Water Stewardship on Rangelands©

A Manager's Handbook

CARRUS land systems

Spring Valley, Nevada
Photo: Nicole McCoy

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Introduction

Why do we care about water?

Water is one of our most highly valued and sought-after natural resources. As populations grow throughout the arid and semi-arid Western United States where water resources are increasingly scarce, cities are outgrowing their easily obtainable water supplies and are seeking to meet growing municipal demand by obtaining water rights from agricultural users as well as through pumping underground aquifers.

Aquifer drawdown is a troubling, but not foregone, result of increasing water demand. If withdrawal is greater than recharge, a negative water balance may result in less water available for vegetation, livestock, or wildlife use. As water levels drop, pumping costs increase. Land subsidence occurs when the subsurface support provided by water is removed and rocks and sediments collapse and compact under the weight of the overlying material. This can reduce or prevent further recharge and is irreversible. Land elevation changes can be observed on the irrigated floodplains of the Humboldt River near Lovelock, Nevada, as well as in the San Joaquin Valley of California, south-central Arizona, and the Houston-Galveston area in Texas.

As with other publicly owned resources such as public land and wildlife, management of the groundwater resource is captive to a triangle of perverse incentives that occurs when the means and motivation to manage a publicly held resource lies with different entities.

> *While landowners may not possess the motivation to manage their lands for aquifer recharge, many possess significant motivation to manage their rangelands for other outcomes such as livestock production and wildlife habitat.*

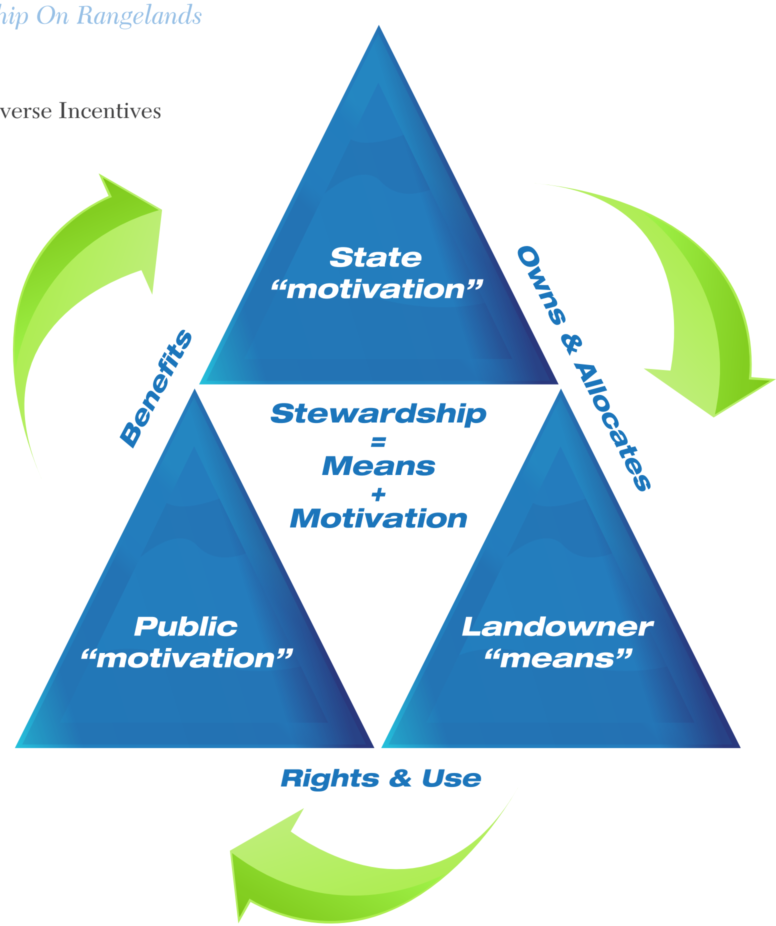
At the top of the triangle is the state, charged with allocating the public's water resource. The state has a strong motivation to see that water is managed to best benefit its residents, but because a state exists primarily in an allocative capacity and cannot really manage water once it is allocated, the state does not possess the means to ensure groundwater recharge. At the bottom left of the triangle is the interested public. The public, the residents of a state who own the water, may possess a strong motivation to encourage good water stewardship. However, the "public" who owns the water is not the same entity that owns and manages the land and therefore cannot directly influence water use on the land. At the bottom right of the triangle is the landowner. Landowners and/or public permittees control the condition of the land surface that captures the water. The landowner may possess rights to water and to the land that affects what happens to that water, but under current law the landowner can only benefit from water by putting it to beneficial use. The landowner cannot benefit directly from managing surface water in a manner that recharges aquifers. Therefore, the system as it currently exists cannot create desirable water outcomes without first aligning means and motivation.

While landowners may not possess the motivation to manage their lands for aquifer recharge, many possess significant motivation to manage their rangelands for other outcomes such as livestock production and wildlife habitat. There is a direct link between the healthy rangeland ecosystems that are necessary to produce livestock and well-managed surface and groundwater. Therefore, landowners have the opportunity to create desirable outcomes from which they will directly benefit while simultaneously improving the ecosystem function. This is where means and motivation align.

Who should use this handbook?

This handbook can be used by anyone concerned about improving water management on rangelands. Water is one of the most limiting factors associated with rangeland management. In arid environments, water is so scarce that it is often believed there is very little that can be done to improve rangeland productivity. The handbook outlines strategies to improve water conservation and efficiency on

Triangle of Perverse Incentives



rangelands in the arid Western United States. It guides the user through the decision-making process for using water stewardship to increase profitability and ecosystem health. The handbook highlights the importance of water management on rangelands and offers practical advice for improving surface water distribution and groundwater recharge.

This handbook is intended to help the reader think critically about water as a budget that can be allocated to alternative uses and leveraged to achieve management goals while meeting increased demands.

What can be done?

Although the amount of precipitation received cannot be controlled, we can manage the soil surface and vegetation to enhance water infiltration and groundwater recharge.

In 2006, the US Census Bureau reported that 5 of the 10 fastest growing states in the nation are located in the arid West. Western states also contain most of the nation's 400 million acres of rangelands. The largest opportunity for groundwater recharge exists in the management of rangelands.

Understanding a landscape's water budget can assist managers in increasing water efficiency, quantity, and quality on their landscape while at the same time making their operation more profitable and enhancing environmental values.

The earth's water cycle is a closed system with an unchangeable quantity of water. Rangeland users have very little control over when and how much precipitation rangelands receive. Once water leaves the surface through runoff or percolation, users again have very little control over how that water is used and where it goes. However, while the water is on or near the surface, the rangeland manager has a great deal of influence on the water cycle.

The water budget of a particular piece of land depends upon how much precipitation is received, how much water leaves the land, and where that water goes.

What can I do?

Rangeland management practices such as grazing management, revegetation, brush and weed management, and soil modification techniques can directly affect the water regime. These practices can bring about increases in range productivity through increased conservation of water and improved water efficiency. Management procedures that increase vegetative cover and stem density can be implemented on grazing operations to increase surface water contribution to underground aquifers.

For rangeland managers, appropriate techniques depend on the physical and biological characteristics of the land. Social, political, and legal barriers may also prevent otherwise good water management practices. Vegetation manipulation and alteration of water distribution can lead to increased return flows into the groundwater system. Utilization of snowmelt in the springtime by using catchments may provide a water supply later in the year. Collaboration with agencies, neighboring ranchers, and interested non-governmental organizations (NGOs) may lead to more efficient solutions by alleviating financial burdens and property rights issues and managing disputes.

Case Study

The Tippett Pass allotment located in White Pine County, Nevada, serves as a case study for this handbook. The case study is used to demonstrate how stakeholders can work through the assessment and planning process to develop and evaluate management alternatives.

Management Tips

This handbook covers a variety of concepts associated with water stewardship on rangelands in the arid and semi-arid West. To help simplify these complex interactions, throughout the handbook we offer quick tips—general guidelines based on common sense, scientific literature, and basic principles. Of course, with such a variety of physical, social, and biological factors facing rangeland management, not all tips may be applicable to every situation.

WATER STEWARDSHIP ON RANGELANDS PRIMER

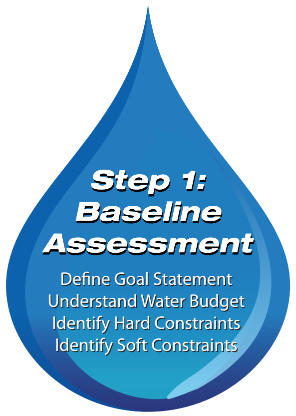
Water Stewardship
on Rangelands Process

Improving watershed management on rangelands requires conceptualizing how complex system interactions can be addressed in a series of relatively straightforward tasks. This handbook employs a simple, iterative approach that guides managers through the Assessment, Planning, and Action process.

In the *Assessment* phase, the user will 1) establish a goal statement against which outcomes will be measured, 2) understand how changes in management can affect a site's water budget, and 3) identify constraints that may affect the feasibility or success of potential management actions.

The *Management Planning* phase is then employed to 1) design alternatives consistent with what was learned in Assessment, 2) evaluate the alternatives against ecological and economic outcomes, and 3) select the alternative that best satisfies the overall goal.

Finally, during the *Action* phase, the user will 1) implement the plan designed during Management Planning, 2) monitor outcomes against expected results and desired outcomes, and 3) adapt management practices to improve outcomes.



Define Goal Statement

The goal statement is the foundation of management planning activities. Good water stewardship requires a thoughtful examination of management goals and their expected outcomes. The goal statement is a broad general statement describing the main purpose of the management plan; e.g., to improve the availability of water for livestock, wildlife, and rangeland habitat.

To help formulate this statement, ask the following questions:

What am I managing these rangelands for?

What would I like to change?

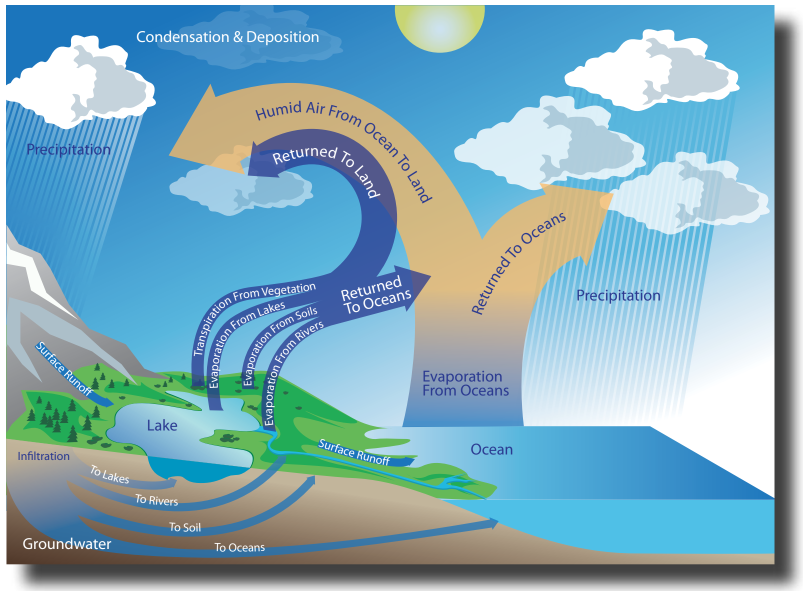
What would I like to accomplish?

