Chapter 1

An Overview of the Southern Nevada Agency Partnership Science and Research Synthesis

Jeanne C. Chambers, Matthew L. Brooks, Kent Turner,
Carol B. Raish, and Steven M. Ostoja

Management Challenge

Southern Nevada is characterized by an arid to semi-arid environment with numerous cultural resources and a high level of biological diversity. Since 1980, the human population of the region has increased at unprecedented rates largely due to the expansion of suburban areas (Hughson 2009). The various human activities associated with this growth and the interactions of those activities with the generally dry and highly variable climate result in numerous stresses to ecosystems, species, and cultural resources. In addition, climate models predict that the rate of temperature increase and, thus, changes in ecological processes, will be highest for ecosystems with low topographic variability including deserts like the Mojave (Loarie and others 2009). These stresses vary in scale and can be characterized as global (e.g., large scale climatic processes and fluctuations), regional (e.g., atmospheric pollution sources from the southwest), and local (e.g., land use practices) (Fenstermaker and others 2009; Chapter 2). Although global and regional stresses have long-term and lasting effects, local stresses are often the most apparent. Human development in the region is increasing the number of roads and utility corridors, resulting in dust generation and desert trash, and causing an expansion of recreational activities. Past and present grazing by livestock, wild horses, and burros is having widespread effects on native vegetation. The spread of invasive non-native plants is altering fire regimes and causing the conversion of native ecosystems to invasive plant dominance. Groundwater pumping and water diversions coupled with invasive aquatic organisms are degrading many of the region's spring, stream, and riparian ecosystems. The cumulative effects of these stresses are placing the region's cultural and biological resources at risk, and causing the loss of habitat for the region's native plant and animal species. There are multiple species of concern in the region, 17 of which are already listed as threatened. Maintaining and restoring the complex variety of ecosystems and resources that occur in southern Nevada in the face of such rapid socio-economic and ecological change presents numerous challenges to Federal land managers.

Southern Nevada Agency Partnership

In 1999, the Southern Nevada Agency Partnership (SNAP) was established to enhance cooperative management among the Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, and USDA Forest Service. SNAP agencies work with each other, the local community, and other partners to address common issues pertaining to public lands in southern Nevada (http://www.SNAP.gov). The vision of

SNAP is public lands and resources management in southern Nevada that provides for sustainable ecosystem goods and services for both present and future generations. SNAP agencies develop interagency programs and projects to enhance services to the public, improve stewardship of public lands, and increase the efficiency and effectiveness of their management activities.

SNAP agencies manage more than seven million acres of public lands in southern Nevada (95 percent of the land in southern Nevada). Federal land includes two national recreation areas, two national conservation areas, four national wildlife refuges, 18 congressionally designated wilderness areas, five wilderness study areas, and 22 areas of critical environmental concern. The partnership's activities are mainly centered in southern Nevada's Clark County (fig. 1.1). However, SNAP partner agencies also manage portions of the Lake Mead National Recreation Area in Mohave County, Arizona, U.S. Fish and Wildlife Service and USDA Forest Service-managed lands in Lincoln and Nye Counties, Nevada, and all lands and activities managed by the Southern Nevada District Office of the Bureau of Land Management. These lands encompass nine distinct ecosystem types (fig. 1.2; table 1.1), support multiple species of management concern and 17 listed species (table 1.2), and are rich in cultural and historic resources.

Science and Research Strategy

The SNAP managers share an interest in development of an interagency science program that is consistent across agency boundaries and that serves to inform management decisions regarding natural resources, cultural resources, and human use of public lands. To meet that objective, the SNAP managers established a science and research team that was charged with development of an interagency science program. The science and research team published the SNAP Science and Research Strategy (Strategy) in 2009 (Turner and others 2009). The Strategy's overall goal is to integrate and coordinate scientific research programs in southern Nevada and to improve the efficiency and effectiveness of these programs. The Strategy is intended to inform and guide SNAP agencies in identifying and articulating the highest priority science and research needs, sharing resources and funds to implement research addressing those needs, communicating research needs to potential research partners, and eliminating redundancy between agency research programs.

Key components of the Strategy are a periodic SNAP science needs assessment and a SNAP Science and Research Synthesis Report (Synthesis Report). The purpose of the needs assessment is to communicate SNAP's immediate science and research needs to the broader scientific research community and to potential research partners. The needs assessment is prepared by the SNAP science and research team based on input from agency managers, resource staff, and scientists and documents high priority regional and management needs. The Synthesis Report summarizes the state of knowledge and key science findings related to the SNAP Science and Research Strategy Goals, identifies knowledge gaps, and provides management implications. It is prepared every 5 years and is used to guide the periodic SNAP science needs assessments. This General Technical Report (GTR) constitutes the first Synthesis Report.

