Adaptive Management Report for the Clark County, Nevada, Multiple Species Habitat Conservation Plan

October 22, 2008

Clark County, Nevada
Department of Air Quality and Environmental Management
Desert Conservation Program
500 South Grand Central Parkway
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This report represents the work of Clark County Desert Conservation Program staff and Clark County Desert Conservation Program's Science Advisor: Desert Research Institute staff, concerning key findings and progress made between June, 2007 and June, 2008 on development of the Clark County Multiple Species Habitat Conservation Plan's Adaptive Management Program. Based on reports and materials prepared by:

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Cover Plate

Collage of the Clark County, Nevada, 11 MSHCP ecosystems – from top left: Bristlecone Pine, Mojave Desert Scrub, Mesquite Catclaw Acacia, Pinyon Juniper, Springs, Alpine, Salt Desert Scrub, Blackbrush, Sagebrush, Desert Riparian and Aquatic, Mixed Conifer.

Photos by: Adelia Barber, Cali Crampton, Matthew Flores, Ann Magliere, Brett Riddle, Don Sada, Robin Tausch, Sue Wainscott, Stuart Weiss and Stephen Zitzer.

ACKNOWLEDGEMENTS

This report results from both long-term efforts by Clark County to implement a Multiple Species Habitat Conservation Plan (MSHCP) with a substantial Adaptive Management Program, and recent short-term collaboration with the Desert Research Institute (DRI) to address critical components of this program, in the capacity of Science Advisor. The report covers the period of March 2006 through June 2008 and focuses on activity during a 12-month period starting in June, 2007. Over the course of the past year, many people in these two organizations have contributed in various ways – resulting in several products and a strong collaboration based on regular communication.

The authors are indebted to Asako Stone (DRI) who facilitated the ecosystem health workshops and took very thorough notes. Our thanks to Marjory Jones, Debi Noack and Lisa Wable - all of whom work at the Desert Research Institute – who assisted with manuscript preparation. The comments and advice provided by an anonymous reviewer of prior DRI reports to Clark County on components of its Science Advisor work are much appreciated, and will have positive long-term impacts on the MSHCP process.

A workshop to develop components of a decision support system for ranking project concepts was facilitated by Ruth Nicholson-Siguenza and Heidi Bigler-Cole – and their assistance resulted in a productive day of debate, negotiation and decision. The workshop was hosted by Clark County and attended by representatives from the Cities of Las Vegas, North Las Vegas, Henderson and Mesquite as well as the National Park Service, Bureau of Land Management, Nevada Department of Transportation, Nevada Department of Wildlife, Nevada Division of Forestry and U.S. Fish and Wildlife Service. Thank you, all participants, for your valuable input (see list in Appendix 4).

Land use and habitat loss reports were produced by Lee Bice and Matt Hamilton, with the assistance of Ron Gregory, all of whom work for Clark County. Workshops addressing ecosystem health for the 11 MSHCP ecosystems were led by ecosystem-specific experts who are continuing to assist with this component of DRI's activity. Special thanks go to this group of scientists: Adelia Barber, Cali Crampton, Matthew Flores, Brett Riddle, Robin Tausch, Stuart Weiss and Stephen Zitzer. These workshops were attended by representatives from Federal, State and County agencies, higher education and a consulting company (see chapter 3). Ongoing discussions between DRI, Rob Sutter, Scott Thomas and the U.S. Fish and Wildlife Service concerning aspects of programmatic effectiveness are contributing to the development of a strategy that will assist the County in evaluating the success of management decisions and of individual projects targeting issues relating to covered species and habitats (chapter 6).

We hope we have not omitted anyone from these acknowledgements, and sincerely apologize if we have done so. As authors, we take ultimate responsibility for this report and any mistakes it contains.

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ACEC	Area of Critical Environmental Concern
AMP	Adaptive Management Program
AMR	Adaptive Management Report
ATtiLA	AnalyTical tools Interface for Landscape Assessments
BCC	Board of County Commissioners
BLM	Bureau of Land Management
CA	Conservation Agreement
CBF	Chesapeake Bay Foundation
CBP	Chesapeake Bay Program
cm	centimeters
CO2	carbon dioxide
DAQEM	Clark County Department of Air Quality and Environmental Management
DCP	Clark County DAQEM, Desert Conservation Program Division
DNWR	Desert National Wildlife Refuge
DOQQ	Digital Ortho Quarter Quads
DRI	Desert Research Institute
EC	Electrical conductance
EPA	United States Environmental Protection Agency
ESA	Endangered Species Act
ft	feet
GIS	Geographic Information System
GMP	General Management Plan
ha	hectares
H_2O	water
HBI	Hilsenhoff Biotic Index
HCP	Habitat Conservation Plan
IA	Implementing Agreement
IDRISI	GIS software, named after a 12^{th} century geographer - Abu Abdallah Muhammad Ibn Muhammad Ibn Abdallah Ibn Idris al Qurtubi al Hasani
IMA	Intensively Managed Area
IPB	Implementing Plan and Budget
ITP	MSHCP's Section 10(a)(1)(B) Incidental Take Permit
km	kilometers
LANDFIRE	Landscape Fire and Resource Management Planning Tools Project
LIMA	Less Intensively Managed Area
MSHCP	Multiple Species Habitat Conservation Plan
MUMA	Multiple Use Managed Area
m	meters
NAFB	Nellis Air Force Base
NAIP	National Agriculture Imagery Program
NCA	National Conservation Area
NDF	Nevada Division of Forestry
NDOT	Nevada Department of Transportation
NDOW	Nevada Department of Wildlife

NETN	Northeast Temperate Network
NLCD	National Land Cover Data set
NPS	United States National Park Service
NRS	Nevada Revised Statutes
OHV	off highway vehicle(s)
PIE	Public Information and Education
RECON	Regional Environmental Consultants, Inc.
RFP	Request for Proposal
RMP	Resource Management Plan
SMNRA	Spring Mountains National Recreation Area
SNPLMA	Southern Nevada Public Lands Management Act
SNWA	Southern Nevada Water Authority
SWReGAP	Southwest Regional GAP
TNC	The Nature Conservancy
UMA	Unmanaged Area
µmhos	the measurement unit for electroconductivity
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WMA	Wildlife Management Area

CHAPTER 1. BACKGROUND AND CONTEXT

1.1 Introduction

The following is a report on the progress made over the last two years by an Adaptive Management Program for the Clark County, Nevada, Multiple Species Habitat Conservation Plan. The Clark County Multiple Species Habitat Conservation Plan (MSHCP: Regional Environmental Consultants [RECON], 2000) is the Habitat Conservation Plan component of a Section 10(a)(1)(B) Incidental Take Permit (ITP: #TE034927-0) issued by the United States Fish and Wildlife Service (USFWS, 2001). The ITP is held by Clark County, Nevada Department of Transportation (NDOT) and the cities of Boulder City, Henderson, Las Vegas, Mesquite, and North Las Vegas (permittees). The ITP was issued on a habitat acre basis, rather than numbers of individuals basis. The ITP exempts the permittees from the take prohibition of Section 9 of the Federal Endangered Species Act (ESA) for up to 145,000 acres (58,679 ha) of take (habitat loss) that is incidental to, but not for the purpose of, otherwise lawful activities covered in the MSHCP (RECON, 2000). Once habitat loss occurs under the ITP, it is assumed that the loss of habitat value is total and permanent for all covered species. The MSHCP describes a set of minimization and mitigation activities that may be funded to reduce and/or offset the anticipated habitat loss over the term of the ITP.

The MSHCP includes all of Clark County and NDOT activities in areas within Clark, Nye, Lincoln, Mineral and Esmeralda counties south of the 38th parallel and below 5,000 feet (1524 m) in elevation and encompasses over five million acres (2,023,428 ha) (Figure 1). The MSHCP's ITP allows up to 145,000 acres (58,679 ha) of habitat loss that may occur over a term of 30 years, effective January 9, 2001. Chapter 2 describes the habitat loss component of the ITP in more detail. The MSHCP describes a mitigation reserve system within Clark County where MSHCP minimization and mitigation actions are to take place. This mitigation reserve system is comprised of federal and state lands that are managed for the purposes of covered species habitat conservation, and is described in more detail below. Seven federal and state agencies have either regulatory authority over the covered species or land management responsibilities for the areas that comprise the MSHCP's mitigation reserve system. These seven agencies (Nevada Department of Wildlife, Nevada Divisions of Forestry and State Parks, USFWS, Bureau of Land Management, National Park Service and US Forest Service) and the permittees signed an Implementing Agreement in 2001 (IA, 2000) that documents how data, funding and decision making will be shared among these agencies and the public.

The MSHCP covers 78 species (Table 1), including the threatened desert tortoise and the endangered Southwest willow flycatcher. All 78 species were considered to be of equal priority in the MSHCP regardless of Federal or state listing status at the time the ITP was issued. The distribution and habitat requirements of these 78 species were described and the potential impacts of the ITP upon these species were analyzed in the MSHCP (RECON, 2000) and the USFWS's Biological Opinion (USFWS, 2000). Because little was known of the distribution of these species within Clark County, Nevada, the analysis was conducted using 11 ecosystems as surrogates for habitat extent of each species (Figure 2 and Table 1). It is recognized that there are differences within each ecosystem in terms of plant associations and the distribution of species, and that the systems are generalized to some extent.

Table 1. MSHCP covered species and ecosystems. Y indicates the occurrence of a species in an ecosystem following MSHCP (RECON, 2000) or the USFWS Biological Opinion (USFWS, 2000).

COMMON	SCIENTIFIC	TAXON GROUP	Alpine	Bristlecone Pine	Mixed Conifer	Pinyon Juniper	Sagebrush	Blackbrush	Salt Desert Scrub	Mojave Desert Scrub	Mesquite Catclaw Acacia	Desert Riparian and Aquatic	Spring
Silver-haired bat	*Lasionycteris noctivagans*	Mammal			Y	Y			Y		Y	Y	Y
Long-eared myotis	*Myotis evotis*	Mammal			Y	Y	Y		Y		Y	Y	Y
Long-legged myotis	*Myotis volans*	Mammal			Y	Y	Y						Y
Palmer's chipmunk	*Tamias palmeri*	Mammal		Y	Y	Y							
Yellow-billed Cuckoo	*Coccyzus americanus*	Bird										Y	
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	Bird										Y	
American Peregrine Falcon	*Falco peregrinus anatum*	Bird			Y	Y	Y					Y	
Blue Grosbeak	*Guiraca caerulea*	Bird										Y	
Phainopepla	*Phainopepla nitens*	Bird									Y	Y	
Summer Tanager	*Piranga rubra*	Bird										Y	
Vermillion Flycatcher	*Pyrocephalus rubinus*	Bird									Y	Y	
Arizona Bell's Vireo	*Vireo bellii arizonae*	Bird										Y	
Glossy snake	*Arizona elegans*	Reptile				Y			Y	Y			
Banded gecko	*Coleonyx variegatus*	Reptile				Y	Y	Y		Y	Y	Y	
Sidewinder	*Crotalus cerastes*	Reptile							Y	Y	Y		
Speckled rattlesnake	*Crotalus mitchellii*	Reptile				Y	Y	Y	Y	Y			
Mojave green rattlesnake	*Crotalus scutulatus scutulatus*	Reptile						Y		Y			
Great Basin collared lizard	*Crotaphytus insularis bicinctores*	Reptile				Y	Y	Y	Y	Y	Y	Y	

COMMON	SCIENTIFIC	TAXON GROUP	Alpine	Bristlecone Pine	Mixed Conifer	Pinyon Juniper	Sagebrush	Blackbrush	Salt Desert Scrub	Mojave Desert Scrub	Mesquite Catclaw Acacia	Desert Riparian and Aquatic	Spring
Desert iguana	*Dipsosaurus dorsalis*	Reptile							Y	Y	Y		
Western red-tailed skink	*Eumeces gilberti rubricaudatus*	Reptile			Y	Y	Y	Y			Y	Y	
Large-spotted leopard lizard	*Gambelia wislizenii wislizenii*	Reptile				Y	Y	Y	Y	Y			
Desert tortoise	*Gopherus agassizii*	Reptile					Y	Y	Y	Y			
California (common) king snake	*Lampropeltis getula californiae*	Reptile							Y	Y			
Western leaf-nosed snake	*Phyllorhynchus decurtatus*	Reptile							Y	Y			
Western long-nosed snake	*Rhinocheilus lecontei lecontei*	Reptile							Y	Y			
Sonoran lyre snake	*Trimorphodon biscutatus lambda*	Reptile			Y	Y				Y			
Relict leopard frog	*Rana onca*	Amphibian										Y	Y
Spring Mountains acastus checkerspot	*Chlosyne acastus robusta*	Invertebrate			Y	Y	Y						
Dark blue butterfly	*Euphilotes enoptes* ssp.	Invertebrate			Y	Y	Y						Y
Morand's checkerspot butterfly	*Euphydryas anicia morandi*	Invertebrate		Y	Y	Y							
Spring Mountains comma skipper	*Hesperia comma mojavensis*	Invertebrate		Y	Y	Y	Y						Y
Spring Mountains icarioides blue	*Icaricia icarioides austinorum*	Invertebrate		Y	Y	Y	Y						Y
Mt Charleston blue butterfly	*Icaricia shasta charlestonensis*	Invertebrate		Y	Y								
Nevada admiral	*Limenitus weidemeyerii nevadae*	Invertebrate		Y	Y	Y							Y

COMMON	SCIENTIFIC	TAXON GROUP	Alpine	Bristlecone Pine	Mixed Conifer	Pinyon Juniper	Sagebrush	Blackbrush	Salt Desert Scrub	Mojave Desert Scrub	Mesquite Catclaw Acacia	Desert Riparian and Aquatic	Spring
Spring Mountains springsnail	*Pyrgulopsis deaconi*	Invertebrate											Y
Southern Nevada springsnail	*Pyrgulopsis turbatrix*	Invertebrate											Y
Carole's silverspot butterfly	*Speyeria zerene carolae*	Invertebrate		Y	Y	Y	Y						
Rough angelica	*Angelica scabrida*	Vascular plant			Y								Y
Charleston pussytoes	*Antennaria soliceps*	Vascular plant	Y	Y									
Sticky ringstem	*Anulocaulis leiosolenus*	Vascular plant							Y	Y			
Las Vegas bearpoppy	*Arctomecon californica*	Vascular plant							Y	Y			
White bearpoppy	*Arctomecon merriamii*	Vascular plant						Y	Y	Y			
Rosy king sandwort	*Arenaria kingii* ssp. *rosea*	Vascular plant		Y	Y								
Clokey milkvetch	*Astragalus aequalis*	Vascular plant			Y	Y	Y						
Threecorner milkvetch	*Astragalus geyeri* var. *triquetrus*	Vascular plant								Y			
Clokey eggvetch	*Astragalus oophorus* var. *clokeyanus*	Vascular plant			Y	Y							
Spring Mountain milkvetch	*Astragalus remotus*	Vascular plant				Y	Y	Y		Y			
Alkali mariposa lily	*Calochortus striatus*	Vascular plant								Y			Y
Clokey paintbrush	*Castilleja martinii* var. *clokeyi*	Vascular plant		Y	Y								
Clokey thistle	*Cirsium clokeyi*	Vascular plant	Y	Y	Y								Y
Jaeger whitlowgrass	*Draba jaegeri*	Vascular plant	Y	Y									
Charleston draba	*Draba paucifructa*	Vascular plant	Y	Y									

