and interval data are usually most important for rangeland monitoring.

A **nominal scale** assigns items to a group or category defined by one or more qualitative measures. Examples of these include: as grazed, ungrazed, lightly grazed, heavily grazed, or the length of the post-grazing recovery (growth) period (full season, most of the season, some chance, little chance, or no chance). There are no numeric values or relationships between variables. The only applicable statistics are the frequency of occurrence and mode of the specific categories. When using the nominal scale, include or consider all possible responses, including the category "don't know" to prevent forcing answers into an inappropriate category. Also, all categories must be clearly defined so they are mutually exclusive of one-another.

An **interval scale** is one where the distance between measures is always the same. Many different examples exist, including: year, percent cover or utilization, plant density, or stubble height. The key point is that the distance from one unit to the next is always the same.

An **ordinal scale** ranks members in order, but the magnitude of each member is not recorded. An example is the most dominant or abundant plant in a sample, second most, third most etc. Such data for many samples could be used to determine if there has been a shift or if there is a difference in dominance between locations.

Ratios describe something in relation to something else, such as a plant root to shoot ratio or creek width to depth ratio. However these are made out of interval scale data.

Analyzing Descriptive Data -- Measures of **central tendency** (mean, median, mode) are single values used to characterize an entire set of data points (e.g., the average value from 50 quadrats used to measure bunchgrass density). The single value identifies the center of the distribution for each population. When two or more populations are sampled, investigators can calculate the central tendency of each and compare their values to one-another through statistical calculations and tests.

The **mode** is applicable to both qualitative (descriptive) and quantitative (numeric) data. The mode represents the response or value that occurs most frequently. It is the easiest statistic to calculate because it is a simple count of the number of responses in each category, of each value, or each range of values if interval data are divided into groups, such as low, middle and high. The mode is not affected by extreme responses or values, but can be unstable when the range of responses can have two or more values (sometimes widely spaced with other values in between) that are the mode. Although the mode identifies the most common response or score, it may not reflect the majority of responses or scores. It is the peak of the distribution curve. The most appropriate use of the mode is for nominal data.

The **median** is the midpoint in a range of scores and is applicable only to quantitative data. Half of the data points are above the median value and half below. When the number of data points is an even number, the median is the midpoint between the two middle scores. Every data set has only one median value, and that value is not influenced by extreme events; therefore, it is informative when interval data are not normally distributed, but skewed by very high or low values.

The **mean** is the arithmetic average of the data. It is the summation of the values for every data point, divided by the number of data points. It is applicable only to quantitative data, and there is only one mean value possible for each variable/attribute measured. Unlike median and mode, the mean is influenced by extreme values. It can be skewed far to the right or left of the median or mode. The mean is a very appropriate statistic for interval data such as biomass production, percent cover, density of plants, residual plant height and many other attributes.

It is often helpful to calculate more than one statistic for central tendency, particularly if data are not normally distributed. The use of two or more measures of central tendency often provides a more accurate interpretation. All measures of central tendency, however, must be interpreted with respect to sample size. Small sample sizes can provide misleading statistics particularly if sample sites are not randomly selected, and/or the data have large variation.

All data sets have variation. The important question is how large or small is that variation. Full interpretation of the mean, median or mode for all data requires that the investigator understand the variability of the population's responses. Interpretation may be quite different if the variation of the data around the mean is large compared to being very small. Common measurements of variation are the range, variance, standard deviation, confidence intervals, and the coefficient of variation, quartiles, skew and kurtosis.

The **range** is simply the difference between the highest and lowest recorded values. The degree of spread from the mean, median, or mode is an indicator of the variability (for the sampled attribute) of the population's responses. These values, however, should be checked to determine if they are outliers from "most" responses. Unique high and low values are extreme compared to most responses may be meaningless as an indicator of the range of variability. An outlier reflects some factor unrelated to the population or communities response.

Variance and standard deviation measure the collective difference between the mean and individual data points.

*Specifically, **variance** is the average of the squared deviations from the mean. Squaring the difference between each data point and the mean makes all values positive and dividing the sum of all of the squares by the number of data points avoids increasing the value with a larger sample size. Standard deviation is the square root of the variance.*

In practical terms, the larger the variance or standard deviation, the greater the dispersion of the individual data points around the mean. That is, many data points are far from the mean value. A small variance or standard deviation indicates very similar responses or measurements and most data points are near the mean.

The smaller the variance or standard deviation, the greater the probability that the mean obtained from the samples collected is close to actual value of the attribute being measured for the entire population. The terms large and small are relative and directly related to the scale of the data set. When the range of responses is from 1 to 5, a variance of 4 (standard deviation = 2) is very large. When the response range is from 1 to 100 a variance of 4 (s.d. = 2) is quite small. From a practical perspective, when the mean for sagebrush cover is 16 percent and it has a variance of 0.50 percent, one can reasonably conclude the sagebrush cover is near 16 percent. If the variance were 5 percent, there would be a good probability the true sagebrush cover on the site could be much less or much greater than 16 percent.

The **confidence interval** is composed of two values, one on each side of the mean, that identify the range of values likely (given a specific probability level) to include the true mean for the population. The calculated mean of a sampled attribute is always the mean value for the data points (samples) collected, and is an estimate of the actual mean of the population. The actual (true) mean for the population is almost always different from the sample mean and can only be determined if every potential sample is measured (often infeasible). The confidence interval identifies specific values on both sides of the sample mean and the true mean of the population is likely to fall within these two values, given a specified level of probability (e.g., 95%). For example, if the sample mean is 25 and the 95 percent confidence interval of the population mean ranges from 21 to 29, there is a 95 percent chance the true mean of the population is a value from 21 to 29. For a given sample mean, the higher the probability selected (99% versus 95%) the broader the confidence interval will be around the mean. Data with high variability have wider