In order to develop a goal statement and identify strategies to achieve the goal, an understanding of the water budget and associated constraints is required.

Understand the Water Budget

The hydrologic cycle is the circulatory transportation of the earth's water resources that links the atmosphere to land, plants and animals, glaciers, and the oceans. The cycle is comprised of several steps: evaporation, condensation, precipitation, infiltration and percolation, and runoff. The cycle is driven by solar energy, which stimulates the evaporation of water into the atmosphere, where it condenses and falls as precipitation. When it falls on land, some infiltrates the soil, percolates through the bedrock, and is stored as groundwater; some water is taken up by plants and transpired into the atmosphere, and some becomes surface runoff forming rivers that drain into the oceans.

Hydrologic Cycle



Terrestrial systems will use water before you. Consider this when calculating your water supply, as well as calculating the correct number of livestock AUMs for the area.

A water budget allocates a basin's water resources between inflows and outflows. Managers seeking to manage the water resource for improved rangelands will benefit from understanding how the hydrologic cycle functions in their specific locale and the resulting water budget associated with their specific landscape.

Water is an input into many rangeland processes. How water is managed determines what outputs can be created with it. Landowners interested in increasing stream flow for fish habitat will manage their budget differently than will managers who seek to increase livestock Animal Unit Monthly, AUMs (1 cow and a calf or 5 sheep feeding on a unit of land for 1 month). This is not to say that increased stream flow and AUM creation are incompatible goals; nevertheless, landowners do need to be aware of how management strategies can influence the variables that comprise the water budget.

The Water Budget

$$P + Qon = ET + Qoff + DS$$

P	Precipitation or Irrigation
Qon	Water Flow onto the Property
ET	Evapotranspiration
Qoff	Water Flow off the Property
DS	Change in Storage

Identify Constraints

This section demonstrates how the variables that comprise the water budget are themselves affected by topography, climate, geology, soils, and vegetation. Ultimately, management outcomes are constrained by physical realities of the landscape. Nevertheless, within these constraints is a great deal of variability, allowing management to have a significant impact on the outcome.

Hard Constraints

Hard constraints are those physical characteristics of the landscape that cannot be changed through management.

Climate

Climate is the prevailing weather conditions of a region. It varies with season, elevation, and latitude. Precipitation, temperature, humidity, and wind define climate, which in turn affects vegetation, soils, and the hydrologic cycle. The seasonality of precipitation and the drought cycle are important considerations. For example, in the arid to semi-arid Great Basin, precipitation ranges from 0 to 12 inches annually and is received mostly in the form of snow at higher elevations during winter. Groundwater and soil moisture is replenished mostly from snowmelt. Drought is a cyclical feature of the climate, and precipitation can vary widely from year to year.

Vegetation types and abundance are influenced by precipitation type, frequency, and amount. Drought and high temperatures are common for this region, constraining vegetation productivity.

For every 1 in. of precipitation put into the ground, 100 lb. more forage is created.

Topography

Topography (slope, aspect, and elevation) determines drainage patterns and vegetation communities and influences the movement of water. Surface water and sediment transport increase with slope steepness, therefore, less water infiltrates into the ground, whereas at lower elevations with less slope, the water velocity slows and sediment is deposited. This influences vegetation community types, which also affect water infiltration and evapotranspiration. Differences in the amount of light and temperature, determined by aspect, also affect plant communities.

Elevation influences relative humidity, temperature, and vegetation types. These factors must be considered when managing water for the utilization of vegetation for wildlife habitat and livestock grazing. Higher elevations generally receive greater precipitation and snow accumulations; aspects situated leeward (downwind) of prevailing winds generally receive greater snow accumulations than windward (upwind) side aspects (due to drifting). Snowdrifts, especially on northerly and easterly aspects, generally result in wetter soils and greater vegetative production (including tall, woody plants), thus influencing plant community composition and increased future snow capture and infiltration.

Geology

Geology is the composition, structure and physical properties of the earth. Geologic processes create the landscape and transform parent material into soils, which influence water transportation and storage. Some water is stored in unsaturated soil as soil moisture that is available for plants. Water also percolates downward into saturated geologic material as groundwater. The water table is the boundary between unsaturated soil and groundwater.

An aquifer is a saturated, permeable, unconfined geologic formation that transports water below the land surface to supply springs and rivers. Aquifer recharge is the process of water infiltrating soil and permeating into groundwater. The amount of surface water that reaches an aquifer is largely dependent on the porosity of the soils and geologic material through which it travels.

Organic ground cover can slow overland flow and protect the soil surface from solar radiation. This allows water to be retained in the soil, leading to increased groundwater and aquifer recharge.

Soils

Soil properties, such as texture (particle size) and structure (aggregation of particles), affect infiltration and movement of water through the soil into the water table. Coarse soils (sand) drain quickly, while fine soils (clay) hold water. Soil structure is characterized by the shape and size that soil particles form into, e.g., granular, platy, blocky, or prismatic. The structural characteristics define pores and channels in the soil that hold air and conduct water. Soil properties determine the soil's ability to supply nutrients to plants, influencing which vegetative communities are supported on a landscape. These soil properties directly influence soil moisture and aeration and are important considerations when managing for water.

Soil disturbance, such as compaction or erosion, limits infiltration, transportation, and storage of water.

Soft Constraints

Soft constraints are the biotic, social, and political factors that affect management but can be modified to achieve management goals.

As you read this section, ask yourself the following questions:

What can I change?

What would it take to modify or mitigate these constraints?

Vegetation

Vegetation types and plant communities have a significant impact on an area's water budget.

Through the process of photosynthesis, plants absorb sunlight and convert water and carbon dioxide into sugar needed for growth and reproduction. Plants pull water and nutrients from the soil through their roots and release water back into the atmosphere (transpiration). Water loss through transpiration is proportional to leaf area and availability of water to the roots of the plants. Preserving soil moisture with plant litter can reduce evaporative loss from the soil surface.

Changing the vegetation composition of an area can provide more usable water in the soil. Woody plants and many perennial forbs have deep-reaching taproots, while grasses have shallower-rooted fibrous root systems. Infiltration is greater and transpiration is less in plant communities dominated by grasses than in those dominated by woody plants.

Wildlife

Alteration of the water regime will affect both livestock and wildlife. Utilization of rangelands is often constrained by location and supply of water resources. Consideration for wildlife should not be limited to sensitive, threatened, or endangered species. Most game species of fish and wildlife respond positively to increased water infiltration, increased spring water flows, and increased surface water availability. Many, but not all species of concern respond similarly. Managing all wildlife in an area can yield economic, recreational, and aesthetic benefits.

Available Acreage

The size of the management area will largely affect what opportunities are available for improving water efficiency.

As management area increases, the opportunity for the rangeland manager and the ecosystem to benefit from small management changes also increases. If the management area is smaller, benefits the rangeland manager can realize are fewer, and the potential to improve ecosystem health is not as great.

By working with neighboring properties or government land management agencies, stakeholders can coordinate management and aggregate resources for more effective water management. The boundaries of the management area often are not the same as the watershed. Benefits of improved vegetation management in the management area may result in increased spring flows elsewhere in the watershed.

Political

Watersheds and groundwater basins share two key resources: land and water. These resources are governed by unique sets of legal rules, such as property and water rights. There are numerous state and federal regulations that influence water management.

Property rights define who, what, when, where, and how a resource may be used. Although it would be impossible to list all potential rights associated with property, they can be generally categorized into temporary/limited rights and perpetual/unlimited rights.

- Temporary/Limited Rights: These rights are limited either in time or in scope. For example, a lease may be limited not only to a specific time period, but may also be limited to certain activities, such as grazing.

- Perpetual/Unlimited Rights: Legally referred to as "fee simple title," these are rights typically associated with ownership of land.

The type of property right held strongly influences land use behavior. For example, a grazing permitee on public lands only has an incentive to engage in activities that improve grazing during the period of the permit. In contrast, the owner of a property has an incentive to not only invest in short-term grazing benefits, but to also invest in creating outcomes that may be realized over a longer term.

Understanding the nature of a property right is essential in developing management alternatives. If a rancher is on a short-term lease, alternatives with short-term benefits may be preferable.

Water rights are a unique subset of property rights and govern who can do what with a water resource. Water law varies from state to state, but most Western water law is based on the doctrine of prior appropriation or the concept of "first in time, first in right." This means that the first person to divert and use water from a source becomes the senior appropriator, or user, and has priority over subsequent, junior appropriators, who exercise their rights in descending order. Senior appropriators are generally entitled to receive all of their water before junior appropriators receive any. Some states, including Texas, recognize both the doctrine of prior appropriation as outlined above, as well as riparian rights, which ties water rights to the ownership of riparian land.

The state owns the water. Water ultimately belongs to society, and the state regulates water use by individuals with water rights. Be sure to understand how water is appropriated as well as specific water law in your area.

Understanding water rights is critical to formulating water management goals. For example, subject to some limited restrictions, Texas landowners have the right to intercept, impound, and use diffused surface water on their land; their rights are superior to those of adjacent lower landowners and to holders of rights on streams into which the water might eventually flow. Most farm tanks are shallow, have large surface areas, and lose large quantities to evaporation and percolation underground. Thousands of small, private tanks exist in some Texas watersheds, and they can have a very adverse effect on stream flow and downstream water use. During the drought of the 1950s, it was calculated that more than 50 percent of surface runoff in some watersheds was intercepted by such private reservoirs. Under present Texas water law, downstream water users have no recourse to protect their existing water rights.

"Use-it-or-lose-it" rules require water right holders to use their entire water right or risk losing the unused portion through forfeiture. This can cause water right holders to use their water rights inefficiently. However, on rangelands, water usage that is inefficient for agricultural purposes can create beneficial uses for wildlife and their habitat and also increase water percolation into the water table. Good water stewardship on rangelands values the health of the ecosystem. Incorporation of these values redefines "efficiency."

For more information on water law specific to your state, contact your state water engineer's office, county assessor, or a water attorney.