COMMON	SCIENTIFIC	TAXON GROUP	Alpine	Bristlecone Pine	Mixed Conifer	Pinyon Juniper	Sagebrush	Blackbrush	Salt Desert Scrub	Mojave Desert Scrub	Mesquite Catclaw Acacia	Desert Riparian and Aquatic	Spring
Inch high fleabane	*Erigeron uncialis* ssp. *conjugans*	Vascular plant		Y	Y	Y	Y						
Forked (Pahrump Valley) buckwheat	*Eriogonum bifurcatum*	Vascular plant							Y		Y		
Sticky buckwheat	*Eriogonum viscidulum*	Vascular plant								Y			
Clokey greasebush	*Glossopetalon clokeyi*	Vascular plant			Y								
Smooth pungent greasebush	*Glossopetalon pungens* var. *glabra*	Vascular plant				Y	Y						
Pungent dwarf greasebush	*Glossopetalon pungens* var. *pungens*	Vascular plant				Y	Y						
Red Rock Canyon aster	*Ionactis caelestis*	Vascular plant			Y								
Hidden ivesia	*Ivesia cryptocaulis*	Vascular plant	Y										
Jaeger ivesia	*Ivesia jaegeri*	Vascular plant		Y	Y								
Hitchcock bladderpod	*Lesquerella hitchcockii*	Vascular plant	Y	Y	Y								
Blue Diamond cholla	*Opuntia whipplei* var. *multigeniculata*	Vascular plant								Y			
Charleston pinewood lousewort	*Pedicularis semibarbata* var. *charlestonensis*	Vascular plant		Y	Y								
White-margined beardtongue	*Penstemon albomarginatus*	Vascular plant						Y		Y			
Charleston beardtongue	*Penstemon leiophyllus* var. *keckii*	Vascular plant	Y	Y	Y								
Jaeger beardtongue	*Penstemon thompsoniae* var. *jaegeri*	Vascular plant			Y	Y							
Parish's phacelia	*Phacelia parishii*	Vascular plant							Y				
Clokey mountain	*Salvia dorrii* var.	Vascular plant		Y	Y	Y							

COMMON	SCIENTIFIC	TAXON GROUP	Alpine	Bristlecone Pine	Mixed Conifer	Pinyon Juniper	Sagebrush	Blackbrush	Salt Desert Scrub	Mojave Desert Scrub	Mesquite Catclaw Acacia	Desert Riparian and Aquatic	Spring
sage	*clokeyi*												
Clokey catchfly	*Silene clokeyi*	Vascular plant	Y	Y									
Charleston tansy	*Sphaeromeria compacta*	Vascular plant	Y	Y									
Charleston kittentails	*Synthyris ranunculina*	Vascular plant	Y	Y	Y								Y
Charleston grounddaisy	*Townsendia jonesii* var. *tumulosa*	Vascular plant	Y	Y	Y	Y							
Limestone violet	*Viola purpurea* var. *charlestonensis*	Vascular plant		Y	Y	Y							
Anacolia menziesii	*Anacolia menziesii*	Non-vascular plant				Y	Y						
Claopodium whippleanum	*Claopodium whippleanum*	Non-vascular plant				Y							
Dicranoweisia crispula	*Dicranoweisia crispula*	Non-vascular plant			Y	Y							
Syntrichia princeps	*Syntrichia princeps*	Non-vascular plant				Y							

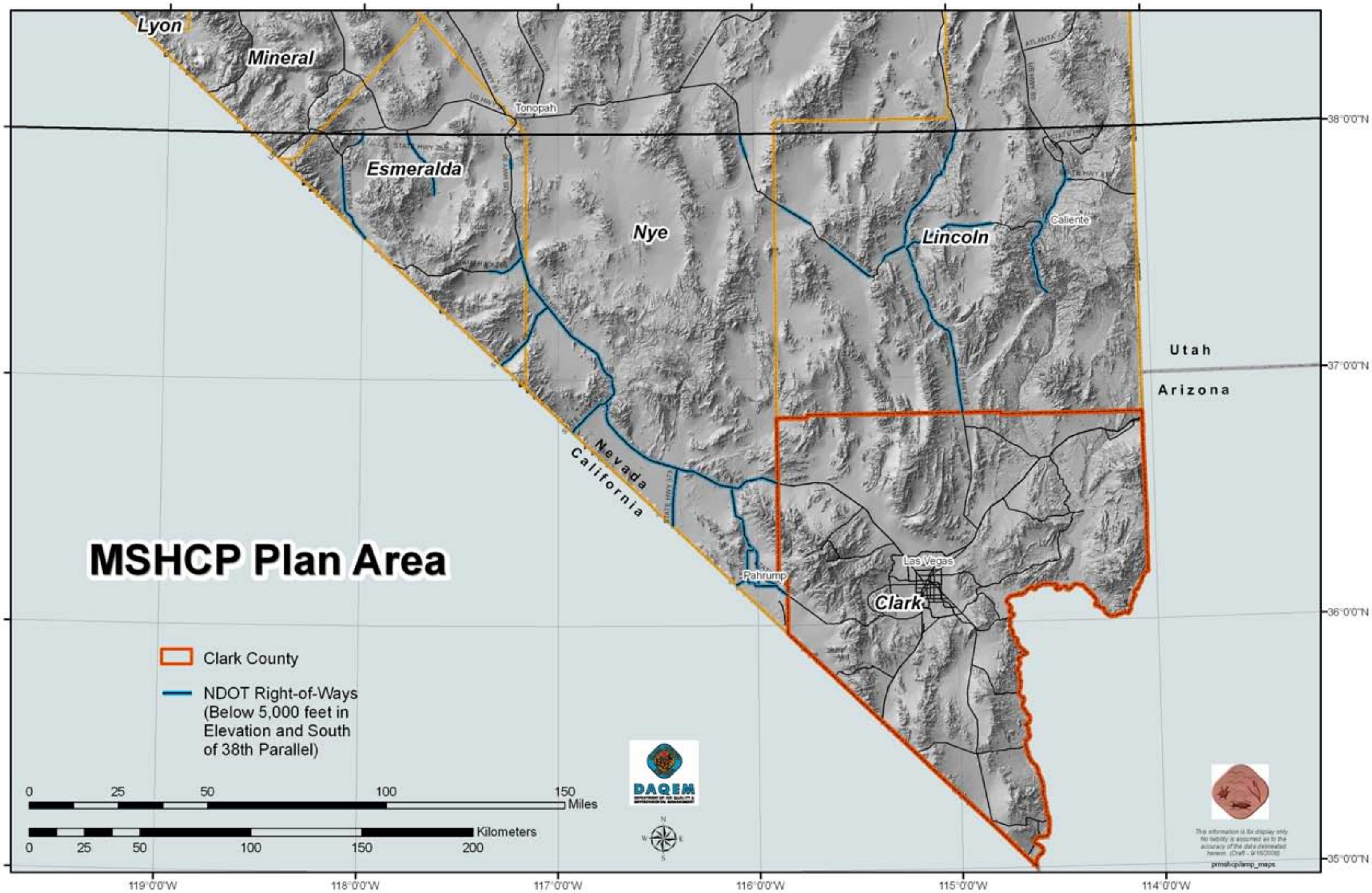

Figure 1. The MSHCP plan area is all of Clark County and certain Nevada Department of Transportation activity areas within desert tortoise habitat in Nevada, totaling over five million areas.

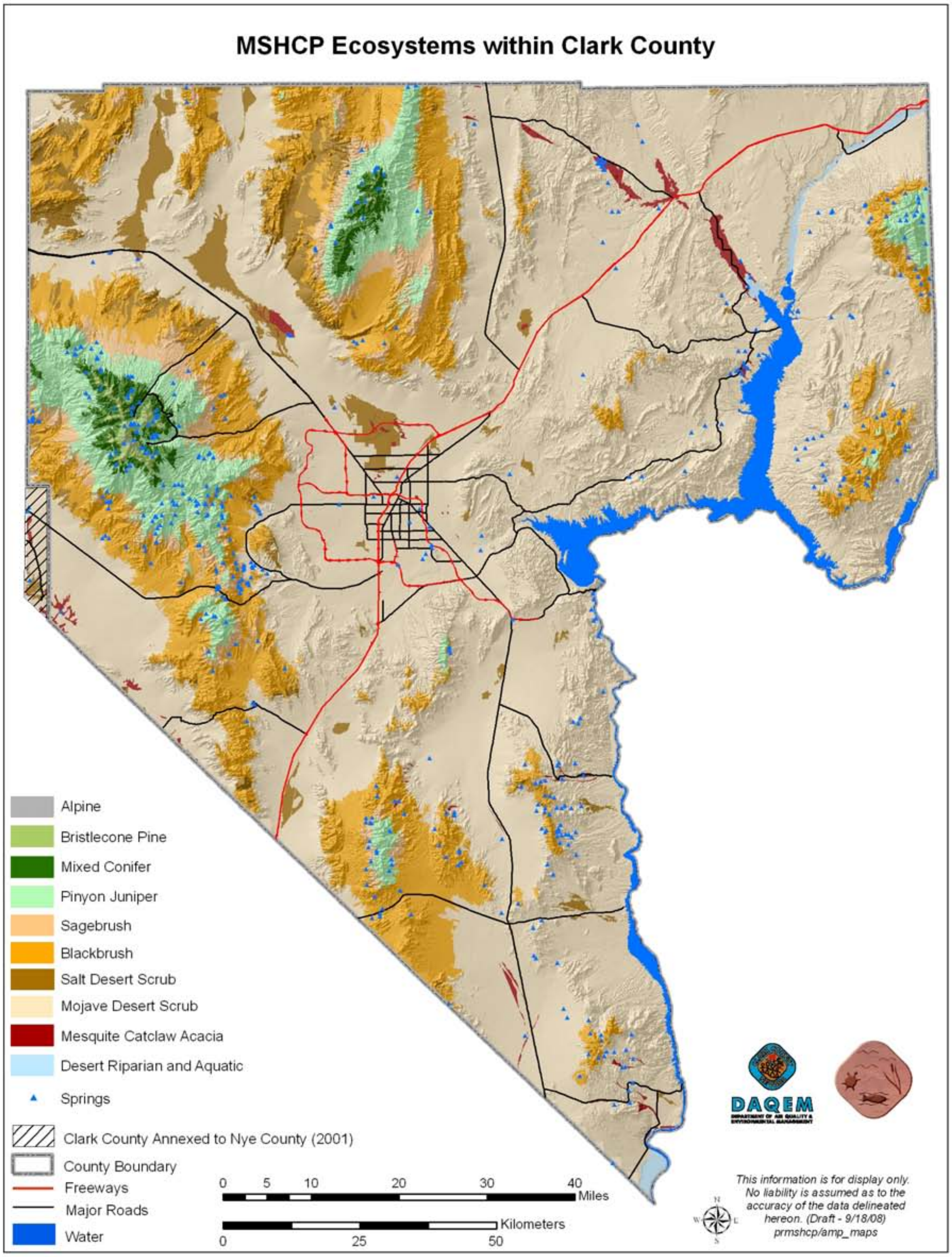

Figure 2. Map of MSHCP ecosystems in Clark County, Nevada

The mitigation reserve system outlined in the MSHCP relies primarily on public (mostly Federal) lands for mitigation activities. These areas (Figure 3) are defined in section 2.4.2.7 of the MSHCP (RECON, 2000) as Intensively Managed Areas (IMAs), Less Intensively Managed Areas (LIMAs), Multiple Use Managed Areas (MUMAs) and Unmanaged Areas (UMAs). The IMAs and LIMAs represent the "reserve system" and MUMAs provide "conservation value as corridors, connections, and buffers for the IMAs and LIMAs where the management preserves the quality of habitat sufficient to allow for unimpeded use and migration of the resident species in the IMAs and LIMAs" (RECON, 2000; p. 2.74). UMAs are those areas where habitat loss under the ITP will primarily occur. The MSHCP's mitigation reserve system categories describe the management of the land, and are neither prescriptive nor proscriptive land management designations. There is no prohibition of habitat loss within the mitigation reserve system categories, but it is expected that habitat loss occurring under the MSHCP's ITP will take place primarily in UMAs, because the ITP does not apply to Federal Lands. Habitat loss could, potentially, occur under the ITP on State lands within IMAs or LIMAs.

Federal lands within Federal disposal boundaries are classified as MUMAs in the MSHCP's conservation reserve system. These lands may be transferred via sale, exchange for other acres, or Recreational and Public Purpose lease to municipalities. Upon transfer to non-Federal ownership, these lands become eligible to be permitted for habitat loss under the MSHCP's ITP. The MSHCP, USFWS analysis of the MSHCP and the ITP anticipated that some or all of these acres might be transferred to non-Federal ownership at some point during the term of the ITP (RECON, 2000; USFWS, 2000; 2001). In addition, possible designation or release of Wilderness Study Areas by Congress and other changes in the mitigation reserve system were anticipated by the MSHCP. Recently the Bureau of Land Management (BLM) conducted a review of all land management designation changes that might affect the MSHCP mitigation reserve system, and the present configuration of the MSHCP mitigation reserve system is shown in Figure 4.