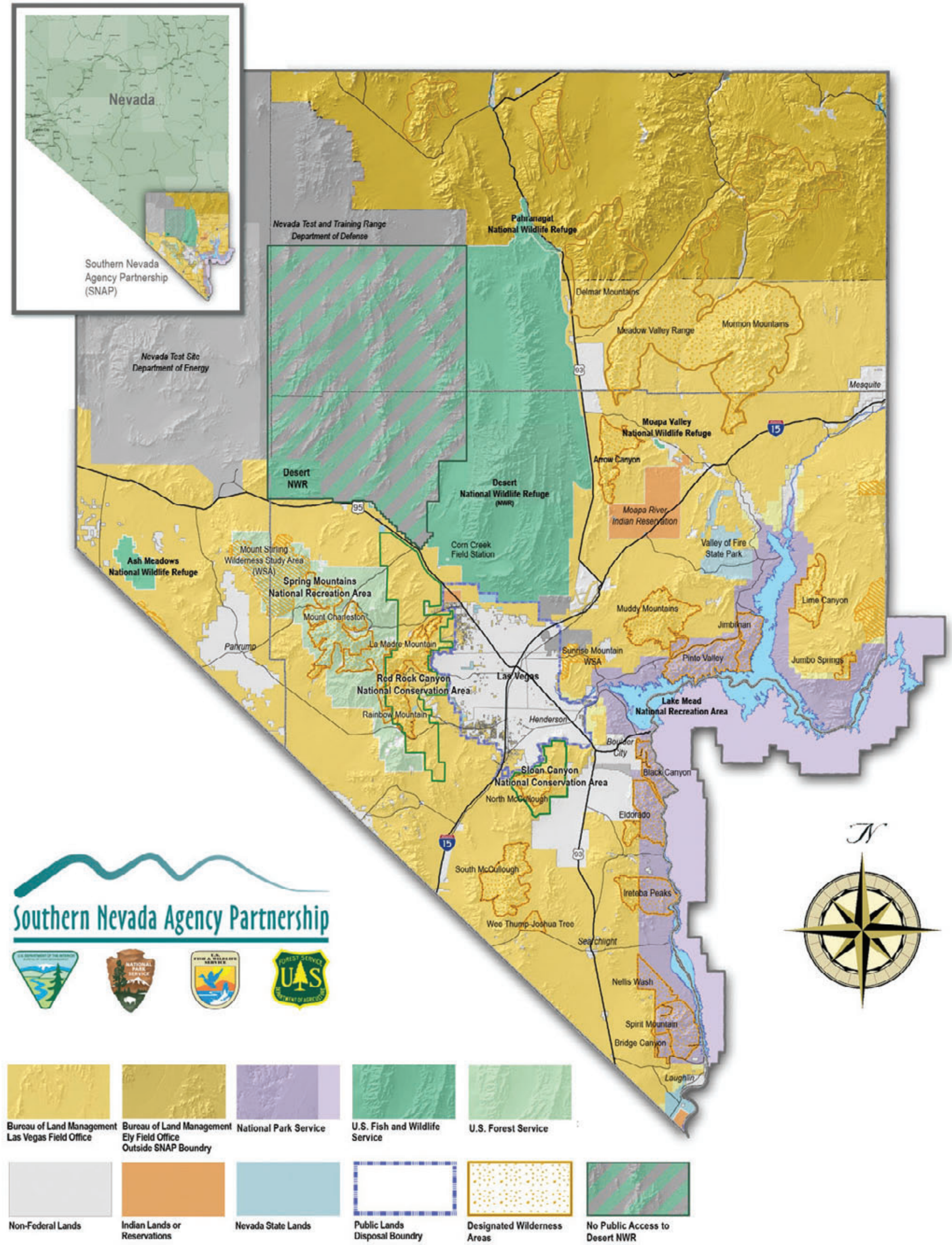

Figure 1.1—Map of the SNAP area illustrating land ownership within the region.

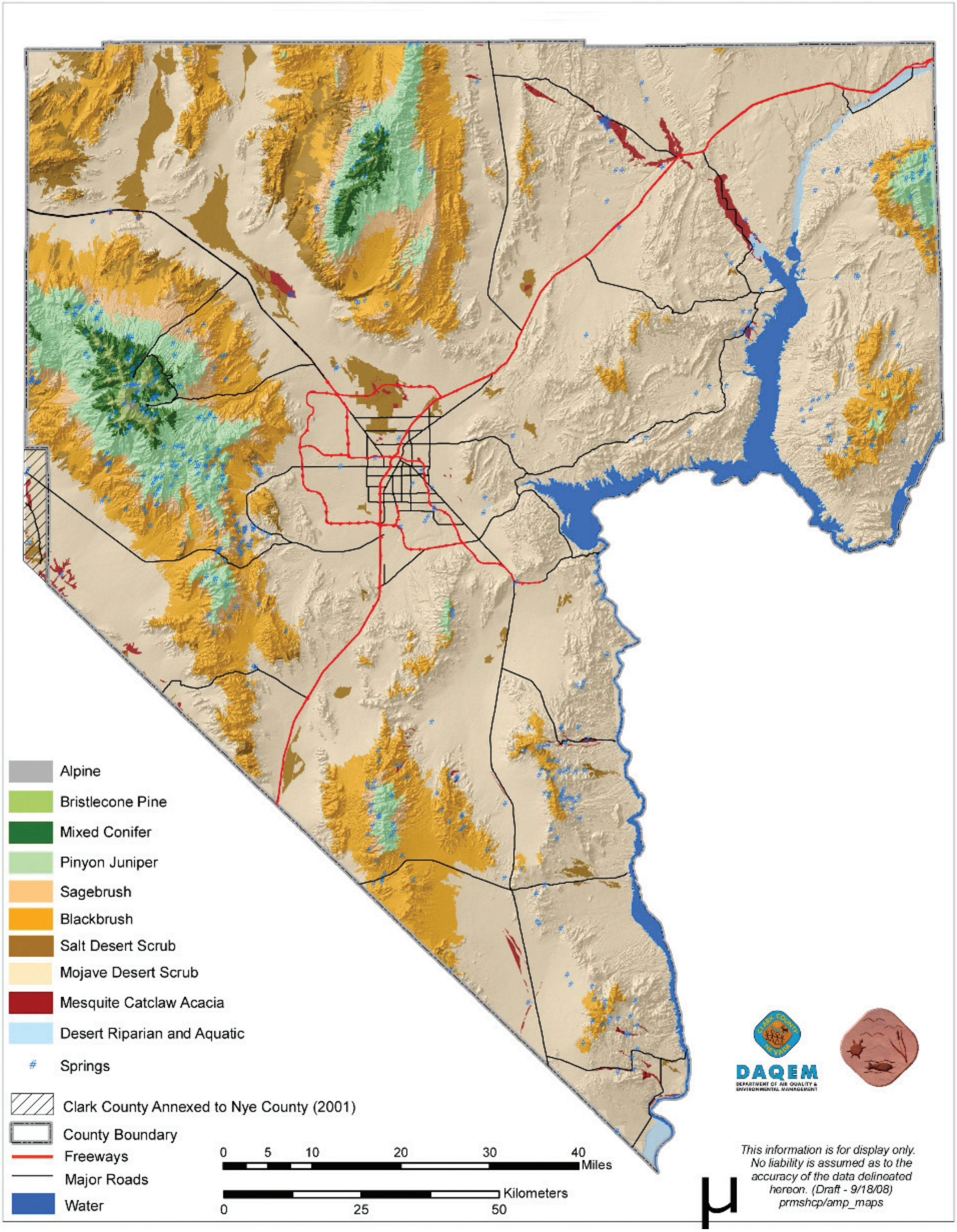

Figure 1.2—Map of the SNAP area illustrating the southern Nevada ecosystem types recognized in the Clark County MSHCP.

Table 1.1—Ecosystem types of southern Nevada defined based on climate, soils, water availability, and vegetation composition and relative abundance. The Clark County Multiple Species Habitat Conservation Plan (MSHCP) recognizes 11 ecosystem types in southern Nevada (RECON 2000). Here, we combine the upland shadscale (*Atriplex confertifolia*) component of the salt desert scrub type with blackbrush (*Coleogyne ramosissima*) and the saltbush (*Atriplex* spp.) component of the salt desert scrub type that occurs in alkaline soils of lowland basin areas with Mojave Desert Scrub.

