Project Name: Science Advisor
Project Number: 2005-DRI-574A-P
Deliverable Number: D14
Reporting Period: October 1, 2007 – March 31, 2008
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Progress and Results Report
Task 7: Covered Species Population Trends and Ecosystem Health Tracking

INTRODUCTION

The Desert Research Institute (DRI) is under contract to Clark County (County) to provide programmatic analysis and science advice to the Desert Conservation Program (DCP) and the Multiple Species Habitat Conservation Plan (MSHCP) Implementing Agreement signatory agencies. The activity undertaken under this contract will place the DCP and County in compliance with the US Fish and Wildlife Service (Service) Section 10 Incidental Take Permit (#TE 034927-0) requirement that the Adaptive Management Program have an objective, science-based adaptive management consultant providing independent assessment of MSHCP implementation. Progress accomplished for Task 7 is described below; this task includes two components: 1—Covered Species Population Trends and 2—Ecosystem Health Tracking.

Covered Species Population Trends

In June, 2007, the County provided DRI with all available species data in ArcMap personal geodatabase format. This database contains sensitive data and is not to be externally circulated or made available. Other data provided by the County at this time included a snail database, the Virgin Rivers data, and Arc files containing reference data.

Based on available data, DRI was asked to develop a template for future projects relating to covered species population tracking, and provide a prototype of a tool for tracking population data containing information on 12 of the covered species. The discussions between DRI and the County leading up to the selection of the 12 covered species were described in a Progress and Results Report (PRR) submitted on October 1, 2007, which the County sent out for peer review, and the comments from the reviewer were subsequently provided to DRI.

In June, 2007 work on this task began with discussion of the 12 species that will be used for the Covered Species Population Tracking, and this was therefore the subject of the first PRR. No additional work was conducted on this portion of Task 7 since the last PRR. This second and final PRR addresses the Ecosystem Health component of the Task which has been the focus of activity over the past six months. The report covers the three-day workshop held in late January, 2008 and provides outlines for the first iteration conceptual models for the 11 MSHCP ecosystems. Using the data to address/refine MSHCP goals is something that must be considered and will be part of the Adaptive Management Report that will be drafted by late June 2008.

Ecosystem Health Tracking

Workshop

The Clark County Multiple Species Habitat Conservation Plan's (MSHCP: RECON 2000) Adaptive Management Program (AMP) tracks habitat loss for 78 covered species by ecosystem to determine the impacts of the Section 10(a) Incidental Take Permit (USFWS 2001). The AMP is tasked with tracking habitat loss by ecosystem in order to ensure balance between take and conservation. Thus, it can be inferred that habitat loss is equivalent to take or land disturbance under the Section 10(a) Incidental Take Permit. In the MSHCP, biological resources are categorized into 11 ecosystems that include the covered species and an assemblage of wide-ranging species that share similar requirements for soils, climate, elevation, or other salient elements of their habitat (Table 1). Although management actions can be implemented to protect or enhance individual covered species, their conservation is best served by programs that prevent declines in their abundance and distribution by maintaining ecosystem processes. A number of programs track the status of covered species in Clark County, but definitions of ecosystem health, and methods to track health, have not been developed.

DRI is tasked to prepare first-iteration conceptual models of Ecosystem Health in the context of the 78 covered species for each of 11 ecosystems identified in the MSHCP (Table 1). This was accomplished during a three-day facilitated workshop that was attended by personnel from the MSHCP Implementing Agreement signatory agencies and academic representatives from several western states. Each ecosystem was considered during a brief introductory presentation by a Keynote Speaker (Table 2) who summarized basic ecological characteristics of each system, current status and threats, fundamental information that is needed to assess ecosystem health, and potential indicators of changing ecosystems. Following expert presentations, a facilitated discussion was lead to clarify the issues and involve agency representatives (Appendix) in model development. A chapter in the 2008 Adaptive Management Report will describe these models in detail, interpret implications for the MSHCP and suggest refinement of the MSHCP biological goals and objectives as appropriate. As an interim, this PRR discusses the organization of the workshops and provides outlines of the 11 ecosystem models, ecological drivers, threats, and potential

indicators. Addressing the links between Tasks 7, 8 and 9 and how Tasks 5 and 6 relate to other activities is outside the scope of DRI's current contract with the County.

Table 1. The 11 ecosystems included in the Clark County MSHCP.

Alpine	Sagebrush	Mesquite/Catclaw
Bristlecone Pine	Blackbrush	Desert Riparian/Aquatic
Mixed Conifer	Salt Desert Scrub	Springs
Pinyon-Juniper	Mojave Desert Scrub	

For the workshop, Ecosystem Health was defined as: "A condition which maintains ecosystem functions, maintains viable biotic populations, and satisfies human needs," for this workshop. The guiding context for the workshop was based on the MSHCP biological goals and objectives, which call for: '…no net unmitigated loss or fragmentation of habitat and maintenance of stable or increasing populations of Covered Species in Intensively Managed Areas and Less Intensively Managed Areas'. These models are brief and create a conceptual framework to guide future studies and monitoring programs. The process of assessing the health of each ecosystem will occur later, after data have been accumulated through studies and monitoring, and biotic or environmental indicators have been identified and validated.

Table 2. Keynote speakers, their affiliation, and the ecosystem(s) that each one discussed during the Clark County MSHCP Ecosystem Health Workshop held January 29 – January 31, 2008.

Speaker	**Affiliation**	**Ecosystem**
Dr. Don Sada	Desert Research Institute, Reno	Desert Riparian
Dr. Don Sada	Desert Research Institute, Reno	Springs
Dr. Stuart Weiss	Creekside Science	Alpine
Adelia Barber	University of California, Santa Cruz	Bristlecone Pine
Matthew Flores	USFS Humboldt-Toyabe National Forest	Mixed Conifer
Dr. Robin Tausch	USFS Rocky Mountain Research Station	Pinyon-Juniper
Dr. Robin Tausch	USFS Rocky Mountain Research Station	Sagebrush
Dr. Brett Riddle	University of Nevada, Las Vegas	Mojave Desert Scrub
Dr. Cali Crampton	University of Nevada, Reno	Mesquite/Catclaw
Dr. Steven Zitzer	Nevada System of Higher Education	Blackbrush
Dr. Steven Zitzer	Nevada System of Higher Education	Salt Desert Scrub

Conceptual Models

The structure of plant and animal communities is influenced by many environmental factors including incident radiation, water, and chemicals that are functions of the interactive process of climate, topography, and geology (Walter 1973). Biological resources within Clark County are organized functionally in nature as assemblages of organisms that can be identified as ecosystems, which share similar characteristics of their optimal distribution along environmental gradients of temperature, moisture, and soil type.

Clark County is relatively small, covers nearly two degrees in both longitude (114-116° W) and latitude (35-37° N), and does not support significant environmental gradients along north-south or east-west vectors. However, a number of environmental gradients attributed to elevation, temperature, precipitation, aspect, and wind occur in the county. Elevation in Clark County ranges from 170 meters at Laughlin to 3,600 meters at Charleston Peak. Temperature is generally inversely correlated with elevation such that lowest temperatures occur at higher elevations (Geiger 1965, Barry 1992), but within this gradient, south-facing slopes are warmer than south facing aspects and shaded areas. Annual precipitation is correlated with elevation, however, prevailing winds bring more moisture to windward hills than leeward hills (rain shadow) and generally decrease moisture. Wind also influences water availability by facilitating evapotranspiration from plants and soils. A conceptual model illustrating relationships between these environmental gradients and the 11 MSHCP ecosystems is similar to other these relationships documented for other ecosystem and vegetation associations (Walter 1973, Ganderton and Coker 2005) (Figure 1). This model illustrates how relationships between elevation, moisture, air temperature, and soil type can be used to distinguish among these ecosystems. Chemicals (nutrients) are in low concentrations at high elevations and relatively high at low elevations. Highest concentrations occur on playas and basin floors where they provide alkaline soils for the salt desert scrub ecosystem. Fine soil grains occur mostly on low and stable slopes and are scarce on steep and unstable slopes. Grain size generally varies with elevation where bedrock and coarse soils are at high elevations and finer grains are at low elevation. There are exceptions to this where fine material deposits on the concave bottom of swales where they accumulate and support alpine meadows. The Mojave desert scrub is unique because it includes a wide variety of distinctive soil types such as sand dunes, gypsum, desert pavement, and cliff/rock outcrops.