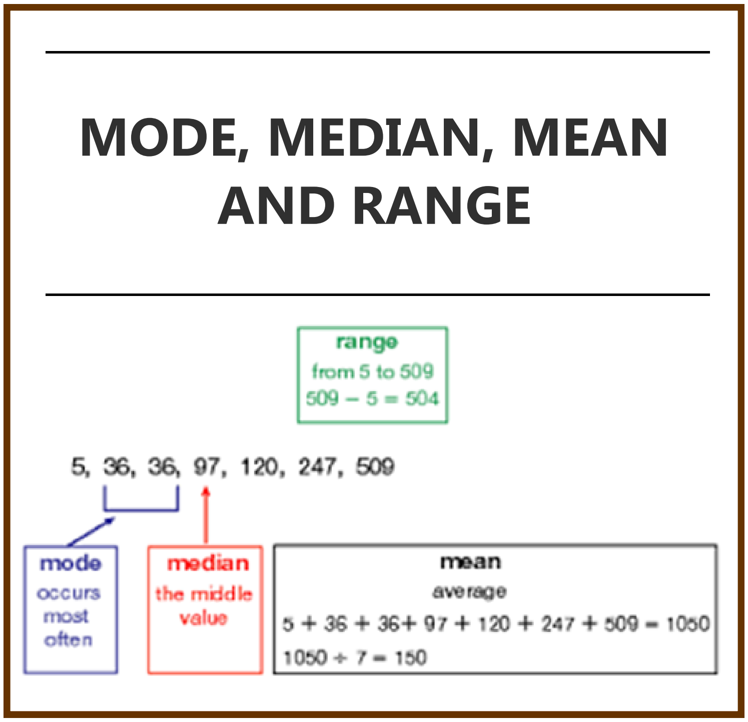

Figure 58. Illustrating the mode, median, mean, and range in a data set. From Houghton Mifflin Math at: https://www.eduplace.com/math/mw/background/5/06a/te_5_06a_overview.html.

confidence intervals than data with low variability. Selecting an appropriate probability value (a function of the importance of the attribute) is important for calculating a confidence interval.

The **coefficient of variation (CV)** is expressed as a percent. It is a relative measure of variability. In contrast, the standard deviation is an absolute measure because it is measured in the same units as the observations. The larger the CV for an attribute, the greater the variability of the attribute sampled. Specifically, the CV is the sample standard deviation divided by the sample mean, multiplied by 100.

Quartiles may be the best indicator of variability when the data distribution is highly skewed. Quartiles are intervals that contain 25 percent of the data points. The width of the intervals is an expression of variability in the data. The width of the quartiles on either side of the mode may be small, but very wide toward the skewed tail. This pattern would indicate most of the population responded similarly, with some extreme outliers. If there are few outliers, it may be best to exclude them from data analysis and interpretation. For example, a sample can be divided into four (quartiles) or any other number of equal width (spread) intervals.

Skew describes how the distribution of the data points compared to the theoretical normal distribution, which is symmetrical. Variation from the normal distribution is skewness. Most data, typically, are skewed to some degree to the right or left of the mode, particularly if extreme values are present. When skewness is high, the assumption of normal distribution is not met, and the use of many **parametric** statistical tests, such as t-tests and analysis of variance, is not valid. The use of the mean to characterize the population may be a poor indicator of central tendency. Likewise the variance and standard deviation would be poor indicators of sample variation.

Non-parametric statistical tests (e.g., Wilcoxon Signed Rank Test, Kruskal-Wallis One-Way ANOVA) are more appropriate statistical tools when the assumptions required for proper application of parametric tests are not met.

Kurtosis reflects whether the distribution of data points or "curve" is peaked or flat. It identifies the steepness of the curve at the mode. Very steep curves indicate each data point has a similar value; thus, low variation. Very shallow (broad curves) indicate wide variation among the data points.

Surveying Populations

Sample Size -- The land manager(s) implementing a monitoring program must determine what proportion of the target population should be sampled to have enough statistical confidence that the data gathered adequately characterizes important ecological attributes (based on management objectives) in the management unit, and is likely to detect the effects of management actions. Most statistics textbooks offer a table for determining sample size.

Most monitoring studies do not test a research hypothesis; therefore, they lack (and do not require) the rigid experimental design required to detect small changes in ecological attributes with very high confidence (i.e., small p-values = small probability of thinking there is an actual difference when there is not). Rather, the quantity and perhaps the quality of the data and associated statistical analyses are explanatory studies, whose intent is to acquire adequate general information about baseline conditions and/or trends for important attributes and/or issues. There is a big difference between the statistical rigor (power) required to test a potential vaccine versus determining whether basal cover of perennial grasses has changed due to a management action. Large samples provide greater confidence that the summarized results accurately reflect the population; however, small samples can provide important information that may not be "statistically significant (i.e., small p-values of 0.05 or less)", but may be "biologically significant", or have management importance.

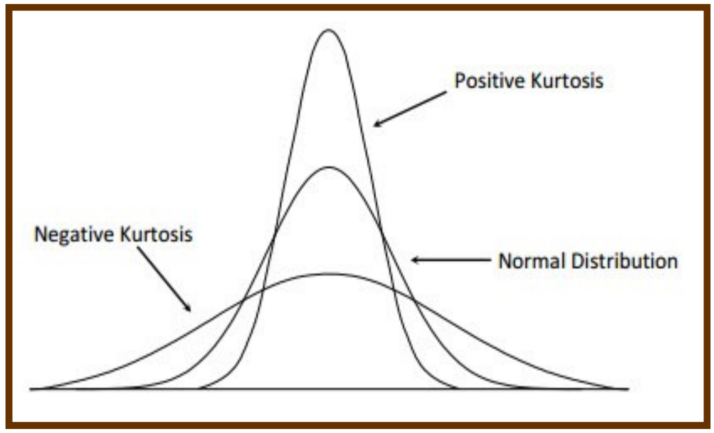

Figure 60. Graphs of negative and positive kurtosis.