In addition to property and water rights, numerous state and federal laws and policies influence the management options available. For example, if threatened or endangered species or their habitat are located on a property or allotment, management options may be limited by the Endangered Species Act.

Consult with representatives from state and federal wildlife and land management agencies to learn what laws and policies may be applicable. For further information on who to contact, see the *Sources of Information* section at the end of the handbook.

Social

The need to share water resources creates intricate social interactions and relationships. Due to the social interdependence of people in watersheds and groundwater basins, management changes on one property will likely affect others in the area. Conflict often arises from misunderstandings, opposing values, and competing interests. Understanding a community's historical values, local attitudes, social norms, and traditions can help moderate conflict while achieving water management goals.

Working with community members and other professionals on a frequent and ongoing

Collaborative Resource Management allows managers to develop partnerships, share resources and ideas, and potentially increase water conservation as well as productivity.

Livestock grazing on the Tippett Pass Allotment in Spring Valley, Nevada
Photo: Nicole McCoy

basis is essential for successful management. For more information, refer to the *Collaborative Management and Partnership Model*, on page 16.

Economic

Are there sufficient funds available to accomplish the objectives? The old adage, *you have to spend money to make money*, often applies to managing rangelands for more effective and efficient water use. While the costs of any alternative should never exceed the benefits created by that alternative (if so, you should find a more effective use of your money!), it may take some creative thinking to obtain the financial resources to implement a project.

Ask how funds might be leveraged using partnerships or with neighbors or by participating in federal or state cost-sharing or grant programs to extend the effectiveness of each dollar spent.

The local Natural Resources Conservation Service (NRCS) office is a great resource to investigate options. Also visit the NRCS website at: www.nrcs.usda.gov.

After the physical, environmental, social, and economic factors that will influence rangeland management have been assessed, develop and evaluate alternatives that will help meet the stated goal.

Develop Alternatives

Management alternatives are comprised of one or more management actions that may be employed to meet the stated goal. Since most goals can be met by different management actions, we recommend development of multiple alternatives. Consider the alternative development stage as an opportunity to brainstorm for innovative approaches to addressing a problem. Try to create at least one alternative that employs an innovative approach to meeting management objectives.

Use multiple approaches and management tactics. Keep your practices simple, but explore the realm of traditional and innovative options to find which one works best to accomplish your goal.

Think regionally! Your management choices will extend beyond your land. Water management practices can affect your neighbors.

Description

Each alternative should include a description of the strategy and the planned outcome. Below are three general categories of management actions that can be used to develop an alternative. Each action will affect one or more of the variables that comprise the water budget. Since precipitation and the quantity of water that arrives on a management unit cannot be changed by management of that unit, the only variable that can be changed is where the water goes once it arrives. Consider how implementation of these management actions will affect evapotranspiration, runoff, and storage.

WORKING WITH OTHERS: PARTNERSHIPS AND COLLABORATION

Collaborative Management can substantially reduce the amount of conflict encountered during water management efforts. This process can be equally beneficial to both private and public land management. When used properly, collaborative management can eliminate many forms of conflict or opposition to water management. The purpose behind collaborative management and partnerships is to bring groups and individuals together to find new solutions and form new ideas to accomplish individual, group, and agency goals. Although it is not possible to eliminate all conflict, through education and compromise, most parties involved will be willing to work together to foster and implement ideas that will be efficient and beneficial to all.

Collaborative management practices are guided by a basic set of principles that can be applied to water management efforts. Every situation is unique. Customizing this model to fit the stakeholders' needs will be essential to a successful collaborative effort.

Principle 1: Set goals – Identify what is to be accomplished, set goals, and form a plan to accomplish the goals.

Principle 2: Identify those affected by your management – Any group or individual with a specific interest or investment in the situation will need to be involved in the management decision.

Principle 3: Determine what outcomes will be acceptable and compatible with your needs – Identify which solutions are unfeasible or unacceptable, but keep in mind the goals of others as well. There may be solutions that achieve several people's goals.

Principle 4: Get people together – Start by getting stakeholder opinion leaders involved in the process. Organize an informal meeting with all interested parties to share and discuss ideas. If the proposed management plan is expected to be controversial or there are heated emotions, it may be a good idea to use a neutral third-party facilitator.

Principle 5: Keep everyone involved – Everyone involved needs an opportunity to be an equal participant in the process in order to avoid opposition through misunderstanding.

Principle 6: Form a plan and take action – Once a mutually acceptable solution has been reached, form a plan and implement the management action.

The purpose behind collaborative management and partnerships is to bring groups and individuals together to find new solutions and form new ideas to accomplish individual, group, and agency goals.

Grazing Management

When grazing is properly managed, it will improve the diversity, density, and vigor of vegetation. A healthy vegetation community has minimal bare ground, with a large percentage of the ground covered by grasses, forbs, and litter. These conditions will allow better water infiltration, help prevent erosion and surface runoff, and create a healthier ecosystem overall. Proper grazing management contributes to plant litter being incorporated into the soil, which then holds moisture longer, reduces erosion, and contributes to nutrient availability for plants.

Stock Water Management

Improving water distribution will better spread wildlife and livestock foraging. Water availability and distribution influences the location and duration of foraging by livestock and many wildlife species. Making water periodically unavailable to livestock and big game can provide windows of recovery from grazing, improving plant and rangeland health. Proper grazing uses alternating periods of herbivory with periods of adequate recovery, which can improve vegetative cover and infiltration while reducing runoff and evapotranspiration.

Vegetation Management

In some scenarios, it may be appropriate to alter vegetation communities through biological, mechanical, or chemical means. Vegetation management can be used to reduce or enhance patchiness; alter vegetation types or communities; extend green hub periods; and increase biomass, biochemical diversity, and resiliency to drought, disease, or disturbance. In general, grasses make excellent vegetation for water quality, infiltration, soil stability, and sediment capture. Forbs and shrubs are good forage and shelter for wildlife and provide soil stability in reclamation areas. Legumes are particularly valuable by providing high protein forage while fertilizing and improving growth of adjacent plants. Plant mosaics are important for species diversity.

Consider using native plants. Some native plants in arid and semi-arid environments have high nutritional value and very low ET rates, making them ideal for rangeland and water management.

Woody or shrubby plants such as pinyon and juniper have deep roots that tap into groundwater systems. These plant types can lower soil moisture by increasing the amount of water lost to the atmosphere through evapotranspiration. The deep root systems of pinyon and juniper give them a competitive advantage over the more desirable grasses. The spread of pinyon-juniper forests reduces the forage quality of the landscape.

In general, grasses make excellent vegetation for water quality, infiltration, soil stability, and sediment capture. Forbs and shrubs are good forage and shelter for wildlife and provide soil stability in reclamation areas. Legumes are particularly valuable by providing high-protein forage while fertilizing and improving growth of adjacent plants. Plant mosaics are important for species diversity.

Objectives

Each alternative must have specific, measurable objectives that tie directly to the overall goal. Objectives should be quantifiable in terms of results, budget, and timeline.

Objectives will help to focus on smaller parts of a larger goal, which can help to accomplish an otherwise overwhelming task. When setting goals and objectives, it should be clear that managing for water could increase the profitability of any land-based enterprise. Rangeland management has a significant influence on watersheds, and proper grazing management is vital to increasing the efficient use of water on rangelands. Improving soil and surface water quantity and quality will improve rangeland health and vegetation.

Evaluate Alternatives

Once the alternatives are described, they will be filtered against the hard and soft constraints described earlier. The outcome of each alternative must be quantifiable (e.g., AUMs created) and expected costs and benefits calculated. We recommend the use of the blank worksheets located in the back of this handbook. The case study demonstrates how this can be accomplished.

Groundwater recharges very slowly. If you exceed the perennial yield of an aquifer, you are taking out water faster than it is being replaced. This will ultimately lead to the depletion or extinction of a valuable resource.

Water Budget

This project is based on water; hence, it is important to consider the impact of each alternative on the landscape's water budget. Think about what impact management actions will have on the input and output variables of the water budget. Will the project reduce evapotranspiration? Will it increase groundwater storage?

Hard Constraints

As the hard constraints are the most critical factors in determining the feasibility of an alternative, they should be addressed first with the following questions:

Are the outcomes defined in this alternative:

- Feasible given my region's topography?
- Possible given the area's precipitation, seasonality, and humidity?
- Achievable given the area's geologic and soil profiles?

If the answer to any of the above is no, determine if the alternative can be modified to make its outcomes consistent with the hard constraint. If not, this alternative should be discarded.

Soft Constraints

If the alternative passes the hard constraint test, move on to soft constraints, and ask the following questions:

Would the management actions I take under this alternative:

Comply with existing law or policy in regard to:

- Wildlife and plants?
- Water rights?
- Property rights?
- Grazing privileges?

Affect my neighbors or affect my neighbors in a way that creates social discord?

Be financially feasible under current circumstances (i.e., the money is in the bank)?

Be possible given the acreage under management?

Be consistent with the area's vegetation?

If the answer to any of the above is no, modify the alternative to make it better fit the constraint while still meeting the project's goals, and/or alter the constraint.

Working Through Soft Constraints

A "no" answer to a soft constraint is not an insurmountable barrier to project success; it may be an inconvenience and may even eventually result in significantly altering or abandoning the alternative, but by working through these constraints, an approach may be found that results in a better outcome than expected.

Law and Policy

Wildlife and plants: State and federal policies regulate management actions affecting plant and wildlife health and abundance. Even within the most restrictive of these policies, the Endangered Species Act, options are available to aid individuals in reaching their objectives while mitigating any potential adverse impacts on plants and wildlife.

Many species of concern benefit from proper grazing and good water management. However, on private property, if harm to a listed species is likely, the landowner can apply for an incidental take permit and prepare a habitat conservation plan that includes likely impacts to the species, the steps that will be taken to minimize those impacts, and the costs of undertaking the plan. If the plan is approved, the landowner can proceed with the proposed action.

On public land, individuals will need to work with their contact at the management agency to develop alternatives acceptable to the agency.

Water rights: As stated earlier, water rights are connected to a specific beneficial use and location. The amount of water specified in a right is fixed.

Pinyon-Juniper Encroachment on the Tippett Pass Allotment
Photo: Nicole McCoy

It is possible to increase a water supply through the purchase or lease of water rights from another appropriator in the area. If a lease of rights is sought, approval to change permanently or temporarily the place and/or nature of use of the water rights must be sought from the state engineer who oversees water rights.

If management goals do not incorporate the authorized beneficial use of the right, it is possible to change the designated use. Again, changes are subject to approval by the state administrative body that oversees water rights.

It is also possible to change the point of diversion of a water right, but this becomes more difficult than the other changes discussed. To change the point of diversion, the right holder must show that the change will have no adverse affect on other water rights holders.