Consensus was reached among workshop participants that each ecosystem health conceptual model should consist of a basic description of its abiotic and biotic characteristics, naturally occurring abiotic and biotic drivers influencing the structure of its plant and animal communities, threats to ecosystem health (ergo human-influenced biotic and abiotic drivers), and potential indicators of ecosystem health.

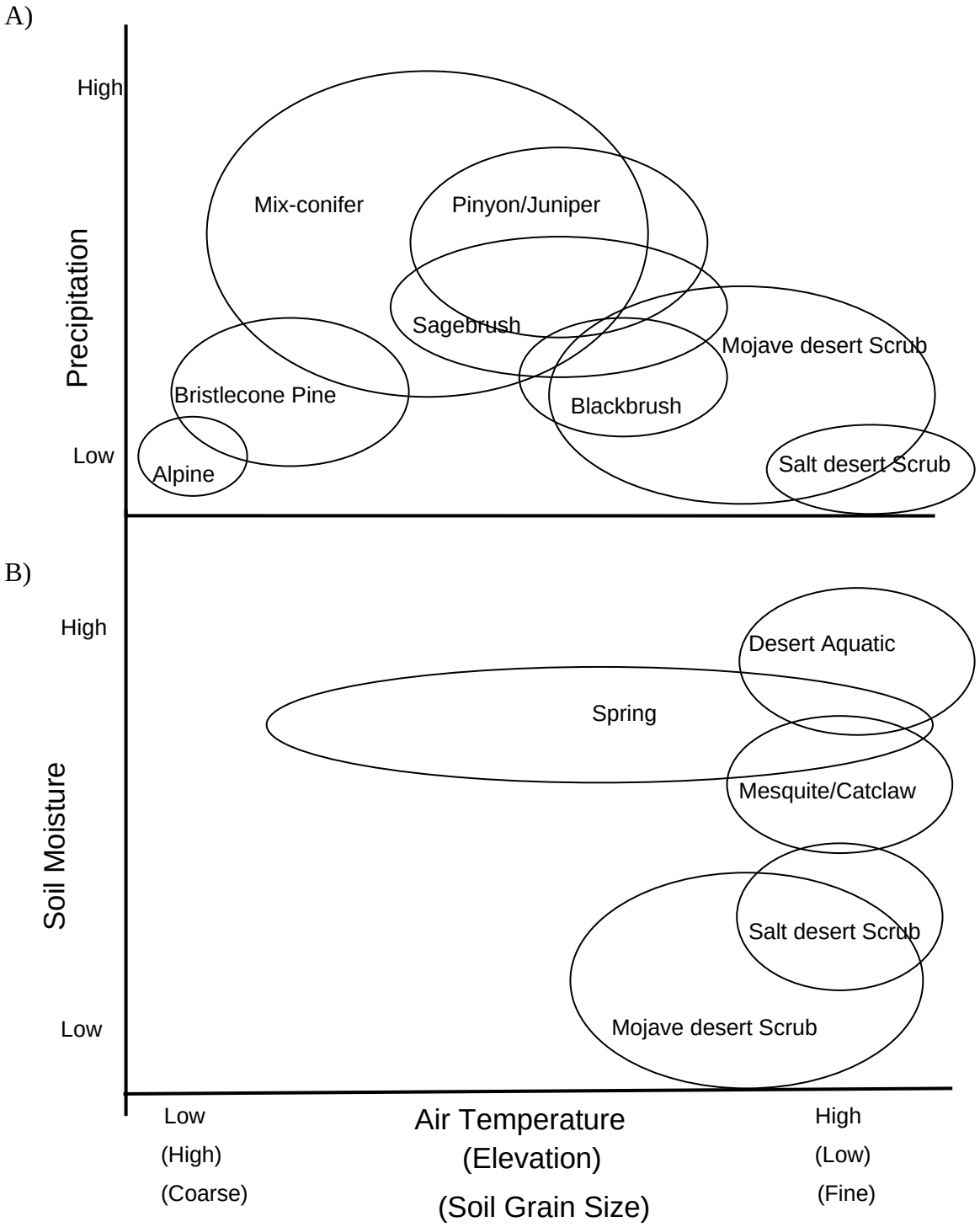

Figure 1. Conceptual model of 11 Clark County MSHCP ecosystems along moisture and air temperature gradients. There are no data to support the sizes, shapes, and relational position of ecosystems. A) Annual precipitation and temperature. B) Soil moisture and temperature.

DESERT RIPARIAN ECOSYSTEM

Distribution and Characteristics

The desert riparian ecosystem is generally lower than 4,000 feet with localized vegetation influenced by an abundance of water in contrast to the surrounding landscape. In Clark County this ecosystem occurs along the Virgin and Muddy Rivers, Las Vegas Valley wash, and the Colorado River. Principal tree species include Fremont cottonwood (*Populus fremontii*) and black cottonwood (*Populus trichocarpa*). Principal shrub species include non-native tamarisk (*Tamarix ramosissima*), sandbar willow (*Salix exigua*), Goodding willow (*S. gooddingii*), velvet ash (*Fraxinus velutina*), desert willow (*Chilopsis linearis*), and mesquite (*Prosopis glandulosa*).

The desert riparian ecosystem provides essential cover, water, food, and breeding sites for many wildlife species in this arid landscape. These winter-deciduous communities are relicts of a more mesic period which have contracted to favorable sites (i.e., river and stream systems) as the Southwest became more arid (Minckley and Brown 1982). Degradations of stream and river systems have occurred from disturbances such as woodcutting and clearing for agriculture and human-induced hydrologic changes such as down cutting of arroyos and lowered water tables due to groundwater pumping. This has contributed to the decline of a number of riparian-dependant birds in the Southwest.

MSHCP Covered Species

The desert riparian ecosystem is habitat for 14 MSHCP covered species, which include two bats, eight birds, three reptiles, and one amphibian.

Common Name	Scientific Name
Silver-haired bat	*Lasionycteris noctivagans*
Long-legged myotis	*Myotis volans*
Long-eared myotis	*Myotis evoltis*
American peregrine falcon	*Falco peregrinus anatum*
Yellow-billed cuckoo	*Coccyzus americanus*
Vermilion flycatcher	*Pyrocephalus rubinus*
Southwestern willow flycatcher	*Empidonax traillii extimus*
Phainopepela	*Phainopepla nitens*
Summer tanager	*Piranga rubra*
Blue grosbeak	*Guiraca caerulea*
Arizona Bell's vireo	*Vireo bellii arizonae*
Banded gecko	*Coleonyx variegatus*
Great Basin collared lizard	*Crotaphytus insularis bicinctores*

Western red-tailed skink	*Emeces gilberti rubricaudatus*
Relict leopard frog	*Rana onca*

Ecosystem Drivers

Abiotic Divers

- Water chemistry
- Hydrograph
- Water temperature
- Water chemistry
- Turbidity
- Temporally variable environment

Biotic Drivers

- Vegetation structure

Ecosystem Health Threats

Major Threats

- Altered hydrograph (dams, diversions, impoundments)
- Channelization (roads, agriculture, railroads, flood control)
- Non-native and invasive species
    - Riparian
    - Aquatic

Potential Ecosystem Health Indicators

Abiotic Indicators

- Degrading water quality
- Discharge

Biotic Indicators

- Increasing abundance on non-native species
- Decreasingly sparse woody vegetation
- Changing abundance of covered species