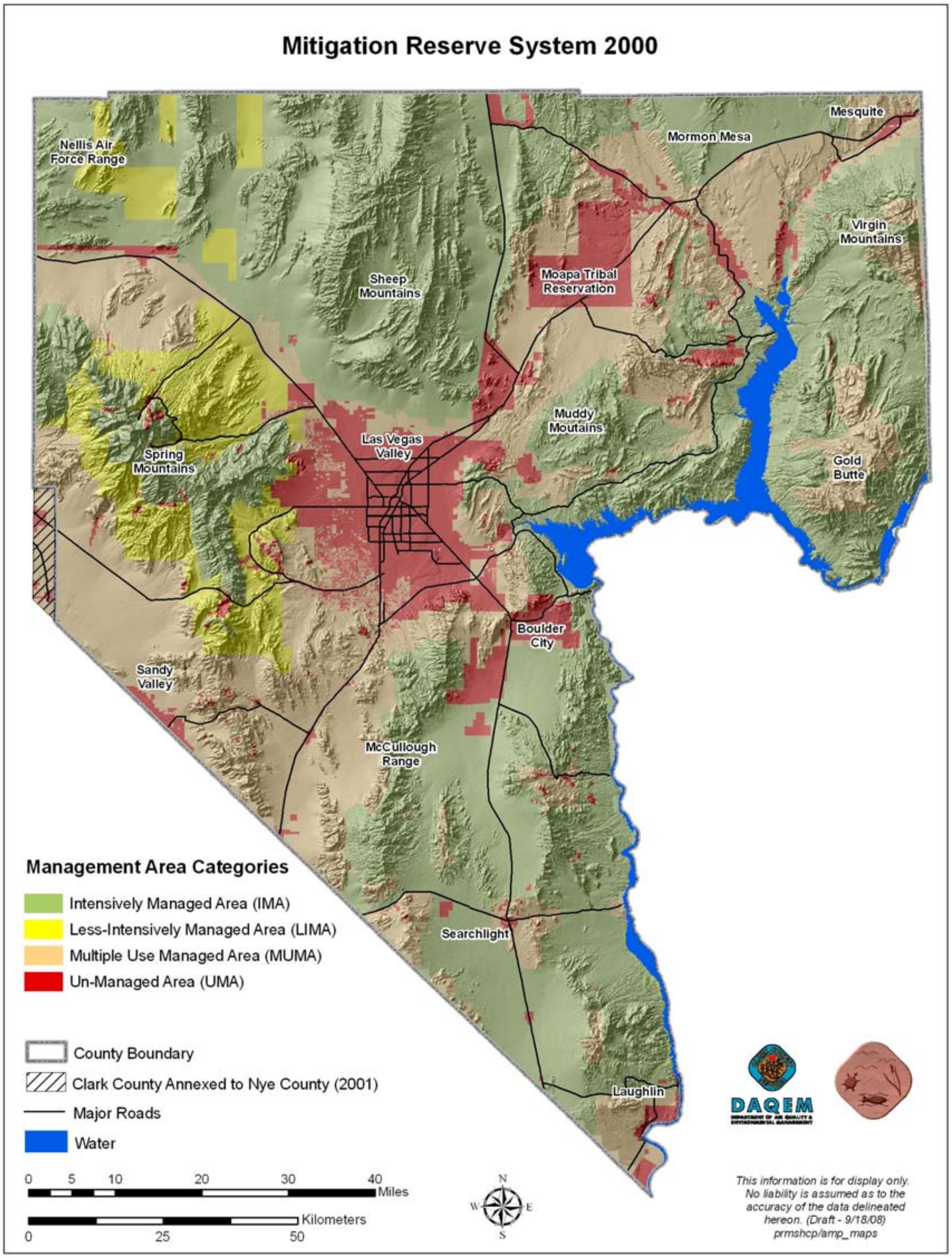

Figure 3. Mitigation Reserve System 2000. Original MSHCP mitigation reserve system based upon land-use designations in existence at that time.

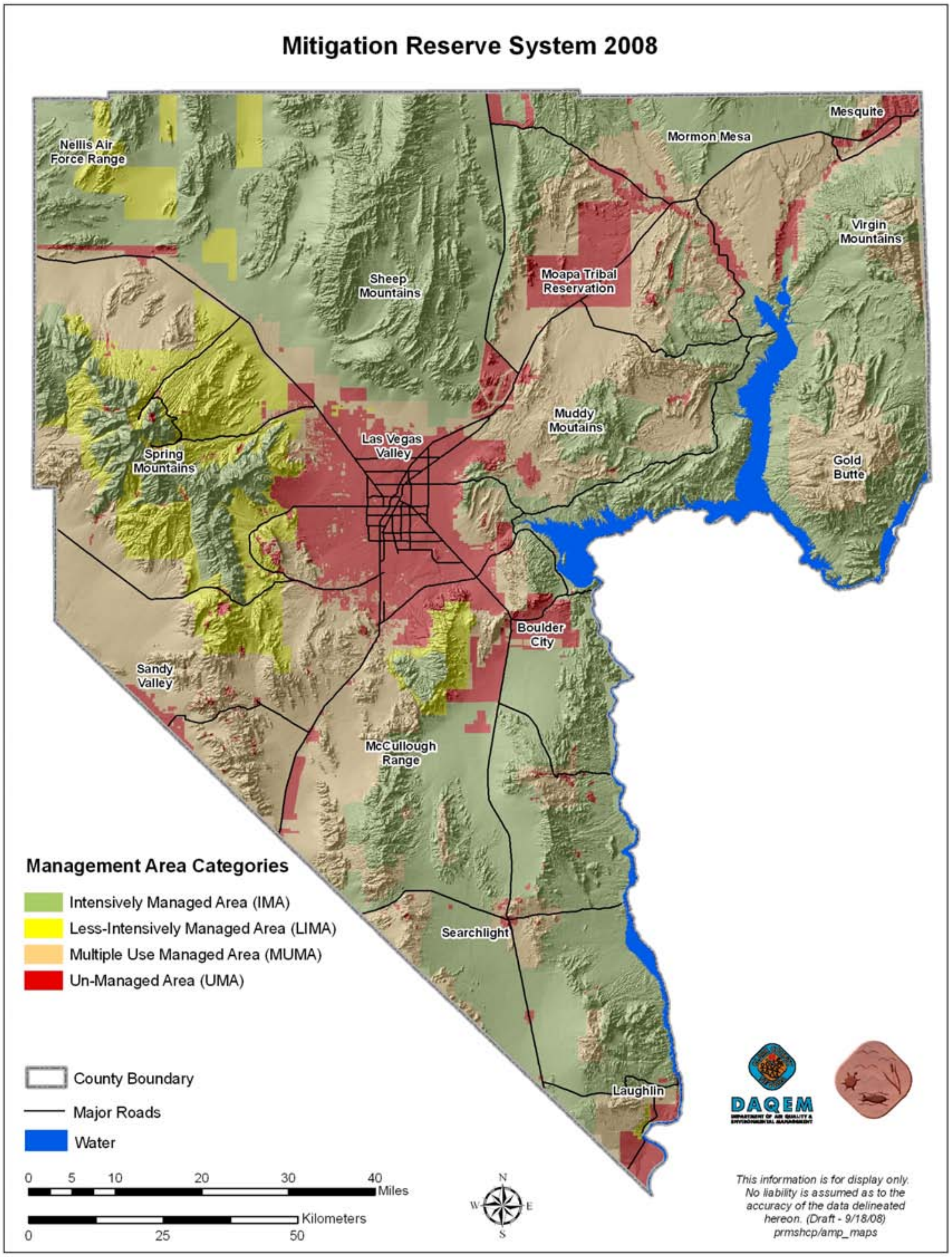

Figure 4. Mitigation Reserve System 2008. Results of an analysis conducted by the Bureau of Land Management to analyze the impacts of present land use designations on the current MSHCP mitigation reserve system.

1.2 MSHCP Goals and Objectives

The MSHCP establishes a general goal to maintain no net unmitigated loss or fragmentation of habitat, primarily within IMAs and LIMAs, or MUMAs that encompass a substantial proportion of habitat occupied by species covered in the plan. The MSHCP also has a goal to maintain stable or increasing populations of covered species. The MSHCP further establishes measurable biological objectives for each covered species (see Appendix 2, RECON, 2000). Measurable biological objectives to meet the goal of stable or increasing populations of covered species include: "a) maintenance of the long-term net habitat value of the ecosystems in Clark County with a particular emphasis on Covered Species and b) recovery of listed species and conservation of unlisted Covered Species" (RECON, 2000). Appendices A and B of the MSHCP contain descriptions of each covered species and their hypothesized habitat requirements within 11 ecosystems in Clark County. Ecosystem-specific goals and objectives were not described. Descriptions of threats and management status are also provided, but no status evaluations were provided that could be used as a baseline for assessing trends or progress in achieving these objectives. Both the MSHCP and peer reviewers of this document highlight the need to establish more specific and measureable biological objectives for the covered species, but this has not yet been accomplished. More details regarding this effort are provided in chapter 4.

The MSHCP identifies a large set of mitigation actions that may be implemented over the term of the ITP to achieve the above mentioned goals and objectives (Appendix 1). In addition, the ITP describes several additional "conditions" or requirements that must be completed in addition to those discretionary mitigation actions (USFWS, 2001). Every two years, a biennial Implementation Plan and Budget is prepared that recommends projects to be funded to implement the MSHCP. Due to the complexity of such a large area and vast number of species covered, an Adaptive Management Program (AMP) has been designed to use available data and science-based expertise to recommend periodic improvements to the implementation of the MSHCP.

1.3 The Desert Conservation Program

The Desert Conservation Program (DCP) is the division of the Clark County, Nevada, Department of Air Quality and Environmental Management (DAQEM) that administers the MSHCP on behalf of the other permittees. The DCP coordinates with other programs and agencies that work in the arena of impact mitigation, and species and habitat conservation. The DCP coordinates with the other Implementing Agreement agencies to monitor activities that potentially impact the MSHCP mitigation reserve system areas (IMAs, LIMAs, MUMAs). These activities can have positive, neutral, and/or negative impacts on these areas, thereby influencing the apparent effectiveness of the mitigation strategy outlined in the MSHCP.

From a conceptual level, Figure 5 depicts the way that information flows to the DCP and its AMP, and how decisions are made using that information. The thin blue arrows indicate general information flow among decisions and actions, and the thicker green arrows indicate the information flow that takes place within the AMP. It is important to note that several key decisions take place outside of the authority of the AMP, such as agency land use designation changes and land management decisions, as well as the increment, timing and location of habitat loss covered by the ITP.

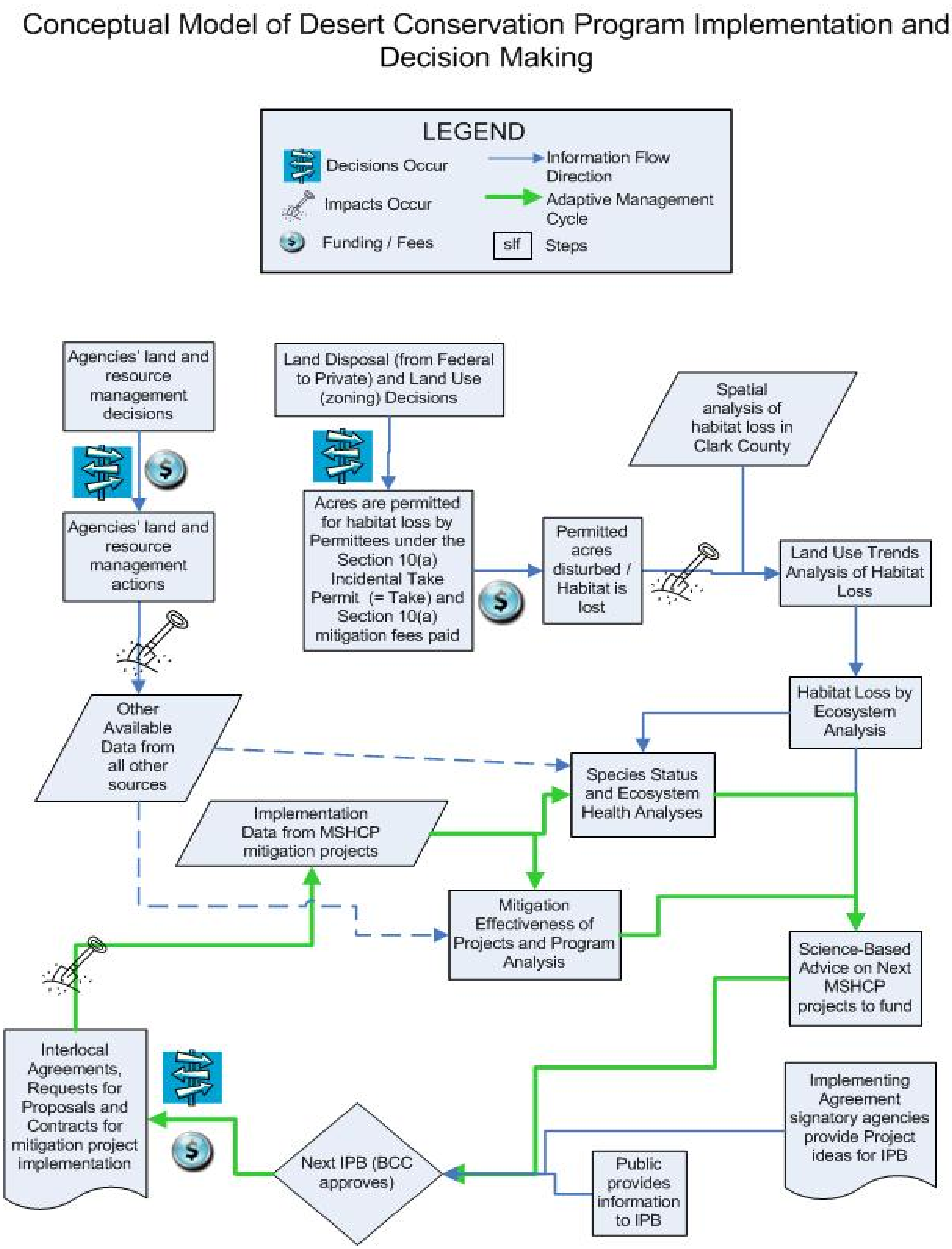

Figure 5. Conceptual Model of Desert Conservation Program Implementation and Decision Making. Information flows from many sources to inform decisions regarding both actions and funding to implement the MSHCP.

In addition to the uses of DCP-produced (and other available) data depicted in Figure 5, the DCP uses the available data to coordinate with permittee departments (such as Clark County's Comprehensive Planning Department and city planning departments) that administer or influence decisions regarding activities that may cause habitat loss under the ITP.

1.4 2008 Adaptive Management Report: Context

The AMP works with a group of independent scientists (Science Advisor, currently Desert Research Institute) to provide objective, science-based review and advice to the Implementing Agreement signatory agencies and to track information as defined in the MSHCP (RECON, 2000) and the Biological Opinion for the ITP (USFWS, 2000 p. 2.11). These activities include:

- Tracking land-use trends in Clark County to ensure that take and habitat disturbance (habitat loss) is balanced with mitigation
- Tracking habitat loss by ecosystem
- Monitoring species population trends and ecosystem health
- Evaluating the effectiveness of management actions at meeting MSHCP mitigation goals.

Every even-numbered year, the AMP prepares an Adaptive Management Report that summarizes efforts to date in completing these activities. The Adaptive Management Report also makes science-based recommendations for future implementation efforts. The previous three Adaptive Management Reports are available on the Clark County website: http://www.accessclarkcounty.com/depts/daqem/epd/Pages/dcp_reports.aspx . In every odd-numbered year, the DCP is also required to report on the status of implementation of the MSHCP (Biennial Progress Report). These reports are also available on the above Clark County website. Completion of the 2008 Adaptive Management Report was delayed from the original publication deadline of March 15, 2008, due to funding and contracting delays.

