Chapter 7

Maintaining and Restoring Sustainable Ecosystems in Southern Nevada

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Executive Summary

Resource managers in southern Nevada are faced with the challenge of determining appropriate goals and objectives and developing viable approaches for maintaining and restoring sustainable ecosystems in the face of rapid socio-ecological and environmental change. Many of southern Nevada's ecosystems are being subjected to anthropogenic stressors that span global, regional, and local scales (Chapter 2), and are crossing ecological thresholds to new and often undesirable alternative states (Chapters 4 and 5). Protection, prevention, and restoration are integral parts of managing for sustainable ecosystems that can supply both ecosystem services and habitat for the diversity of plants and animals that occupy the region. This summary addresses the restoration aspects of Sub-goal 1.3 in the SNAP Science Research Strategy, which is to "Restore and sustain proper function of southern Nevada's watersheds and landscapes" (see table 1.1).

Managing for Resilience and Resistance

The overarching objective for restoration and management of southern Nevada ecosystems is to maintain and restore sustainable ecosystems that are resilient to disturbance and resistant to invasion. Resilience is the capacity of an ecosystem to regain its fundamental structure and functioning when subjected to stresses like drought, species invasions, or wildfire. It is a function of the underlying ecosystem attributes and processes that determine ecosystem recovery. Resistance is the capacity of an ecosystem to retain its fundamental structure and functioning (or remain largely unchanged) despite stresses, disturbances or invasive species. Resistance to invasion is a function of the biotic and abiotic factors and ecological processes in an ecosystem that limit the establishment and population growth of an invading species

The abiotic and biotic attributes and ecosystem processes that determine resilience to stressors and resistance to invasion can be illustrated with a simple conceptual model (fig. 7.1). Environmental characteristics as defined by climate, topography, and soils determine the abiotic and biotic attributes and processes of an ecosystem. In turn, the abiotic and biotic attributes and processes provide feedbacks to one another and determine the inherent potential of an ecosystem to support a given set of ecological conditions and plant species. Over time, climate, disturbance, and stressors affect the abiotic and biotic attributes and processes and determine the current ecological conditions of the system. The current ecological conditions, as influenced by the legacy of past disturbances and stressors, determine resilience to disturbance and resistance to invaders at any point in time.

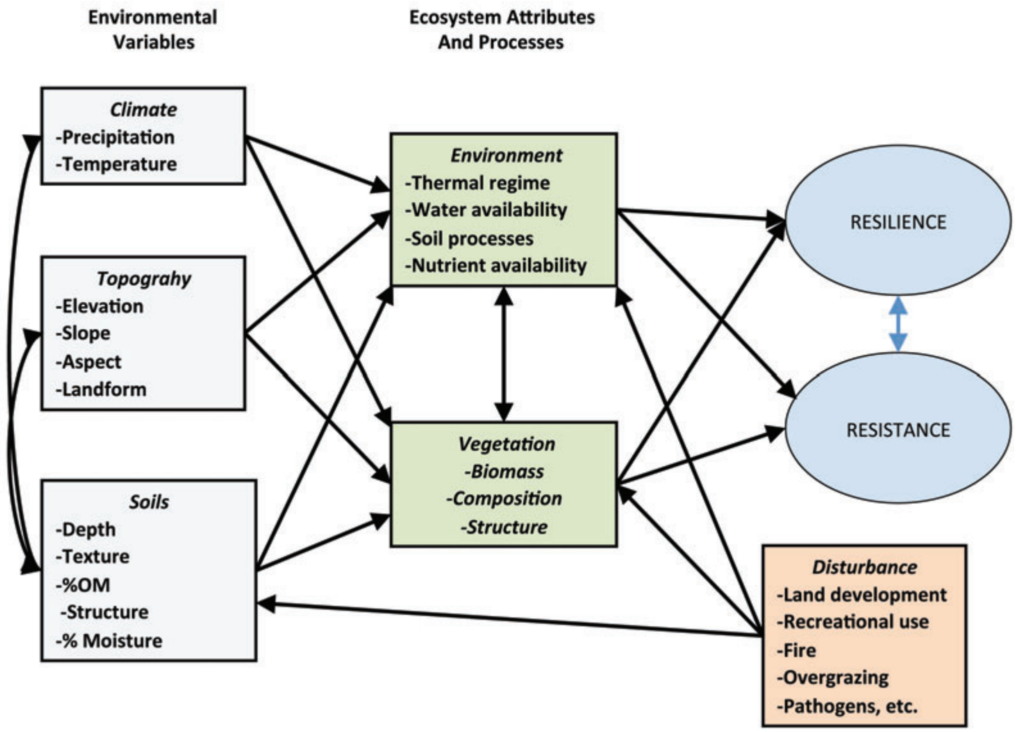

Figure 7.1–The environmental variables and the ecosystem attributes that influence resilience to disturbance and resistance to invasion. Disturbances can decrease ecological site conditions and negatively affect resilience and resistance.