SPRING ECOSYSTEM

Distribution and Characteristics

Springs are small-scale aquatic systems that occur where ground water reaches the surface (Meinzer 1923). They range widely in size, water chemistry, morphology, landscape setting, and persistence. Some dry each year, some dry only during extended droughts, while some persist for millennia. Several hundred springs are scattered throughout Clark County and basic environmental and biological characteristics of most large springs have been inventoried (Sada and Nachlinger 1996, 1998; Sada 2000). They support 13 MSHCP covered species, diverse aquatic communities, and their riparian zones are habitat for numerous terrestrial species (Jaeger et al. 2001, Bradford et al. 2003, Sada et al. 2005, Fleishman et al. 2006). Springs also support the listed endangered Moapa dace (*Moapa coriacea*) and a number of crenobiontic species that are endemic to Clark County (e.g., LaRivers 1949, 1950, 1962; Hershler 1998, Schmude 1999). Geology, aquifer characteristics, size and provenance, geography, and climate influence water chemistry and constitute the hydrologic context for springs. Springs in Clark County are generally supported by mountain block, local, or regional aquifers. These aquifers can be generally described as:

- Mountain Block Aquifer—Springs in mountainous recharge areas are supported by mountain block aquifers. These aquifers are small (watershed scale) and support small, cold (<10^{o}C), springs with low chemical concentrations (electrical conductance [EC] <500 µmhos). Harsh conditions in these springs are mostly attributed to natural factors such as freezing, periodic drying (seasonal or during droughts), avalanche, fire, etc. Human caused disturbances consist mostly of livestock trampling and recreation. These systems are minimally impacted by groundwater removal in adjacent valleys because they are generally perched and not connected to valley floor aquifers. High quality springs are persistent, unaffected by stochastic events, and have high species richness in aquatic and riparian communities.

- Local Aquifer—Local aquifers support springs that are usually in valleys, often around the margins of a valley, but not on mountains. These aquifers are generally larger than mountain aquifers and their springs are often larger, less affected by drought and they dry less frequently. Most local springs are cool (10^{o} to <25^{o} C), their chemical concentrations are low (EC <1000 µmhos). Most of these springs have been altered by livestock trampling, diversion, and/or recreation. These systems may be impacted by groundwater removal. Geothermal spring waters (> 40 ^{o} C) are generally supported by local aquifers with deep circulation that heats water, and because most mineral solubilities increase with increasing temperature, these waters generally have high chemical concentrations. These are harsh environments. High quality local aquifer springs have good water quality, are large, persistent, unaffected by stochastic events, and have high species richness in aquatic and riparian communities. Many have crenobiontic macroinvertebrates.

- Regional Aquifer--Springs supported by regional aquifers are generally large. Regional aquifers extend through several topographic basins and may encompass thousands of square kilometers. Most importantly, they are persistent (do not dry) over long periods of time (tens of thousands of years), so they are minimally affected by drought. Regional springs are warm (25^{o} to 40^{o} C) and their chemical

concentrations are relatively benign (EC generally ranges from 500 to 1000 µmhos, but may be as high as 1500 µmhos). These springs are minimally affected by natural events because they are large and located on valley floors where scouring floods are uncommon. Most regional springs have been affected by agricultural practices (pesticides, ground water pumping, removal of vegetation, and surface diversions into pipes, canals, etc., and livestock grazing). Regional springs are usually occupied by a variety of endemic vertebrates and macroinvertebrates, and many occur in association with endemic plant species. Many of these springs are also occupied by a wide variety of non-native species, including fish, crayfish, and mollusks.

The MSHCP reported 506 springs in Clark County. This number has not been verified, and work by Bradford et al. (2002), Sada and Nachlinger (1996, 1998), Sada (2000), and others indicate that most of these springs dry frequently and that fewer than 200 persistent springs occur in Clark County. Springs occur from approximately 250 m (800 ft.) to 3,300 m (11,000) elevation and all landscape settings (e.g., mountains, gullies, valley floors, hillside, etc.).

In addition to hydrologic context, springs are influenced by the frequency, duration, and magnitude of stressors such as harsh water chemistry, drying, scouring by flood or avalanche, and human activity (Figure 2). Studies by Sada and Nachlinger (1996, 1998), Bradford et al. (2003), Sada et al. (2005), Fleishman et al. (2006) revealed basic aspects of spring ecology in Clark County:

MSHCP Covered Species

The spring ecosystem includes four species of plants, three butterflies, three bats, two springsnails, and one amphibian.

Common Name	Scientific Name
Rough angelica	*Angelica scabrida*
Clokey thistle	*Cirsium clokeyi*
Alkali mariposa lilly	*Calochortus striatus*
Charleston kittentails	*Synthyris ranunculina*
Dark blue butterfly	*Euphilotes enoptes* ssp.
Nevada admiral	*Limenitius weidemeyerii nevadae*
Spring Mtns. comma skipper	*Hesperia comma mojavensis*
Silver-haired bat	*Lasionycteris noctivagans*
Long-legged myotis	*Myotis volans*
Long-eared myotis	*Myotis evoltis*
So. east Nevada springsnail	*Pyrgulopsis turbatrix*
Spring Mtns. springsnail	*Pyrgulopsis deaconi*
Relict leopard frog	*Rana onca*

Ecosystem Drivers

Abiotic Divers

- Water chemistry
- Aquifer provinence
- Persistence
- Size
- Morphology (rheocrene, limnocrene, helocrene)
- Landscape association (mountain, valley, gully, etc.)

Biotic Drivers

- Community structure (e.g., presence of fish, other predators, and non-native species)

Ecosystem Health Threats

Major Threats

- Diversion
- Groundwater pumping
- Impoundment
- Recreation
- Non-native ungulates (livestock, elk, horses, burros)
- Non-native riparian and aquatic species

Minor Threats

- Climate change

Potential Ecosystem Health Indicators

Abiotic Indicators

- Water chemistry
- Discharge rate

Biotic Indicators

- Spatial and temporal variability in the structure of aquatic and riparian communities
- Changes in crenobiontic abundance and distribution
- Abundance of non-native species

ALPINE ECOSYSTEM

Distribution and Characteristics

The alpine ecosystem is defined as the biotic zone on mountains above the natural limit of tree establishment dominated by herbaceous plants (Billings 1973). This ecosystem occurs above 3,500 meters on Mt. Charleston in the Spring Mountains area in Clark County. It is above timber line and on all aspects, slopes, and ridge lines where light is intense light, temperatures are extreme, and there are strong winds, a seasonal snow cap, short growing season, and poor nutrients (Broll and Keplin 2005). Its vegetation consists of herbaceous and high-altitude tundra communities that can be categorized into two major types, alpine fell-fields and alpine meadows, according to vegetation and soil characteristics (Clokey 1951).

MSHCP Covered Species

The alpine ecosystem in Clark County provides habitat for 11 covered species. All of them are plants.

Common Name	Scientific Name
Charleston pussytoes	*Antennaria soliceps*
Clokey thistle	*Cirsium clokeyi*
Jaeger whitlowgrass	*Draba jaegeri*
Charleston draba	*Draba paucifructa*
Hidden ivesia	*Ivesia cryptocaulis*
Hitchcock bladderpod	*Lesquerella hitchcockii*
Charleston beardtongue	*Penstemon leiophyllus* var. *keckii*
Clokey catchfly	*Silene clokeyi*
Charleston tansy	*Sphaeromeria compacta*
Charleston kittentails	*Synthyris ranunculina*
Charleston grounddaisy	*Townsendia jonesii* var. *tumulosa*

Ecosystem Drivers

<u>Abiotic Drivers</u>

- Topography: elevation, slope, aspect, and ridge line.
- Weather patterns:
    - Cold temperatures
    - High Winds
    - Precipitation (snow and rain): timing, duration, and intensity
- Avalanches and erosions create new fell-fields.

Biotic Drivers

- Vegetation succession: fell-field, meadow, pines.