Ecosystem	Elevation	Location	Description	Reference
Alpine	3,500 m (11, 483 ft)	Spring Mountains on Mt. Charleston	Alpine fell-fields on exposed rocky, dry soils and alpine meadows that occur in swales where moisture and fine-textured soils accumulate. The isolated nature of this system has facilitated development of a unique assemblage of plants, including several endemics.	Clokey 1951
Bristlecone pine	2,600 m (8,530 ft)	Spring and Sheep mountain ranges	Evergreen forest dominated by widely-spaced bristlecone pine (*Pinus longaeva*). Limber pine (*Pinus flexilus*) can be abundant at lower elevations within this zone. Associated shrub species include dwarf juniper (*Juniperus communis*), Clokey mountain sage (*Salvia dorrii* var. *clokeyi*), and sagebrush (*Artemisia* spp.)	Ackerman 2003; Pase and Brown 1982; RECON 2000
Mixed conifer	Between 1,200 m (3,937 ft) and 3,200 m (10,498 ft)	Spring and Sheep mountain ranges	Tree and shrub communities dominated by (1) white fir (*Abies concolor*) at higher elevations and (2) Ponderosa pine (*Pinus ponderosa*) or (3) Ponderosa pine/mountain shrub at mid-low elevations. Associated species at mid-low elevations are single-leaf piñon (*P. monophylla*), Utah juniper (*Juniperus osteosperma*) and mountain mahogany (*Cercocarpus* spp.). Understory shrubs include Gambel oak (*Quercus gambelii)*, manzanita (*Arctostaphylos* spp.), and snowberry (*Symphoricarpos albus*).	Ackerman 2003; RECON 2000
Piñon -juniper	From 1,500 m (4,921 ft) to 2,500 m (8,202 ft)	Spring, Sheep, and Virgin mountain ranges with island communities in the Delamar, McCullough, Papoose, and Parahnagat ranges (fig.1.2).	Tree and shrub communities dominated by singleleaf piñon, Gambel oak, mountain mahogany, and sagebrush (*Artemisia* spp.) at upper elevations, and Utah juniper, Rocky Mountain juniper (*Juniperus scopulorum*), western juniper (*Juniperus occidentalis*), rabbitbrush (*Chrysothamnus* spp.), and sagebrush at lower elevations. Associated perennial grass species include (*Agropyron* spp.), bluegrass (*Poa* spp.), and needlegrass (*Achnatherum* spp.).	RECON 2000
Sagebrush	From 1,500 m (4,921 ft) to 2,800 m (9,186 ft)	Spring, Sheep, and Virgin ranges in Clark County and in ranges farther north in Lincoln County (fig. 1.2). Co-occurs with several ecosystem types.	Several different community types that are dominated by three subspecies of big sagebrush (*Artemisia tridentata* ssp. *tridentata, A. tridentata* ssp. *wyomingensis and A. tridentata* ssp. *vaseyana*), low sagebrush (*A. arbuscula*), Bigelow sagebrush (*A. bigelovii*), and black sagebrush (*A. nova*). Other shrub species characteristic of these communities include rabbitbrush (*Chrysothamnus* and *Ericamera* spp.), snakeweed (*Gutierrezia sarothrae*), spiny hopsage (*Grayia spinosa),* and cliffrose (*Purshia neomexicana*). Associated perennial grass species include (*Agropyron* spp.), bluegrass (*Poa* spp.), and needlegrass (*Achnatherum* spp.).	RECON 2000
Blackbrush/ shadscale	Between 1,200 m (3,937 ft) and 1,800 m (5,905 ft)	Wide-spread below the piñon and juniper and sagebrush zones, and above the Mojave Desert scrub zone (fig. 1.2)	Blackbrush (*Coleogyne ramosissima*) tends to dominate areas with shallow limestone-derived soils, whereas shadscale (*Atriplex confertifolia*) tends to dominate on heavy, rocky soils. Other subdominant shrub species include cliffrose, budsage (*Artemisia spinescens*), Mormon tea (*Ephedra* spp.), snakeweed, wolfberry (*Lycium* spp.), and spiny hopsage. Additional species include Utah juniper, Joshua tree (*Yucca brevifolia*), banana yucca (*Yucca baccata*), Indian ricegrass (*Achnatherum hymenoides*), needlegrass, and galleta grass (*Pleuraphis jamesii*).	Brooks and others 2007

(continued)

Table 1.1—(Continue)

Ecosystem	Elevation	Location	Description	Reference
Mojave Desert scrub (most common ecosystem)	Below 1,200 m (3,937 ft)	Wide-spread in southern Nevada	Dominated by thermophile vegetation types characterized by creosotebush (*Larrea tridentata*) in upland areas and saltbush species (*Atriplex* spp.) in alkaline soils of lowland basin areas. *Bajadas,* the most common landform, are dominated by creosotebush and white bursage (*Ambrosia dumosa*); subdominants include desert thorn (*Lycium andersonii*), bladder sage (*Salazaria mexicana*), indigo bush (*Psorothamnus fremontii*), blackbrush, brittlebush (*Encelia farinosa*), and burro bush (*Hymenoclea salsola*). *Sand dunes, gypsum soils, cliff/rock outcrops, and steep slopes* occur as isolated patches that support unique plant and animal communities. Dominant vegetation in these patches include Joshua tree (*Yucca brevifolia*), prickly pear cactus (*Opuntia* spp.), yucca (*Yucca* spp.), cholla (*Cylindropuntia* spp.), and hedgehog cactus (*Echinocereus* spp.). *Areas with perennial groundwater* not more than 10 m from the surface are characterized by the mesquite/catclaw community which occurs in patches (1 to over 1000 ha; 2.5 to over 2,500 acres) on diverse soils in scattered clumps on valley floors and near desert springs. Dominant tree species are screwbean mesquite (*Prosopis pubescens*), honey mesquite (*P. glandulosa*), catclaw acacia (*Acacia greggii*), and smoke tree (*Psorothamnus spinosa*); associated shrubs are fourwing saltbush (*Atriplex canescens*), quailbush (*A. lentiformis*), arrowweed (*Pluchea sericea*), creosotebush, burro bush (*Hymenoclea salsola*), bebbia (*Bebbia juncea*), and sandpaper plant (*Petalonyx nitidus*).	Clokey 1951; Schoenherr 1992; Crampton and others 2006
Riparian/ aquatic	Below 1200 m (3,937 ft)	Lowland riparian/ aquatic systems occur in southern Nevada, along the Virgin and Muddy Rivers, Las Vegas Wash, and the Colorado River. Mountain riparian/ aquatic systems occur in high elevations of Spring Mountains.	Riparan/aquatic ecosystems are characterized by flows that are either persistent or intermittent, particularly during summer. Under natural, unregulated conditions, the aquatic component is relatively harsh because of seasonally high water temperatures, harsh water chemistry, high turbidity, scouring floods, and sandy substrates. In perennial reaches, the riparian community includes woody, deciduous, and emergent obligatory and facultative wetland vegetation. Principal native woody vegetation includes Fremont cottonwood (*Populus fremontii*), black cottonwood (*Populus trichocarpa*), sandbar willow (*Salix exigua*), Gooding willow (*S. gooddingii*), velvet ash (*Fraxinus velutina*), desert willow (*Chilopsis linearis*), and honey mesquite. Mountain riparian/aquatic ecosystems are characterized by streams with highly variable base flows that have low to nonexistent discharges in dry years.	RECON 2000; Chapter 3
Springs		Throughout Clark County	Small-scale aquatic systems that occur where ground water reaches the soil surface. Several hundred springs are scattered throughout Clark County that are generally supported by mountain block, local, or regional aquifers. They range widely in size, water chemistry, morphology, landscape setting, and persistence. Springs support diverse aquatic communities and riparian zones. Spring environments are most influenced by the type of aquifer and amount of flow, landscape position, and disturbance regime (see Chapter 3).	Chapter 3