Southern Nevada ecosystems differ in ecological resilience and resistance because of strong elevation/climate gradients and large differences in their environmental characteristics. The Clark County MSHCP categorizes 11 ecosystems based on elevation and soil moisture (fig. 7.2). In general, temperature regimes and effective precipitation are the primary drivers of ecological processes because they determine overall resource availability and ecosystem productivity. The resilience of southern Nevada ecosystems to disturbance and stress typically increases along these environmental/productivity gradients. These gradients also determine the likelihood that climate conditions are suitable for establishment of invasive annual grasses and other invaders. Ecosystems influenced by elevated water tables and high levels of soil moisture are in a separate category, as environmental conditions can vary considerably among these ecosystems, and factors like soil and water chemistry are important drivers of ecosystem processes.

Restoration Considerations

Restoration and management priorities and activities differ significantly among southern Nevada ecosystems because of the large variation in their environmental characteristics and, consequently, resilience to disturbance and resistance to invasive species. Overarching strategies are protection, prevention and restoration (table 7.1). Passive restoration to eliminate or minimize stress is a component of protection and prevention; active restoration is a component of prevention and restoration. Guidelines for the restoration and management of the diverse ecosystems in southern Nevada can be developed based on an understanding of their relative resilience and resistance, the dominant stressors affecting them, and the most appropriate actions to maintain and restore them (table 7.2).