Significant changes have been made to the AMP since production of the 2006 Adaptive Management Report. Many of these changes address recommendations made in the 2006 Adaptive Management Report (Clark County, 2006a), and a checklist of the status of those recommendations is provided in Appendix 2. Building upon those recommendations, model development of the previously convened Adaptive Management Science Team (Clark County, 2006a), and the results of the Desert Conservation Program's Program Management Analysis (Kirchhoff & Associates, 2005), the AMP initiated the following modifications in 2006:

- Reducing conflicts of interest by:
    - eliminating real and/or perceived conflicts of interest on the Adaptive Management Science Team
    - conducting a competitive solicitation for a Science Advisor that was free of real and perceived conflicts of interest
    - increasing independence of science-based oversight of the DCP and AMP

- Increasing public access to products of and information about MSHCP implementation projects
- Clearly delineating tasks to be performed by the Science Advisor
- Assembling a database of the spatial and aspatial data generated by the MSHCP to date.

To accomplish the above, the AMP first focused on a revision (Clark County, 2006b) of the Adaptive Management Science Plan (Clark County, 2003) to implement technical peer review and independent science-based oversight of the AMP. This included clarification of the tasks of the AMP via discussions with the USFWS, development of a more detailed scope of work for the Science Advisor, and competitive solicitation and selection of the current Science Advisor from organizations not concurrently receiving other MSHCP funding.

To increase technical peer review of the DCP and the AMP and to reduce real and/or perceived conflicts of interest, the Adaptive Management Science Team was revised to include only members whose organizations did not receive MSHCP funding, and they were tasked with peer review of Science Advisor products (Clark County, 2006a). Technical peer review of DCP implementation and information gathering projects are outsourced to USGS, and USGS projects were peer reviewed by experts selected by the DCP's AMP staff. Several projects approved for the 2005-2007 Implementation Plan and Budget were approved with technical conditions for funding, and AMP staff focused on review of scopes of work for those projects to ensure that those technical conditions have been adequately met, including solicitation of external technical review where necessary. The DCP contracting procedures were updated to require projects to state objectives and list the MSHCP elements (species, ecosystems, threats and actions) addressed by the project. Projects were also provided a public forum for progress reporting during symposia held in October 2006 and August 2008.

The AMP staff worked with DCP contracting staff and the Clark County District Attorney's Office to resolve issues surrounding confidential data under Nevada Revised Statutes, intellectual property law, and negotiations with agencies regarding ownership and rights to the use of data generated using MSHCP funds. The DCP contracting procedures were updated to include data management plans and annual data deliverables. The AMP staff also continued to request, receive, and organize data produced by MSHCP funding. These data were provided to the current Science Advisor, shared with USFWS, and are being used to respond to questions posed by Implementing Agreement signatory agencies.

1.5 2008 Adaptive Management Report: Content

This 2008 Adaptive Management Report is the fourth biennial Adaptive Management Report. This report and the AMP have benefited from several rounds of technical peer review of the components of the AMP. The DCP received two major progress reports on the below topics from its Science Advisor in October 2007 and April 2008. These progress reports were peer reviewed and the peer reviewer comments were addressed by DRI or the DCP as appropriate and incorporated in subsequent products to the extent practicable. A draft of this Adaptive Management Report also received peer review and this final report addresses review comments to the extent practicable. Work to date on each of the below topics is summarized in chapters prepared by the DCP and its Science Advisor, respectively. The topics addressed in this report include:

- Clark County land-use (habitat loss) trends. Chapter 2 includes the DCP's analysis of all county-wide land-use trends. This is a spatial analysis of habitat loss during the term of the ITP, for which a geographic information system (GIS) procedure to track this trend was developed. The analysis considers changes occurring from February 2001 to December 2007. This chapter was prepared by DCP staff.
- Conceptual models for the 11 MSHCP ecosystems in the context of ecosystem health.
- Habitat loss by ecosystem in Clark County. Chapter 3 includes two parts. The first part was prepared by the Science Advisor and presents first iterations of conceptual models for the assessment of health of the 11 MSHCP ecosystems. The second part of this chapter is an assessment of habitat loss in each of these ecosystems that was prepared by DCP staff.
- Initial stages in development of a functional prototype of a covered species population tracking system. Chapter 4 summarizes work accomplished on developing a system to track the status of covered species through information compiled in a database for each species.
- A functional prototype of an implementation status tracking system. Chapter 5 presents the results of efforts by the Science Advisor to design a database that tracks MSHCP mitigation action projects that are proposed or funded by Clark County. This database will be used in the future to determine if habitat loss is balanced with mitigation actions.
- Recommendations for a programmatic effectiveness monitoring strategy. Chapter 6 summarizes progress of the Science Advisor toward developing a program to assess the effectiveness of MSHCP mitigation actions using a strategy that determines how project-specific effectiveness monitoring, the results of the above analyses, and other data can be used to inform a programmatic assessment of MSHCP effectiveness.
- A decision support system to make project-level prioritized recommendations for the 2009-2011 Implementation Plan and Budget. A decision support framework that was designed by Clark County and used by the Science Advisor to rank discretionary (non-permit conditions) mitigation action projects proposed for funding by the Implementing Agencies and the results of DRI's science-based recommendations are presented in chapter 7.
- Chapter 8 includes concluding remarks and summarizes the recommendations made throughout the document.

CHAPTER 2. LAND USE TRENDS

2.1 Introduction

The Clark County MSHCP's (RECON, 2000) AMP tracks land use trends within the ITP (USFWS, 2001) area in order to balance habitat loss under the ITP with mitigation actions. This chapter presents the methods used and results from an analysis of habitat loss. Additional information to allow future analysis of the balance between habitat loss and mitigation actions is being organized and these efforts are described in chapters 3 and 5.

The MSHCP's goals for species management are described in terms of the habitat quality in each of the mitigation reserve system categories (RECON, 2000). Thus, an understanding of how habitat loss impacts lands within each category provides valuable information to track progress toward those goals. The MSHCP, USFWS analysis of the MSHCP and the ITP also anticipated that other changes in MSHCP management area category designation might take place during the term of the ITP (RECON, 2000; USFWS, 2000; 2001), and a process for evaluating such changes was described in the MSHCP (RECON, 2000 p. 2.292). Such an analysis has recently been completed by the Bureau of Land Management, but the data sets were not available for analysis in this report.

The methods used to address several habitat loss trend questions and results of each analysis are discussed in the following sections.

2.2 How Many Acres Have Been Permitted for Habitat Loss Under the MSHCP's ITP?

As described in chapter 1, incidental take of acres under the ITP is described as "habitat loss." For each non-Federal acre of habitat loss permitted under the ITP, a fee of $550.00 is paid into an MSHCP mitigation fund. Up to a total of 15,000 acres (6,070 ha) may be exempted from the fee if the acres of habitat loss are to serve a municipal purpose. A total of 145,000 acres (58,679 ha) of habitat loss on non-Federal land is permitted during the term of the MSHCP's ITP (USFWS, 2001).

The DCP tracks the acres permitted for habitat loss under the ITP. A report is submitted quarterly to the US Fish and Wildlife Service and shared with interested parties. As of December 31, 2007, a total of 61,978 acres (25,082 ha), or 42.7% of the allowable habitat loss, had been permitted. Of those acres, 2,134 (864 ha) were acres claiming exemption from fee payment due to the anticipated municipal use of the permitted acres. An audit of reported fee-exempt acres is underway, and the reported number of permitted, fee-exempt acres is subject to update upon receipt of these audit results. When the number of acres remaining available for habitat loss under the ITP is reported, the conservative assumption is made that all 15,000 (6,070 ha) of the fee-exempt acres have been permitted. Thus, the calculation of the number of acres remaining under the ITP includes 59,845 (24,218 ha) permitted acres for which the $550.00 per acre fee has been paid, as well as an assumption that all 15,000 (6,070 ha) of the fee-exempt municipal-purposes acres have been permitted, leaving 70,155 acres (28,391 ha) (41.3%) available for habitat loss under the ITP. However, for comparison to the spatial analyses of actual habitat loss described below, the best available data were used, and the figure of 61,978 acres (25,082 ha) permitted for habitat loss is used.

2.3 How Many Acres of Habitat Loss Has Actually Occurred During the Term of the MSHCP's ITP?

A spatial analysis of actual habitat loss during the term (February 9, 2001 to December 31, 2007) of the ITP was conducted. The intent of this analysis was to improve upon a previous land use analysis completed in July 2007 (Clark County, 2007a) and to calculate the approximate number of acres of actual habitat loss within the ITP area during the term of the ITP. The time period of analysis was from March 2001 to March 2007, based upon the acquisition dates of available aerial imagery data sets.

For the purpose of this analysis, 2001 and 2007 land use data sets were produced by Clark County GIS analysts. Because this land use trends analysis is focused on the loss of habitat under the terms of the MSHCP's ITP, a binary urban classification coding scheme was applied to each of the land use data sets (urban (=habitat loss), not urban). For this analysis, all agricultural areas were included in the urban classification code. Agricultural areas in Clark County have experienced little change during the period analyzed.

As described in a previous report (Clark County, 2007a), the 2001 land use data set was primarily based on Clark County aerial photography (March 2001). In areas where the aerial photography was not collected, USGS Landsat satellite imagery from 2000 and 2001 was used. To create the 2001 land use data set, Clark County aerial photography and or Landsat imagery was displayed using a GIS (ArcGIS). All urban areas were captured and input into the ArcGIS geodatabase. This was accomplished by screen digitizing urban areas using ArcGIS. The 2007 land use data set was produced using the same technique and solely based on the Clark County March 2007 aerial photography data. A minimum mapping distance of approximately 2 acres (0.8 ha) was used for capturing urban areas while screen digitizing, and the results are rounded to the nearest 1 acre (0.4 ha) in the analyses below. Total urban acreages were calculated within each data set. Quality control efforts are documented in the previous report (Clark County, 2007a), and did not include ground-truthing.

This spatial analysis shows a total of 56,512 acres (22,870 ha: Table 2) of habitat loss occurred in Clark County from March 2001 to March 2007. This result was compared to the 61,978.46 acres (25,082 ha) permitted for habitat loss report for December 31, 2007. There is a difference between the results of the two analyses, showing 5,475 acres (2,216 ha) more were permitted for habitat loss than actually occurred, but this is a less than 10% difference. It is expected at any point in time that more acres would be permitted for habitat loss than had yet occurred, as it is expected that a permit would be received prior to that habitat loss occurring. Possible other reasons for this difference could include the difference between the time periods analyzed, discrepancies in acres permitted but exempt from payment of the per-acre fee, scale of the spatial analysis, and potential errors in classification made by the GIS analysts.

The aspatial tracking of acres permitted for habitat loss is through the actual term of the MSHCP's ITP, from February 9, 2001 to December 31, 2007, while the spatial analysis of actual habitat loss on-the-ground during the term of the ITP was limited to the time period between available aerial imagery data sets, from March 2001 to March 2007. Some acres permitted for habitat loss under the predecessor to the MSHCP may have actually been lost (disturbed) during the period analyzed by the spatial analysis, which would be an error of commission. Conversely, the spatial analysis of actual habitat loss is limited to the date(s) the aerial imagery was acquired, which may be different across the area of analysis, and does not correspond exactly to the time that the ITP was issued in February 2001.

In addition, the minimum digitized screen mapping area used in creation of the geodatabases was approximately 2 acres (0.8 ha), which means developed areas less than 2 acres (0.8 ha) might not have been digitized and could account for some of the acreage differences between the two analyses. There is also a margin of error introduced due to the interpretation of the photography by the GIS analysts.

Table 2. Acres of habitat loss in Clark County within Federal Disposal Areas in 2001 and 2007

	Total Acres	2001 Urban	2007 Urban	Acres of Habitat Loss between 2001 and 2007
Las Vegas Valley Disposal Area only	330,644 (133,807 ha)	177,901 (71,994 ha)	225,719 (91,345 ha)	47,817 (19,351 ha)
All Federal Disposal Areas	406,049 (164,322 ha)	178,862 (72,383 ha)	228,660 (92,535 ha)	49,798 (20,153 ha)
Outside Federal Disposal Areas	4,650,638 (1,882,046 ha)	25,177 (10,189 ha)	31,891 (12,906 ha)	6,714 (2,717 ha)

2.4 How Many Acres of Habitat Loss Have Occurred Within the Federal Disposal Areas Within the MSHCP's ITP Area?

In addition to the private and local municipality lands within Clark County, approximately 100,000 acres (40,469 ha) of Federal lands within Clark County remain within designated Federal Disposal Area boundaries (Figure 6). These 100,000 acres (40,469 ha) are eligible for transfer from Federal ownership to private or municipal ownership (personal communication to Sue Wainscott from Ron Gregory, Clark County Department of Air Quality and Environmental Management, January 3, 2008). As described in chapter 1, the MSHCP, USFWS analysis of the MSHCP, and the ITP anticipated that some or all of these acres might be transferred to non-Federal ownership at some point during the term of the ITP (RECON, 2000; USFWS, 2000; 2001). An additional large area that might be disposed of and developed under a separate, Federal action (not covered by the ITP, but addressed in an ESA section 7 consultation) is also shown on Figure 6: the proposed Ivanpah airport and district areas.

The extent of urban areas in each of the 2001 and 2007 GIS land use geodatabases was spatially compared with the Federal Disposal Area boundaries (Figure 7). Note that within each disposal area, lands presently in Federal management would be categorized as MUMAs, while non-Federal lands within the disposal area would be UMAs. Table 2 displays the acres of habitat loss within Clark County and the designated Federal Disposal Areas. As shown in Table 2, of the 56,512 total acres (22,870 ha) of habitat loss occurred in Clark County during this time period, 47,817 acres (19,251 ha, or 84.6%) occurred within the Las Vegas Valley Federal Disposal Area. An additional 1,981 acres (802 ha, or 3.5%) of habitat loss occurred in the other Federal Disposal Areas, and 6,714 acres (2,717 ha, or 11.9%) of habitat loss occurred in areas outside of designated Federal Disposal Areas during this time period.