Table 1.2—Southern Nevada Agency Partnership species of management concern.

Common name	Species name
Amphibian	
Relict leopard frog	*Rana onca*
Birds	
Northern Goshawk	*Accipiter gentilis*
Western Yellow-billed Cuckoo	*Coccyzus americanus occidentalis*
Southwestern Willow Flycatcher	*Empidonax trailii extimus*
American Peregrine Falcon	*Falco peregrinus anatum*
Bald Eagle	*Haliaeetus leucocephalus*
Blue Grosbeak	*Passerina caerulea*
Phainopepla	*Phainopepla nitens*
Summer Tanager	*Piranga rubra*
Vermillion Flycatcher	*Pyrocephalus rubinus*
Yuma Clapper Rail	*Rallus longirostrus yumanensis*
Arizona Bell's Vireo	*Vireo bellii arizonae*
Fishes	
Meadow Valley Wash desert sucker	*Catostomus clarki* ssp. 2
Devils Hole pupfish	*Cyprinodon diabolis*
Ash Meadows Amargosa pupfish	*Cyprinodon nevadensis mionectes*
Warm Springs pupfish	*Cyprinodon nevadensis pectoralis*
Pahrump poolfish	*Empetrichthys latos latos*
Pahranagat roundtail chub	*Gila robusta jordani*
Virgin River chub	*Gila seminuda*
Virgin River chub (Muddy River pop.)	*Gila seminuda* pop. 2
Virgin River spinedace	*Lepidomeda mollispinis mollispinis*
Moapa dace	*Moapa coriacea*
Woundfin	*Plagopterus argentissimus*
Moapa speckled dace	*Rhinichthys osculus moapae*
Ash Meadows speckled dace	*Rhinichthys osculus nevadensis*
Pahranagat speckled dace	*Rhinichthys osculus velifer*
Meadow Valley speckled dace	*Rhinichthys osculus* ssp. 11
Razorback sucker	*Xyrauchen texanus*
Reptiles	
Western redtail skink	*Eumeces gilberti rubricaudatus*
Agassiz's Desert tortoise	*Gopherus agassizii*
Banded Gila monster	*Heloderma suspectum cinctum*
Invertebrates	
Ash Meadows naucorid	*Ambrysus amargosus*
Warm Springs naucorid	*Ambrysus relictus*
Acastus Checkerspot	*Chlosyne acastus robusta*
Spring Mountains dark blue	*Euphilotes ancilla purpura*
Morand's checkerspot	*Euphydryas chalcedona morandi*
Spring Mountains Comma Skipper	*Hesperia colorado mojavensis*
Charleston ant	*Lasius nevadensis*
Nevada Admiral	*Limenitis weidemeyerii nevadae*
Amargosa naucorid	*Pelocoris shoshone amargosus*
Spring Mountains icarioides blue	*Plebejus icarioides austinorum*
Mount Charleston Blue	*Plebejus shasta charlestonensis*
Giuliani's dune scarab beetle	*Pseudocotalpa giulianii*
Moapa pebblesnail	*Pyrgulopsis avernalis*
Blue Point pyrg	*Pyrgulopsis coloradensis*
Spring Mountains pyrg	*Pyrgulopsis deaconi*
Corn Creek pyrg	*Pyrgulopsis fausta*

(continued)

Table 1.2 (Continued).

Common name	Species name
Invertebrates	
Southeast Nevada pyrg	*Pyrgulopsis turbatrix*
Carole's fritillary	*Speyeria carolae*
Moapa Warm Spring riffle beetle	*Stenelmis moapa*
Mammals	
Pale lump-nosed bat	*Corynorhinus townsendii pallescens*
Spotted bat	*Euderma maculatum*
Allen's big-eared bat	*Idionycteris phyllotis*
Silver-haired bat	*Lasionycteris noctivagans*
Pahranagat Valley montane vole	*Microtus montanus fucosus*
Fringed myotis	*Myotis thysanodes*
Palmer's chipmunk	*Neotamias palmeri*
Hidden Forest Uinta chipmunk	*Neotamias umbrinus nevadensis*
Big free-tailed bat	*Nyctinomops macrotis*
Bighorn sheep	*Ovis canadensis nelsoni*
Plants	
Rough angelica	*Angelica scabrida*
Charleston pussytoes	*Antennaria soliceps*
Sticky ringstem	*Anulocaulis leiosolenus* var. *leiosolenus*
Las Vegas bearpoppy	*Arctomecon californica*
King's rosy sandwort	*Arenaria kingii* spp. *rosea*
Clokey milkvetch	*Astragalus aequalis*
Threecorner milkvetch	*Astragalus geyeri* var. *triquetrus*
Clokey eggvetch	*Astragalus oophorus* var. *clokeyanus*
Spring Mountains milkvetch	*Astragalus remotus*
Ash Meadows milkvetch	*Astragalus phoenix*
Upswept moonwort	*Botrychium ascendens*
Dainty moonwort	*Botrychium crenulatum*
Slender moonwort	*Botrychium lineare*
Spring-loving centaury	*Centaurim namophilum*
Las Vegas cryptantha	*Cryptantha insolita*
Jaeger whitlowgrass	*Draba jaegeri*
Charleston draba	*Draba paucifructa*
Ash Meadows sunray	*Enceliopsis nudicaulis* var. *corrugate*
Nevada willowherb	*Epilobium nevadense*
Pahrump Valley buckwheat	*Eriogonum bifucatum*
Las Vegas buckwheat	*Eriogonum corymbosum var. nilesii*
Sticky buckwheat	*Eriogonum viscidulum*
Clokey greasebush	*Glossopetalon clokeyi*
Ash Meadows gumplant	*Grindelia fraxinopratensis*
Charleston ivesia	*Ivesia cryptocaulis*
Jaeger ivesia	*Ivesia jaegeri*
Ash Meadows ivesia	*Ivesia kingii* var. *eremica*
Ash Meadows blazingstar	*Mentzelia leucophylla*
Amargosa niterwort	*Nitrophila mohavensis*
White-margined beardtongue	*Penstemon albomarginatus*
Bicolored beardtongue	*Penstemon bicolor* ssp. *bicolor*
Rosy two-colored beardtongue	*Penstemon bicolor* ssp. *roseus*
Jaeger beardtongue	*Penstemon thompsoniae* spp. *jaegeri*
Clokey's catchfly	*Silene clokeyi*
Charleston tansy	*Sphaeromeria compacta*
Charleston kittentails	*Synthyris ranunculina*
Charleston grounddaisy	*Townsendia jonesii* var. *tumulosa*
Charleston violet	*Viola charlestonensis*