Sampling Methods -- Specific sampling methods include simple random sampling, systematic sampling, stratified sampling, and cluster sampling. With **random sampling**, every member (or all locations) in a given population (area) have an equal chance of being selected. Complete random sampling for questions that address large spatial areas typically requires more resources than are available for most rangeland monitoring programs. Random sampling may be appropriate for attributes measured on one (or only a few) small critical areas where one is looking for change across time at that location. **Systematic sampling** typically places the

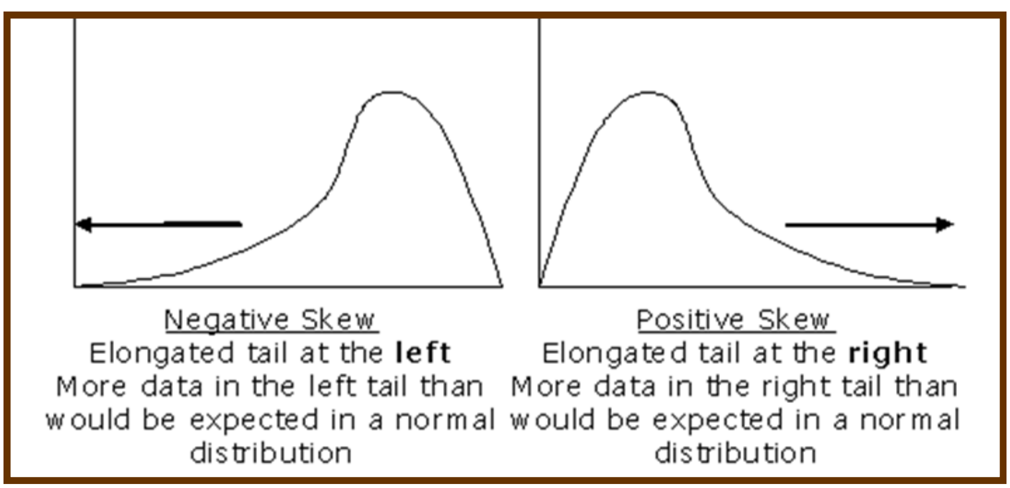

Figure 59. Graphs of negative and positive skew.

entire population on a list, randomly selects one individual or starting point, and all subsequent sample units (quadrats, transects, plants, etc.) are equally spaced (e.g., quadrat placed every 5 feet on a transect). **Stratified sampling** identifies certain subgroups in the population and samples each group in proportion to their numbers in the total population, or their degree of importance. The goal of stratification is to identify (separate) discrete entities (e.g., ecological sites) that are important, and collect the right number of samples from each entity of interest. This approach is intended to decrease variability by focusing only on the area, group, or subpopulation of interest. This saves money (smaller sample sizes) and results in appropriate statistical power. **Cluster sampling** does not target any individual as part of a sample, but rather a naturally occurring group, that occurs in a hierarchy. For example, sampling a stream in a watershed may occur at three levels: the watershed, specific reaches and channel units within a reach. Each of these groups forms a natural cluster. Within each cluster, samples are often obtained with either random or proportional sampling.

Sources of Sampling Error -- There are several potential pitfalls that investigators must consider when sampling a population. These include:

- **Sampling error -** the result of surveying only part of the population and results in statistics that differ substantially from actual value of the population. For example, basal cover of bunchgrasses for the sample obtained was 6.8 percent, but basal cover for the population is actually 5.1%. Sampling error is a function of sample size and is greatest when the sample is small and population variability large. The best method for overcoming sampling error is to increase sample size, or if appropriate stratify the management unit into appropriate sub-units that are more homogeneous. The sub-units must be relevant to the management goals and objectives. Management sub-units that are not relevant to identified management goals, objectives or issues may be excluded from having sampling sites.

- **Measurement error** reflects variation in the data due to the lack of uniformity in the data collection process within and/or among sites. Measurement error often occurs due to poor definitions of the attributes being measured, inconsistent application of the monitoring protocol, the use of damaged sampling equipment; not locating or establishing sample units (transects, quadrats, etc.) with the same protocol at each location; collecting data in windy vs calm conditions, and any other factor that results in the same measurement of the same sampling unit being different, if the data were collected a second time.

Test statistics and p-values -- When two sets of data are compared and statistically analyzed, the comparison is usually of their mean values (and their variation) . The comparison often is for data from the same site collected in two or more years, or data collected from different locations in the same year (but across sites with some unifying feature and management objective). If the data comparison involves two samples (years or sites) the test statistic is a two sample t-test. When data from three or more samples (years or locations) are compared, the one-way analysis of variance is the best analytical tool. When the ANOVA suggests there is a high probability that one or more of the means differ from the others a means separation test (e.g., Tukey or Least Significant Difference) can be used to show which means likely are different from one-another.

Comparisons of means from different data collection periods (years) or locations (sites) will include a management hypothesis (also called null hypothesis in statistics books) and an alternative hypothesis. The management hypothesis typically states that the change in management has had no effect, correlation or association toward the attribute measured. For example, there is no difference in basal cover of desired perennial bunchgrasses five years after changing management from annual season-long grazing (i.e., growing season use every year) to rest-rotation grazing (periodic annual rest). The alternative management hypothesis may be stated as: five years after the implementation of rest-rotation grazing there will be an increase in the basal cover of desired perennial bunchgrasses. The management question is: can the difference in mean basal cover of perennial bunchgrasses be confidently attributed to the change in grazing management, or is it likely due to some factor other than the change in management.

All statistical tests compute a p-value, which is presented in decimal format with a range from 0 to 1.0 (e.g., $p= 0.10$). The p-value is the probability of getting the results you obtained (or a more extreme difference between the mean values) given that the management (null) hypothesis is true (i.e., management had no effect on the means and they are similar). This probability reflects the evidence for or against the management hypothesis. The smaller the p-value (closer to zero) the greater the evidence (stronger confidence one has) against the management hypothesis (no difference due to management). The larger the p-value (closer to 1.0) the stronger the evidence for the management (null) hypothesis (no difference due to the treatments). P-values do not prove or disprove the management hypothesis (or the alternative hypothesis) but only provide strong to weak evidence (probability) for or against a hypothesis. Scientists who implement rigorous experiments often state that when a comparison of two or more means results in a p-value of 0.05 or less, the means are significantly different and would reject the null/management hypothesis, and accept the alternative hypothesis. They typically conclude that if the test statistic had a p-value of 0.06 the means would not be significantly different from one-another and would accept the null hypothesis. For land management, much larger p-values may be quite acceptable (e.g., p = 0.20 or 0.30) if the change has been consistent across monitoring sites and in a desired direction. Management looks for the preponderance of evidence, not conclusive evidence.

When samples are collected from either the same or different populations the mean values will almost always be different. For example, basal cover of perennial grasses may be 8.24 percent in one sample and 8.31 percent five years later. The practical question is: is there a strong or weak probability (evidence) that the difference between the two means is due to the management applied to the site? The p-value provides evidence for or against the management hypothesis, but provides little if any information about the size of the effect of the management action. The size of the effect of a management action can be estimated with effect size statistics.