Ecosystem Health Threats

Major Threats

- Climate change
- Atmospheric nitrogen disposition
- Pollinator decline

Potential Threats

- Disease for pollinator insects
- Establishment of non-native vegetation

Potential Ecosystem Health Indicators

Potential Biotic Indicators:

- Spatial structure (fell-fields vs. meadows) and successional advance/shift
- Phenological factors
- Insect species composition (especially for meadows)
- Endemic demography and distribution

Potential Abiotic Indicators:

- Air/snow chemistry
- Precipitation dynamics

BRISTLECONE PINE ECOSYSTEM

Distribution and Characteristics

The bristlecone pine ecosystem is an evergreen conifer woodland that is characterized by the presence of pure stands of bristlecone pine trees (*Pinus longaeva*). It extends from the alpine ecosystem down to lower elevations where it contacts limber pine (*P. flexilis*). In Clark County this ecosystems ranges in elevation from 2,700 meters to 2,500 meters in the Spring and Sheep Mountains on exposed, dry, rocky slopes and ridges in the subalpine zone up to tree line (Pase and Brown 1982). The subalpine environment is extreme with cold temperatures, intense sunlight, poor nutrient soil, and long snow cover season, but this environment is milder than the alpine ecosystem which occurs at higher elevations (Broll and Keplin 2005). Topography such as slope, aspect, and elevation creates habitat for bristlecone pines and its associated flora and fauna. Bristlecone pines

grow on nutrient-poor alkaline soils with gravel, large rocks, and coarse sand that is derived from dolomite (Lanner 2007). Most soils within this ecosystem are seasonally dry because of high winds, excessive drainage, and low organic content.

Bristlecone pines are long-lived and grow slowly, and mortality is frequently attributed to lightening strikes. The sparse distribution of trees is prevents these fires from spreading across the landscape. This forest has low understory diversity and productivity. Associated shrub species, such as dwarf juniper (*Juniperus communis*), Clokey mountain sage (*Salvia dorrii* var. *clokeyi*), and sagebrush (*Artemisia* spp.) are widely scattered through the forest except in natural openings and near forest edges. Bristlecone recruitment is low because of high seed mortality attributed to predation. Recruitment is highly periodic with greatest success occurring only once in several decades. Dead bristlecone pines decay slowly in this cold environment, persist for thousands of years, and provide a distinctive microhabitat that provides shelter that is necessary to support their recruitment and other animal species in this ecosystem. In general, species diversity and productivity are low in this ecosystem.

Abiotic Characteristics

- High elevation, extreme physical environment (cold, windy, snowy, short growing season)
- Topography (slope, aspect) interacts with weather to provide habitable sites.
- Low nutrient dolomite soil
- Low incidence of fire affecting forest structure

Biotic Characteristics

- Low species richness
- Widely spaced
- Very high seed predation (therefore low seed dispersal)
- Recent (50 years) episodic recruitment
- Low understory productivity and diversity in the forest

Ecosystem Drivers

Abiotic Drivers

- Cold temperature
- Climate (cool & wet vs. hot & dry)
- Lightening (cause of death)
- Precipitation regime (monsoonal vs. snowpack)
- Geology: dolomite

Biotic Drivers

- Abundance, diversity, and characteristics of mycorrhizae
- Deadwood = recruitment and habitat for other species (microhabitat provides shelter and retains moisture)

MSHCP Covered Species

There are 23 covered species including six butterflies and 17 species of plants in the bristlecone pine ecosystem. These plants are endemic to forest and woodland habitats within the Spring and Sheep Mountains.

Common Name	Scientific Name
Spring Mountains icarioides blue	*Icaricia icarioides* ssp.
Mt. Charleston blue butterfly	*Icaricia shasta charlestonensis*
Morand's checkerspot butterfly	*Euphydryas anicia morandi*
Carole's silverspot butterfly	*Speyeria zerene carolae*
Nevada admiral	*Limenitus weidemeyerii nevadae*
Spring Mountains comma skipper	*Hesperia comma mojavensis*
Charleston pussytoes	*Antennaria soliceps*
Clokey thistle	*Cirsium clokeyi*
Jaeger whitlowgrass	*Draba jaegeri*
Rosy king sandwort	*Arenaria kingii* ssp. *rosea*
Clokey paintbrush	*Castelleja martinii* var. *clokeyi*
Charleston draba	*Draba paucifructa*
Inch high fleabane	*Erigeron uncialis* ssp. *conjugans*
Jaeger ivesia	*Ivesia jaegeri*
Hitchcock bladderpod	*Lesquerella hitchcockii*
Charleston pinewood lousewort	*Pedicularis semibarbata* var. *charlestonensis*
Charleston beardtongue	*Penstemon leiophyllus* var. *keckii*
Clokey mountain sage	*Salvia dorrii* var. *clokeyi*
Clokey catchfly	*Silene clokeyi*
Charleston tansy	*Sphaeromeria compacta*
Charleston kittentails	*Synthyris ranunculina*
Charleston grounddaisy	*Townsendia jonesii* var. *tumulosa*
Limestone (Charleston) violet	*Viola purpurea* var. *charlestonensis*

Ecosystem Health Threats

Major Threats

- Climate change
- Recreation
    - harvesting
    - camping

Potential Threats

- Bark beetle mortality
- White pine blister rust mortality
- Changing in fire regimes
- Establishment of non-native species

Potential Ecosystem Health Indicators

Biotic Indicators

- Bristlecone recruitment
    - Distribution, rate, patch size
- Tree mortality
- Deadwood density
- Forb community struture
- Tree growth rates
    - trunk
    - foliage

Abiotic Indicator

- Temperature change
- Precipitation dynamics (e.g., monsoon vs. snowpack)

MIXED CONIFER ECOSYSTEM

Distribution and Characteristics

In Clark County, the mixed conifer ecosystem is typically composed of evergreen conifers and shrubs and ranges in elevation from 2,100 to 3,200 meters. The annual precipitation is high, 50 cm, from winter snows and summer storms in this ecosystem. Trees grow taller than 20 meters and canopies contact with neighbor trees with 30-60% canopy cover (Schoenherr 1992). Species diversity is high for trees, shrubs, forbs, and animals. Frequent low intensity fires remove excess biomass, recycle nutrients back into soil, and create open forest. Infrequent high intensity fires create patches for succession and break up uniform habitat, which generates a heterogeneity of successional states and facilitates maintaining high species richness in this ecosystem. There are three community types in Clark County: white fir (*Abies concolor*), ponderosa pine (*Pinus ponderosa*), and ponderosa pine/mountain shrub. White fir and ponderosa pine communities occur in the Spring and Sheep Mountains and ponderosa pine/mountain shrub communities occur in these ranges and as small patches in the Virgin Mountains.

The white fir community is dominated by white fir and generally occurs on north- and east-facing slopes at elevations between 2,200 and 3,200 meters in the Spring and Sheep Mountains. Associated trees include bristlecone pine (*P. longaeva*) and limber pine (*P. flexilis*) at the higher elevations within its range, and ponderosa pine at lower elevations. Shrub species in the white fir community include mountain mahogany (*Cercocarpus ledifolius*) and Rocky Mountain juniper (*Juniperus communis*).

The ponderosa pine community is the most extensive of the conifer forest habitats in Clark County, comprising some 42,000 acres. This community ranges from 1,200 to 2,700 meters and is dominated by ponderosa pine, which often occurs in nearly pure stands. Associated tree species are white fir, bristlecone pine, pinyon (*P. monophylla*), juniper (*J. osteosperma*), white fir, limber pine, and mountain mahogany. Associated shrubs include sagebrush (*Artemisia* spp.), oak (*Quercus gambelii*), alder leaf mountain mahogany (*C. montanus*), snowberry (*Symphoricarpos* spp.), manzanita (*Arctostaphylos* spp.), and little leaf mountain mahogany (*C. intricatus*).

Ponderosa pine/mountain shrub community is an extension of the conifer forest community characterized by lower canopy coverage of ponderosa pine (less than 30 percent) and co-dominance of mountain shrubs such as oak, alder leaf mountain mahogany (*C. montanus*), snowberry, manzanita (*Arctosyaphylus* sp.), and little leaf mountain mahogany.

Abiotic Characteristics

- High moisture/precipitation (20 inches annually)
- Preferable for summer fire

Biotic Characteristics

- Closed canopy (30-60%)
- Tall tree stands (> 20 m)
- Mosaic of successional states
- High diversity in trees, shrubs, forbs, animals
- High butterfly density
- High endemism

MSHCP Species

There are 33 covered species in the mixed conifer ecosystem, including three species of bats, Palmer's chipmunk, one raptor, one lizard, one snake, eight

butterflies, 17 vascular plants, and one non-vascular plant. All eight butterflies are endemic and 15 plant species are endemic.