The SNAP Science and Research Strategy established several goals for interagency science and research that is conducted in support of resource management in southern Nevada. The goals were developed based on individual agency goals, the SNAP Board vision, the interagency science and research team's charter goals, the input of individual agency specialists, and input from interdisciplinary scientists that was obtained during several planning workshops. Each major goal has a set of Sub-goals and questions that address specific science needs. The three main Goals are:

Goal 1. Restore, sustain, and enhance southern Nevada's ecosystems.
Goal 2. Provide for responsible use of southern Nevada's lands in a manner that preserves heritage resources and promotes an understanding of human interaction with the landscape.
Goal 3. Promote scientifically informed and integrated approaches to effective, efficient, and adaptive management.

Science and Research Synthesis Report

The Goals and Sub-goals of the SNAP Science and Research Strategy provide key focal areas for both the periodic science needs assessments and the Synthesis Report. The Synthesis Report addresses information related to Goals 1 and 2 and their associated Sub-goals (table 1.3). The Sub-goals address the topics of fire, invasive species, landscapes and watersheds, biological diversity, cultural resources, historic content, recreation, land uses, and education. The Synthesis Report provides a summary of the state of knowledge related to each of the nine Sub-goals, addresses knowledge gaps, and provides management implications. It builds on previous efforts to develop the necessary scientific understanding for adaptive management of southern Nevada ecosystems, such as the Multi Species Habitat Conservation Plan (MSHCP) (RECON 2000) and a 2007 workshop on the characteristics of southern Nevada ecosystems and the threats to ecosystem health (Desert Research Institute 2008). The Synthesis Report is organized around the topics addressed in the Sub-goals, and table 1.3 provides a crosswalk between the chapters in this document and the Goals and Sub-goals in the SNAP Strategy. An overview of the biophysical setting and cultural resources as well as the management concepts discussed in the report follow.

Biophysical Setting of Southern Nevada

Southern Nevada straddles a broad ecotone between the Central Basin and Range of the Cold Desert ecoregion to the north and the Mojave Basin and Range of the Warm Desert ecoregion to the south (U.S. Environmental Protection Agency 2002, 2010; fig. 1.2). The topography is characterized by broad basins separated by isolated mountain ranges that are punctuated by steep environmental gradients. These local environmental gradients mirror large-scale latitudinal gradients and result in Cold Desert and mesic forest conditions occurring at higher elevations on mountains within the Warm Desert ecoregion.

Climate within the region is spatially and temporally variable, and slope, aspect, and especially elevation—which ranges from 170 m (557 ft) at Laughlin, Nevada, to 3,632 m (11,913 ft) at Charleston Peak in the Spring Mountains—strongly influence both precipitation and temperature. Recorded precipitation ranges from a long-term yearly mean of 10.5 cm (4.1 in), with a minimum of 1.4 cm (0.6 in) and maximum of 27.1 cm (10.7 in) at 662 m (2,170 ft) elevation in Las Vegas, to a mean of 60.1 cm (23.6 in), with a minimum of 30.8 cm (12.1 in) and maximum of 90.0 cm (35.4 in) at 2,289 m (7,510 ft) at Mt. Charleston Lodge in the Spring Mountains (Western Regional

Table 1.3—A crosswalk relating the chapters in this document to the Goals and Sub-goals in the SNAP Science and Research Strategy.

Goal/Chapter	Sub-goal
Goal 1. Restore, sustain, and enhance southern Nevada's ecosystems	
Chapter 1. An Overview of the southern Nevada Agency Partnership Science and Research Synthesis	
Chapter 2. Southern Nevada Ecosystem Stressors	
Chapter 3. Water and Water Use in Southern Nevada	*Sub-Goal 1.3.* Restore and sustain proper function of southern Nevada's watersheds and landscapes
Chapter 4. Invasive Species in Southern Nevada	*Sub-Goal 1.2.* Protect southern Nevada's ecosystems from the adverse impacts of invasive species
Chapter 5. Fire History, Effects, and Management in Southern Nevada	*Sub-Goal 1.1.* Manage wildland fire to sustain southern Nevada's ecosystems
Chapter 6. Species of Conservation Concern and Environmental Stressors: Local, Regional, and Global Effects	*Sub-Goal 1.4.* Sustain and enhance southern Nevada's biotic communities to preserve biodiversity and maintain viable populations
Chapter 7. Maintaining and Restoring, Sustainable Ecosystems in Southern Nevada	*Sub-Goal 1.3.* Restore and sustain proper function of southern Nevada's watersheds and landscapes
Goal 2. Provide for responsible use of southern Nevada's lands in a manner that preserves heritage resources and promotes an understanding of human interaction with the landscape	
Chapter 8. Human Interactions with the Environment through Time in Southern Nevada	*Sub-Goal 2.1.* Develop an understanding of human interactions with the environment through time
Chapter 9. Preserving Heritage Resources through Responsible Use of Southern Nevada's Lands	*Sub-Goal 2.2*. Preserve heritage resources through responsible use of southern Nevada's lands
Chapter 10. Recreation Use on Federal Lands in Southern Nevada	*Sub-Goal 2.4.* Provide for appropriate (type and location), quality, and diverse recreational experiences, resulting in responsible visitor use on federal lands in southern Nevada
*Chapter 11***.** Science-based Management of Public Lands in Southern Nevada	*Sub-Goal 2.3.* Manage current and future authorized southern Nevada land uses in a manner that balances public need and ecosystem sustainability
	Sub-Goal 2.5. Promote an effective conservation education and interpretation program to improve the quality of resources and enhance public use and enjoyment of southern Nevada public lands