Effect Size Statistics -- Effect size equations (statistics) report the magnitude and direction of the difference between two means. There is not a direct relationship between the size of a p-value and the magnitude of effect for a management action (Table 1). A small p-value (P<0.05) can occur with either a small or large management effect, as can large p-values. Monitoring studies often do not achieve small p-values for numerous reasons, and the cost of establishing enough monitoring sites and collecting large enough sample sizes to obtain very small p-values would prevent most if not all monitoring from occurring. P-values between 0.06 and 0.20 (or perhaps even larger) may lead on to conclude that there is strong support for the management hypothesis. That is, there is sufficient evidence (i.e., high probability) to conclude that there is no difference in the means because of management actions. Management, however, can still have had an effect that may range from nearly nothing to very large, with either small and large p-values. Effect size statistics look at practical vs statistical significance.

Table 1. Student perceptions in Agriculture.

	Agriculture program		No agriculture program					
	M	*SD*	*M*	*SD*	*t*	*df*	*p-value*	*Cohen's d*
Student perceptions of agriculture	20.11	2.68	19.86	2.55	2.00	1767	0.046	0.10

The data below in Table 1. compares General Agriculture Perceptions by Students in Schools with an Agriculture Program versus Students in Schools with No Agriculture Program (N = 1,953). Traditional statistical analysis found a significant difference between the mean (p=0.046). Effect size analysis, however, found at best a very small effective difference (*Cohen's d*) in perceptions about agriculture regardless of the type of school attended. This example illustrates the hazard of using only p-values to interpret data. This example is from Kotrlik et al. (2011).

Three effect size statistics can be used to analyze whether or not a change in management has resulted in a desired effect. Each uses standard descriptive statistics to measure effect size. The equations are based upon the mean difference for data collected between two sites or two dates, and that difference is divided by the standard deviation from the control site, or a pooled value from the standard deviations from both sites. Among the three equations *Cohen's d* and *Hedge's g* are most popular, with *Hedge's g* providing a slightly better result for small sample sizes. One does not need to understand the equations for calculating the pooled standard deviation. Numerous internet based sites can be used to calculate effect size using your mean and standard deviation data for any data set. To obtain effect size results you can use interactive calculators on the following sites: http://www.polyu.edu.hk/mm/effectsizefaqs/calculator/calculator.html

http://www.psychometrica.de/effect_size.html#cohen

The general guideline for interpreting the effect size statistic from the three aforementioned equations is as follows: no effect to a small effect when the effect size value ≤ 0.30; a moderate effect for effect values between 0.30 and 0.59; a large effect when the effect size ranges from 0.60 and 0.89, and a very large effect when effect size value ≥0.90. As with all guidelines, a question is, what are the practical interpretations of the data and the results of the statistical analyses. To address this question, it may be useful to compare the effect size obtained to the maximum possible or expected effect size effect given your understanding of the ecological relationships involved.

Data Presentation

Summarized data should be presented in a logical

EFFECT SIZE EQUATIONS

$$\text{Cohen's } d = \frac{M_1 - M_2}{SD_{pooled}}$$

$$\text{Glass's } \Delta = \frac{M_1 - M_2}{SD_{control}}$$

$$\text{Hedges' } g = \frac{M_1 - M_2}{SD^*_{pooled}}$$

Figure 61. Three most common effect size equations.

and concise manner. This may include a combination of text, charts, tables, and graphs.

Text increases clarity and provides an analysis/ interpretation of the results. Text becomes important if there are other data that were not collected by the investigators of the current monitoring study, but which they use in the analysis of their results or to justify their conclusions or management recommendations. This is important because most of this appendix is about detecting change or differences. The concern is, was this related to the management applied. Short-term monitoring is essential for interpreting long-term trends, and context is essential for interpreting spatial differences .

Charts -- combine pictures, words and/or numbers that often show important trends and variation. Charts can graphically illustrate sequential steps much clearer, and often more concisely, than lengthy text. Charts delineate and organize complex ideas, procedures and lists of information.

Tables -- summarize large amounts of data and can illustrate differences between groups or populations. They report a numeric value for a category that can be qualitative (e.g., light utilization) or quantitative (e.g., percent cover). Tables group variables from data sets to illustrate comparisons. The table below shows the variables measured across the top row and then the summary statistics for each variable. Data are from Davies et al. (2006).

Graphs -- can also present summarized quantitative data. They are excellent for describing changes, relationships and trends. Graphs often convey information much quicker and clearer than text. Graphs allow the reader to visually observe the results and interpret their meaning, without having to read and interpret lengthy text. Graphs are generally preferred over tables when a visual result enhances understanding about the magnitude of differences at one point in time, or trends in change across time. Tables are appropriate when the specific numbers are needed to convey critical interpretation of data.

Pie graphs and histograms are excellent graphics for showing frequency data, when data are available for two or more categories or populations. **Pie graphs** are best for qualitative categories given a limited number of categories and succinct category labels. The pie chart below depicts the means from the table above.

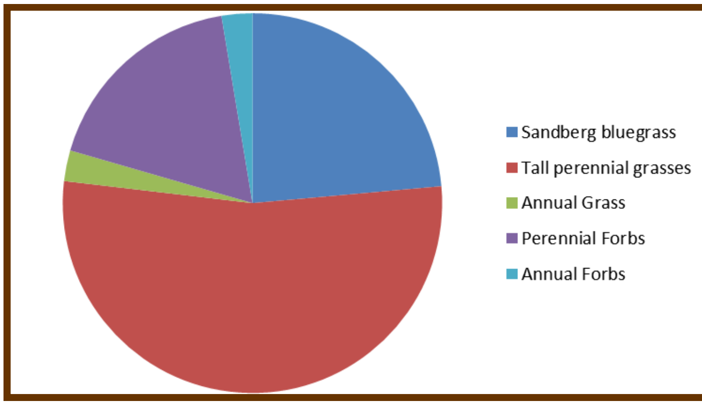

Figure 62. Vegetation data from Davies et al. (2006).

Table 2. Vegetation data from Davies et al. (2006).