Common Name	Scientific Name
Silver-haired bat	*Lasionycteris noctivagans*
Long-eared myotis	*Myotis evotis*
Long-legged myotis	*Myotis volans*
Palmer's chipmunk	*Tamias palmeri*
American peregrine falcon	*Falco peregrinus anatum*
Western red-tailed skink	*Eumeces gilberti rubricaudatus*
Sonoran lyre snake	*Timorphodon biscutatus lambda*
Dark blue butterfly	*Euphilotes enoptes purpurea*
Spring Mountains icarioides blue	*Icaricia icarioides austinorum*
Spring Mountains acastus checkerspot	*Chlosyne acastus robusta*
Spring Mountains/Mt. Charleston blue butterfly	*Icaricia shasta charlestonensis*
Morand's checkerspot butterfly	*Euphydryas anicia morandi*
Carole's silverspot butterfly	*Speyeria zerene carolae*
Nevada admiral	*Limenitus weidemeyerii nevadae*
Spring Mountains comma skipper	*Hesperia comma mojavensis*
Clokey milkvetch	*Astragalus aequalis*
Clokey eggvetch	*Astragalus oophorus* var. *clokeyanus*
Rough angelica	*Angelica scabrida*
Rosy king sandwort	*Arenaria kingii* ssp. *rosea*
Clokey paintbrush	*Castelleja martinii* var. *clokeyi*
Clokey thistle	*Cirsium clokeyi*
Inch high fleabane	*Erigeron uncialis* ssp. *conjugans*
Clokey greasebush (forsellesia)	*Glossopetalon (=Forsellesia) clokeyi*
Red Rock Canyon aster	*Ionactis caelestis*
Jaeger ivesia	*Ivesia jaegeri*
Hitchcock bladderpod	*Lesquerella hitchcockii*
Charleston pinewood lousewort	*Pedicularis semibarbata* var. *charlestonensis*
Jaeger beardtongue	*Penstemon thompsoneae* var. *jaegeri*
Clokey mountain sage	*Salvia dorrii* var. *clokeyi*
Charleston kittentails	*Synthyris ranunculina*
Charleston grounddaisy	*Townsendia jonesii* var. *tumulosa*
Limestone (Charleston) violet	*Viola purpurea* var. *charlestonensis*
Dicranoweisia moss	*Dicranoweisia crispula*

Ecosystem Drivers

Abiotic Drivers

- Moisture (high precipitation of snowfall/rainfall)
- Temperature, length of growth season
- Fire
    - Frequent small fire cleans understory shrubs and recycles nutrients
    - Infrequent large fire removes old trees and creates mosaic of age stands.
- Avalanches

Biotic Drivers

- Symbiosis: conifer seeds and seed-dispersed animals (birds and rodents)

Ecosystem Health Threats

Major Threats

- Change of fire regimes by past fire management (fire suppression)
    - Mega fires
    - Forest densification
- Rural development
    - fragmentation
    - mining
- Recreation
- Water diversion

Minor and Potential Threats

- Non-native invasive species
- Grazing
- Pollution (ozone)

Potential Ecosystem Health Indicators

Biotic Indicators

- Forest structure
- Species richness and composition
- Population and distribution of MSHCP species

Abiotic Indicators

- Air and snow chemistry
- Precipitation characteristics
- Fire intensity and frequency

PINYON-JUNIPER ECOSYSTEM

Distribution and Characteristics

The pinyon-juniper ecosystem is an open woodland of low, round crowned, bushy trees (Lanner 1975) that are needle-leaved, evergreen, and depending on site suitability, the height of woody vegetation ranges from 10-15 meters (Kuchler 1977, Tueller and Clark 1975). Trees are well spaced. Individual tree crowns rarely touch and canopy cover general is less than 50 percent (Larson 1980). These open groves of over-story trees often have a dense to open layer of shrubs reaching heights of 1.5 meters with, sometimes, low herbaceous plants (Kuchler 1977). In Clark County, the pinyon-juniper ecosystem is distributed as elevational bands around the Spring Mountains, Sheep Mountains, and Virgin Mountains with an island community in the McCullough Mountains at elevations ranging from 1,500 to 2,500 meters. In higher elevations, single leaf pinyon (*Pinus monophylla*) dominates this ecosystem with other coniferous trees and shrub species of oak (*Quercus gambelii*) and mountain mahogany (*Cercocarpus* spp.) In lower evevation, Utah juniper (*Juniperus osteosperma*) dominates this ecosystem with Rocky Mountain juniper (*J. scopulorum*) and western juniper (*J. occidentalis*) and shrub species of rabbitbrush (*Chrysothamnus spp.*) and blackbrush (*Coleogyne ramosissima*). However, single leaf pinyon and Utah juniper co-dominate at middle elevation and sagebrush (*Artemisia spp.*) co-exists in all elevations within this ecosystem.

Stand structure varies depending on site quality and elevation. Dense pinyon-juniper occurs on favorable sites with little disturbance, while distance between trees increases and tree size decreases on drier sites (Lanner 1975). Pinyon-juniper stands are rather open at lower elevation and become denser at higher elevations (Zarn 1977). Studies have shown that there are two types of dense in pinyon-juniper stands (Tausch and Hood 2007, Miller et al 2008). Diverse age-class stands are old pre-settlement growth and even age-class stands are young post-settlement growth. The change of fire regimes after European settlement may cause this dichotomy (Tausch and Hood 2007, Miller et al 2008). Pinyon pines and junipers are very flammable and not fire-resistant. Fires and avalanches clear old stands and create mosaic of stands in different density, therefore, diversify associated perennial grass, forbs, and shrubs.

Ecosystem Drivers

<u>Abiotic Drivers</u>

- Climate
    - CO_2 level
    - temperature
    - draught, monsoon
- Soil depth
- Slope (topographic position)

- Fire regime
- Avalanches

Biotic Drivers

- Seed dispersal
    - seed dispersal animals (birds and small mammals)

MSHCP Covered Species

MSHCP covered species are similar to the conifer forest associations but with lower altitude species. The animal species includes three bats, one mammal, one raptor, seven reptiles, and seven butterflies. The plant list includes eight vascular and four non-vascular species. The peregrine falcon forages and nests in this habitat.

Common Name	Scientific Name
Silver-haired bat	*Lasionycteris noctivagans*
Long-eared myotis	*Myotis evotis*
Long-legged myotis	*Myotis volans*
Palmer's chipmunk	*Tamias palmeri*
American peregrine falcon	*Falco peregrinus anatum*
Banded gecko	*Coleonyx variegatus*
Large-spotted leopard lizard	*Gambelia wislizenii wislizenii*
Great Basin collared lizard	*Crotaphytus insularis bicinctores*
Western red-tailed skink	*Eumeces gilberti rubricaudatus*
Glossy snake	*Arizona elegans*
Sonoran lyre snake	*Timorphodon biscutatus lambda*
Speckled rattlesnake	*Crotalus mitchelli*
Dark blue butterfly	*Euphilotes enoptes purpurea*
Spring Mountains icarioides blue	*Icaricia icarioides austinorum*
Spring Mountains acastus checkerspot	*Chlosyne acastus robusta*
Morand's checkerspot butterfly	*Euphydryas anicia morandi*
Carole's silverspot butterfly	*Speyeria zerene carolae*
Nevada admiral	*Limenitus weidemeyerii nevadae*
Spring Mountains comma skipper	*Hesperia comma mojavensis*
Clokey milkvetch	*Astragalus aequalis*
Clokey eggvetch	*Astragalus oophorus* var. *clokeyanus*
Spring Mountains milkvetch	*Astragalus remotus*
Inch high fleabane	*Erigeron uncialis ssp. Conjugans*
Smooth pungent (dwarf) greasebush	*Glossopetalon pungens var. glabra*
Pungent dwarf greasebush	*Glossopetalon pungens var. pungens*