Climate Center 2011). Most of the yearly precipitation falls during the winter months, but the southeastern part of the region receives relatively more summer precipitation than the northern or western areas. Temperatures in the region range from a long-term yearly mean of 19.5 °C (67.1 °F), with a minimum of 12.3 °C (54.1 °F) and a maximum of 27.0 °C (80.6 °F) at Las Vegas, to a mean of 7.8 °C (46.0 °F) with a minimum of 0.2 °C (32.3 °F) and maximum of 15.8 °C (60.4 °F) at Mt. Charleston Lodge (Western Regional Climate Center 2011).

The elevation/climate gradients in combination with the local topography of the region strongly affect soil characteristics, plant species composition, and productivity of vegetation communities and, consequently, animal species distributions. Lower elevation soils are typically classified as Entisols, Aridisols, or Inceptisols while higher elevation soils are Mollisols and, when derived from carbonate substrates, Alfisols (U.S. Environmental Protection Agency 2010). Wetland soils are Inceptisols or Mollisols (U.S. Environmental Protection Agency 2010). The diverse Warm and Cold Desert ecosystem types have been present in southern Nevada at least since the end of the last ice age and the beginning of the Holocene 10,000 years ago (Van Devender 1977; Van Devender and Spaulding 1979), although the ecotones between the major ecosystem types are presently higher in elevation than they were at the beginning of the Holocene (Spaulding 1990). Low elevation basins and the toeslopes of mountain ranges have warmer and more arid climates typical of warm deserts and are dominated by Warm Desert Mojave Desert Scrub ecosystems (table 1.1). Less common cold desert shrublands (blackbrush and sagebrush), woodlands (pinyon and juniper), forest stands (mixed conifer), and even bristlecone pine and alpine ecosystem types have cooler and more mesic climates and occur with increasing elevation within these mountain ranges. Spring and riparian ecosystems occur across the elevation/climate gradient, but spring ecosystems occur where local geology and hydrology result in water flowing to the surface, and riparian/aquatic ecosystems are associated with streams and rivers that flow during the majority of the year. These ecosystems differ in soil characteristics, water chemistry, and species composition depending on topographic location and setting.

The strong topographic differences and diverse ecosystem types result in a high number of species in southern Nevada (Kolter and Brown 1988). Also, the degree of habitat diversity and geographic isolation of similar habitat types like mountain ranges has produced a high degree of endemism. For example, there are many species of endemic butterflies (Fleishman and others 2001; Forister and others 2004). Finally, the climatic history of the region also has contributed to high levels of endemism. The region is much drier today than it was even 10,000 years ago, and this has resulted in highly isolated aquatic remnant habitats that support a large number of endemic pupfish (*Cyprinodon* spp.) and other species (Brown 1971; Miller 1950).

Cultural Setting

Southern Nevada is rich in irreplaceable cultural and historical resources that include archaeological remains, historic sites, cultural landscapes, and other areas of significance to Native American and other cultural groups. There is evidence of human occupation of southern Nevada from about 12,000 years ago. These early residents were nomadic hunters of large Pleistocene fauna who also used both small game and plant resources (Harper and others 2006). Climate change during the early Holocene resulted in broad adaptation to a range of resources, and small, mobile groups of hunter-gatherers moved between ecological zones utilizing plant resources and small game (Ezzo and Majewski 1996). Agriculture began prior to 2350 years ago and increased in intensity until ca. 750/650 years ago (AD 1200/1300). Exploitation of wild resources and seasonal movement continued during this time period. Southwestern Puebloan peoples that were characterized by agriculture and the use of pit structures, the bow and arrow, ceramics, above-ground rooms, and pueblos occupied the region during this period (Lyneis 1995). After about 650 years ago, archeological remains reflect a return to a more nomadic foraging way of life, supplemented by smaller-scale agriculture (Altschul and Fairley 1989; Ezzo and Majewski 1996). This adaptation is associated with the Southern Paiute who were residents of the region during European contact and who continue to live in southern Nevada today. European contact began in the 1700s with the Spanish and continued with the well-documented establishment of Mormon settlements in the mid-1800s (Sterner and Ezzo 1996). The now seemingly inhospitable desert has a long history of change and has provided diverse ecosystems from which native people and later historic immigrants have been able to sustain themselves.

Concepts for Management

Management aimed at maintaining sustainable ecosystems is essential if public lands in southern Nevada are to continue to support both public needs and habitat for the region's diverse assemblage of plants and animals. Sustainable or "healthy" ecosystems supply important ecological services and goods. Over the normal cycle of disturbance events, sustainable ecosystems retain characteristic processes including hydrologic flux and storage, geomorphic processes, biogeochemical cycling and storage, biological activity and productivity, and biotic population regeneration and reproduction (modified from Chapin and others 1996 and Christensen and others 1996). Thus, managing for sustainable ecosystems in southern Nevada requires maintaining or restoring the ecological processes that structure the region's ecosystems.

A large number of studies have revealed a tight connection between ecosystem sustainability and ecological resilience to stress and disturbance and resistance to invasive species (see Folke and others 2002). Resilience is defined as the capacity of an ecosystem to regain its fundamental structure, processes, and functioning (or recover) when subjected to stressors or disturbances like drought, livestock grazing, or wildfire (e.g. Allen and others 2005; Hollings 1973; Walker and others 1999). A reduction in resilience can increase the vulnerability of an ecosystem and reduce its ability to recover following stress or disturbance. The inherent resilience of southern Nevada ecosystems to stress and disturbance differs due to the strong elevation/climate gradients in the region and the large differences in abiotic and biotic characteristics along these gradients. In general, the resilience of intact desert ecosystems tends to increase along gradients of increasing available resources (water and nutrients) and annual net primary productivity (Brooks and Chambers 2011; Chambers and others 2007; Wisdom and Chambers 2009). Thus, higher precipitation and more moderate temperatures at moderately high elevations result in greater productivity and can increase the capacity of native communities to recover following stress or disturbance.