Statistic	Sandberg bluegrass	Tall perennial grasses	Annual Grass	Perennial Forbs	Annual Forbs	Total Herbaceous
Mean	5.4	12.2	0.6	4.1	0.6	22.9
Median	5.3	10.9	0.1	3.6	0.4	21.9
Minimum	0.0	4.5	0.0	0.0	trace	5.9
Maximum	13.2	28.3	9.8	11.9	5.6	46.5
Standard error	0.23	0.5	0.1	0.3	0.1	0.66

Histograms -- can be used for any data and illustrate distribution of responses. Categories or intervals are placed along the x-axis, and the frequency identified on the y-axis. For the example below, the x-axis is the range of winter precipitation by half inch increments (from least to greatest since first recorded) and the y-axis is how many values have occurred in each one-half inch increment. The red-line is the curve of the normal distribution.

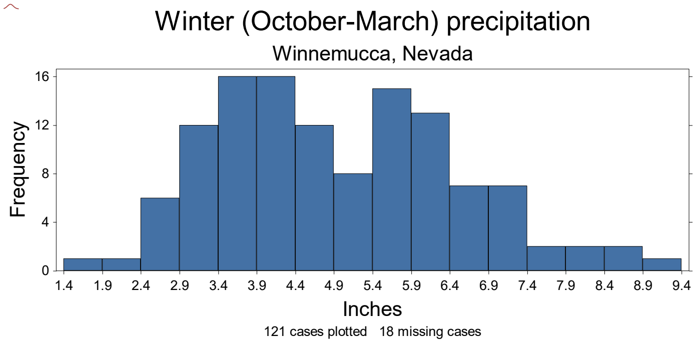

Figure 63 Histogram

Line graphs -- are excellent for illustrating change across time. **Bar graphs** demonstrate differences between two attributes at specific points in time. Bar graphs can be simple (single comparisons) or complex (multiple comparisons), and can be structured horizontally or vertically. Each bar summarizes a quantitative attribute (total, mean, median) about one or more populations for a specific attribute or question.

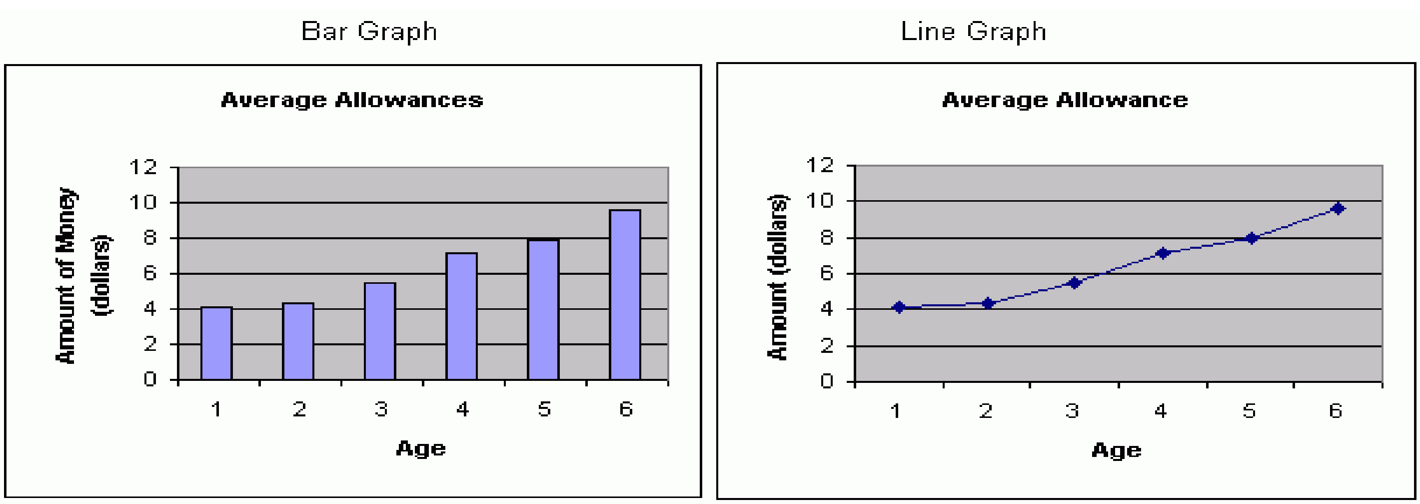

Figure 64. Bar graph and line graph.

Scatter plots -- display the relationship between two variables, on an x-y graph. When variables are tightly grouped together, usually in a linear (or curvilinear) pattern, they typically have a strong correlation. Wide scattering of the data points around the mean or median, or around a regression line indicates high variability in the data and poor or weak relationships or trends. In the scatter plot below, the solid line (just above the value 8) is the regression line for the relationship between year and inches of precipitation. The nearly flat trajectory of the line suggests almost no change (trend) in water-year precipitation since the 1870's. Wide spacing between the line and many data points across the entire period of record, demonstrate great variability in water-year precipitation among years.

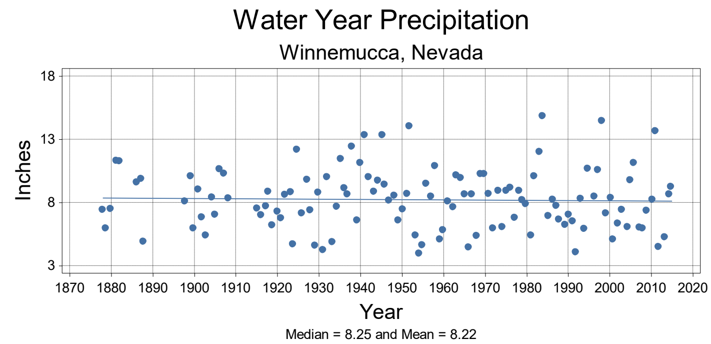

Figure 65 Scatter plot

Web sites to access statistical tools

Web Pages to perform statistical calculations can be found at: http://statpages.info/index.html

This site provides access to many different websites that provide simple to complex statistical analysis, plot data, create charts and other graphics, etc. All of the calculations and statistical tests described in this appendix, except for effect size statistics, can be conducted at many of the websites found on this website.

Web pages for effect size calculations and explanations of effect size statistics can be found at:

http://www.polyu.edu.hk/mm/effectsizefaqs/calculator/calculator.html

http://www.psychometrica.de/effect_size.html#cohen

APPENDIX J - USE MAPPING, KEY SPECIES METHOD,AND PROPER USE

Use Mapping -- Use pattern mapping is an excellent way to understand how grazing by livestock, wildlife, horses and burros, ground squirrels, etc. connects to the rangeland resource in larger pastures. Across the West, livestock distribution is commonly the biggest management problem and opportunity. Distribution varies according to slope, aspect, location of waters, palatability of forages, patterns of residual forage, season of use, animal habits, etc.