Jaeger beardtongue	*Penstemon thompsoneae* var. *jaegeri*
Clokey mountain sage	*Salvia dorrii* var. *clokeyi*
Anacolia menziesii	*Anacolia menziesii*
Claopodium whippleanum	*Claopodium whippleanum*
Dicranoweisia crispula	*Dicranoweisia crispula*
Syntrichia princeps	*Syntrichia princeps*

Ecosystem Health Threats

Threats

- Climate change
- Woodland expansion
- Changing fire regimes
- Increase in cheat grass (invasive species)

Minor and Potential Threats

- Rural development
    - Road creation
- Recreation
    - Fire
    - Erosion
    - Introduction of weeds
- Grazing
- Bark beetles
- Pinyon pine blister rust
- Air chemistry
    - CO_2 fertilization

Potential Ecosystem Health Indicators

Biotic Indicators

- Tree density and cheat grass cover
- Shrub density, tree (overstory) density
- Tree community structure
- Age structure
- Photo records
- Understory biomass

Abiotic Indicator

- Fire history

SAGEBRUSH ECOSYSTEM

Description and Distribution

The sagebrush ecosystem is often composed of pure, large, open, discontinuous stands of big sagebrush (*Artemisia tridentata*) of fairly uniform height on coarse

soils. Big sagebrush, an aromatic evergreen shrub with 20-200 years of life, tends to have a single short thick stem, then branches into a nearly globular crown (Welch 2005). Plant height ranges from 0.5 to 3 meters and density ranges from very open, widely spaced, small plants to large, closely spaced plants with canopies touching. In addition to a deep root system, big sagebrush has a well developed lateral root system near the soil surface and consequently excluding most other plants in an area up to three times their crown area and producing stands with shrubs of very uniform size and spacing (Neal 1988). This ecosystem in Clark County typically ranges in elevation from 1,500 to 2,800 meter in the Spring, Sheep, and Virgin Mountains.

Sagebrush is a collective term applied to shrubby member of herbaceous genus, *Artemisia*: big sagebrush (*A. tridentata*), low sagebrush (*A. arbuscula*), Bigelow sagebrush (*A*. *bigelovii*), or black sagebrush (*A. nova*). The dominant sagebrush species changes with the changes of topography, soil composition, and moisture (Neal 1988). At elevations below 2,800 meters feet in the Spring Mountains, big sagebrush can be found in pure stands and commonly in mixed communities with mountain mahogany (*Cercocarpus ledifolius*) and Utah juniper (*Juniperus osteosperma*) (Clokey 1951). Associated tree species are pinyon (*Pinus monophylla*) and ponderosa pine (*Pinus ponderosa*). Other associated shrub species includes rabbitbrush (*Chrysothamnus* spp.), snakeweed (*Gutierrezia sarothrae*), blackbrush (*Coleogyne ramosissima*), shadscale (*Atriplex confertifolia*), spiny hopsage (*Grayia spinosa),* and bitterbrush (*Purshia tridentata*). Associated grass species includes perennial bunchgrasses (*Agropyron* spp.), the introduced cheat grass (*Bromus tectorum*), bluegrass (*Poa* spp.), needlegrass (*Stipa* spp.), fescues (*Festuca* spp.), and galleta (*Pleuraphis jamesii*). Grass species usually make up less than 25 percent cover.

Ecosystem Drivers

- Fire regime
- Precipitation
    - Quantity
    - Capacity availability
- Soil type
- Moisture regime (monsoon)
- Orographic effects (topographical location of precipitation)
- Big Sagebrush (beneficial effects)

MSHCP Species

The sagebrush ecosystem provides habitat for 20 covered species. The animal species includes two bats, one falcon, six reptiles, and five butterflies. Plant list

includes five vascular and one non-vascular species. Dark blue butterfly (*Euphilotes enoptes purpurea*) occurs in this ecosystem exclusively.

Comman Name	Scientific Name
Long-eared myotis	*Myotis evotis*
Long-legged myotis	*Myotis volans*
American peregrine falcon	*Falco peregrinus anatum*
Desert tortoise	*Gopherus agassizii*
Banded gecko	*Coleonyx variegatus*
Great Basin collared lizard	*Crotaphytus insularis bicinctores*
Large-spotted leopard lizard	*Gambelia wislizenii wislizenii*
Western red-tailed skink	*Eumeces gilberti rubricaudatus*
Speckled rattlesnake	*Crotalus mitchelli*
Dark blue butterfly	*Euphilotes enoptes purpurea*
Spring Mountains icarioides blue	*Icaricia icarioides austinorum*
Spring Mountains acastus checkerspot	*Chlosyne acastus robusta*
Carole's silverspot butterfly	*Speyeria zerene carolae*
Spring Mountains comma skipper	*Hesperia comma mojavensis*
Clokey milkvetch	*Astragalus aequalis*
Spring Mountains milkvetch	*Astragalus remotus*
Inch-high fleabane	*Erigeron uncialis ssp. conjugans*
Smooth pungent (dwarf) greasebush	*Glossopetalon pungens var. glabra*
Pungent dwarf greasebush	*Glossopetalon pungens var. pungens*
Anacolia menziesii	*Anacolia menziesii*

Ecosystem Health Threats

Major Threats

- Cheat grass (competes for water, affects fire regime)
- Mega fire
- PJ phase shift
- Over-grazing
- Maladapted genotype

Minor and potential Threats

- Climate change
- Air chemistry
- Rural development
- Recreation (e.g. OHV)
- Military activities

Potential Ecosystem Health Indicators

Biotic Indicators

- Changes in:
    - Density of sagebrush and distribution and occurrence of pinyon –juniper community
    - Recruitment and mortality of big sagebrush
    - Species composition
    - Cheat grass
    - Ant community
    - Cryptobiotic crust

MOJAVE DESERT SCRUB ECOSYSTEM

Description and Distribution

The Mojave desert scrub ecosystem is characterized by widely spaced shrubs, 0.5-3 meters tall, on well-drained secondary soils of slopes, fans, and valleys (Schoenherr 1992). This lowland ecosystem occurs below 1,200 meters and is the most widespread of the 11 MSHCP ecosystems in Clark County. Creosote bush (*Larrea tridentata*) is the dominant species. White bursage (*Ambrosia dumosa*) co-dominates with creosote bush in valley bottoms and lowlands of mild slope aspect. Associate shrubs are white bursage (*Ambrosia dumosa*), indigo bush (*Psorothamnus fremontii*), desert thorn (*Lycium* spp.), include blackbrush (*Coleogyne ramosissima*), brittlebush (*Encelia farinosa*), burro bush (*Hymenoclea salsola*). Other associated species include Joshua tree (*Yucca brevifolia*), yucca (*Yucca* spp.), teddy bear cholla (*Opuntia bigelovii*), prickly pear (*Opuntia basilaris*), and hedgehog cacti (*Echinoceres* spp.).

The most common landform of this ecosystem is bajada, which is composed by alluvial fans, washes, and desert pavements. Other landforms, such as sand dunes, gypsum soils, cliff/rock outcrops, are isolated patches as ecological islands characterized by endemic plants and animals within the Mojave desert scrub ecosystem.

Sand dunes are hills of sand built by eolian processes that require sources of sand and prevailing wind. Therefore, sand dunes are associated with playas, remnant lakes of arid lowland basins, and intermittent watercourses. Dune habitats provide niches for highly specialized plants and animals, including numerous rare and endangered species, e.g. White-margined beardtongue (*Penstemon albomarginatus*), Three-corner milkvetch (*Astragalus geyeri* var. *triquetrus*), desert kangaroo rat (*Dipodomys deserti*), sidewinder (*Crotalus cerastes*), and many insect species.

Gypsum soils in this ecosystem consist of a weathered layer of parent material, containing sponge gypsum, over massive rock gypsum or gypsum thin-bedded with limestone, mudstones, and shales. The surface is typically hard or has a cryptogamic crust. Saline gypsum sites are similar but are exposed to salt-charged groundwater at the surface near the site. Gypsum sites have less dense vegetation with fewer annuals than alluvial sites. Saline gypsum soils have almost no annuals and few short-lived species. However, gypsum soils in the eastern Mojave desert are characterized by a suite of endemic species restricted to gypsum soils, such as Las Vegas bearpoppy (*Arctomecon californica*), Blue Diamond cholla (*Opuntia whipplei* var. *multigeniculata*), and Sticky ringstem (*Anulocaulis leisolenus*).