Non-native invaders are having major effects on the sustainability of southern Nevada's terrestrial and aquatic ecosystems and are a major management concern. Resistance is the capacity of an ecosystem to retain its fundamental structure, processes, 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 (D'Antonio and Thomsen 2004). Resistance of ecosystems to widely distributed invasive species like cheatgrass (*Bromus tectorum*) and red brome (*Bromus madritensis*) often reflects the climate suitablility of the species or its ability to establish and persist under a given set of environmental conditions. In general, resistance to annual invaders tends to be higher in the most stressful environments (true desert and alpine ecosystems) because only a limited suite of species is adapted to establish and persist due to the harsh conditions. For example, establishment of the invasive annual grass, cheatgrass, in the Great Basin is limited in salt desert shrub types at the low end of the precipitation gradient due to insufficient water availability (Meyer and others 2001), while growth and reproduction is limited in mountain brush types at high elevations due to insufficient degree days (Chambers and others 2007).

Several factors interact to influence resilience to stress and disturbance and resistance to invasive species in desert ecosystems. Climate, topography, and soils determine the abiotic and biotic attributes of an ecosystem and thus the potential to support a given ecosystem type or community. The abiotic attributes that characterize ecosystems are hydrologic flux and storage, biogeochemical cycling and storage, and geomorphic processes, while biotic attributes are biological productivity, composition and structure, and population regulation and regeneration. Climate change, disturbance and stress act on these attributes and influence the relative resilience and resistance of the ecosystem over time. Changes in resilience and resistance are indicated by factors like soil stability and past or present erosion, the composition and abundance of native plants and animals, seed banks and seed sources, and the composition and abundance of invasive species. The severity and frequency of disturbance can alter resilience to stress and disturbance and resistance to invasive species and, consequently, the capacity of a site to support desirable alternative states (Briske and others 2008). In the deserts of North America, inappropriate grazing by wild horses, burros, and livestock has significantly influenced resilience and resistance by reducing a major structural and functional component, specifically native perennial herbaceous species, and by serving as a dispersal agent for non-native invaders (Milchunas and others 1988; Van de Koppel and others 2002). Loss of perennial herbaceous species decreases the resistance of desert ecosystems to invasion (Chambers and others 2007) and resilience to disturbances like drought and wildfires (D'Antonio and others 2009). Once established, invasive species promote shorter fire return intervals and larger fire sizes than southern Nevada deserts experienced historically. These changes can result in positive feedbacks for the invader and negative effects on native species, especially woody perennials and succulents (Brooks and others 2004).

Adaptive management that is aimed at maintaining or increasing resistance and resilience can reduce the uncertainty associated with management decisions and increase the region's capacity to deal with stresses without losing options for the future (Folke and others 2002). Key aspects of adaptive management are a scientific understanding of the underlying processes structuring southern Nevada ecosystems, the effects of the numerous stresses on these ecosystems and their associated species, and the factors that influence their resilience to stress and disturbance and resistance to invasion. Routine monitoring of the effects of stresses, disturbances, and management actions on the ecological conditions of the Region's diverse ecosystems can provide the necessary feedback for adaptive management. Periodic science syntheses, such as those in this GTR, give information on the current state of knowledge, the ecological trajectories of the region's ecosystems and species, and needed information for effective management.

References

Ackerman, T.L. 2003. A flora of the desert national wildlife range, Nevada. In: Bair, J.; Tiehm, A. (eds). Mentzelia. No. 7. 90 p.

Allen, C.R.; Gunderson, L.; Johnson, A.R. 2005. The use of discontinuities and functional groups to assess relative resilience in complex systems. Ecosystems. 8:958-966.

Altschul, J.H.; Fairley, H.C. 1989. Man, models, and management: an overview of the archaeology of the Arizona Strip and its cultural resources. Washington, DC: U.S. Department of the Interior, Bureau of Land Management.

Briske, D.D., Bestelmeyer, B.T.; Stringham, T.K.; Shaver, P.L. 2008. Recommendations for development of resilience based state and transition models. Rangeland Ecology and Management. 61:359–367.

Brooks, M.L.; Chambers, J.C. 2011. Invasive plants and altered fire regimes in the deserts of North America. Rangeland Ecology and Management. 64:431–438. doi: 10.2111/REM-D-09-00165.1.

Brooks, M.L.; D'Antonio, C.M.; Richardson, D.M.; Grace, J.B.; Keeley, J.E.; DiTomaso, J.M.; Hobbs, R.J.; Pellant, M.; Pyke, D. 2004. Effects of invasive alien plants on fire regimes. Bioscience. 54:677-688.

Brooks, M.L.; Esque, T.C.; Duck, T. 2007. Creosotebush, blackbrush, and interior chaparral shrublands. In: Hood, S.M.; Miller, M. (eds.). Fire ecology and management of the major ecosystems of Southern Utah. Gen. Tech. Rep. RMRS-GTR-202. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 57-71.

Brown, J. H., 1971. The desert pupfish. Scientific American. 225:104-110.

Chambers, J.C.; Roundy, B.A.; Blank, R.R.; Meyer, S.E; Whittaker, A. 2007. What makes Great Basin sagebrush ecosystems invasible by *Bromus tectorum*? Ecological Monographs. 77:117-145.

Chapin, F.S., III.; Torn, S.E.; Tateno, M. 1996. Principles of ecosystem sustainability. The American Naturalist. 148:1016-1037.

Clokey, I.W. 1951. Flora of the Charleston Mountains, Clark County, Nevada. Berkeley, CA: University of California Press. 274 p.

Christensen, N.L.; Bartuska, A.M.; Brown, J.H.; [and others]. 1996. The report of the Ecological Society of America Committee on the scientific basis for ecosystem management. Ecological Applications. 6:665-691.

Crampton, L.; Krueger J.; Murphy, D. 2006. Conservation management strategy for mesquite and acacia woodlands in Clark County, Nevada. [Place of publication unknown]: U.S. Bureau of Land Management, Las Vegas Field Office.

D'Antonio, C.M.; Chambers, J.C.; Loh, R.; Tunison, J.T. 2009. Applying ecological concepts to the management of widespread grass invasions. In: Inderjit, R.L. (ed.). Ecological invasions and restoration. Netherlands: Springer: 123-149.

D'Antonio, C.M.; Thomsen, M. 2004. Ecological resistance in theory and practice. Weed Technology. 18:1572-1577.

Desert Research Institute. 2008. Task 7: First iteration conceptual models for 11 MSHCP ecosystems. Annual Report. Project 2005-DRI-574A-P. Reno, NV: Desert Research Institute.

Ezzo, J.A.; Majewski, T. 1996. The cultural resources of the project area: prehistory, protohistory, and ethnography. In: Ezzo, J.A. (ed.). A Class I cultural resources survey of the Moapa and Virgin Valleys, Clark County, Nevada. Statistical Research Technical Series No. 58. Boulder City, NV: Statistical Research: 35-77.