Water law is a complicated and difficult legal field. When dealing with possible modifications to a water right, an attorney specializing in water law should be consulted. Any changes to a right are subject to the application and approval process of state administrative bodies, usually the state water engineer's office.

Property rights: Most private landowners will not need to modify alternatives based on their property rights. Those who lease lands from other private landowners need to ensure that management changes are consistent with their lease.

Those managing or leasing public lands should work closely with a representative from the agency providing the permit. State and federal agencies will require all alternatives to meet agency goals and comply with state and federal law.

Grazing privileges: Alternatives developed for use on public lands will have to comply with agency standards for rangeland health. These standards can vary between regions, but often include the requirements that watersheds are properly functioning, ecological processes are not compromised, water quality complies with state standards, and habitats of protected species are preserved.

Social

If current management alternatives raise issues with neighbors or others, it is likely that a modification to the alternative is needed. To ensure that desired management outcomes can be met while minimizing the impact to others, collaboration with the affected parties will be needed.

Economic

If an alternative appears to be outside the realm of financial feasibility, there are other options: 1) the alternative can be modified to reduce expenses; 2) outside funding can be sought out; or 3) alternatives can be shown to provide multiple benefits.

Many organizations, including local, state, and federal government, provide grants to landowners to promote desirable management. For more information on funding options, see the *Sources of Information* section.

Acreage

If landscape size is inadequate to meet desired outcomes, it is possible to work with others in the area to accomplish them. If management alternatives promise to increase operation profitability, there is a strong chance that they will increase the profitability of other operations in the area. In this case, it will be beneficial to partner with others.

Vegetation

If the vegetative landscape of an area is not conducive to the desired outcomes, it is possible to modify the plant community. An informed neighbor, county extension agent, or NRCS range conservation technician may be able to provide information on vegetation treatments that have worked in the area, planting season, and water needs.

Implement the Chosen Alternative

An Irish proverb says, *You will never plough a field if you only turn it over in your mind.* Taking action may be the most difficult aspect of the management process; desired outcomes cannot be achieved without implementation.

Monitor Outcomes

Monitoring is the collection, analysis, and interpretation of resource data to evaluate progress toward meeting management objectives. An effective monitoring system will:

- Be able to identify the cause of resource problems.
- Provide grazing and other management direction.
- Provide ecological trend data for long-term evaluation of the land system.

Keep it simple. The easier the plan, the easier it is to identify something that could be done better and adapt.

Monitoring should also:

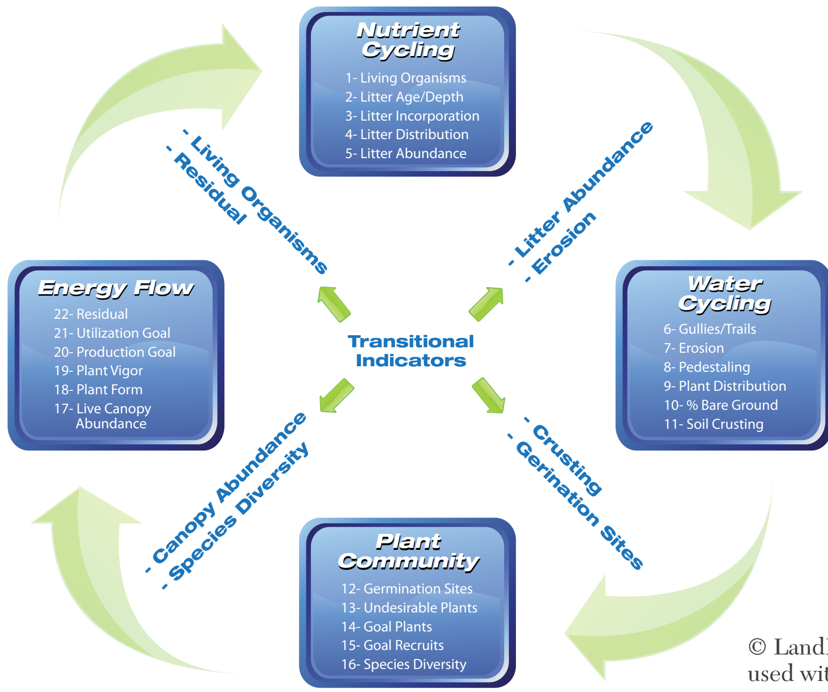
- Determine whether management objectives are realistic and achievable.
- Evaluate management strategies to better meet the identified objectives.
- Provide a record of conditions, events, and management practices.
- Determine whether the management plans are being followed and track how they were modified in practice.

Many methods can be employed to perform monitoring. Determine which method is most appropriate to the situation. The most important aspect of monitoring is being able to *do it* – make sure to choose a feasible monitoring protocol.

When a new management plan is put in place, don't expect drastic changes — you might see a decline in productivity before you see results. Expect about 3 years before you see change due to a new management plan.

As the monitoring program is designed and implemented, the first question that should be answered is, "What should I monitor to determine if the management action achieved the desired outcomes?"

One option is to use a monitoring approach that broadly considers the ecological health and function of the land system. In this case, landowners should use mechanisms that will evaluate land processes associated with water and nutrient cycling, biotic function, and energy flow attributes.



For example, if we have implemented a series of actions to decrease woody vegetation using fire or mechanical treatments and increase plant litter and herbaceous cover of grass and forbs through better grazing management to improve infiltration, how do we measure our results?

- State our objectives
- Measure changes in plant community composition and cover before and after treatment
- Measure infiltration or groundwater depth (i.e., monitor a well)

Time Efficiency

For busy land managers, using a monitoring approach that is efficient and repeatable is a priority. Ideally, the chosen system will have good capacity to handle, store, and report findings over time.

There are numerous public and a few private monitoring methods that range in application from basic assessments to rigorous data collection methodologies. All have advantages and disadvantages. As already mentioned, it is more important to apply a method the manager will use than to incorporate an approach that is too intensive or time consuming to apply.

Steps for designing and implementing a rangeland-monitoring program include:

- Assemble and consult background information. Background information provides a point of reference to compare how management actions affect the landscape.
- Divide the landscape into monitoring units.
- Divide the landscape with respect to slope, aspect, and material from which the soil was formed. Soil series and components that are functionally similar are relatively equivalent in potential to produce a particular type and amount of vegetation. Further, create subdivisions for historical and natural disturbances and/or types of management.

Identify and Select Key and Critical Areas

This selection is based on a qualitative assessment and is not a random selection process. Key areas that are representative of a larger area will likely reflect the effects of management changes on these larger areas.

Critical areas may be representative of areas of disturbance, such as burns, overgrazing, or roads. They may also be areas of special interest such as those that contain endangered or sensitive species, invasive species, or archaeological and historic sites.

Identify Indicators

Select ecological indicators such as plant communities, energy flow, and nutrient and water cycling that will help gauge progress and are best suited to the intended purpose.

For example, the primary questions (clues) being considered when evaluating water cycling will usually be: 1) Is moisture (where it first makes soil contact) effectively infiltrating into the soil? 2) Is topsoil remaining on the site? 3) How well covered is the soil surface?

Additionally, relating to nutrient cycling, managers should seek to determine if there is an adequate and expected supply of organic surface cover on the soil, and how quickly these materials are being recycled back into the soil system.

Biotic function is typically goal driven and will ask if the desired species (flora and fauna) are abundant, diverse, and expressing healthy age structure.

Lastly, energy flow factors will consider whether the capture of solar energy is being optimized and transferred effectively to other users of the landscape.

Assessment and Interpretation

First, a manager should develop decision architecture of the future monitoring program using a format that breaks the land into land types and concern areas, at some representative scale. In the following case study, a 75,000-acre ranch determined that one monitoring site for each 5,000 acres of land could be developed within a 5-year period and completely maintained on an annual basis into the future.

Monitoring Schedule

Develop a schedule that allows the monitoring program to be developed over time.

The monitoring schedule helps organize the sequence of monitoring sites, which will be maintained and eventually completed. It is very helpful for a user to understand how much time will be spent on the project each year and what will be completed and when in relation to the overall program.

Monitoring Map

Lastly, it is important to develop some type of map that depicts where monitor sites are generally located across the property.

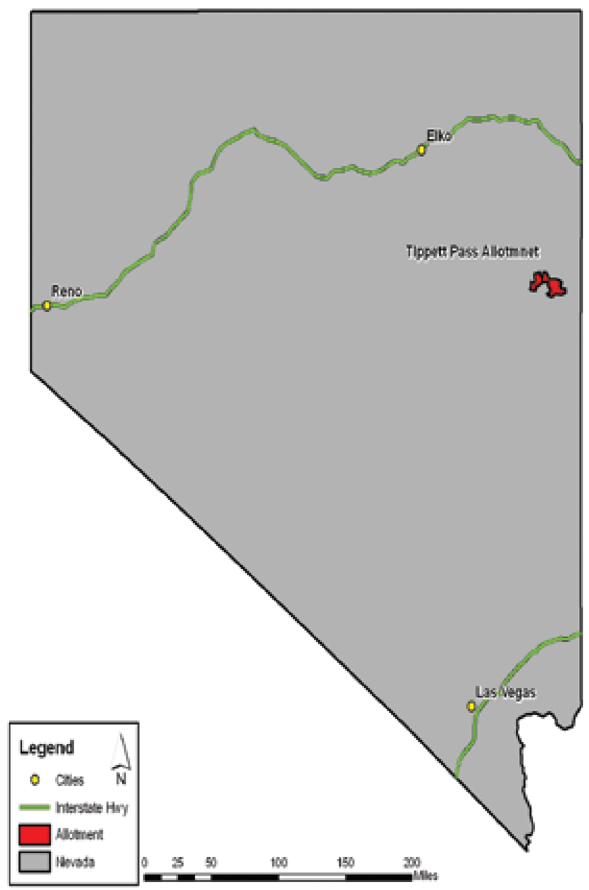
Adapt Management Practices

Based on the information gathered from monitoring efforts, managers should develop practices that address causes of concern in the areas of the study.

CASE STUDY

To demonstrate the use of the handbook, we selected as a case study a rangeland site with extremely limiting hard constraints and a complex interplay of soft constraints in a location with increasing sub-surface water demands from a major municipality.