Rock outcrops, cliffs, boulder fields, and lava flows are where the part of a rock formation that appears above the surface of the surrounding soils and provide special habitat for plants and animals, e.g. western chuckwalla (*Sauromalus obesus*), Great Basin collared lizard (*Crotaphytus insularis bicinctores*), Speckled rattlesnake (*Crotalus mitchelli*).

Abiotic Characteristics

- Interrelations of elevation, substrate, and land form.
- Elevation
- Substrate characteristics
    - Parent material, grain size, weathering
- Land form (please refer to the species list)
    - Bajadas
        - Alluvial fans
        - Washes (caliche capstone, other kinds)
        - Desert pavement
    - Sand dunes
    - Gypsum soils
    - Ciff/rock outcrops
- Low productivity

Biotic Characteristics (relevant to land form type)

a) Alluvial fans

- desert tortoise
- leopard lizard
- horned lizard (generalist)
- reptiles (Mojave green rattlesnake)

b) Sand (d=dunes, s=sheet)

- white margined penstemon (s)
- sticky buckwheat
- bees
- side winder
- beaver dam breadroot
- scorpions
- threecorner milkvetch
- desert pocket mouse
- zebratail lizard (?)
- desert kangaroo rat
- scarab beetles (d)

c) Gypsum

- Las Vegas bear poppy
- white bear poppy
- silverleaf sunray
- nakedstem sunray
- bees
- Las Vegas buckwheat
- ring stern
- palmers phacelia
- parry's sand paper plant
- Lancaster milk vetch

d) Cliff/rock outcrops

- chuckwalla
- gila monster
- ringtail
- desert wood rat (?)
- peregrine falcons
- bats
- big horns sheep
- collard lizards
- speckled rattle snake
- red spotted toads
- cliff golden bush
- barrel cactus
- prairie falcons
- golden eagle

e) Washes (caliche capstone, other kinds)

i) caliche capstone

- burrowing owl
- desert tortoise
- gilla monster
- (burrowing animals)

ii) other types of wash

- thrashers
- zebratails
- side winders
- snakes (?)
- Mojave green rattlesnake
- desert tortoise
- penstemon
- bicolor (bicolor, roseus)

f) Desert pavement (possibly include this to alluvial fans)

- *Phacelia neglecta*

Ecosystem Drivers

Abiotic Drivers

- Climate
  - Precipitation (frequency, timing, duration)
  - Temperature
- Topography (elevation, slope, and aspect)
- Soils (landforms)
- Wild fires
- Erosion

MSHCP Covered Species

The Mojave desert scrub ecosystem provides habitat for 23 MSHCP covered species. Animal list includes 14 reptiles and plant list includes nine vascular species.

Common Name	Scientific Name
Desert tortoise	*Gopherus agassizii*
Banded gecko	*Coleonyx variegatus*
Desert iguana	*Dipsosaurus dorsalis*
Western chuckwalla	*Sauromalus obesus obesus*
Great Basin collared lizard	*Crotaphytus insularis bicinctores*
Large-spotted leopard lizard	*Gambelia wislizenii wislizenii*
California (common) kingsnake	*Lampropeltis getulus californiae*
Glossy snake	*Arizona elegans*
Western long-nosed snake	*Rhinocheilus lecontei lecontei*
Western leaf-nosed snake	*Phyllorhynchus decurtatus*
Sonoran lyre snake	*Trimorphodon biscutatus lambda*
Sidewinder	*Crotalus cerastes*
Speckled rattlesnake	*Crotalus mitchelli*
Mojave green rattlesnake	*Crotalus scutulatus scutulatus*
Blue Diamond cholla	*Opuntia whipplei* var. *multigeniculata*
Sticky ringstem	*Anulocaulis leisolenus*
Las Vegas bearpoppy	*Arctomecon californica*
White bearpoppy	*Arctomecon merriamii*
Threecorner milkvetch	*Astragalus geyeri* var. *triquetrus*
Spring Mountains milkvetch	*Astragalus remotus*
Alkali mariposa lily	*Calochortus striatus*
Sticky buckwheat	*Eriogonum viscidulum*
White-margined beardtongue	*Penstemon albomarginatus*

Ecosystem Health Threats

Major Threats

- Urbanization
    - Habitat destruction, habitat conversion, habitat fragmentation
- Roads and utility corridors
    - Increasing wilderness access
    - Spreading invasive species
- Recreation (OHV)
    - Soil compaction
    - Soil erosion
    - Air chemistry (dust)
- Wildfires

Minor and Potential Threats

- Feral cats and dogs predation
- Grazing
- Mining
- Desert dumping
    - Direct pollution
    - Increase in predation (by ravens and foxes)
- Collecting & hunting

Potential Ecosystem Health Indicators

Biotic Indicators

- Community structure
    - Composition of plants and animals
- Species richness
- Changes in vegetation
    - Percent cover
    - Physical structure
    - Species composition

Abiotic Indicators

- Disturbance (soil stability)
- Fragmentation
- Road network

BLACKBRUSH ECOSYSTEM

Description and Distribution

The blackbrush ecosystem is typically a woody evergreen shrubland dominated by blackbrush (*Coleogyne ramosissima*), with associated plant species including shrubs including ephedra (*Ephedra* spp), wolfberry (*Lycium* spp), hopsage (*Grayia spinosa*), and grasses (Brooks, et al 2007). The blackbrush canopy cover ranges from 20-50 percent and canopy height ranges from 0.25 – 2.5 meters, and individual plant lives up to 300 years. In Clark County, the blackbrush ecosystem occupies on coarse, rocky soils of upper bajadas, slopes, and valleys below 1,800 meters. Blackbrush prefer aridisols with fine textured vesicular, a horizons that severely limit water infiltration and movement. Its density is highest in late seral stands on shallow, sandy soils with strong petrocalcic (caliche) horizons. Density is lowest in deeper, silty soils, or at its lower boundaries. The aridisol layer prohibits growth of new of blackbrush and other plant. Ground dwelling animal species, such s rats and insects,

create holes that allow water infiltration and seedling growth. Primary associated trees include western juniper (*Juniperus osteosperma*) and primary associated shrubs include spiny hopsage (*Grayia spinosa*), mormon tea (*Ephedra* spp.), shadscale (*Atriplex confertifolia*), desert thorn (*Lycium* spp.), snakeweed (*Gutierrezia sarothrae*), and creosote (*Larrea tridentata*). Other associated species include Joshua tree (*Yucca brevifolia*) and yucca (*Yucca* spp.).

MSHCP Species

There are 11 covered species in the blackbrush ecosystem of Clark County. Animal list includes eight reptiles and plant list includes three vascular species.

Common Name	Scientific Name
Desert tortoise	*Gopherus agassizii*
Banded gecko	*Coleonyx variegatus*
Western chuckwalla	*Sauromalus obesus obesus*
Great Basin collared lizard	*Crotaphytus insularis bicinctores*
Large-spotted leopard lizard	*Gambelia wislizenii wislizenii*
Western red-tailed skink	*Eumeces gilberti rubricaudatus*
Speckled rattlesnake	*Crotalus mitchelli*
Mojave green rattlesnake	*Crotalus scutulatus scutulatus*
Spring Mountains milkvetch	*Astragalus remotus*
White-margined beardtongue (penstemon)	*Penstemon albomarginatus*
White bearpoppy	*Arctomecon merriamii*

Ecosystem Drivers

Abiotic Drivers

- Precipitation (timing, amount)
- Temperature change
- Topographic stability, elevation
- Fire
- Aeolian disposition
- Vesicular horizontal development

Biotic Drivers

- Rodent density, small mammal & insect burrowing

Ecosystem Health Threats

Major Threats

- Fire
- Invasive species (fire ants)
- Rural and urban development
- Decreased recruitment
- Livestock grazing
- Recreational activities (foot traffic, OHVs)

Potential Threats

- Pesticides
- Land use change
- Climate change
- Air chemistry (CO_2 fertilizer)