The best kind of base map for delineation of use zones is an aerial photo or orthophotoquad showing soils or ecological sites and physical features such as fences, waters, 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.

Commonly used classes of use levels 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) and in the *Ranchers' Monitoring Guide* (Perryman et al. 2006; 2017). Key species utilization on key areas can be used as a component of use pattern mapping. However, use pattern mapping based only on key areas misses most of the pattern.

Mapping proceeds as the pasture is traversed. When another use zone is observed, the level 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; 2017).

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; 2017)). A seasonal use map provides early indications of grazing issues (e.g. distribution or differential use by different species).

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. Because vegetation is needed for riparian functions, specifically note 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 for a variety of reasons. However, utilization patterns can change because of management actions including 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 be tied to objectives and opportunities for enhancing rangeland, plant, or animal health. Management changes that affect distribution include use of stockmanship to place livestock, other herding, water locations, season of use, use or placement of supplements or salt, changing pasture size or shape, animal numbers, duration of grazing period, fire, 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 key species. This method is described in the interagency technical reference on utilization studies and residual measurements (BLM 1999b) and in the *Ranchers' Monitoring Guide* (Perryman et al. 2006; 2017).

Training for this utilization method requires observers 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 is common in use mapping. Utilization cages can be employed in conjunction with this method on key areas to provide reference 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 in combination with actual use data, trend in species composition, use patterns, 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 the one that best addresses site-specific conditions and objectives. For example, residual vegetation is preferred in areas where vegetation is relatively evenly dispersed, such as meadows or where growing the next crop of annual brome grasses prevents transition to an even more degraded state. 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 (Bedell 1998). Proper use is species specific. It may also be affected by the ecological site, state, and phase, and varies to a great degree with neighboring plants, the opportunity for plants to grow or regrow, season of use, and duration and intensity of use.

Determination of key species and desired 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 to achieve objectives. Considerations of proper use often drive targets for within season triggers and end-of-season indicators in allotment management or multiple-use management plans. Proper use, based on grazing management and setting should be checked against trend data to determine if the current proper use is appropriate or needs adjustment.

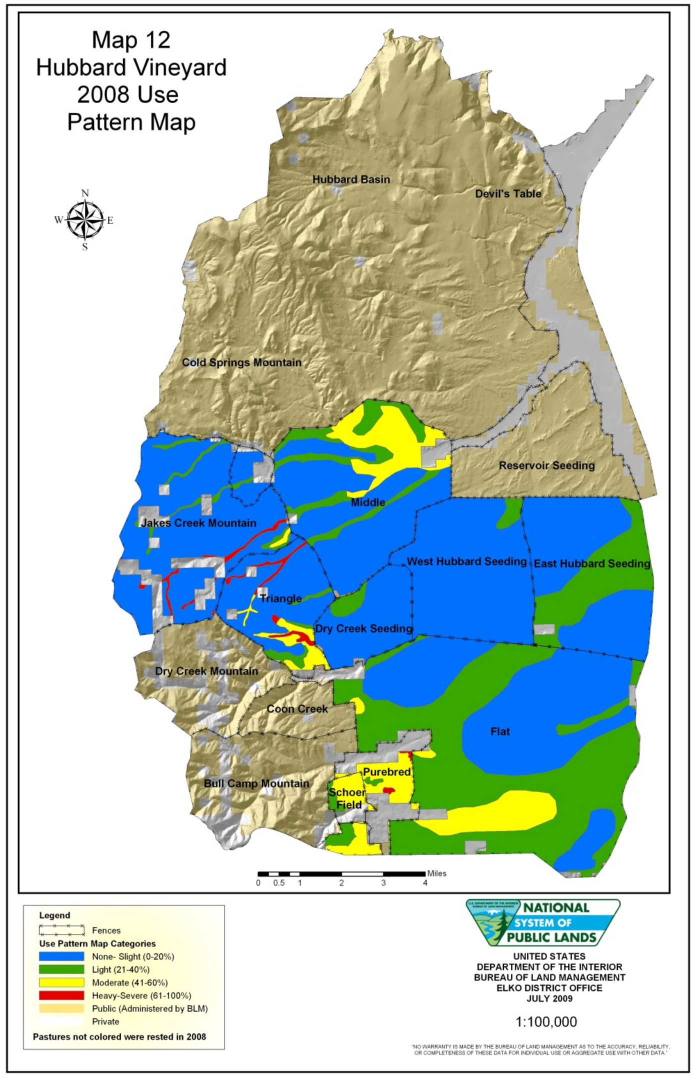

Figure 66. Distribution of grazing intensity can be influenced by season of use, weather, infrastructure like fences and location or number of waters, topography, stockmanship, placement of supplement, past use patterns, and animal selection or training. Mapping use patterns provides clues for management, selection of monitoring locations, and a record of use in a given year to interpret long-term monitoring.

APPENDIX K - MONITORING-PLAN FORMS

The following two forms can be copied and filled out, 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 (implementation and effectiveness) monitoring that will take place at each key area, critical area, photo point, or designated monitoring area.

An important first step at a monitoring plot is to characterize the plot location and determine which of the possible ecological sites best represents the plot location among those that can occur in a soil map unit: 1: Describe the location of the plot, 2: Describe the topography of the plot, 3: Describe the landscape unit and position, 4) Dig a small soil pit and describe it, 5) Determine soil map unit component and ecological site (Herrick et al. 2005b).

Monitoring plan (Form 1) (Copy form1 and fill it out for each objective.)