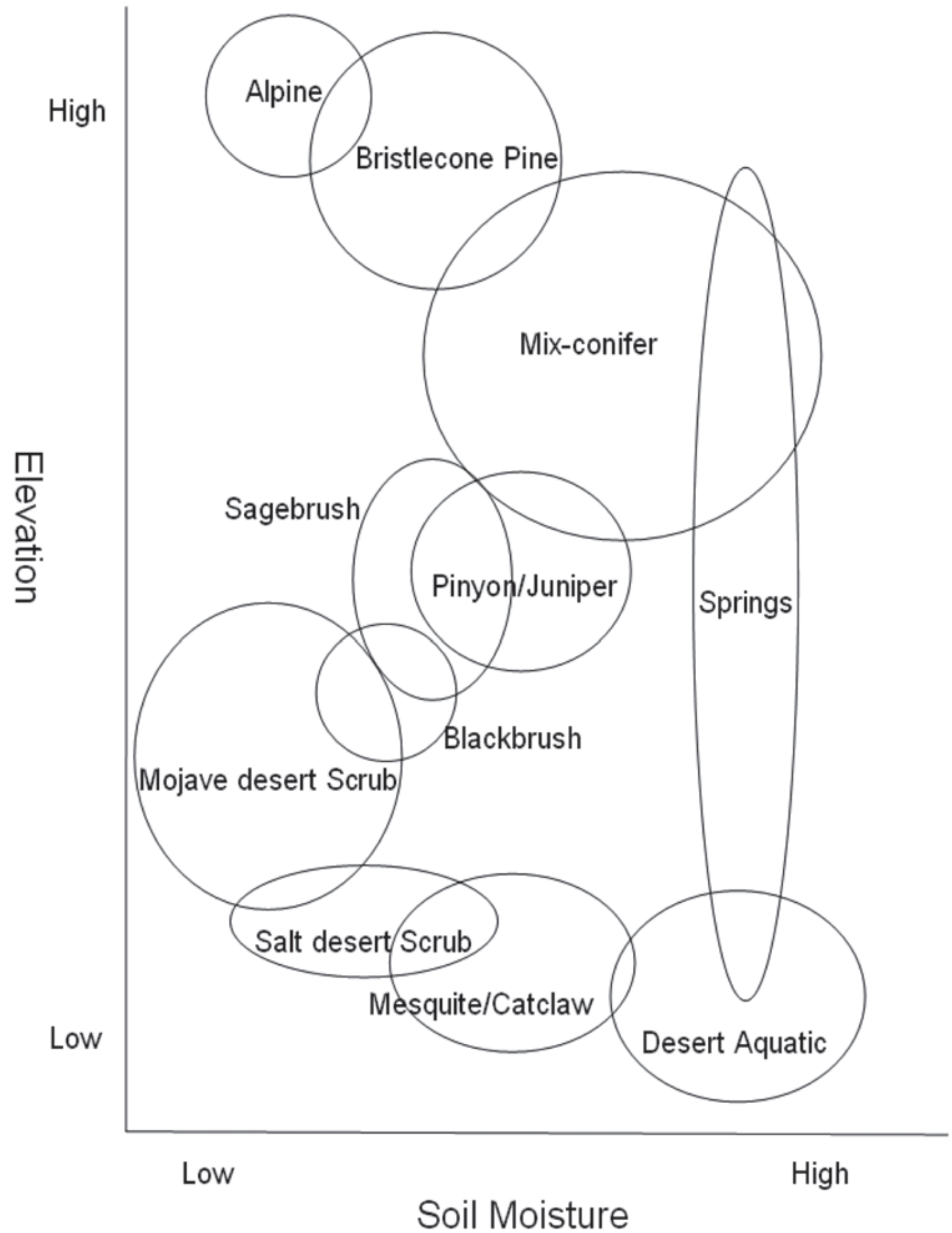

Figure 7.2–A conceptual model that categorizes 11 ecosystems of the Clark County MSHCP along two environmental gradients: elevation and soil moisture. This model is based on general knowledge of the environmental gradients that influence southern Nevada ecosystems. The shape, size, and relative position of the ellipses and circles are hypothetical (from Desert Research Institute 2008).

Table 7.1—An approach for categorizing management activities in southern Nevada ecosystems based on protection, prevention and restoration (modified from D'Antonio and Chambers 2006; Brooks and Chambers 2011).

Protection	
Focus	Ecosystems with low resilience and/or resistance, ecosystems of high conservation concern, and ecosystems at risk of crossing ecological thresholds to new alternative states.
Objectives	Eliminate or minimize current and future stressors.
Activities	Closure or active control of recreational use and burro and cattle grazing to allow natural regeneration; fire suppression in Mojave Desert scrub, blackbrush and lower elevation sagebrush and piñon and juniper ecosystems to prevent an invasive annual grass-fire cycle; control of placement and development of road and utility corridors, urban expansion, and solar energy projects to minimize fragmentation and surface disturbance.
Prevention	
Focus	Ecosystems with inherently higher resilience and/or resistance and ecosystems in moderate to high ecological condition.
Objectives	Maintain or increase resilience and resistance of areas with declining ecological conditions.
Activities	Vegetation management to decrease risk of high severity fires, maintain understory composition, and prevent invasion; mechanical vegetation management treatments to decrease decadent or over-dense shrubs and increase perennial herbaceous vegetation.
Restoration	
Focus	Ecosystems known to respond favorably to restoration treatments and ecosystems of conservation concern.
Objectives	Increase resilience and resistance of ecosystems by revegetating or rehabilitating areas disturbed by fire, recreational activities, road and utility corridors, urban expansion, solar energy projects, and other surface disturbances. Provide assisted migration for species being displaced by climate change.
Activities	Soil surface stabilization to curtail dust; seedbed preparation to mitigate soil physical and chemical disturbance and provide favorable conditions for plant establishment; transplanting or seeding native species adapted to the local environment and climate warming.

Consideration of the predicted effects of climate change on the different ecosystems and the implications for management will be needed to maintain and restore southern Nevada ecosystems. Climate change models predict high rates of temperature increase for desert ecosystems like the Mojave. By 2100, climate change is likely to result in the disappearance of some existing climate conditions, the appearance of some novel climatic conditions, and the formation of new communities with no past or present analogs. Bioclimatic envelope models predict shifts in the distributions of keystone species like creosote bush and Joshua tree, and of invasive species like cheatgrass. Due to the rapid rate of change, many species may require assisted migration, and "transformative" restoration may be needed in areas that no longer have the climate conditions necessary to support the current set of species.