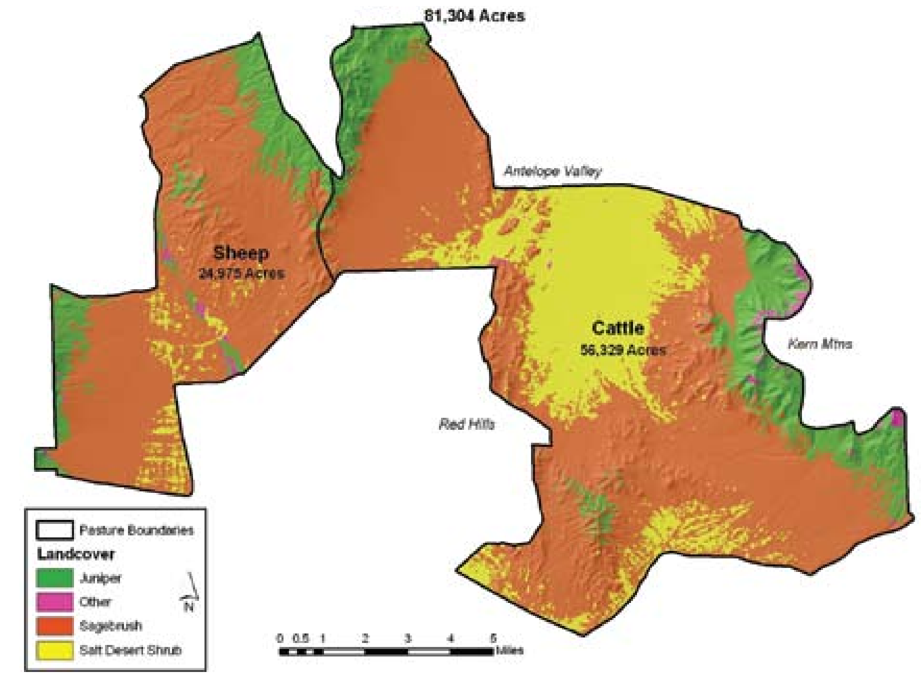
The Tippett Pass allotment is located in northeastern Nevada in White Pine County. The allotment comprises approximately 81,304 acres and is situated approximately 90 miles south of Wendover, Nevada, in the north end of Spring Valley.



Location of Tippett Pass Allotment

Spring Valley is a sparsely populated area with an economy based on ranching and mining. Most of the land is used as native range pasture. The allotment is owned by the Bureau of Land Management (BLM) and is split at Tippett Pass, with the western side (24,975 acres) used for sheep grazing and the eastern side (56,329 acres) used for livestock. The grazing permits are held by the Southern Nevada Water Authority (SNWA), who leases the permits to the C & L Cattle Co., who in turn subleases the eastern portion to Agee Smith, a Nevada cattle operator.

Tippett Pass Allotment



The Tippett Pass allotment was acquired by the SNWA through the purchase of the Reed Robison Ranch, which is one of several ranches purchased by SNWA in Spring Valley. The SNWA has begun work on an extensive groundwater project, which will annually pump 40,000 acre-feet of water out of Spring Valley for the municipal needs of the greater Las Vegas area.

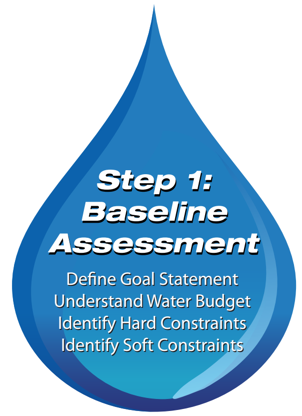
The SNWA has no plans for offsite use of its surface water rights in Spring Valley but instead plans to use its newly acquired ranches to manage the Spring Valley basin to ensure the sustainability of traditional land uses in the area.

In the past, 700 animal units were permitted on the eastern portion of the allotment from November 1 through June 1. Prior to Mr. Smith's arrival, the BLM reduced the allowable animal units to 300 due to rangeland degradation that was occurring on the allotment. Currently, he is permitted to run 400 head from November 1 through the end of April.

Mr. Smith is concerned about livestock overuse in key areas of the allotment and underutilization in others. Currently, the producer does not use the west portion of the Antelope Valley. It is thick with brush, particularly Wyoming sage, which contains very limited grass under story. Pinyon-juniper encroachment from the Kerns Mountains in the east and the Red Hills in the southwest, along with the spread of Wyoming sage, are a concern. The livestock currently overutilize the center of the allotment where the well is located.

Mr. Smith has taken the initiative to explore what he can do to manage the allotment in a manner that both improves the ecosystem and increases profitability.

CASE STUDY



Define Goal Statement

As there are multiple owners/lessees involved in the management of the allotment, it should be expected that there may be multiple goals.

The BLM seeks to manage the Tippett Pass allotment to improve livestock forage and wildlife habitat.

SNWA's goal for the Tippett Pass allotment is for it to be managed in a way that improves the area's ecology and increases groundwater recharge.

Mr. Smith's goal is to improve the overall health of the ecosystem while maintaining a sustainable livestock operation. He would like to see the allotment generate more AUMs that could be used by both livestock and wildlife.

Although slightly different from one another, the goals of the three stakeholders are compatible. A goal statement that represents the needs of all those involved is:

Goal Statement

The Tippett Pass allotment will be managed to increase groundwater recharge and improve vegetative community function and vigor, in order to provide more wildlife habitat and livestock forage.

Tippett Pass Water Budget

Precipitation on the Tippett Pass allotment ranges from 2 to 12 inches of precipitation annually. Higher precipitation occurs in the Kerns Mountains to the east; Mr. Smith believes most of the allotment receives an average of 5 inches per year. The months of November through March represent about 35% of the annual precipitation. Due to steep topography and unfavorable geology (discussed below), much of this water runs off the hillsides and onto an impermeable saltpan where it evaporates. Hence, little water infiltrates the soil to recharge underground aquifers.

The allotment's management challenge will be to promote infiltration of the precipitation, thereby reducing runoff, erosion, and evaporation.

CASE STUDY

Identify Hard Constraints

Climate

The climate is that of a typical Nevada high desert environment. Summers are hot, especially in lower elevations, while the winters are cold. Precipitation is light in the valleys year round. At higher elevations, snow accumulation can reach considerable depths. The temperature ranges from 98°F to -22°F with an average of 70°F. Rain occurs, but is not common and should not be relied upon for a major water source.

Topography

The allotment ranges in elevation from 5,700 to 7,200 feet. There are several mountain ranges that border the allotment: the Kerns Mountain Range on the eastern side, Red Hills to the southeast, the southern Antelope Range in the north, and the Schell Creek Range on the west.

Soils

The majority of the soils on the allotment are coarse loams with low water holding capacity. The allotment has several areas that are unusable for grazing due to the dense stands of Wyoming sage (*Artemisia tridentata*). The soil property of these areas is predominately a deep and very gravelly coarse sandy loam underlain with a cemented (caliche) layer. In these areas, water runs off of the allotment onto an impermeable salt pan where it evaporates. The water is available to the deep-rooted sage, but beyond the reach of the more desirable forbs, allowing the sage to gain competitive advantage.

The allotment also has several stands of white sage (*Ceratoides lanata*), a desirable browse shrub. The soil property of these areas is predominately a finer-textured deep silty loam, which has a good water holding capacity. Water percolates slowly and is more readily available to shallower-rooted forbs.

Geology

The allotment consists of a mix of Paleozoic limestone and dolomite, with minor shale and sandstone present. The entire basin and range is a mountain and valley fault system. Water recharge occurs predominately in the foothills of both the Kerns and Schell ranges. A caliche layer extends throughout the valleys and acts essentially like a buffer that does not allow water to permeate farther into the soil. Therefore, major recharge to the aquifer below the allotment is unknown, although it is assumed to occur along possible faults in the rock layers. Interviews with ranchers in the valley revealed a local belief in the existence of both shallow and deep aquifers.

Identify Soft Constraints

Vegetation

Vegetation on the allotment includes Indian ricegrass (*Achnatherum hymenoides*), white sage (*Ceratoides lanata*), bud sage (*Artemisia spinescens*), shadscale (*Atriplex confertifolia*), Mormon tea (*Ephedra spp.*), cheatgrass (*Bromus tectorum*), and several other species. Pinyon pine (*Pinus edulis*), juniper (*Juniperus ssp.*), and Wyoming sage (*Artemisia tridentata*) have been spreading out from the Kerns and Schell ranges farther into the valleys below. Both pinyon and juniper are high water use species. As these continue to encroach on the valleys, the soil moisture available for other herbaceous vegetation production has declined.

CASE STUDY

CASE STUDY

Wildlife

Spring Valley, Nevada, is home to numerous wildlife species. Wild ungulates include mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), and pronghorn (*Antilocapra americana*). The valley is also home to several species of concern including sage grouse (*Centrocercus urophasianus*), sage sparrow (*Amphispiza belli*), sage thrasher (*Oreoscoptes montanus*), Brewer's sparrow (*Spizella breweri*), pygmy rabbit (*Sylvilagus idahoensis*), and sage vole (*Lagurus curtatus*). Wild horses are also found on the allotment.

Replacing some pinyon and juniper stands with diverse, healthy sagebrush communities, improved water distribution, and proper grazing will benefit all of these species.

Political

Property Rights: As Mr. Smith is a secondary lessee on the Tippett Pass allotment, his lease is renewed on a year-to-year basis. The producer therefore has a tightly defined use right; he financially benefits from his livestock operation. However, his control rights are relatively weak. Mr. Smith must seek management input and approval from the BLM, the SNWA, and C & L Cattle Co.

The year-to-year nature of his lease makes his property right insecure. Although the producer has a strong internal motivation for improving rangeland conditions on the allotment, the year-to-year lease provides an external disincentive for him to engage in improvements that may incur costs now but have later benefits.

Water Rights: The water on the allotment is primarily groundwater that is used for livestock grazing. Potential diversion points for the allotment are known locally as Antelope Well, Mike Springs, and Glenco Springs.

Antelope Well is allegedly located in Section 1 of T21N R67E. Although the Nevada state engineer does not have any record of a well in Section 1 of T21N R67E, there is a well in Section 36 of T22N R67E. The permit for that well was obtained in the name of the BLM. There is no water right associated with this well; it appears that Antelope Well is not a legal diversion at this time.

The source described as Mike Springs is allegedly located in Section 2 of T21N R68E. There is one water right in that section. It is a vested right filed in 1921 by a Mr. Henrion for the watering of 500 head of stock. However, the paperwork indicates that this water is diverted from a stream source. It might be just a mix-up, but it bears verification.

The source identified as Glenco does not show up on the records of the state engineer either as a source of water or as a water right.

The SNWA and BLM will need to resolve these issues before any water management can occur on the allotment.

Law and Policy: Mr. Smith's management is affected by both state and federal policies. His status as a lessee with grazing privileges on a BLM allotment requires him to work with BLM Range Conservation Technicians to develop management plans for allotments under his use.

As the allotment is federal land, the producer's management alternatives may need to go through the evaluation process under the National Environmental Policy Act (NEPA). This would include an Environmental Assessment (EA) and possibly an Environmental Impact Statement (EIS) before he could implement a management change. The NEPA process promotes good decision making that balances ecosystem health and human needs. However, the process can be time consuming, which should be taken into account when planning management alternatives.