Fenstermaker, L.F.; McDonald, E.V.; Webb, R.H. 2009. Regional threats to the Mojave Desert. In: Webb, R.H.; Fenstermaker, L.F.; Heaton, J.S.; [and others]. (eds.). The Mojave Desert: ecosystem processes and sustainability. Las Vegas, NV: University of Nevada Press: 7-10.

Fleishman, E.; Austin, G.T; Murphy, D.D. 2001. Biogeography of Great Basin butterflies: revisiting patterns, paradigms, and climate change scenarios. Biological Journal of the Linnean Society. 74:501-515.

Folke, C.; Carpenter, S.; Elmqvist, T.; [and others]. 2002. Resilience and sustainable development: building adaptive capacity in a world of transformations. Scientific background paper on resilience for the process of The World summit on sustainable development on behalf of The Environmental Advisory Council to the Swedish Government. Stolkholm, Sweden: Ministry of the Environment. 74 p.

Folke, C.; Carpenter, S.; Walker, B.; [and others]. 2004. Regime Shifts, Resilience, and Biodiversity in Ecosystem Management. Annual Review of Ecology, Evolution, and Systematics. 35:557-581**.**

Forister, M.L.; Fordyce, J.A; Shapiro, A.M. 2004. Geological barriers and restricted gene flow in the holarctic skipper Hesperia comma (*Hesperiidae*). Molecular Ecology. 13: 3489-3499.

Harper, C.; Ahlstrom, R.V.N.; Eskenazi, S. 2006. Introduction. In: Harper, C. (ed.). A room with a view: Data recovery of an early historical rockshelter site located in the Upper Moapa Valley, Clark County, Nevada. HRA Papers in Archaeology No. 5. Las Vegas, NV: HRA. 1-14.

Holling, C.S. 1973. Resilience and stability in ecological systems. Annual Review of Ecology and Systematics. 4:1-23.

Hughson, D.L. 2009. Human population in the Mojave Desert: Resources and sustainability. In: Webb, R.H.; Fenstermaker, L.F.; Heaton, J.S.; Hughson, D.L.; McDonald, E.V; Miller, D.M. eds. The Mojave Desert: Ecosystem processes and sustainability. Las Vegas, NV: University of Nevada Press: 57-77.

Kotler, B.P.; Brown, J.S. 1988. Environmental heterogeneity and the coexistence of desert rodents. Annual Review of Ecology and Systematics. 19:281-307.

Loarie, S.R.; Duffy, P.B.; Hamilton, H.; [and others]. 2009. The velocity of climate change. Nature. 462:1052-1055.

Lyneis, M.M. 1995. The Virgin Anasazi, far western Puebloans. Journal of World Prehistory. 9(2):199-241.

Meyer S.E.; Garvin, S.C.; Beckstead, J. 2001. Factors mediating cheatgrass invasion of intact salt desert shrubland. In: McArthur D.E.; Fairbanks, D.J. Comps. Shrubland Ecosystem Genetics and Biodiversity: Proceedings. Proc RMRS-P-21. Ogden UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 224-232.

Milchunas, D.G.; Sala, O.E.; Lauenroth, W.K. 1988. A generalized model of the effects of grazing by large herbivores on grassland community structure. American Naturalist. 132:87-106.

Miller, R.R. 1950. Speciation in fishes of the genera *Cyprinodon* and *Empetrichtys*, inhabiting the Death Valley region. Evolution. 4:155-163.

Pase, C.P.; Brown, D.E. 1982. Rocky Mountain (petran) and madrean montane coniferous forests. In: Brown, D.E., (ed.). Biotic communities of the American Southwest-United States and Mexico. Desert Plants. 4(1/4):43-48.

RECON (Regional Environmental Consultants, Inc.). 2000. Final Clark County Nevada multiple species habitat conservation plan and environmental impact statement. Prepared for Clark County Administrative Services. 550 p. plus appendices.

Shoenherr, A.A. 1992. A natural history of California. Berkeley, CA: University of California Press. 772 p.

Sterner, M.A.; Ezzo, J.A. 1996. Religion, ranching, and railroads: the history of the Muddy and Virgin River Valleys. In: Ezzo, J.A. (ed.). A Class I cultural resources survey of the Moapa and Virgin Valleys, Clark County, Nevada. Statistical Research Technical Series No. 58, Boulder City, NV: Statistical Research: 79-130.

Spaulding, W.G. 1990. Vegetational and climate development of the Mojave Desert: the last glacial maximum to the present. In: Betancourt, J.L.; Van Devender, T.R.; Martin, P.S. (eds.). Packrat middens: the last 40,000 years of biotic change. Tucson: University of Arizona Press: 166-199.

Turner, K.; LaVoie, A.M.; Ronning, C.J.; [and others]. 2009. SNAP Science and Research Strategy (Strategy). Southern Nevada Agency Partnership. Online: http://snap.gov/upload/SNAP-S-R-Strategy-2009r.pdf. [2011, April 6].

U.S. Environmental Protection Agency. 2002. Level III ecoregions of the continental United States. Derived from Omernik,J.M. 1987 Ecoregions of the conterminous United States. Map (scale 1:7,500,000). Annals of the Association of American Geographers 77(1): 118-125. Corvallis, OR: U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory. Map M-1, various scales.

U.S. Environmental Protection Agency. 2010. Ecoregions of Nevada. Western Ecology Center. Online: http://www.epa.gov/wed/pages/ecoregions/nv_eco.htm#Ecoregions. [2011, 5 April].

Van de Koppel, J.; Reitkerk, M.; Langevelde, F.V.; [and others]. 2002. Spatial heterogeneity and irreversible vegetation change in semiarid grazing systems. American Naturalist. 159:209-218.

Van Devender, T.R. 1977. Holocene woodlands in the southwestern deserts. Science. 198:189-192.

Van Devender, T.R.; Spaulding, W.G. 1979. Development of vegetation and climate in the Southwestern United States. Science. 204:701–710.

Walker B.H.; Kinzig A.; Langridge J. 1999. Plant attribute diversity, resilience, and ecosystem function: the nature and significance of dominant and minor species. Ecosystems. 2:1-20.

Western Regional Climate Center. 2011. Online: http://www.wrcc.dri.edu/index.html. [2011, 5 April].

Wisdom, M.J.; Chambers, J.C. 2009. Concepts for ecologically-based management of Great Basin shrublands. Restoration Ecology. 17:740-749.