Table 7.2—Resilience and resistance characteristics of the major ecosystem types in southern Nevada and guidelines for appropriate management actions.		
Ecosystem	**Resilience and resistance**	**Guidelines for appropriate management actions**
Alpine and Bristlecone pine	*Resilience* – Very low to low. Extreme temperatures, short growing seasons, slow growth, and low establishment rates. Low capacity to adapt/migrate with climate warming. *Resistance* – Moderate to high. Few annual species are adapted to the extreme environment; resistance may decrease as climate warms.	*Protection* – Primary emphasis. Minimize stress from recreational activities, including firewood gathering. Monitor changes in temperature and precipitation and in species distributions and community composition. *Prevention* – Rarely warranted except to suppress fires with potential to spread. *Restoration* – Rarely warranted except for assisted migration of trees or revegetation of areas with die-off. Information on species environmental and establishment requirements is required.
Mixed conifer	*Resilience* – Moderate to high. Relatively high precipitation, long growing seasons, and moderate growth and establishment rates. Potential to migrate upslope with climate warming. *Resistance* – Moderate to low. Multiple non-native invaders adapted to environmental conditions; competition with invaders from established native plants can be high.	*Protection* – Control inappropriate recreational activities and overgrazing; detect and eradicate invasive species. *Prevention* – Warranted to decrease fuel loads, restore understory composition, and decrease invasion. Potential for Wildland Fire Use and prescribed fire where risk of large or high severity fire is low and fire spread can be controlled, and for tree thinning followed by surface fire or pile burning in WUI and areas with higher fuel loads. However, more information is needed on the responses of southern Nevada ecosystems. *Restoration* – Warranted following surface disturbance or in areas with insufficient fire tolerant understory species for site recovery after fire. Seed burial (drilling) or transplanting natives adapted to local site conditions and climate warming preferred.
Piñon and Juniper	*Resilience* – Moderate. Moderate precipitation, long growing seasons, moderate to slow growth and establishment. Potential for die-off at lower elevations with climate warming. *Resistance* – Low. Many non-native invaders adapted to environmental conditions; competition from established shrubs and herbaceous species dependent on site productivity and ecological condition.	*Protection*- Control inappropriate recreational activities and overgrazing; detect and eradicate invasive species; suppress fires at lower elevations and that threaten ecosystem integrity. *Prevention*-Warranted to decrease fuel loads, restore understory composition, and decrease invasion. Focus is on mesic sites in early to intermediate stages of tree expansion, and in moderate to high ecological condition. Potential for Wildland Fire Use and prescribed fire on productive sites at high elevation; mechanical treatments more appropriate on sites with low productivity. *Restoration* – Warranted following surface disturbance and in areas with insufficient fire tolerant understory species for site recovery after fire. Seed burial (drilling) or transplanting natives adapted to local site conditions and climate warming preferred.
Sagebrush	*Resilience* – Moderate to low. Types at higher elevations and with deeper soils have moderate resilience; types at lower elevations and on shallow soils have low resilience. *Resistance* – Moderate to low. Types at higher elevations are more resistant to annuals invaders than those at lower elevations. Resistance generally decreases as site productivity or herbaceous perennial species and ecological condition decreases.	*Protection*- Control inappropriate recreational activities and overgrazing, detect and eradicate invasive species, suppress fires at lower elevations and that threaten ecosystem integrity. *Prevention*– Warranted to restore or maintain sagebrush types, and increase understory species and resistance to invaders. Focus is on resilient and resistant sites. Potential for Wildland Fire Use and prescribed fire to control tree expansion, and shrub mowing and selective herbicides to decrease competition from overstory sagebrush. Information on ecosystem response is needed. *Restoration* – Warranted following surface disturbance and in areas with insufficient fire tolerant understory species for site recovery after fire. Seed burial (drilling) or transplanting natives adapted to local site conditions and climate warming preferred. Livestock closures required post-restoration to facilitate recovery.

(continued)