Since Mr. Smith is a sublessee, both the Nevada Department of Wildlife (NDOW) and the BLM work with the primary lessee, C & L Cattle Co. (through October 2007) and SNWA (after October 2007). He would like to work more closely with the agencies to ensure that management alternatives meet the requirements of those agencies in regard to the management of sensitive and endangered species that could be affected by management changes on the allotment.

Social: Mr. Smith is a relative newcomer to Spring Valley, and his base ranch (Cottonwood) is located in Wells, Nevada. He has developed strong relationships with long-term valley residents and is viewed as an innovator by many in Spring Valley.

The recent presence of the SNWA in Spring Valley and the planned groundwater project in the area has brought water management to the forefront of local rangeland issues. Ranchers are concerned with the long-term sustainability of their water source now that large quantities of groundwater will be piped out of the valley. By working with Mr. Smith, who is respected by the community, SNWA has the opportunity to demonstrate how water management can be improved while also enhancing rangeland conditions and ranch profitability.

Agee Smith

Photo: Nicole McCoy

Economic Factors: Mr. Smith's major constraint is the short term of his lease. As his grazing right is renewed annually, it may not be wise for him to invest scarce financial and labor resources into improving the allotment without assurance that he can benefit from his improvements over a longer term. To reduce this risk, he should consider partnering with the BLM and SNWA in a cost-sharing program to make key improvements.

The BLM has already indicated they would like to help Mr. Smith repair a water pipeline to improve water distribution to locations for his cattle and to reduce the impact on vegetation around the primary well. SNWA has also indicated that they have the financial and engineering resources to assist with the project.

Develop Alternatives

This section describes management actions that could be implemented on the Tippett Pass allotment.

Water Management

Water distribution for cattle and wildlife consumption is a major limiting factor on the Tippett Pass allotment and is the first priority of both management alternatives. Hundreds of acres exist that have adequate forage to support livestock and wildlife, yet cannot be utilized due to the lack of water. Currently, there are only three functioning watering locations on the allotment, two of which are located in areas where forage production is relatively low and the cattle do not generally bunch. Antelope Well, the third source, is where the majority of the livestock water and loaf during the day. There is approximately 95% bare ground in the immediate area of this well; conditions improve marginally as distance from the well increases. Most of the precipitation that reaches the ground near Antelope Well evaporates or runs off before it can permeate the soil.

For the first 3 years Mr. Smith leased the allotment (2000-2003), he and a hired man hauled water to multiple sites distributed throughout the allotment. While livestock still loafed at Antelope Well periodically, grazing use was much better distributed throughout the allotment and there was more vegetation surrounding the well. Unfortunately, the time, labor, water, and fuel costs of hauling water made continuing this practice cost-prohibitive.

Additional water locations need to be developed in order to utilize other areas on the allotment and avoid overutilization around Antelope Well. By simply distributing water for wildlife and livestock consumption throughout the Tippett Pass allotment, Mr. Smith can expect to see better livestock utilization. This step will set the stage to improve grazing management, which will in turn improve rangeland health, wildlife habitat, and overall watershed productivity.

CASE STUDY

Grazing Management

As water distribution problems are resolved, proper grazing management will become the key to increasing rangeland productivity and groundwater infiltration. Livestock, wild horses, and big game could be moved in a rotational pattern using water and possibly some temporary electric fencing. This will allow Mr. Smith to control the level of utilization across the allotment and leave plant litter to protect the soil surface and hold moisture. New seedling opportunity is enhanced to increase plant density and reduce bare ground over time. With the opportunity to better utilize the entire landscape through management, he will be able to provide total rest to an area each year for drought mitigation and wildlife use. Commit to more hands-on cattle distribution.

Vegetation Management

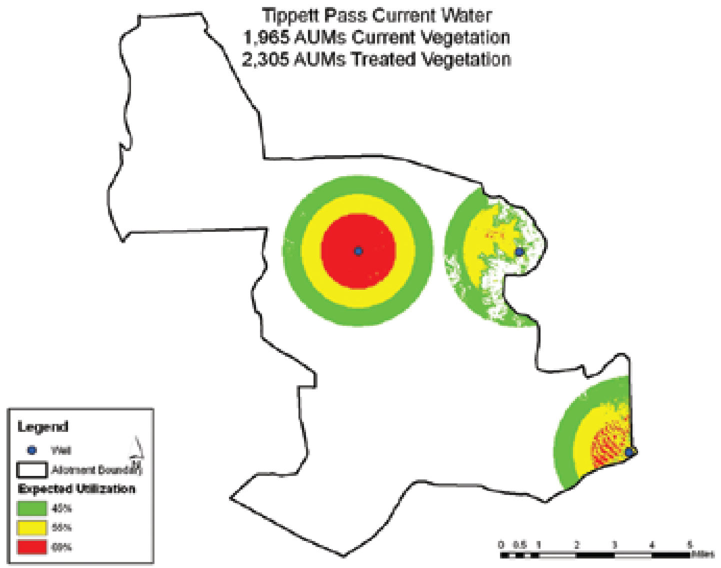
In the Antelope Valley portion of the Tippett Pass allotment, the current composition of vegetation communities (i.e., salt desert shrub and Great Basin sagebrush) are satisfactory for current uses. However, the vigor of the vegetation in this area could be improved to provide better feed for wildlife and livestock.

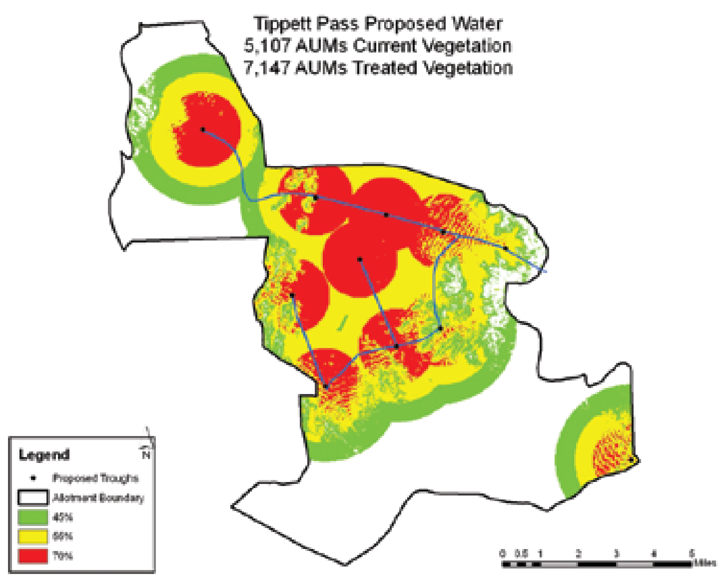
On the sage flat between Tippett Pass and Antelope Valley and the very southernmost end of the allotment (watered by the Mike Springs troughs), it would be beneficial to decrease sagebrush density in order to allow establishment of more grasses and forbs to improve water infiltration and decrease soil erosion. Evapotranspiration is a primary cost of brush encroachment; management of woody vegetation can increase aquifer recharge.

It may be worthwhile to thin some of the higher elevation pinyon-juniper communities that are encroaching from the Kern Mountains and Red Hills. This will prevent further incursions, allowing more grasses and forbs to establish in the understory and reduce water loss and erosion on these higher elevation sites, where much of the precipitation is received.

Tippett Pass Allotment looking east toward the Kerns Mountains
Photo: Nicole McCoy

Impact of Improved Water Distribution and Vegetation Management





Alternative Development

Three potential management alternatives were developed using the management actions discussed above. All three alternatives use the same water development plans and employ a "proper grazing" strategy based on time control and bunching and herding livestock with adequate recovery periods between grazing bouts. Alternatives B and C employ additional vegetation management actions that remove pinyon-juniper, replacing it with sage, grass, and forbs, and reduce the sagebrush canopy.

In each case, we are hoping to increase herbaceous cover and forage, create more wildlife habitat, abundance, and diversity, and improve water infiltration—hopefully even recharging aquifers (especially by reducing pinyon-juniper in the foothills, the highest potential area for recharge).

Alternatives A, B, C: Water Distribution

Antelope Well produces plenty of water to support a multiple trough pipeline system. Each trough and water location would be plumbed so that it could be shut off. This would encourage livestock, wild horses, and big game wildlife movement by changing which trough supplies water. This would also provide a means for proper utilization and livestock rotation without the construction of fences.

The cost of water developments including labor and materials for 22 miles of pipeline and 9 troughs is estimated at $135,000; estimated annual maintenance costs for 20 years were assumed at $100 per mile. As a result of the water developments, the number of AUMs that can be utilized by livestock will increase from 2,000 to 5,000.

Alternatives B & C: Vegetation Management

Much of the pinyon-juniper incursion from the Red Hills and Kerns Mountains are recent enough that by reducing stand density, native forbs and grasses will likely be able to recover on their own. These alternatives would treat 2,000 acres of the more recent incursions through mechanical thinning (200 acres per year for 10 years) at a cost of $100/acre. We expect pinyon-juniper treatments to increase soil moisture as well as groundwater and aquifer recharge as more water is held in the soil, allowing it to permeate into the aquifer instead of running off the foothills down onto the caliche layer.

Currently, approximately 34,000 acres of the allotment is decadent sagebrush which has little value to either livestock or wildlife. Even though the water developments will increase livestock access to the allotment, by thinning the sagebrush by 75%, we expect to increase the AUMs that can be utilized by livestock to 7,000. Treatment would employ a "take some, leave some" approach to develop mosaics and reduce sagebrush through mulching and simultaneous seeding with a mix of plant species suited to the site and appropriate for livestock, horses, and wildlife.

Brush management is usually accomplished with standard methods involving mechanical or chemical treatments. In the course of developing alternatives, Mr. Smith explored the potential of using an innovative but highly experimental approach to reducing sagebrush density. One method (Alternative C) may be less energy intensive than the other. However, the mechanical method (Alternative B) has a longer record of accomplishment.

Alternative B: Mechanical Brush Control

This alternative proposes the use of mechanical treatments to reduce sagebrush density on approximately 34,000 acres. A range aerator can treat approximately 20 acres per day. Assuming that there are 100 days per year the aerator could be used, 2,000 acres per year for 17 years would be treated. Cost per acre to treat and re-seed is conservatively estimated at $125.

Since treated areas would have to rest for a year before livestock grazing resumes, the project would begin in Antelope Valley (currently not used by cattle due to sagebrush density) so that Mr. Smith would not lose any of his existing grazing capacity.