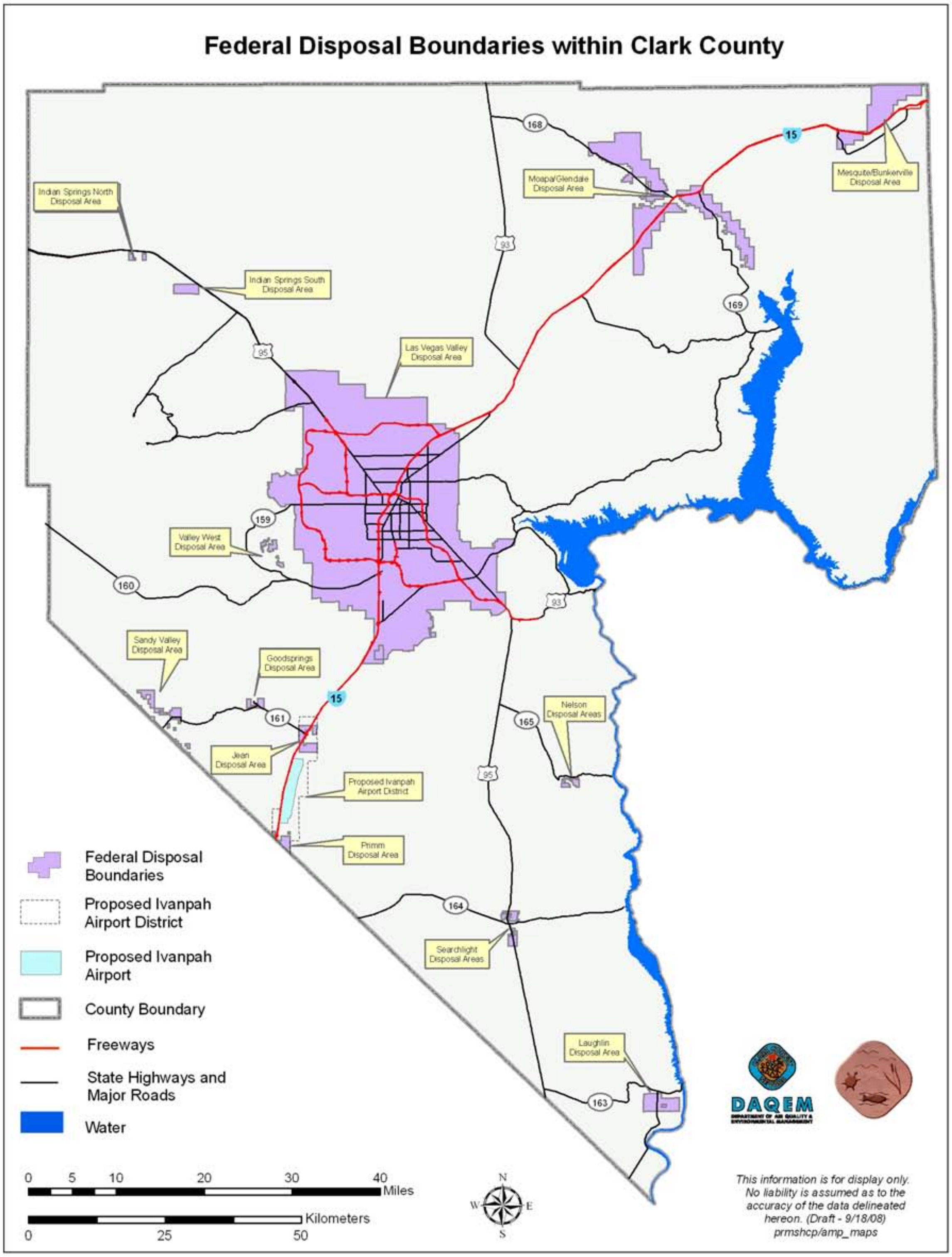

Figure 6. Federal Disposal Area boundaries within Clark County, Nevada.

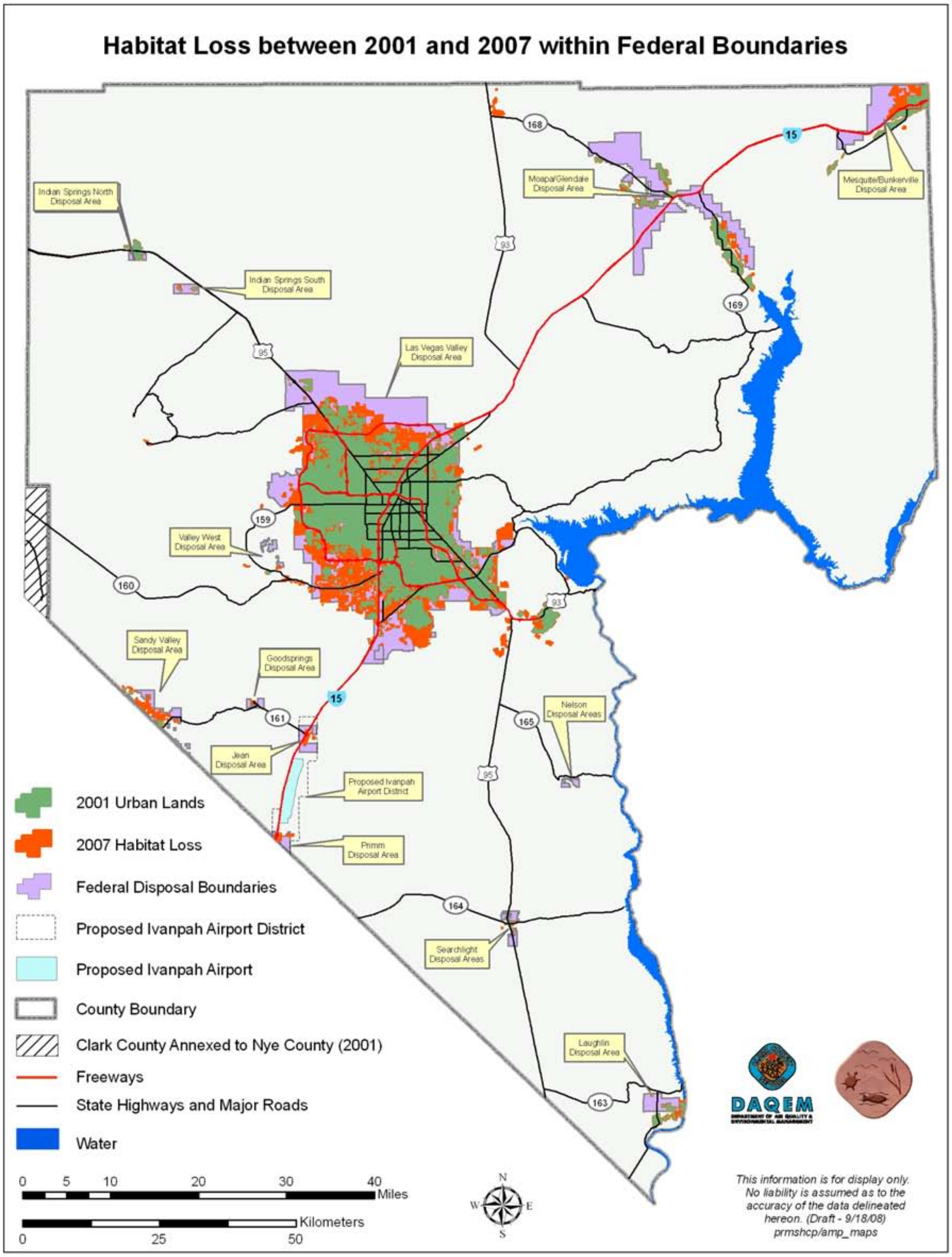

Figure 7. Habitat loss between 2001 and 2007 within Federal Disposal Area boundaries.

2.5 How Many Acres of Habitat Loss has Occurred In Each of The MSHCP's Management Area Categories?

As described in chapter 1, the MSHCP also anticipated that habitat loss would occur primarily in UMAs and MUMAs. The extent of urban acres in each of the 2001 and 2007 GIS land use geodatabases was spatially compared with the original MSHCP Management Area boundaries, and the number of acres of habitat loss in each category was calculated. Table 3 displays the results of the analysis. Of the 56,512 acres (22,870 ha) of actual habitat loss, 523 (220 ha, or 0.9%) were in IMAs, 79 (32 ha, or 0.1%) were in LIMAs, 19,848 (8,032 ha, or 35.1%) were in MUMAs, and the majority (36,062 acres (14,593 ha or 63.8%)) were in UMAs. This analysis shows that 55,910 acres (22,626 ha, or 99%) of the disturbance has taken place within UMAs and MUMAs. The USFWS analysis of the potential impacts of the MSHCP's ITP (USFWS, 2000) anticipated that the majority of habitat loss would take place within UMAs or MUMAs that had become UMAs through disposal of portions of Federal Disposal Area lands. It is likely that those MUMAs habitat loss areas to date were disposed of and were actually UMAs at the time of habitat loss (which would be consistent with the MSHCP's ITP terms), but the GIS data from the BLM's MSHCP Management Area designation change analysis were not available to compare to the above analysis.

Table 3. Acres of habitat loss in Clark County 2001 compared to 2007 within MSHCP management area categories.

	Total Acres	2001 Urban	2007 Urban	Acres of Habitat Loss between 2001 and 2007
IMA	2,650,010 (1,072,421 ha)	544 (220 ha)	1,067 (432 ha)	523 (212 ha)
LIMA	380,914 (154,150 ha)	76 (31 ha)	155 (63 ha)	79 (32 ha)
MUMA	1,505,875 (609,406 ha)	20,314 (8,221 ha)	40,161 (16,253 ha)	19,848 (8,032 ha)
UMA	519,888 (210,391 ha)	183,107 (74,101 ha)	219,169 (88,695 ha)	36,062 (14,593 ha)
Clark County total	5,056,687 (2,046,369 ha)	204,040 (82,572 ha)	260,551 (105,441 ha)	56,512 (22,870 ha)

2.6 Summary

Both the aspatial tracking of the acres permitted for habitat loss during the term of the MSHCP ITP (February 2007 to December 31, 2007 [61,978 (25,082 ha)]) and the spatial analysis of acres of actual habitat loss (56,512 [22,870 ha]) during the term of available imagery (March 2001 - March 2007) show similar results within a reasonable margin of difference. The MSHCP anticipated habitat loss of 63,475 acres (25,287 ha) within the first six years of the ITP term (RECON, 2000, p. 2.284) and our analyses show that both the actual habitat loss and permitted for habitat loss figures are within a reasonable margin of difference from this value. The spatial analysis of acres of habitat loss within MSHCP mitigation reserve system categories also shows that the majority of acres of habitat loss (55,911 [22,626 ha] or 99%) were within UMAs and MUMAs.

2.6.1 Recommendation: Refine land cover classification used for land use trends analysis

It has been recommended by the MSHCP's Science Advisor (DRI, 2007) that future analyses of habitat loss and land use trends include refining the land use classification schema to include a more robust and finer classification system. A combination of land use/land cover classification system could be used. A common land use/land cover classification system that could be used is the Anderson Level I land use/land cover classification system (Anderson et al. 1976). In time this could be developed into a more complex classification system like the one used in Anderson Level II or in the USFS National Land Cover Data set (NLCD) products (Homer et al. 2007).

The Anderson classification system incorporates different resolution imagery to create a hierarchical land use/land cover classification. An example of level I would be a generic urban, or forest land cover. Level II is more detailed, where forest might be specified as deciduous, evergreen, or mixed. To achieve this level of classification the land use data sets would have to be enhanced by use of GIS reference data such as parcel data from Clark County and other permittees; US Department of Agriculture National Agriculture Imagery Program (NAIP) imagery; Digital Ortho Quarter Quads (DOQQs); other imagery data such as Quickbird, roads, government lands data sets; and color infrared aerial photography. However, because this analysis is concerned primarily with the extent of habitat loss under the ITP, it is not clear whether the benefits of a more refined land use classification would result in more accurate or finer resolution of a binary data set consisting of urban and nont urban classes.

2.6.2 Recommendation: Use new Clark County boundary in future analyses

The Clark County boundary was realigned in the early 2000s. The BLM's current analysis of changes in MSHCP Management Area categories includes incorporation of this post 2002 County boundary. In future spatial and aspatial analyses, the current Clark County boundary and acreage figure should be used.

2.6.3 Recommendation: Use newly available land use trend data in future analyses

Upon completion of the audit of fee-exempt habitat loss permitting, the results of the aspatial tracking system should be more accurate and should be used in future land use tracking analyses. The updated MSHCP Management Area categories data set, just developed by the BLM, should be used in future analyses involving the MSHCP Management Area categories. In addition, to better predict development patterns, the Southern Nevada Regional Planning Coalition and Clark County Regional Transportation Commission are coordinating development of a demographic spatial data set for Clark County that includes land use projections. Land use projection data will be provided by Henderson, North Las Vegas, Las Vegas, Mesquite, and Clark County. This data set will depict both areas of likely future habitat loss and requests for additional disposal of Federal lands, and coupled with the updated MSHCP Management Area categories data, will be useful to project anticipated disturbance for future land use trends analyses.

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CHAPTER 3. ECOSYSTEMS

In the MSHCP (RECON 2000), 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 (Figure 8). In this chapter, descriptions of those ecosystems are updated and first iteration conceptual models are presented for each. In addition, results of the land use trends spatial analysis (chapter 3) are compared to the spatial extent of the ecosystems to better understand how habitat loss under the MSHCP's ITP may be impacting the habitats of the 78 covered species.

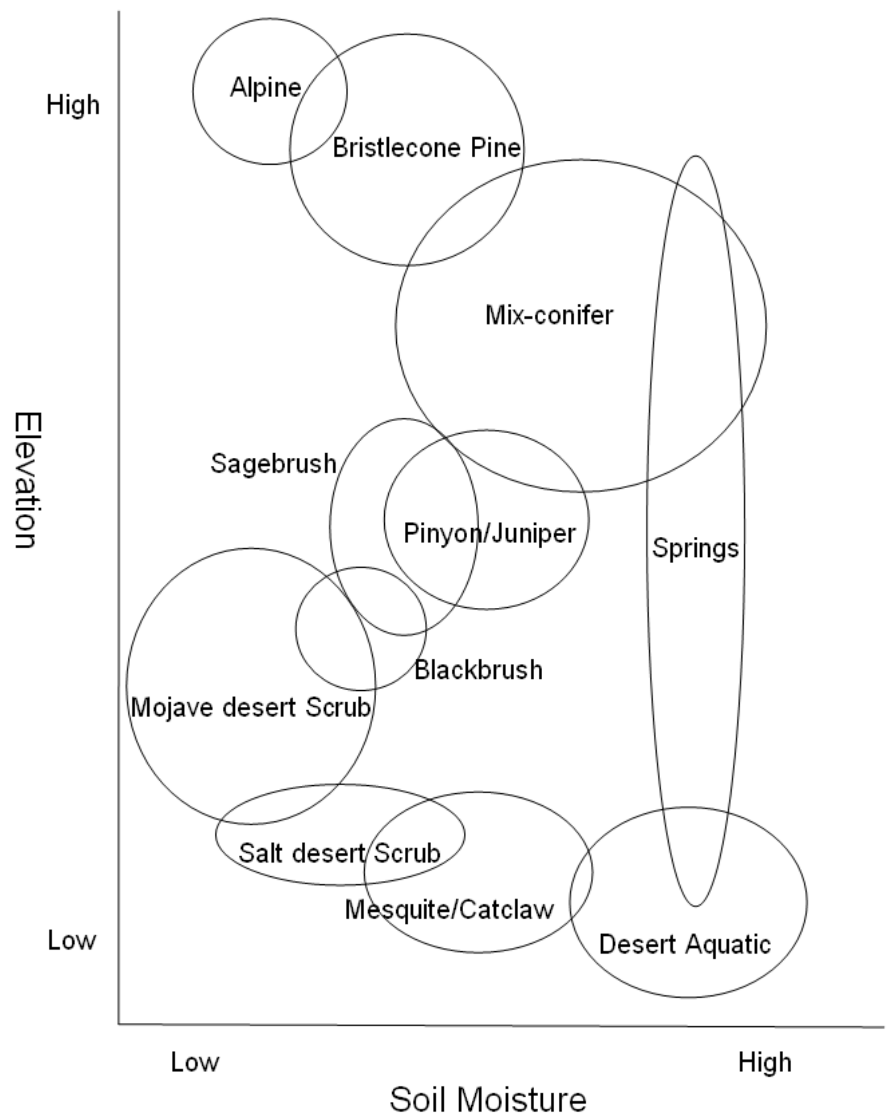

Figure 8. A conceptual model to categorize 11 ecosystems of Clark County MSHCP along two environmental gradients: elevation and soil moisture. This model is based on general knowledge of environmental gradients of ecosystems, so the shape, size, and relative position of the ellipses and circles are hypothetical.