Table 7.2—(Continued)		
Ecosystem	**Resilience and resistance**	**Guidelines for appropriate management actions**
Blackbrush	*Resilience* – Low to very low. Low precipitation, moderately high temperatures, episodic recruitment. Potential to migrate upslope with climate warming. *Resistance* – Low to very low. Environmental conditions conducive to establishment of invasive annual bromes. Low competition from native species due to low productivity.	*Protection* – Primary emphasis. Suppress fires, actively control cattle and burro grazing and inappropriate recreational activities, detect and eradicate new invaders. *Prevention* – Not warranted under most circumstances. *Restoration* – Warranted following surface disturbance and in areas with insufficient fire tolerant understory species for site recovery after fire. Seed burial (drilling) or transplanting natives adapted to local site conditions and climate warming preferred. Livestock closures required after fire and restoration activities to facilitate recovery of native perennial plants.
Mojave Desert scrub	*Resilience* – Very low. Extreme environmental conditions, episodic recruitment, slow ecosystem recovery. *Resistance*– Low. Environmental conditions of more mesic systems conducive to establishment of annual grasses; few species adapted to most extreme conditions. Low competition from natives due to low productivity.	*Protection* – Primary emphasis. Suppress fires, actively control inappropriate recreational activities and overgrazing by cattle, horses and burros, detect and eradicate new invaders. *Prevention* – Not warranted under most circumstances. *Restoration* – Warranted following surface disturbance and in areas with insufficient fire tolerant understory species for site recovery after fire. Seed burial (drilling) or transplanting natives adapted to local site conditions and climate warming preferred. Livestock closures required after fire and restoration to facilitate recovery of native perennial plants.
Riparian and Spring	*Resilience* –Low to moderately high. High water availability but high water temperatures, harsh water chemistry, and scouring floods. Water availability likely to decrease with climate warming. *Resistance* – Low. Many invasive species in a variety of taxa adapted to high availability of water.	*Protection*– Maintain or increase current water allocations and in stream flows, actively control inappropriate land uses, recreational activities and overgrazing, detect and eradicate new invaders. *Prevention*- Warranted to reduce non-native tamarisk and Russian olive and to manage fuels. Biocontrol, prescribed fire, mechanical treatments, or herbicides can be used, but restoration of native species must follow. *Restoration*– Warranted to maintain river and stream channels by manipulating flow regimes, and to restore or create habitat for native species of concern. Methods include manipulating water depths, velocities and temperatures to meet requirements for species establishment and persistence, and revegetating with native species adapted to the site conditions.

Knowledge Gaps

Cross-cutting information needs for restoration and management of southern Nevada's diverse ecosystems include a better understanding of the factors that determine resilience and resistance and of the interacting effects of the region's stressors. Knowledge of the environmental conditions required for establishment and persistence of native plant species and methods for their restoration also is needed. Information needs relative to the region's major stressors follow:

Climate Change. More accurate predictions of changes in both temperature and precipitation; ecosystem specific information on the effects of climate change on species distributions, disturbance regimes and recovery processes.

Land Use. Knowledge of the distribution and extent of current and future land uses and their effects on current and future ecosystem resilience; information on the minimum patch sizes and degree of fragmentation that ecosystems can tolerate and still persist; land use planning tools to ensure land use is consistent with maintaining and restoring ecosystems.

Invasive Species. Increased knowledge of feedbacks to invasion from regional stressors like increased CO_2, altered fire regimes, and overgrazing; knowledge of the environmental conditions required for establishment and persistence of invasive plants and of their capacities to adapt and migrate in a warming environment; methods for controlling invaders and restoring natives that are consistent with ecosystem restoration and maintenance.

Fire. Increased knowledge of fire effectson annual species invasion and ecosystem recovery for the different ecological sites that characterize Mojave Desert scrub and blackbrush ecosystems; increased knowledge of the interacting effects of precipitation, ecosystem productivity, and understory species composition on fire return intervals for southern Nevada mixed conifer and piñon and juniper ecosystems; fire and fire surrogate tools for mixed conifer, piñon and juniper, and sagebrush ecosystems.

Management Implications

Protection is a critical component of restoring and maintaining southern Nevada ecosystems due to the arid environment and numerous stressors. Preventative management is a viable option only in more mesic or higher elevations ecosystems that do not comprise much of the total land area. Restoration is challenging in all ecosystems. Maintaining sustainable ecosystems will require a greater focus on assessing ecological condition, prioritizing restoration and management activities, and selecting the most appropriate treatments. Monitoring and adaptive management will be essential.

Assessment and Prioritization

An integrated and consistent assessment of southern Nevada ecosystems and their relative resilience and resistance is necessary to categorize and prioritize management and restoration activities. Addressing the widespread stressors affecting these ecosystems and providing habitat for species of concern requires a broad scale approach that crosses administrative boundaries. Most management plans now encompass landscapes with multiple project areas and are developed in consultation with partner agencies. Several tools already exist for developing landscape-scale and cross-boundary assessments. Soil surveys exist for most of southern Nevada including spring systems and lands managed by the BLM, most of the Desert National Wildlife Refuge, and Lake Mead and are available from the USDA Natural Resources Conservation Service (NRCS). Soil characteristics, along with climate and topography, determine the potential to support a given ecological site type (fig. 7.1). Draft ecological site descriptions (ESDs) exist for most of the region that has soil surveys and are available from the Nevada State Office, NRCS. Soil types and ESDs can be used in a GIS environment as the basis for evaluating the relative resilience and resistance of the ecosystems in the region, and the degree to which current ecological conditions deviate from potential conditions. Recent research has developed geospatial tools for identifying critical habitat for species of concern in the Great Basin that could be used in southern Nevada. Methods also have been developed to examine linkages among adjacent ESDs and the interacting effects of landforms and disturbances.