Alternative C: Multi-Species Grazing Brush Control

This alternative proposes to use multi-species grazing of sheep and cattle to reduce sagebrush density, allowing grasses and forbs to re-establish. Sheep can be trained to eat sagebrush and have been used at fairly small scales (<20 acres) for thinning decadent stands. The success seen at these small scales—almost total elimination of sagebrush in thinned areas—indicates it may be reasonable to consider using sheep to conduct large treatments.

We assume that the same 34,000 acres used in mechanical treatment could also be treated with sheep. Sagebrush is most palatable in the winter when turpine levels are low, and a herd of 1,500 sheep could spend up to 120 days in the treatment area, although 90 days may be more reasonable since cattle will still be using the allotment. Since this method is still experimental, a herd of sheep must be trained to eat sagebrush before it can be used. The most successful age to train sheep to eat sagebrush is when they are yearlings, which means that only replacement ewes would be trained. Assuming a 20% replacement rate on a herd of 1,500, 300 sheep per year would be trained each year for 5 years. Training costs are assumed at $10/head for 1 week of conditioning. Sheep eating sagebrush may need an energy and/or protein supplement. We added the cost of feeding 1-1.5 lb. of a free choice mix of beet pulp and alfalfa pellets, estimated to cost $.27 per day per sheep eating sagebrush. Increased herding costs are estimated at $1,200 per month. In the fifth year, all 1,500 sheep would graze the allotment. Sheep would return to the allotment every 3 years afterward for maintenance purposes; intermittent training costs needed for these re-treatment periods were included in our calculations.

SUMMARY OF ALTERNATIVES

	Alternative A	Alternative B	Alternative C
Action			
Water Development	22 miles of pipeline; 9 troughs		
Pinyon-Juniper Control	None	2,000 acres total; 200 acres/year beginning year 2; mechanical treatment	
Sagebrush Management	None	34,000 acres; mechanical treatments years 3-17	34,000 acres; multi-species grazing years 2-5; intermittent sheep retraining and treatment every 3 years through year 20
Total Benefits Created over 20 Years			
Livestock AUMs	85,500	99,850	120,500
Wildlife/Wild Horse AUMs	21,375	24,963	30,125

Evaluate Alternatives

The alternatives are qualitatively and quantitatively evaluated on the worksheet shown on page 34. All pass the hard constraints but encounter some hurdles with the soft constraints. "No" answers on the worksheet are discussed below.

Soft Constraints

The management actions proposed under both alternatives are currently not consistent with existing law and policy. As a permittee, Mr. Smith must get authorization to perform any management actions on the allotment, including water development and vegetation treatments. Fortunately, he has already learned that the BLM and the SNWA would like to see more water development occur on the property, so getting permission for this management action is likely feasible.

Since it appears that there are no water rights associated with the three water sources, the primary lessee (SNWA) will need to secure water rights before any of the alternatives can commence. If these sources were used prior to the enforcement of appropriation statutes, whoever wants the water right might be able to file evidence proving the existence of a vested water right (this will not be possible for the Antelope Well, which wasn't drilled until the 1950s). The best way to cover all the bases would be to file a new water right application for each of those three sources with the Nevada State Engineer.

The vegetation treatments may present another difficulty. Any vegetation treatment will require Mr. Smith to work closely with the BLM to ensure that all federal laws are followed. He will also have to work with NDOW to provide appropriate plant communities in key sage grouse and deer use areas. Additionally, he should seek input from the local sage grouse working group, who may be able to assist with planning and funding.

Livestock bunching around Antelope Well

Photo: Nicole McCoy

While mechanical treatments are common on federal land, the equipment used for the treatment can be problematic. Because range aerators disturb soils, it may be necessary to obtain archaeological clearances and complete the NEPA process before an aerator can be used. This will likely delay implementation of the treatment 2 years or more.

Multi-species grazing will need to be approved by the BLM, NDOW, and the primary lessee. It has not been used for habitat manipulation purposes, which will require Mr. Smith to work with the BLM to evaluate AUMs using sagebrush as a major dietary component. While NDOW will not allow the grazing of domestic sheep within close proximity of either desert or mountain bighorn sheep, there are no wild sheep in the proximity of Tippett Pass and domestic sheep are already grazed throughout the area.

A social challenge that Mr. Smith may face in implementing multi-species grazing is engaging a sheep operator who is willing to learn how to use his sheep to conduct vegetation treatments. He is optimistic that he will be able to find and work with a local operator.

Tippett Pass Allotment Alternative Comparison

	A	B	C
Water Budget: How will the management actions I take under this alternative affect my water budget?			
Precipitation or irrigation	No change	No change	No change
Water flow onto the property	No change	No change	No change
Evapotranspiration	No change	Decrease	Decrease
Water flow off of the property	No change	Decrease	Decrease
Change in storage	No change	Increase	Increase
Hard Constraints: Is the outcome feasible given (if "no," discard or modify alternative):			
Precipitation, seasonality, humidity?	Yes	Yes	Yes
Topography?	Yes	Yes	Yes
Geology?	Yes	Yes	Yes
Soils?	Yes	Yes	Yes
Soft Constraints: Are the management actions for this alternative and the outcomes they generate consistent with (if "no," describe what may be done to achieve a "yes"):			
Federal, state, and local laws	No; Mr. Smith will consult with the primary lessee as well as BLM and NDOW	No; Mr. Smith will consult with the primary lessee as well as BLM and NDOW	No; Mr. Smith will consult with the primary lessee as well as BLM and NDOW
Water and property rights	Yes	Yes	Yes
Grazing privileges	Yes	Yes	No. Multi-species grazing is currently not permitted on the allotment; Mr. Smith will consult with the primary lessee as well as the BLM
Biotic concerns such as wildlife and vegetation	Yes	Yes	Yes
Norms and values of neighboring landowners and the surrounding community	Yes	Yes	No. Multi-species grazing is not commonly used in the area and may not be well understood by neighboring permittees. Mr. Smith will work with these neighbors to explain his strategy and assuage concerns
The acreage under management	Yes	Yes	Yes
Financial and material resources currently available	No; Mr. Smith will pursue partnerships with SNWA and the BLM. He may also apply for financial support through the NRCS	No; Mr. Smith will pursue partnerships with SNWA and the BLM. He may also apply for financial support through the NRCS	No; Mr. Smith will need several partnerships to increase his resources. He will pursue a partnership with a neighboring sheep rancher for sheep and he will explore partnership opportunities with SNWA and the BLM. He may also apply for financial support through the NRCS

Costs and Benefits

The quantified costs and benefits of each alternative are presented in the "Tippett Pass Alternative Worksheet" and "Summary of Costs and Benefits." While costs are fairly straightforward, dollar-quantifying benefits can be a bit trickier. Pounds of forage is a good proxy for understanding how much water is being held in the soil, but the benefits created by management actions have to be relevant to those who are incentivized to make management changes. Therefore, the benefits of the management alternatives are presented in terms of AUMs utilized by livestock as well as those available to wildlife. Since calculated livestock utilization ranged from 45% to 70%, we assumed that for each AUM utilized by livestock, another .25 AUM is available to wildlife and/or wild horses. Each AUM (livestock and wildlife) is valued at $20.

We used a 20-year time horizon and a 9% discount rate (3% inflation) to calculate the net present value (NPV) of each alternative. A summary of costs and benefits is presented in the table below.

Alternative A: Water Development
The water development alternative is assumed to be completed by the end of the first year, and livestock AUMs would increase incrementally to a high of 5,107 beginning in the fourth year. The NPV of this alternative is $1.25 million; if only the value of livestock AUMs are included, NPV is reduced to $845,000.

Alternative B: Water Development plus Mechanical Brush Treatment
As with the first alternative, increased AUMs from the water developments total 5,107 annually. Mechanical brush and pinyon-juniper treatments start at the end of the second year and create 2,043 additional AUMs over the course of 15 years, and last through year 20. Sagebrush control constitutes the greatest cost at $2.4 million. The net present value of this alternative is negative at -$1.41 million; if only the value of livestock AUMs are included, NPV drops to -$1.57 million.

CASE STUDY

Alternative C: Water Development plus Multi-Species Grazing Brush Treatment
This alternative incurs the same costs for water development and pinyon-juniper control as Alternative B. However, the discounted present cost of multi-species grazing is only $54,000; this includes the cost of training, herding, and supplement. The full benefits from multi-species grazing are assumed to begin in the sixth year of the project and are maintained through year 20. This alternative's NPV is $1.62 million; if only livestock AUMs are included, NPV is $950,000.

Alternative Selection

Alternative B results in a negative NPV and thus will not recover the costs of investment, even when wildlife AUMs are included in its value.

Alternatives A and C each have positive NPVs and are both feasible once the soft constraints have been managed. Furthermore, both of these alternatives have positive NPVs if only livestock AUMs are included, which means that Mr. Smith could recover his investment even if he did not financially benefit from the increase in wildlife and wild horse AUMs that these alternatives create.

However, if we recall the management goal statement for the allotment, the Tippett Pass allotment will be managed to increase groundwater recharge and improve vegetative community function and vigor, in order to provide more wildlife habitat and livestock forage, Alternative C becomes preferable to Alternative A.

Alternative A did not include vegetation treatments, which means that although water is better distributed across the allotment for wildlife and livestock use, the alternative does not improve vegetative communities, nor does it allow for improved groundwater recharge. As pinyon-juniper and/or sagebrush may continue to encroach onto the allotment, the groundwater resource may decline over time.

The Southern Nevada Water Authority purchased this ranch for its groundwater resource; they and other municipalities are likely to value surface management strategies that increase the likelihood that appropriate steps are being taken to preserve and even improve the groundwater resource.

Although it is highly experimental, Alternative C possesses the greatest capacity to achieve management objectives. Mr. Smith believes that it possesses sufficient potential to illustrate how grazing—often seen as a consumptive use of the resource—can be used to regenerate ecosystems and improve groundwater recharge at low cost with high returns. Before acting on this alternative, he must explore cost-sharing and partnership opportunities with the BLM and SNWA to ensure that adequate resources are available for the project.

Tippett Pass Allotment Cost/Benefit Comparison

	A	B	C
Water Distribution	$151,000	$151,000	$151,000
Vegetation Management: Brush control	0	$2,400,000	$54,000
Vegetation Management: P-J control	0	$140,000	$140,000
Total Management Cost	$151,000	$2.7 million	$345,000
Value of AUMs	$1.25 million	$1.41 million	$1.62 million
Net Present Value	$1.1 million	-$1.29 million	$1.27 million
Net Present Value – livestock only	$845,000	-$1.57 million	950,000

A word about financial analysis

Conducting a long-term financial analysis can be intimidating for someone unfamiliar with the technique. Feel free to contact Carrus Land Systems, LLC, at information@carruslandsystems.com for easy-to-use tools or other assistance.