Monitoring plan for the ___________________________ land or management unit Date_____________

What is the issue being addressed: ____
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)____

Monitoring Area Plan (Form 2)

(Copy form 2 for each study site, key area (KA), critical area (CA), photo point (PP), or designated monitoring area (DMA).) (Or use this form to guide filling out a narrative monitoring plan. Some sections may not apply to each location)

Name of this study site, etc. ________________________ **KA** **CA** **PP** **DMA** (circle one)

GPS or narrative location ____

Date established ____________________________________ By whom ______________________________

Where are the baseline data and other past data stored? ____

What short-term triggers will be monitored here? ____

How will it be monitored? ____

Target value(s) ____

When will it be monitored?____

By whom? ____

What will it trigger? ____

What end-point or annual indicator will be monitored at this location? __________________________________

How will it be measured? ____

Target value(s) ________________________________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 L - RANGELAND MANAGEMENT AGENCY OFFICES IN NEVADA

Nevada Agencies

Nevada Department of Agriculture St. Office
775-353-3601
405 S 21st St.
Sparks, NV 89431
http://agri.nv.gov/

Nevada Department of Wildlife
(775) 688-1500
6980 Sierra Center Pkwy #120
Reno, NV 89511
http://www.ndow.org/

Nevada Indian Commission
(775) 687-8333
5366 Snyder Ave.
Carson City, Nevada 89701
http://nic.nv.gov/

University of Nevada Agricultural Experiment Station
(775) 784-6237
College of Agriculture, Biotechnology, and Natural Resources
Fleischman Agriculture Building, 9th and Evans
Reno, NV 89557
http://www.unr.edu/cabnr

University of Nevada Cooperative Extension
(775) 784-7070
Fleischman Agriculture Building, 9th and Evans
Reno, NV 89557
http://www.unce.unr.edu/

Desert Research Institute, Reno and Las Vegas
https://www.dri.edu/

Nevada Department of Conservation and Natural Resources
(775) 684-2700
Office of the Director | 901 S. Stewart St., Ste. 1003
Carson City, NV 89701
http://dcnr.nv.gov/

Nevada Division of Environmental Protection
(775) 687-4670
901 South Stewart St., Ste. 4001
Carson City, Nevada 89701
http://ndep.nv.gov/index.htm

Nevada Division of Forestry | (775) 684-2500
2478 Fairview Dr.
Carson City, Nevada 89701
http://forestry.nv.gov/

Nevada Natural Heritage Program
(775) 684-2900
901 S. Stewart St., Ste. 5002
Carson City, NV 89701-5245
http://heritage.nv.gov/

State Historic Preservation Office
775-684-3448
901 S. Stewart St. , Ste. 5004
Carson City NV 89701
http://shpo.nv.gov/

Nevada Division of Water Resources
(775) 684-2800
901 S. Stewart St., Ste. 2002
Carson City, NV 89701
http://water.nv.gov/

Nevada Conservation Districts Program
(775) 684-2700
901 S. Stewart St., Ste. 1003
Carson City, NV 89701
http://dcnr.nv.gov/conservation-district-program/

Nevada State Conservation Commission
(775) 684-2700
901 S. Stewart St., Ste. 1003
Carson City, NV 89701
http://dcnr.nv.gov/conservation-district-program/conservation-commission/

Nevada Sagebrush Ecosystem Program
(775) 684-8600
201 S. Roop St., Ste. 101
Carson City, Nevada 89701
http://sagebrusheco.nv.gov/

Federal Agencies

U.S. Department of Agriculture

Agricultural Research Service Great Basin Rangelands Research
(775) 784-6057
920 Valley Rd.
Reno, NV 89512
https://www.ars.usda.gov/pacific-west-area/reno-nv/great-basin-rangelands-research/

Natural Resources Conservation Service (NRCS) Nevada State Office | (775) 857-8500
1365 Corporate Blvd | Reno, NV 89502
http://www.nrcs.usda.gov/wps/portal/nrcs/site/nv/home/

Inyo National Forest
760-873-2400
351 Pacu Ln., Ste. 200

Bishop, CA 93514
http://www.fs.usda.gov/inyo

Forest Service - Humboldt-Toiyabe National Forest Supervisor's Office
(775) 331-6444
1200 Franklin Way
Sparks, NV 89431
http://www.fs.usda.gov/htnf/

USFS - Rocky Mountain Research Station
Reno Great Basin Ecology Laboratory
(775) 784-5329
920 Valley Rd
Reno, NV 89512
http://www.fs.fed.us/rmrs/research-labs/reno-great-basin-ecology-laboratory

U.S. Department of Interior

Bureau of Land Management State Office
775-861-6400
1340 Financial Blvd.
Reno, NV 89502
http://www.blm.gov/nv/st/en.html

Bureau of Indian Affairs – Western Nevada Agency
775-887-3500
311 E. Washington
Carson City, NV
http://www.bia.gov/WhoWeAre/RegionalOffices/Western/WeAre/WesternNevada/index.htm

Bureau of Indian Affairs – Eastern Nevada Agency
775-738-5165
2719-4 Argent Ave.
Elko, NV 89801
http://www.bia.gov/WhoWeAre/RegionalOffices/Western/WeAre/EasternNevada/index.htm

Fish and Wildlife Service
(775) 861-6300
Nevada Fish and Wildlife Office
1340 Financial Blvd.
Reno, NV 89502
https://www.fws.gov/nevada/

National Park Service - Great Basin National Park
775-234-7331
100 Great Basin National Park
Baker, NV 89311
https://www.nps.gov/grba/index.htm

US Geological Survey - Nevada Water Science Center
775-887-7600
2730 N. Deer Run Rd.
Carson City, NV 89701
http://nevada.usgs.gov/water/

Lake Mead National Recreation Area
(702) 293-8990
601 Nevada Hwy.
Boulder City, NV 89005
https://www.nps.gov/lake/index.htm

U.S. Department of Defense

U. S. Navy Fallon Naval Air Station
(775) 426-5161
4755 Pasture Rd.
Fallon, NV 89496
http://www.cnic.navy.mil/regions/cnrsw/installations/nas_fallon.html

Nellis Air Force Base LMR
702-652-2750
http://www.nellis.af.mil/Home.aspx

Rangeland Management/monitoring Consultants:

Society for Range Management (SRM)
http://www.rangelands.org/srm.shtml
The SRM maintains a list of rangeland consultants.

Nongovernmental organizations focused on rangeland management:

The Nature Conservancy Northern Nevada Office
(775) 322-4990
1 E. 1st St., Ste. 1007
Reno, NV 89501
http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/nevada/

Eastern Nevada Landscape Coalition
775-289-7974
1500 Avenue F
Ely, NV 89301
http://www.envlc.org/

Stewardship Alliance of Northeast Elko (SANE)
http://www.ndow.org/uploadedFiles/ndoworg/Content/Nevada_Wildlife/Conservation/SANE-Sagebrush-Ecosystem-Conservation-Plan.pdf

Shoesole Resource Management Group
(775) 752-0817
HC 62 Box 1300, O'Neil Route | Wells, Nevada 89835
http://theshoesole.org/

Northeast Nevada Stewardship Group
PO BOX 1677
Elko, NV 89803
http://nnsg.org/

Modoc Washoe Experimental Stewardship Program
c/o BLM Northern California District, Surprise Field Station
602 Cressler St.
Cedarville, CA 96104

APPENDIX M - GLOSSARY, ACRONYMNS, AND ABBREVIATIONS

Actual Use – Documentation of livestock use and management in a pasture, or a use area within 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. Actual use concepts can be tracked and applied to wild horses and other large herbivores.