Restoration and Management Approaches

Once an area has been prioritized for active restoration and/or management, a series of logical steps can be used to develop the restoration plan: identifying landscape priorities and ecological sites, determining the current state of the site, selecting the appropriate action(s), and determining post-treatment management. A useful approach that asks questions to identify the information required in each step is provided in table 7.3. These questions can be modified to include the specific information needed for restoration of different ecosystem types.

Table 7.3—General guidelines for conducting a restoration project in southern Nevada (modified from Miller and others 2007; Pyke 2011; Tausch and others 2009).

Steps in the process	Questions to be addressed
I. Identify landscape priorities and ecological sites	1. Where are priority sites for protection, prevention and restoration? Consider the landscape context.
	2. What are the topographic characteristics and soils of the site? Verify soils mapped to the location and collect information on soil texture, depth and basic chemistry (pH, calcium carbonate, etc.)
	3. How will topographic characteristics and soils affect vegetation establishment and erosion? Evaluate erosion risk based on topography and soil characteristics.
	4. What is the potential native plant community for the site? Match soil components to their correlated ESD. This provides a list of potential species for the site.
II. Determine current state of the site	5. Is the site still within the reference state of the state and transition model for this ecological site?
III. Select appropriate action	6. How far does the site deviate from the reference state?
	7. Do sufficient perennial shrubs and herbaceous species exist to facilitate recovery? No action is needed.
	8. Are invasive species a minor component? Protection or preventative management may prevent conversion.
	9. Do invasive species dominate the site while native life forms are missing or severely under represented? Active restoration is required to restore habitat.
	10. Are species from drier or warmer ecological sites present? Restoration with species from the drier or warmer site should be considered.
	11. Have soils or other aspects of the physical environment been altered? The site may have crossed a threshold and represent a new ecological site type requiring new site-specific restoration approaches.
IV. Determine post-treatment management	12. How long should the site be protected before land uses begin? In general, sites with lower resilience and resistance should be protected for longer periods.
	13. How will monitoring be performed? Restoration effectiveness monitoring includes a complete set of measurements, analyses, and a report.
	14. Are adjustments to the restoration approach needed? Adaptive management is applied to future projects by compiling information based on consistent findings from multiple locations.

Monitoring Activities

Monitoring programs designed to track ecosystem changes in response to both stressors and management actions can be used to increase understanding of ecosystem resilience and resistance, realign restoration and management approaches, and implement adaptive management. Information is increasing on likely changes in southern Nevada ecosystems with additional stress and climate warming, but a large degree of uncertainty still exits. Strategic placement of monitoring sites and repeated measurements of key abiotic (precipitation, temperature, evaporation) and biotic (dominant native and exotic species) variables and ecological conditions can be used to decrease uncertainty and increase the effectiveness of management decisions. Monitoring sites should span the environmental/ productivity gradients and ecosystem types that occur in southern Nevada. In addition, areas of high priority should be monitored including (1) ecosystem types of small extent under development pressure like mesquite/catclaw and salt desert shrub; (2) ecosystems that support numerous species of conservation concern like springs and riparian areas; (3) ecotones between ecosystem types where changes in response to climate are expected to be largest; (4) ecological sites with different climatic conditions and soils that are exhibiting invasion and repeated fires; and (5) ecological sites with different climatic conditions and soils that are exhibiting tree expansion and increased fire risk. Monitoring the response of ecosystems to management actions and active restoration also is of high priority as it provides information on treatment effectiveness that can be used to adjust methodologies.

Monitoring activities are most beneficial when consistent approaches are used among and within agencies to collect, analyze, and report monitoring data. Common databases can be used by agency partners to record and share monitoring data, like the USGS Land Treatment Digital Library, to facilitate this process.

For a complete discussion of topics in this executive summary, see *Chapter 7, Maintaining and Restoring, Sustainable Ecosystems in Southern Nevada*, in "The Southern Nevada Agency Partnership Science and Research Synthesis—Science to Support Land Management in Southern Nevada" (RMRS-GTR-303).

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