Conclusion

Good water stewardship on rangelands is a critical issue for landowners, agencies, and the general public. However, it is the land steward who holds the power to ensure that water stewardship principles are employed on rangelands. Not only is livestock grazing compatible with good water stewardship, but water developments, vegetation treatments, and grazing practices used to improve rangeland ecosystems for landowner benefit can also increase wildlife habitat, soil and water quality, and aquifer recharge. As urban populations grow throughout the West, water scarcity issues will continually rise to the forefront of public policy. It is important to recognize that good management isn't about allocating a limited quantity of water, but instead is about using sound principles and practices to efficiently use this renewable resource.

CASE STUDY

SOURCES OF INFORMATION

Finding and Applying Practical Information from a Scientific Journal Article

There may be no existing studies of rangeland and the potential impacts of water management for a specific area, but scientific journal articles and other sources can provide helpful information. It may take time to get used to scientific jargon, but with patience, it is possible to find practical information from such sources. When reading an article, consider: Are the vegetation types examined in the study the same as my project? Is the climate similar? Are the anticipated land uses similar to those studied? Through this process, guidelines can be developed for application to the proposed water project.

The websites below may be helpful in obtaining pertinent information:

Climate data: The following website provides information on precipitation, maximum and minimum temperature, and evapotranspiration.

1. Go to http://climate.usurf.usu.edu
2. Go to Data Products
3. Choose desired area by clicking on map
4. Click on an operating station. This allows you to select information about temperature, precipitation, ETO (reference evapotranspiration rate).

Soils, Vegetation, and Geology: How to Access Soil Information
Contact your local NRCS office and speak with a professional. This office also provides Major Land Resource Area (MLRA) reports that contain an extensive amount of information for the area of interest. These reports will begin with an overview, followed by land use, elevation and topography, climate, potential natural vegetation, water resources, soils, and water and chemical transport.

To find a local NRCS office, go to www.nrcs.usda.gov and click on the "Contact Us" link in the upper portion of the first page.

The above information can also be accessed through the NRCS website at www.nrcs.usda.gov.

Federal Laws: This site contains information on federal laws and policies that may affect management plans. Cornell University Law School. www.law.cornell.edu/topics/land_use.html

State Laws and Policies: The BLM website reviews the water laws of 11 Western states (Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, and Wyoming). Special attention is paid to the states' water rights systems, application processes, groundwater regulations, general adjudication processes, and stream flow programs. Where information is available, comment is made on how each state handles federal reserved water rights and other BLM-specific information. http://www.blm.gov/nstc/WaterLaws/index.html

Additional helpful information:

Agency Information:
Bureau of Land Management (BLM): http://www.blm.gov/wo/st/en.html
National Park Service: http://www.nps.gov/
United States Bureau of Reclamation: http://www.usbr.gov
USDA Forest Service: http://www.fs.fed.us/

Government agencies are good information sources for vegetation types, manipulation techniques, and laws and policy.

Monitoring:

The Land EKG website is an excellent source for evaluating different monitoring methods. This site also provides contacts for consultants, publications, and workshops that will help in monitoring.
www.landekg.com

The manual *Bullseye! Targeting Your Rangeland Health Objectives*, by Kirk Gadzia and Todd Graham (2006), illustrates alternative practical approaches to monitoring and can be obtained through the Quivera Coalition at http://quiviracoalition.org.

A complete discussion of numerous monitoring methods, the Monitoring Manual For Grassland, Shrubland, and Savanna Ecosystems, is available online at:
http://usda-ars.nmsu.edu/Monit_Assess/monitoring_main.php
University Extension Specialists: Local extension services can be found at:
http://www.urbanext.uiuc.edu/netlinks/ces.html
Urban Programs Research Network:
This site links to each state's Cooperative Extension Service, which provides vegetation information and consultant contacts for a particular area:
http://www.urbanext.uiuc.edu/netlinks/ces.html

Working with others:

This site provides useful information on collaboration and adaptive management processes and techniques. Ecosystem Management Initiative. http://www.snre.umich.edu/ecomgt

GLOSSARY

Abiotic factor[3]: A physical, meteorological, geological, or chemical aspect of the environment.

Animal Unit Monthly (AUM)[4]: Equal to one cow and a calf, or five sheep, feeding on a unit of land for 1 month.

Allotment: A section of land set aside for a specific use (grazing, recreation, timber, wildlife, etc.).

Aquifer/groundwater recharge: Percolation of water into underground water systems.

Arid[2]: Land that has an extremely low yearly precipitation, receiving much less rain or snowfall annually than would support the climatological demand for evaporation and transpiration.

Bedrock horizons: Differentiated layers of solid rock material lying beneath the earth's surface.

BMP: Best Management Practices. The best use of available knowledge and technology.

Biomass[3]: The total mass of living organisms in a given volume or mass of soil.

Caliche[3]: Cemented horizon, or layer of soil within a soil profile that may inhibit water infiltration.

Capillary Action[6]: The movement of water through the soil due to matric forces (the attractive charge between soil particle and water molecule).

Clay[6]: 1) A soil separate consisting of particles <0.002 mm in diameter. 2) A soil textural class containing >40% clay, <45% sand, and <40% silt. These particles give soil a sticky and firm feeling.

Collaborative Resource Management (CRM)[5]: The process whereby various user groups are involved in discussion of alternate resource uses and collectively diagnose management problems, establish goals and objectives, and evaluate multiple-use resource management.

Ephemeral streams: Streams that only exist for a limited time following precipitation or snowmelt.

Erosion[3]: The wearing away of the land surface by rain or irrigation water, wind, ice, or other natural or anthropogenic agents that abrade, detach, and remove geologic parent material or soil from one point on the earth's surface and deposit it elsewhere.

Evaporation: A process of a liquid receiving sufficient energy (heat) to change to a gas.

Evapotranspiration: The sum of evaporation and plant transpiration. Evaporation accounts for the movement of water to the air from sources such as the soil, canopy interception, and bodies of water. Transpiration accounts for the movement of water within a plant and the subsequent loss of water as vapor through stomata in its leaves.

Exacerbate: To worsen a situation.

Groundwater[6]: Subsurface water in the zone of saturation that is free to move under the influence of gravity, often horizontally to stream channels.

Hydraulic conductivity[6]: An expression of the readiness with which a liquid, such as water, flows through a solid, such as soil, in response to a given potential gradient.

Indicator species: Species that serve as early warnings that a community or an ecosystem is being degraded.

Infiltration[6]: The downward entry of water into the soil.

Intermittent streams: Streams that periodically stop flowing during the drier seasons.

Invasive species[5]: A species that was absent in undisturbed portions of the original vegetation of a specific range site and that will invade or increase following disturbance or continued heavy grazing.

Key area: A small area that is a representation of a larger area.

Leaching[1]: A process in which various chemicals in upper layers of soil are dissolved and carried to lower layers and, in some cases, to groundwater.

Limited Liability Company: A legalized company format providing its members with limited liability concerns. It is usually beneficial to small companies with few members.

Monitoring: The orderly collection, analysis, and interpretation of resource data to evaluate progress toward meeting management objectives.

Native species: A species originating from or indigenous to the area.

Perennial streams: Streams that flow year-round.

Piezometer[2]: A small-diameter water well used to measure the hydraulic head of groundwater in aquifers. Similarly, it may also be a tube or manometer used to measure the pressure of a fluid at a specific location in a column.

Porosity[1]: The pores (cracks and spaces) in rocks or soil, or the percentage of the rock's or soil's volume not occupied by the rock or soil itself.

Reclamation: To return to a more desirable condition.

Rural[2] (also referred to as "the country"): Sparsely settled places away from the influence of large cities. Rural areas can have an agricultural character, though many rural areas are characterized by an economy based on logging, mining, petroleum and natural gas exploration, or tourism.

Sand[3]: Soil particles from .05 mm to 2.0 mm in diameter. A soil composed primarily of these soil particles will feel more coarse than those composed of primarily clay or silt.

Semi-arid[2]: A climatic region that receives low annual rainfall (250-500 mm or 10-20 in.) and has predominately shrub or short-grass vegetation.

Silt[3]: Soil particles from .002 mm to .05 mm in diameter. These particles give soil a fluffy or floury texture.

Soil horizon: A layer of soil or soil material approximately parallel to the land surface and differing from adjacent genetically related layers in physical, chemical, and biological properties or characteristics such as color, structure, texture, consistency, kinds and number of organisms present, degree of acidity or alkalinity, etc.

Stubble height: The amount of vegetation left after grazing.

Subsidence[7]: The decline in land surface elevation by removal of subsurface support. One mechanism is the compaction of an aquifer due to overpumping.

Transpiration: Evaporative loss of water to the atmosphere from leaf pores of plants.

Utilization: The amount of vegetation consumed after grazing, usually measured as a percentage.

[1] Miller, Jr., G. Tyler. 1994. Living in the Environment: Principles, Connections, and Solutions. 8th ed. Belmont, CA: Wadsworth Pub. Co.
[2] www.m-w.com/dictionary
[3] http://en.wikipedia.org
[4] Knight, Dennis H. 1994. Mountains and Plains: The Ecology of Wyoming Landscapes. New Haven, CT: Yale University Press.
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[6] Brady, Nyle C. and Ray R. Weil. 1999. The Nature and Property of Soils. 12th ed. Upper Saddle River, NJ: Prentice Hall.
[7] Alley, William M., Thomas E. Reilly, and O. Lehn Frank. 1999. Sustainability of Ground-Water Resources. Denver, CO: U.S. Geological Survey.

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WORKSHEET

Alternative Comparison Worksheet

	A	B	C
Water Budget: How will the management actions I take under this alternative affect my water budget?			
Precipitation or irrigation			
Water flow onto the property			
Evapotranspiration			
Water flow off of the property			
Change in storage			
Hard Constraints: Is the outcome feasible given (if "no," discard or modify alternative):			
Precipitation, seasonality, humidity?			
Topography?			
Geology?			
Soils?			
Soft Constraints: Are the management actions for this alternative and the outcomes they generate consistent with (if "no," describe what may be done to achieve a "yes"):			
Federal, state, and local laws			
Water and property rights			
Grazing privileges			
Biotic concerns such as wildlife and vegetation			
Norms and values of neighboring landowners and the surrounding community			
The acreage under management			
Financial and material resources currently available			

WORKSHEET

WORKSHEET

Cost/Benefit Comparison Worksheet

	A	B	C
Management Costs			
Water Distribution			
Vegetation Management: Brush control			
Vegetation Management: P-J control			
Total Management Cost			
Value of AUMs			
Net Present Value			
Net Present Value – livestock only			

NOTES