3.1 First Iteration Conceptual Models for 11 MSHCP Ecosystems

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. For this reason, the AMP is tasked with tracking the health of those ecosystems. Many programs conducted by State and Federal agencies track the status of covered species in Clark County, but definitions of ecosystem health, and methods to track health, have not been developed.

3.1.1 Workshop

DRI was tasked with preparing first-iteration conceptual models of ecosystem health in the context of the 78 covered species for each of 11 ecosystems identified in the MSHCP (Figure 8). 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 (see Appendix 3 for a list of workshop participants). Each ecosystem was considered during a brief introductory presentation by an invited scientist (Table 4) 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 led to clarify the issues and involve agency representatives in model development. This process resulted in drafting a conceptual model for each ecosystem, which was reviewed by each expert. These models provide a framework that can be used as a foundation for more precise delineations of ecosystem health, to focus future research, prioritize threats, and delineate expectations for the suite of management strategies that may affect each ecosystem. Since these are first iteration models, many quantitative details of biotic/abiotic interactions (both by natural and human influences), ecosystem characteristics, monitoring programs, and ecosystem health indicators are weakly described. These details should be fully described when more comprehensive models are developed in the future. For the most part, details within these first iteration models are either quantified or generally summarized in cited literature and studies. In other situations, additional research may be needed to provide clarity.

Table 4. 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.

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

For the workshop, proper **ecosystem health** was defined as: “A condition which maintains ecosystem functions, maintains viable biotic populations, and satisfies human needs.” 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” (RECON, 2000; see also Appendix 1). These models are brief, first-iterations and create a conceptual framework to guide future model refinement, studies and development of 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.

3.1.2 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 communities of organisms that can be identified as ecosystems, which share similar characteristics of their distribution along environmental gradients of temperature, moisture, soil type, and chemistry. The structure of these communities may also be altered by human activities, whose influence may exceed, or include factors, what can be attributed to natural factors. The influence of natural and human factors on these communities is related to the magnitude, duration, and frequency of disturbances or stressors (human factors include removing vegetation, dewatering streams and springs, etc.; natural disturbances include drought, fire, flood, etc.). The integrity of these communities can usually be maintained under regimes of natural disturbances and some level and frequency of human disturbance. Ecological consequences of the long term effects of disturbance increases with magnitude, frequency, and duration such that restoring natural conditions (ergo restoring conditions to maintain ecosystem functions and viable biotic populations of native species) to systems affected by human activity becomes problematic beyond a disturbance threshold. Tolerance thresholds are difficult to quantify and differ among ecosystems, but they can be determined through research and monitoring.

Clark County 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, topographic factors, slope, aspect, and especially elevation, which ranges from 170 m (558 ft) at Laughlin to 3,600 m (11,810 ft) at Charleston Peak, influence a number of environmental gradients such as temperature, precipitation, soil chemicals, and soil types in the county. 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 north facing aspects and shaded areas. Annual precipitation is correlated with elevation, i.e., high precipitation at middle elevation and declining at higher and lower elevation, however, prevailing winds bring more moisture to windward slopes than leeward slopes (which may be in a rain shadow). Wind also influences water availability by facilitating evapotranspiration from plants and soils. Figure 8 illustrates that the relationships among these environmental gradients and the 11 MSHCP ecosystems are similar to relationships documented for other ecosystem and vegetation associations (Walter, 1973; Ganderton and Coker, 2005). 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 particles occur mostly on low and stable slopes and are scarce on steep and unstable slopes. Soil particle 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 is deposited on the concave bottom of swales where they accumulate and support alpine meadows.

Basic characteristics of most MSHCP ecosystems can be relatively well described. The Mojave Desert Scrub ecosystem is unique because it includes a wide variety of distinctive ecosystems that can be attributed to sand dune, gypsum, desert pavement, and cliff/rock outcrop soil types. There are overlaps between ecosystems associated with soil types that are associated with environmental gradients, and boundaries between two adjacent ecosystems are not wide and relatively indistinct. Each of these ecosystems is neither isolated nor independent from other ecosystems with this desert scrub, and modification of one ecosystem will likely influence its adjacent systems. The conceptual model for this ecosystem includes a summary of systems that are associated with each soil type.

Development of conceptual models for ecosystem health provides a framework to understand natural and human factors affecting each system, which can be used to provide a foundation for management and habitat conservation. In addition to ecosystem health tracking for individual ecosystems, a holistic perspective is also critical to provide general ideas and broader concepts.

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. A healthy ecosystem is stable within the boundaries of its natural variability, sustainable, free from distress and degradation, actively maintaining its organization and autonomy over time, and resilient to stress (Haskell et al., 1992). Natural drivers are natural factors that shape ecosystems and keep them healthy. These drivers maintain ecosystems in a healthy, natural state that can be defined by abiotic and biotic characteristics that are unique for each ecosystem.

Workshop participants also agreed that human factors affecting an ecosystem could be categorized as a threat to ecosystem health, and that any factor that changes the natural characteristics of a well-functioned and self-sustained healthy ecosystem is a threat to that ecosystem. Threats are disturbances or stressors that alter abiotic and biotic environments by introducing a suite of drivers that degrade ecosystems by altering functional characteristics of energy flow. Threats usually are anthropogenic, occur either locally or globally, and influence an ecosystem either directly (e.g., drying streams, increasing fire frequency, etc.) or indirectly (e.g., climate change, etc.). Any quantitative measurement or qualitative description that can document changes in functional characteristics of an ecosystem or the occurrence of new drivers or threats that alter ecosystem characteristics can be an indicator of ecosystem health. Good indicators provide early signals of ecosystem change, they are usually identified through detailed research of the ecosystem, and they differ among ecosytems. Figure 9 illustrates a conceptual model of relationships between drivers, threats, biotic and abiotic characteristics, and healthy and degraded ecosystems (ergo ecosystems whose functional characteristics no longer exist and viable biotic populations of occupying native species are absent).

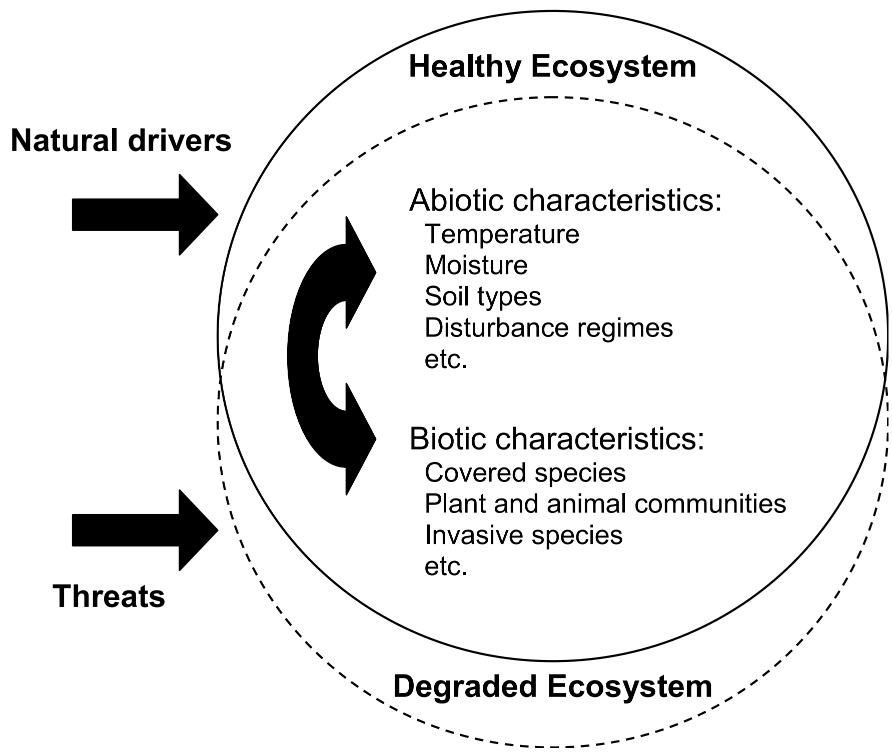

Figure 9. A conceptual model illustrating relationships among natural drivers, threats, abiotic and biotic characteristics, and healthy and degraded ecosystems (ergo ecosystems whose functional characteristics no longer exist and viable biotic populations of occupying native species are absent). Natural drivers are factors that maintain a healthy, naturally functioning ecosystem. Threats are factors that degrade ecosystems. Any quantitative measurement or qualitative description that documents changes in drivers, threats, or biotic and abiotic characteristics may be an indicator of ecosystem change.

Ecosystem health conceptual models are presented in the following section by describing ecosystem biotic and abiotic characteristics, listing MSHCP species they support, describing natural drivers and threats, and listing potential indicators of ecosystem health. These are first iteration models that provide a conceptual framework to assess management and needs for additional information. As conceptual models, they are relatively broad discussions that do not include quantitative assessments or a thorough set of relevant literature. This level of detail should be developed during future work that more definitively considers the health of these ecosystems, how health is tracked, indicator species or communities, and ecological thresholds. The next phase of model development may be illustrated by the Spring ecosystem model, which is more detailed than other first iteration models and provides an example of how future models may be more fully developed for other ecosystems.

3.1.3 Spring Ecosystem

3.1.3.1 Description and Characteristics

Springs are small-scale aquatic systems that occur where ground water reaches the surface (Meinzer, 1923). They consist of a source and a downstream reach that may be flowing (referred to as a spring brook) or ponded, and 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. Differences among springs can be largely attributed to factors influencing characteristics of aquifers, such as geology, climate, topography, and flow patterns. 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 14 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 in Clark County are also inhabited by many obligate spring-dwelling invertebrates and vertebrates with limited distribution (e.g., LaRivers, 1949; 1950; 1962; Hershler, 1998; Schmude, 1999). There is wide variation among springs and few springs are alike due to differences in water chemistry, slope, substrate composition, persistence, morphology, size, etc. It is not currently possible to predict the species occurring in riparian and aquatic communities of individual springs because the interactions between biotic and physicochemical characteristics of springs are poorly understood. It appears that crenobiontic species (e.g., springsnails, native fishes, rare plants) are indicators of high quality, persistent (possibly for millennia or millions of years) springs and that springs stressed by environmental harshness (attributed to either natural or human factors) are occupied by stressed conditions.

The MSHCP reported 506 springs in Clark County (RECON, 2000). This number has not been verified, and work by Bradford et al. (2003), Sada and Nachlinger (1996, 1998), Sada (2000), and others indicate that most Clark County springs dry frequently and that fewer than 200 persistent springs occur in the county. Springs occur from approximately 250 m (820 ft) to 3,300 m (10,825 ft) elevation and in all landscape settings (e.g., mountains, gullies, valley floors, hillside, etc.). Springs also support the listed endangered Moapa dace (*Moapa coriacea*) and a number of crenobiontic species that are endemic to Clark County.

Recent studies by Sada et al. (2005) Fleishman et al. (2006) and Bradford et al. (2003) have contributed greatly to knowledge of Clark County springs. Additional knowledge is needed to understand the response of aquatic and riparian communities to incremental changes in stress, quantify relationship between physicochemical characteristics of environments and structure of aquatic and riparian communities, and quantify reference biotic conditions relevant to the effect of natural stressors on riparian and aquatic communities.

3.1.3.2 MSHCP Covered Species

Spring ecosystems are habitat for 14 covered species, which include four plants, three butterflies and bats, two springsnails, and one amphibian (Table 5).

Table 5. Covered species found in Spring ecosystems.

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

3.1.3.3 Ecosystem Drivers

Geology, aquifer characteristics, size and provenance, geography, and climate influence water chemistry and constitute the hydrologic context for springs (Figure 10). 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, 50^{o} F) 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, 50^{o} to <77^{o} F), and their chemical concentrations are low (EC <1,000 µmhos). Most of these springs have been altered by livestock trampling, diversion, and/or recreation. 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. These systems may be impacted by groundwater removal. Geothermal spring waters (> 40^{o} C, 104^{o} F) 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 and may be affected by geothermal development.