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

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 and its interpretation so that managers can learn about resource potentials, important problems, and the resource attributes in play for making changes to address issues (BLM Handbook 4180-1).

Climate -- How the atmosphere behaves (e.g. averages and record highs, lows, and durations) over relatively long periods of time (many years).

Colonizer – A plant adapted to begin growth on recently deposited sediments or on recently disturbed areas (Winward 2000). Syn. pioneering/ colonizing riparian vegetation (Dickard et al. 2015).

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 – The proportion of the soil surface covered by a vertical projection of the cover class of interest, regardless of what is above or below the object: plant parts (foliar cover), plant bases (basal cover), litter (litter cover), lichens, mosses, duff, etc. The opposite of bare ground (Herrick et al. 2005b)

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 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 – Those 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 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.

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 (Burton et al. 2011).

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 (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).

Droop Height – The height of a grass or forb measured from the ground to the point where the plant naturally bends (maximum natural height). There may be no droop to some plants with relatively short stature (Connelly et al. 2003)

Ecological site – A conceptual division of the landscape that is defined as a distinctive kind of land based on recurring soil, landform, geological, and climate characteristics that differs from other kinds of land in its ability to produce distinctive kinds and amounts of vegetation and in its ability to respond similarly to management actions and natural disturbances (Caudle et al. 2013).

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 period 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 indicates 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 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, good principles, 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.

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.

GIS – Geographic Information System – A system designed to capture, store, manipulate analyze manage or present all types of spatial or geographical data.

GPS – Global Positioning System – A space or cell tower based navigation system that provides location and time information.

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 <u>not</u> an estimate of percent utilization which also includes utilization after plants are dormant and/or may be modified by regrowth. Syn. *intensity*.

Grazing Response Index (GRI) – A tool for evaluating past grazing and planning future grazing that considers the intensity, frequency and opportunity for growth and/or regrowth (Reed et al. 1999; Perryman et al. 2006; 2017). Each factor is valued at -1, 0, or $\pm$ 1 (up to $\pm$ 2 for opportunity for growth and/or regrowth).

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 along streams with defined channels. In meadows without defined channels, it is the lowest part of the meadow where flood waters would be deepest (Burton et al. (2011).

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).

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 or slowly moving 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. Also called effectiveness monitoring, it is used to periodically assess progress toward meeting 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).

Objective – 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. Syn. Resource Objective.

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) or weather.

Photograph – An image captured by various means, including film, digital camera, video, etc.

Plant height – The maximum (or average maximum) height of woody or herbaceous (see droop height) vegetation within a defined sampling quadrat (or plot area)

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 specie's 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 functional attributes characteristic of a locale, including normal variability (SRM 1999).

Reference State – A reference state is recognized in each state and transition model that describes the ecological potential and natural or historical range of variability of the ecological site. Due to natural disturbance and climatic processes, reference conditions can be represented by more than one community phase depending on the time period in which an ecological site is observed (Caudle et al. 2013).

Remote sensing – Detecting information about the character of a resource from afar, such as through photography or other imagery, often obtained from aircraft 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 capacity of ecological processes to recover following a disturbance. Resilience can be defined in terms of the rate of recovery, the extent of recovery during a particular period of time, or both (Pellant et al. 2005).

Resistance – The capacity of ecological processes to continue to function without change following a disturbance (Pellant et al. 2005).

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. Syn. Objectives

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, Lotic – A lotic riparian area is considered to be in PFC, or "functioning properly," when adequate vegetation, landform, or woody material is present to:

- Dissipate stream energy associated with high waterflow, thereby reducing erosion and improving water quality.
- Capture sediment and aid floodplain development.
- Improve floodwater retention and ground-water recharge.
- Develop root masses that stabilize streambanks against erosion.
- Maintain channel characteristics.

A riparian area in PFC will, in turn, provide associated values, such as wildlife habitat or recreation opportunities. (Dickard et al. 2015).

Riparian Proper Functioning Condition, Lentic -- Lentic riparian-wetland areas are functioning properly when adequate vegetation, landform, or debris is present to: dissipate energies associated with wind action, wave action, and overland flow from adjacent sites, thereby reducing erosion and improving water quality; filter sediment and aid floodplain development; improve flood-water retention and ground-water recharge; develop root masses that stabilize islands and shoreline features against cutting action; restrict water percolation; develop diverse ponding characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, water bird breeding, and other uses; and support greater biodiversity (Prichard et al. 2003).

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 and helps interpret long-term or implementation 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 system 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 by the stream during rare flood events, if ever.

Streambank alteration – Streambank disturbance caused by animals (e.g., elk, moose, deer, cattle, sheep, goats, and horses) walking along the streambanks or the margins of the stream. The animals' weight can cause shearing that results in a breakdown of the streambank and subsequent widening of the stream channel. Streambank alteration also exposes bare soil, increasing the risk of erosion of the streambank. Animals walking in the channel margins may increase the amount of soil exposed to the erosive effects of water by breaking or cutting through the vegetation and exposing roots and/or soil. Excessive trampling causes soil compaction, resulting in decreased vegetative cover, less vigorous root systems, and more exposure of the soil surface to erosion. (Burton et al. 2011).

Streambank stability – A measure of the degree to which an erosional streambank is covered by vegetation or anchored rock or logs versus the degree to which a streambank is showing signs of active erosion with a fracture, slump, slough, or bare bank. (Burton et al. 2011).

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. Sustainable often refers to the triple bottom line of ecological, economic, and social factors.

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, for ensuring that end-point indicators are met.

Ungulate – A large herbivore with a hoof. Cattle, sheep, deer, antelope and elk are ruminants, llamas are camelids, and horses are equids. All 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.

Weather -- The conditions of the atmosphere over a short period of time (months), for example, temperature, precipitation, humidity, cloudiness, brightness, and wind.

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

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