Potential Ecosystem Health Indicators

Biotic Indicators

- Kangaroo rat and pocket mouse populations (related to seed dispersal)
- Blackbrush demographics (cover, size, age, class distribution, recruitment & mortality)
- Evidence of burrowing activity
- Diversity for annual and perennial plant species
- Community structure (invasive cover)

Abiotic Indicators

- Soil hydraulic conductivity
- Fragmentation

MESQUITE/CATCLAW ECOSYSTEM

Description and Distribution

The mesquite/catclaw ecosystem is isolated patches of woody shrubs or trees associated with perennial groundwater no deeper than 10 meters (Schoenherr 1992). It typically occurs along the edges of large water courses such as rivers and perennial streams, but they can also be found in scattered clumps on sandy hummocks and near desert springs (Crampton et al. 2006). Honey mesquite (*Prosopis glandulosa*), screwbean mesquite (*P. pubescens*), catclaw acacia (*Acacia greggii*), and smoke tree (*Psorthamnus spinosa*) are dominant tree species (Clokey

1951, Crampton et al. 2006). Associated shrubs are fourwing saltbush (*Atriplex canescens*), quailbush (*A. lentiformis*), arrowweed (*Pluchea sericea*), creosote (*Larrea tridentata*), burro bush (*Hymenoclea salsola*), bebbia (*Bebbia juncea*), and sandpaper plant (*Petalonyx nitidus*). Parasitic desert mistletoe (*Phoradendron californicum*) occurs on big stems of big trees in some patches and enriches wildlife species richness in this ecosystem. In a landscape dominated by desert scrub, these patches of woodland serve as important breeding, foraging, and resting places for many animal species. Clark County is the northern extent of the range of this ecosystem.

Characteristics

- Isolated woodland patches
- Clark County is the northern extent of the range
- Near perennial access to shallow ground water, high surface flows (mashes, streams, dry lakes)
- Gravels, sands, clays, loams, silts, gypsum soils.
- Generally lower elevations (< 1200m)
- Mistletoe serves an important role
- Variable across landscapes (density and structure)
- Freeze intolerant (Acacia more so than Mesquite)

MSHCP Species

The mesquite/catclaw ecosystem provides habitat for 11 covered species. Animal list includes two bats, two birds, and six reptiles. Plant list includes one vascular species, Pahrump Valley buckwheat (*Eriogonum bifurcatum*).

Common Name	Scientific Name
Silver-haired bat	*Lasionycteris noctivagans*
Long-eared myotis	*Myotis evotis*
Phainopepla	*Phainopepla nitens*
Vermilion flycatcher	*Pyrocephalus rubinus*
Banded gecko	*Coleonyx variegatus*
Desert iguana	*Dipsosaurus dorsalis*
Western chuckwalla	*Sauromalus obesus obesus*
Great Basin collared lizard	*Crotaphytus insularis bicinctores*
Western red-tailed skink	*Eumeces gilberti rubricaudatus*
Sidewinder	*Crotalus cerastes*
Pahrump Valley buckwheat	*Eriogonum bifurcatum*

Ecosystem Drivers

Abiotic Drivers

- Climate, weather
- Water availability
    - Depth to groundwater
    - Precipitation
- Soils: gravels, sands, clays, loams, silts, gypsum

Biotic Drivers

- Seed dispersal and predation

Ecosystem Threats

Major Threats

- Urban and agricultural development
- Invasive plant species (tamarisks and red brome)
- Fire
- Water diversion
    - Flood control
    - Surface and ground water use (development and management)

Minor and Potential Threats

- Road building
- Livestock and feral animals (grazing and trampling by cattle, horses, and burros)
- Recreation (camping, OHV, wood collection)

Potential Ecosystem Health Indicators

Biotic Indicators

- Recruitment and mortality
- Vegetation structure
    - Height
    - Growth form
    - Density
    - Age and age class structure
- Species diversity and richness
- Desert mistletoe density (load)
- Phainopepla population

Abiotic Indicators

- Depth to groundwater
- Water stress

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Appendix A. Clark County MSHCP Ecosystem Health Workshop participants and their professional affiliation on January 29, 2008 (Day 1). CC = Clark County, NPS = U.S. National Park Service, NPS PLI = U.S. National Park Service, Public Lands Institute, EPS = U.S. Environmental Protection Agency, UNLV = University of Nevada, Las Vegas, FWS = U.S. Fish and Wildlife Service, BLM = U.S. Bureau of Land Management, USFS = U.S. Forest Service, DRI = Desert Research Institute, NSHE = Nevada System of Higher Education.

Participant	Affiliation
Lee Bice	CC
Liz Bickmore	CC
Dianne Bangle	NPS PLI
Dave Bradford	EPA
Fred Edwards	FWS
Matt Flores	USFS
Ross Haley	NPS
Joe Hutchinson	NPS
Jef Jaeger	UNLV
Bill Kepner	EPA
Sonja Kokos	CC
Jeri Krueger	FWS
Judith Lancaster	DRI
Amy LaVoie	FWS
Peter Lee	DRI
Dave Mouat	DRI
Alice Newton	NPS
Craig Palmer	UNLV PLI
Burton Pendleton	USFS
Carrie Ronning	BLM
Don Sada	DRI
Adam Schmidt	USFS
Asako Stone	DRI
Robin Tausch	USFS
Sue Wainscott	CC
Stu Wiess	Creekside Center for Earth Observation
Steve Zitzer	NSHE

Appendix B. Clark County MSHCP Ecosystem Health Workshop participants and their professional affiliation on January 30, 2008 (Day 2). CC = Clark County, NPS = U.S. National Park Service, NPS PLI = U.S. National Park Service, Public Lands Institute, EPS = U.S. Environmental Protection Agency, UNLV = University of Nevada, Las Vegas, FWS = U.S. Fish and Wildlife Service, BLM = U.S. Bureau of Land Management, USFS = U.S. Forest Service, DRI = Desert Research Institute, NSHE = Nevada System of Higher Education, USDA/NRCS = U.S. Department of Agriculture, Natural Resource Conservation Service, UNR = University of Nevada, Reno.

Participant	Affiliation
Adelia Barber	UC Santa Cruz
Dave Bradford	EPA
Cali Crampton	UNR
David Charlet	College of Southern Nevada
Fred Edwards	FWS
Dawn Fletcher	NPS PLI
Matt Flores	USFS
Matt Hamilton	CC
Josh Hoines	NPS
Jef Jaeger	UNLV
Bill Kepner	EPA
Sonja Kokos	CC
Jeri Krueger	FWS
Judith Lancaster	DRI
Peter Lee	DRI
Doug Merkler	USDA/NRCS
Alice Newton	NPS
Craig Palmer	UNLV PLI
Burton Pendleton	USFS
Carrie Ronning	BLM
Don Sada	DRI
Asako Stone	DRI
Robin Tausch	USFS
Sue Wainscott	CC
Stu Weiss	Creekside Center for Earth Observation

Appendix C. Clark County MSHCP Ecosystem Health Workshop participants and their professional affiliation on January 31, 2008 (Day 3). CC = Clark County, NPS = U.S. National Park Service, NPS PLI = U.S. National Park Service, Public Lands Institute, EPS = U.S. Environmental Protection Agency, UNLV = University of Nevada, Las Vegas, FWS = U.S. Fish and Wildlife Service, BLM = U.S. Bureau of Land Management, USFS = U.S. Forest Service, DRI = Desert Research Institute, NSHE = Nevada System of Higher Education.

Participant	Affiliation
Dianne Bangle	NPS PLI
Dave Bradford	EPA
Fred Edwards	FWS
Matt Flores	USFS
Ross Haley	NPS
Matt Hamilton	CC
Jef Jaeger	UNLV
Bill Kepner	EPA
Jeri Krueger	FWS
Judith Lancaster	DRI
Peter Lee	DRI
Alice Newton	NPS
Burton Pendleton	USFS
Brett Riddle	UNLV
Carrie Ronning	BLM
Don Sada	DRI
Asako Stone	DRI
Robin Tausch	USFS
John Tennant	CC
Sue Wainscott	CC
Steve Zitzer	NSHE