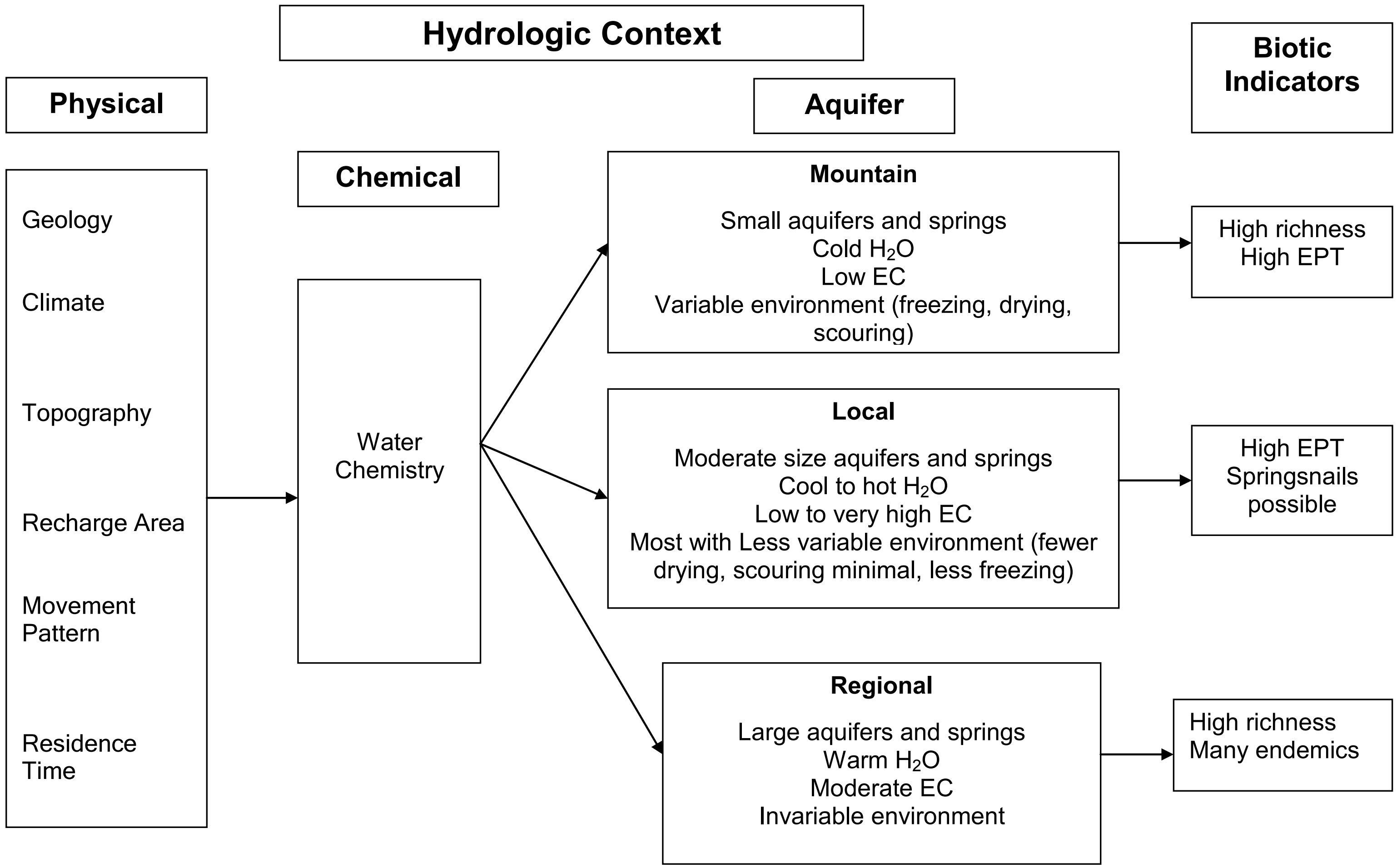

Figure 10. The hydrologic context of Clark County springs and basic characteristics of biotic communities in persistent springs that are minimally stressed by harsh environments caused by natural conditions or created by human activity. EPT = proportion of mayflies (Ephemerpotera), stoneflies (Plecoptera), and caddis flies (Trichoptera) in the community.

- Regional Aquifer—Springs supported by regional aquifers are generally large. Regional aquifers extend through several topographic basins and may encompass thousands of square km. 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, 77^{o} to 104^{o} F) and their chemical concentrations are relatively benign (EC generally ranges from 500 to 1,000 µmhos, but may be as high as 1,500 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.

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 11). Aquatic system sample programs can be designed to quantify characteristics of each system and track temporal changes (Sada et al. 2001). Studies by Sada and Nachlinger (1996, 1998) Bradford et al. (2003) Sada et al. (2005) and Fleishman et al. (2006) revealed basic aspects of spring ecology in Clark County.

Drivers Summary

Abiotic Drivers

- Spring environments are most influenced by aquifer provenance, landscape position, and disturbance regime
- Persistent springs have highest aquatic and riparian richness
- Richness in aquatic and riparian communities is correlative with discharge
- Functional characteristics of riparian and aquatic communities appear to vary along a stressor gradient where:

Aquatic System

  - Highly stressed aquatic systems are occupied by highly tolerant and adaptable aquatic species
  - The proportion of tolerant species in the community is correlative with stress.
  - As stress decreases, the proportion of intolerant species in the aquatic community increases
  - Highest quality systems are minimally stressed, have high species richness, and may be inhabited by obligate spring species
  - Stress affects the abundance of (and may extirpate) covered species.

-

Spring Environment		Functional Characteristics of Community	
Harsh Environment • Ephemeral • Water chemistry o temperature o chemical concentration • Frequent scouring • High human impact	ENVIRONMENTAL HARSHNESS/STRESS ↑	**Harsh Environment** • Low species richness • Crenobiontics absent • Tolerant organisms o midges o vagile species • Nonnative species dominant	**Harsh Environment** • Low species richness • Low vegetation cover • Upland spp. & grasses may dominate • Nonnatives may dominate • Wood vegetation sparse • Obligatory wetland spp. Absent (facultative species may occur)
Benign Environment • Stable environment o persistent o good water quality • Low to moderate temperature • Low human impact		**Benign Environment** • High species richness • Crenobiontics possible • Nonnative species absent • Intolerant organisms dominate o caddisflies o springsnails	**Benign Environment** • High species richness • Dense cover • Woody vegetation dense • Obligatory and facultative wetland species present

Figure 11. General characteristics of minimally and highly stressed springs and the relationship between stress level and functional characteristics of their aquatic and riparian systems.

Riparian System

- o Highly stressed riparian systems support more grasses, upland, and non-native species
- o The frequency of tolerant species in the community is correlated with stress
- o As stress decreases, obligatory and facultative wetland species become more frequent in the community
- o Highest quality systems are minimally stressed, species richness is high, and obligatory wetland and native woody riparian species are present
- o Stress affects the abundance of (and may extirpate) covered species

- Amphibians preferentially occupy lower reaches of spring brook where the density of riparian vegetation is low.

3.1.3.4 Ecosystem Health Threats

Most arid land springs have been used as water supplies for livestock, recreation, and domestic purposes (e.g., Shepard, 1993; Sada and Vinyard, 2002). Surveys of large springs in Clark County during the late 1990s by Sada and Nachlinger (1996; 1998) and Sada (2000) found that most springs were highly disturbed by diversion and non-native ungulates (Table 6). A number of springs are also altered by groundwater pumping and recreation, and many large springs support introduced aquatic and riparian species (e.g., crayfish, aquarium fish, salt cedar, palm trees). Non-native fish have adversely affected the abundance and distribution of most native fishes in Southern Nevada through competition for resources and predation (e.g., Sada, 1990; Scoppettone, 1993; Werdon, 1996) Groundwater pumping in Southern Nevada has caused extinction and the extirpation of populations of several species (e.g., Miller, 1961; Minckley and Deacon; 1968, Deacon, et al., 2007). Relationships between groundwater pumping and spring discharge in Southern Nevada were examined by Dudley and Larson (1976) in Ash Meadows and Mayer and Congdon (2007) in the Moapa area.

Table 6. The percent of the largest springs in Clark County that were slightly, moderately, and highly stressed by human and natural factors in the late 1990s (Sada and Nachlinger, 1996; 1998; Sada, 2000). N = 125. Many springs were stressed by more than one factor (e.g., diverted and heavily trampled by cattle). Many small springs were not surveyed by these studies, most of these springs are believed to frequently dry under natural conditions.

Stressor	Slight	Moderate	High
Diversion	64	10	29
Burros, Horses, Elk	74	9	17
Cattle	84	5	11
Flood	83	10	7
Recreation	92	4	4
Avalanche	98	< 1	< 1
Fire	98	1	< 1
Drying	98	< 1	< 1
Non-native aquatic species	----	----	10

Ecosystem Threats Summary

Major threats

- Human disturbance
    - Diversion
    - Groundwater pumping
    - Non-native ungulates
    - Non-native aquatic species
    - Recreation

3.1.3.5 Potential Ecosystem Health Indicators

Information compiled by Sada and Nachlinger (1996; 1998) and analyzed by Sada et al. (2005) and Fleishman et al. (2006) indicates that community metrics may be used to assess ecosystem health (Figures 12 and 13). A decline in species richness, increasing abundance of non-native species, and increasing abundance of tolerant species in riparian and aquatic communities may indicate a decline in health. Improving health may be indicated by increasing richness, decline of non-native species, and increased proportion of intolerant species in riparian and aquatic communities. Trends in these community metrics can be determined through monitoring programs that are conducted over several years.

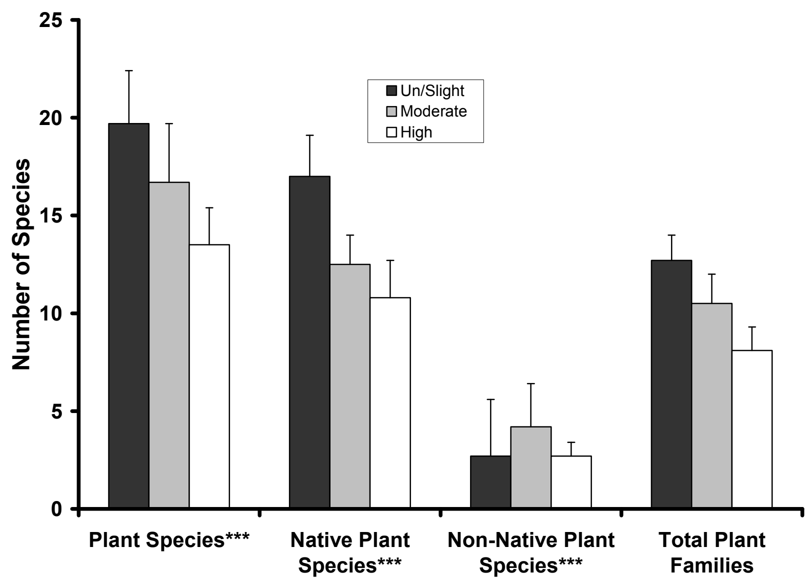

Figure 12. Representative functional characteristics of riparian communities in unstressed or slightly stressed, moderately, and highly stressed Clark County springs. Data compiled by Sada and Nachlinger (1996; 1998).

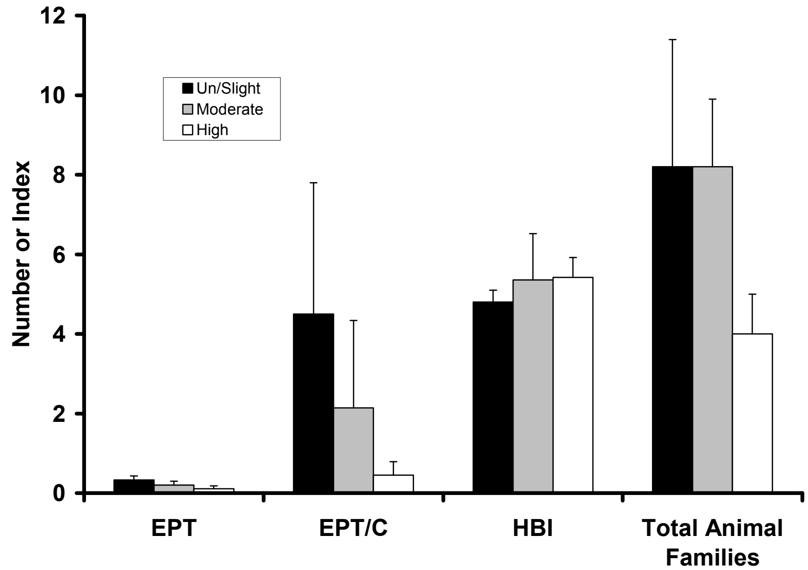

Figure 13. Representative functional characteristics of aquatic communities in unstressed or slightly stressed, moderately, and highly stressed Clark County springs. Data compiled by Sada and Nachlinger (1996; 1998). EPT = as described for Figure 11. EPT/C = EPT/proportion of midges (Chironomidae) relative to EPT in the aquatic community. HBI = Hilsenhoff Biotic Index (Hilsenhoff, 1987).

3.1.4 Desert Riparian and Aquatic Ecosystem

3.1.4.1 Descritpion and Characteristics

The Desert Riparian and Aquatic ecosystem in Clark County generally occurs lower than 1200 m elevation along the Virgin and Muddy rivers, Las Vegas Wash, and the Colorado River (RECON, 2000). In its natural condition (ergo a condition that maintains ecosystem functions and viable biotic populations of native species), the aquatic component of this ecosystem is relatively harsh because of seasonally high water temperatures, harsh water chemistry, high turbidity, scouring floods, and sandy substrates. Water is persistent in some reaches and in others flow is intermittent, particularly during the summer. In perennial reaches the riparian community includes fish, aquatic macroinvertebrates, and 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*), Goodding willow (*S. gooddingii*), velvet ash (*Fraxinus velutina*), desert willow (*Chilopsis linearis*), and mesquite (*Prosopis glandulosa*). Vegetation structure is more complex along perennial reaches and woody vegetation along intermittent reaches is relatively sparse and consists mostly of desert willow and acacia (*Acacia* spp.). Minckley and Brown (1982) believed these riparian communities are relict woodlands that have contracted to rivers and streams from systems that were more wide spread in the southwestern U.S. during ancient mesic periods.

This ecosystem provides essential cover, water, food, and breeding sites for many wildlife species. It is possibly the most degraded ecosystem (ergo an ecosystem whose functional characteristics no longer exist and viable biotic populations of occupying native species are absent) in Clark County as it bears little resemblance to historical conditions because of alterations from flow regulation, invasive aquatic and riparian species, and channelization (stream or river banks armored with rocks or other artificial, hard structures). This system has also been altered by woodcutting, cleared for agriculture, and pumped for groundwater, all of which have lowered water tables and facilitated the down cutting of arroyos.

Characteristics Summary

- Strong hydraulic processes
    - Floods: discharge highly variable
    - Intermittent reaches vary from flowing to dry
- Harsh water chemistry, seasonally high temperature and turbidity
- Fine substrates

Water Persistence

- Ephemeral
    - Temporary and intermittent water
    - Vegetation is less structurally complex (vertical and horizontal)
    - Native woody vegetation sparse (desert willow, *Acacia*)
    - Less complex food web
- Persistent
    - Perennial water
    - Obligatory and facultative wetland species
    - Vegetation structurally complex, relatively dense
    - Fish present
    - Stronger emergent vegetation component
    - Many species of native woody vegetation (cottonwood, ash, mesquite, willow)

3.1.4.2 MSHCP Covered Species

The desert riparian ecosystem is habitat for 14 MSHCP covered species (Table 7), which include two bats, eight birds, three reptiles, and one amphibian. Most of these species depend on readily available water and they are exclusively or primarily associated with this ecosystem. The Southwestern willow flycatcher is a riparian-dependent bird species that is federally listed as endangered.

Table 7. Covered species found in the desert riparian ecosystem.

Common Name	Scientific Name
Silver-haired bat	*Lasionycteris noctivagans*
Long-eared myotis	*Myotis evotis*
American peregrine falcon	*Falco peregrinus anatum*
Yellow-billed cuckoo	*Coccyzus americanus*
Vermilion flycatcher	*Pyrocephalus rubinus*
Southwestern willow flycatcher	*Empidonax traillii extimus*
Phainopepla	*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	*Eumeces gilberti rubricaudatus*
Relict leopard frog	*Rana onca*

3.1.4.3 Ecosystem Drivers

The Desert Riparian and Aquatic ecosystem in Clark County is a dynamic system (experiences a wide variety of environmental conditions) that is sustained by water and strongly influenced by its persistence, scouring floods, and chemistry, temperature, and turbidity. Many of these factors are influenced by local precipitation, geology, and topography. Persistence has a strong influence on riparian and aquatic communities. Perennial reaches support fish and aquatic macroinvertebrates, have higher species richness, and include facultative and obligatory wetland vegetation. Aquatic communities may only occur seasonally in reaches that dry during summer, and riparian communities in these areas are depauperate and usually include only sparse woody vegetation. These systems are also influenced by the amplitude, magnitude, frequency, duration, and timing of winter and monsoon floods. Floods may remove riparian vegetation and facilitate recruitment of some species (e.g., Mahoney and Rood, 1998). Work in other systems illustrates that floods are primary factors influencing aquatic communities (Poff et al., 1997). Harsh conditions that are created by water chemistry, temperature, and turbidity limit aquatic communities to species that can tolerate high temperature, turbidity, and stressful physiological conditions. Riparian vegetation is a biotic driver in this ecosystem because it reduces soil erosion and provides shade that cools water temperature. Submerged aquatic vegetation also increases aquatic habitat complexity.

Drivers Summary

Abiotic Drivers

- Interaction of precipitation patterns, topography, and geology
- Persistence of water
- Flow behavior (hydrograph)
    - Amplitude, magnitude, frequency, duration, and timing of floods
- Water chemistry

    - Physiologically important chemicals (e.g., electrical conductance, salinity, etc.)
    - Water temperature
    - Turbidity

Biotic Drivers

- Vegetation structure

3.1.4.4 Ecosystem Health Threats

The Desert Riparian and Aquatic ecosystem in Clark County may be the most degraded of the 11 MSHCP ecosystems. It has been altered by flow regulation, channelization, and non-native invasive species. The quantity of flowing water has been decreased by dams and diversions that remove water and alter the hydrograph by minimizing peak flood flows. Dams also functionally change lotic (flowing water, as compared to lentic environments characterized by ponded water) environments by replacing flowing habitats with lakes or impoundments. The banks of many stream reaches have also been channelized with gabions and riprap to enhance water movement during floods and to protect agricultural lands, roads, and railroads. Non-native invasive species, such as salt cedar (*Tamarisk*), have replaced native vegetation and reduced riparian biodiversity (Dudley and DeLoach, 2004). Non-native aquatic species such as red shiner (*Notropis leutrensis*), mosquito fish (*Gambusia affinis*), and cichlids (*Oreochromis* spp.) have adversely affected native fishes (e.g., USFWS, 1995; Scoppettone et al., 2005). Additional minor and potential threats are wood harvesting, grazing, mining, and wildfire. Fires, wood harvesting, and grazing degrade these systems by removing vegetation, decreasing recruitment, and enhancing the riparian zone for invasive species. Mining may degrade water quality and increase turbidity.

Threats Summary

Major Threats

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

Minor and Potential Threats

- Wood harvesting
- Fire
- Grazing

3.1.4.5 Potential Ecosystem Health Indicators

Indicators of a degrading desert/aquatic riparian ecosystem would be manifested as increased abundance of invasive species, decreased extent of native riparian and aquatic communities (attributed to channelization, diversion, invasive species, etc.), changes in the natural hydrograph, and the decreased abundance of covered species. The following monitoring programs are suggested to assess these factors:

- Determine changes in the distribution and abundance of invasive riparian and aquatic species
- Determine changes in the composition and physical structure of riparian communities
- Determine level of physiognomic and floristic complexity. Greater physiognomic and floristic complexity is indicative of healthy riparian ecosystem and decreasing complexity would indicate degraded conditions
- Determine changes in the abundance and distribution of covered species
- Monitor stream discharge to determine the extent it has changed from characteristics of the natural hydrograph

Indicators Summary

Abiotic Indicators

- Discharge rate and changes in annual volume, and the amplitude, magnitude, frequency, duration, and timing of flood events

Biotic Indicators

- Aquatic species composition and community structure
    - Native fish communities
    - Non-native invasive species
- Woody vegetation
    - Physiognomy: physical structure
    - Floristics: community composition
    - Non-native invasive species
- Abundance and distribution of covered species

3.1.5 Alpine Ecosystem

3.1.5.1 Distribution and Characteristics

The Alpine ecosystem is defined as the biotic zone of herbaceous and high-altitude tundra vegetation that occurs on mountains above the timberline (Billings, 1973). This ecosystem occurs on all aspects, slopes, and ridge lines where there are extremely low temperatures, strong winds, a seasonal snow cover, short growing season, and low soil nutrients (Billings, 1973; Broll and Keplin, 2005). Sunlight is intense at exposed, unshaded sites. In Clark County, this ecosystem exists above 3,500 m (11, 490 ft) in the Spring Mountains and on Mt. Charleston (Clokey, 1951), where it comprises alpine fell-fields on exposed rocky, dry soils, and alpine meadows that occur in swales where moisture and sand and silt soils accumulate.

The Spring Mountains are entirely surrounded by desert, which has isolated the Alpine ecosystem and facilitated the development of a unique assemblage of plants, including several endemics and the following MSHCP covered species: Jaeger whitlowgrass (*Draba jaegeri*), Charleston tansy (*Sphaeromeria compacta*), hidden ivesia (*Ivesia cryptocaulis*), and Clokey catchfly (*Silene clokeyi*). Due to high elevation, the growing season is short and typically extends from June to August. This ecosystem is particularly susceptible to damage from human activities because of the short growing season, which limits annual plant growth and increases the amount of time required for recovery (Billings, 1973).

3.1.5.2 MSHCP Covered Species

The Alpine ecosystem in Clark County provides habitat for 11 covered species (Table 8), all of which are vascular plants.

Table 8. Covered species found in the Alpine ecosystem.

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*

3.1.5.3 Ecosystem Drivers

Climate is the most important factor influencing this ecosystem's biotic structure and function (Billings, 1973; Bowman, 2001; Korner, 2003), and it is characterized by high winds, low temperatures, and interactions between topography and weather, which strongly influence spatial heterogeneity of vegetation patches and microclimates. Billings (1973, Figure 1) illustrated how ridge tops are exposed and dry because strong winds prevent the accumulation of snow on their windward side and tops. Snow is blown onto the lee slopes, where it accumulates in drifts that melt and provide soil moisture for the lower slopes. Above the tree line, fell-fields are created and maintained by strong winds that blow away the soil and expose bare rocks and gravel. Below the timberline, thin and sandy soils accumulate in patches to form isolated meadows, some of which extend down slope into the bristlecone pine (*Pinus longaeva*) ecosystem.

Avalanches, a natural disturbance in this system, expose new ground for primary succession of alpine plant communities. Succession begins on exposed rocks in fell-fields where pioneer species establish and alter the environment by breaking rocks and forming loci for accumulating soils, where over time, alpine meadow vegetation develops only on stable areas of accumulated soil (Cox, 1933). Later, pines and other woody plants may grow on well drained soils. In addition to vegetation succession, other important biotic drivers are plant-animal interactions and mycorrhizal symbiosis. Pollination (Shaw and Taylor, 1986) and herbivory (Metcheva et al., 2008) are important plant-animal interactions that influence the balance of the Alpine ecosystem. Symbiosis of mycorrhizal fungi provides critical nitrogen fixation for nutrient-poor alpine soils (Kernaghan and Harper, 2001).

Drivers Summary

Abiotic Drivers

- Pollinator insect disease
- Topography: elevation, slope, aspect, and ridge line
  - Microhabitat distribution
- Climate
  - Cold temperatures
  - High Winds
  - Precipitation (snow and rain): timing, duration, and intensity
- Avalanches create new fell-fields

Biotic Drivers

- Vegetation succession: fell-field, meadow, pines
- Plant-animal interaction (pollinators and herbivores)
- Mycorrhizal fungi

3.1.5.4 Ecosystem Health Threats

This ecosystem is fragile due to difficult growing conditions in this harsh environment. The system has low resilience, and as a consequence, relatively minor disturbances may alter it, and recovery may be slow or problematic (Billings, 1973). Climate change was identified as the most significant threat to this ecosystem during the ecosystem health workshop, followed by atmospheric nitrogen deposition, and then factors that may cause change in the abundance or species composition of pollinators. Climate change may alter temperature and precipitation patterns that are among the major physical drivers for this ecosystem. A warming climate may increase temperature and facilitate the upward advance of bristlecone pines into the Alpine ecosystem (Van de Ven et al., 2007; Barber, unpublished data), which, in turn, may drive endemic alpine (and covered) plant species into extinction.

Nitrogen deposition will increase soil nutrients, which may alter the composition of plant communities and increase the occurrence of nitrophilous species (Weiss, 2006). Nitrogen inputs may be particularly high, and its effect substantial, in wet meadows where windblown snow accumulates and water limitations are relatively minor. Water limitations in rocky fell-field communities may restrict the response to growth in these areas from increased nitrogen deposition. Changing climate may affect pollinators by increasing disease, which would cause a concomitant decline in the abundance of host plant species. Direct human disturbances are relatively rare in this ecosystem because it is remote and must be accessed by hiking. However, increased recreation from hiking and camping may cause greater soil compaction and increase erosion. Recreation may also be a vector for introduction of non-native species. Flores (unpublished data) recorded a dandelion (*Taraxacum* sp.), a common garden weed, in the alpine system.

Threats Summary

Major Threats

- Climate change
- Atmospheric nitrogen disposition
- Decrease in pollinators

Potential Threats

- Pollinator insect disease
- Invasive plants, e.g., dandelion

3.1.5.5 Potential Ecosystem Health Indicators

The workshop participants suggested several monitoring programs to assess changes in health of the Alpine ecosystem:

- Delineate fell-field, meadows, and timberline through time to understand patch size, spatial structure, and potential successional shift
- Monitor demography and distribution of endemic plant species (which includes most of the MSHCP covered species in this ecosystem)
- Monitor composition of the pollinating insect assemblage and determine the asynchronous relationship between plant's and pollinator's phenology
- Monitor environmental factors (e.g., temperature, precipitation, air chemistry, nitrogen, pH, and other pollutants, etc.) in concert with biological monitoring to determine biotic-environment relationships, and track how these factors vary over time
- Although there is insufficient information to provide guidance in the Spring Mountains, small mammals may also be used as indicators to track change in this ecosystem (Metcheva et al., 2008)

Indicator Summary

Abiotic Indicators

- Air temperature
- Air/snow chemistry
- Precipitation dynamics

Biotic Indicators

- Spatial structure and extent of fell-fields and meadows
- Successional shift in fell-field and meadow plant communities

- Demography and distribution of endemic plants
- Pollinator assemblage composition (especially for meadows) and phenology

3.1.6 Bristlecone Pine Ecosystem

3.1.6.1 Distribution and Characteristics

The Bristlecone Pine ecosystem is comprised of evergreen conifer woodland dominated by widely spaced Great Basin bristlecone pine (*Pinus longaeva*), with frequent pure stands from the tree line down to its contact with limber pine (*P. flexilis*).

In Clark County, this ecosystem ranges in elevation from 2,700 m to 3,500 m (8,858 ft to 11,490 ft), and occurs 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). Bristlecone pines grow very slowly and they are very long-lived. Their crowns are rounded or irregular and high winds at timberline sometimes create a krummholz form. Dense bristlecone pine forests have low understory species richness and productivity. Associated shrub species, such as dwarf juniper (*Juniperus communis*), Clokey mountain sage (*Salvia dorrii* var. *clokeyi*), and sagebrush (*Artemisia* sp.) are widely scattered except in natural openings and near forest edges (RECON, 2000). Dead bristlecone pines decay slowly in this cold environment, persist for thousands of years, and provide special microhabitats that are shelter for its recruitment and other animal species in this ecosystem. Recruitment is episodic and affected by annual climate and by seed predation attributed to rodents and birds. Fires are usually caused by lightning, but they are infrequent and typically affect small areas. However, areas with more dense forests, such as north facing slopes, may be susceptible to larger fires.

Bristlecone pines grow on dolomitic, nutrient-poor alkaline substrate that is gravelly with many rocks and coarse sand (Lanner, 2007). Soils in this ecosystem are dry because of low organic content and rapid drainage through coarse material. This environment is milder than that characterizing the Alpine ecosystem, but it is also extreme because of cold temperatures, intense sunlight, low soil nutrients, a short growing season, and lengthy periods of snow cover (Broll and Keplin, 2005). Tree distribution is also influenced by slope, aspect, and elevation. These features interact with weather, affecting availability of suitable microhabitats for bristlecone pines and its associated flora and fauna.

Characteristics Summary

Abiotic Characteristics

- High elevation, extreme physical environment (cold, windy, snowy, short growing season)
- Topography (slope, aspect) interacts with weather to provide habitable sites
- Dolomite (limestone), low soil nutrients
- Low fire risk in most areas
- Persistent dead wood creating recruitment microhabitat

Biotic Characteristics

- Low species richness

- Low productivity
- Sparse vegetation
- Very high seed predation (low seed dispersal)
- Recent (50 years) episodic recruitment

3.1.6.2 MSHCP Covered Species

The Bristlecone Pine ecosystem provides habitat for 24 MSHCP covered species (Table 9), comprising one mammal (Palmer's chipmunk), six butterflies and 17 vascular plants.

Table 9. Covered species found in the Bristlecone Pine ecosystem.

Common Name	Scientific Name
Palmer's chipmunk	*Tamias palmeri*
Spring Mountains icarioides blue	*Icaricia icarioides* ssp.
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*
Charleston pussytoes	*Antennaria soliceps*
Rosy king sandwort	*Arenaria kingii* ssp. *rosea*
Clokey paintbrush	*Castelleja martinii* var. *clokeyi*
Clokey thistle	*Cirsium clokeyi*
Jaeger whitlowgrass	*Draba jaegeri*
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. *harlestonensis*
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*

3.1.6.3 Ecosystem Drivers

Weather and dolomite (nutrient poor) soil are two primary environmental factors influencing bristlecone pine abundance and distribution (Beasley and Klemmedson, 1973; 1980). Nitrogen fixing mycorrhizal fungi may enhance bristlecone pine growth on poor nutrient soil (Fisher and Fule, 2004). Bristlecone pine recruits and survives better in years that have a higher average precipitation plus overall cooler summer temperatures. These trees may have such extreme life expectancies because the harsh environment provides good protection from diseases and herbivorous insects (Lanner, 2007). Currently, the major natural mortality is caused by lightning and lightning caused fire. Dead bristlecone pines decay slowly, persist for a long time, and provide shelter, trap soils, and retain moisture. This facilitates bristlecone recruitment and creates microhabitat for other plant and animal species. Recruitment is episodic and occurs mostly during years when optimal precipitation patterns and temperatures occur. Seed predation by rodents and birds is extremely high.

Drivers Summary

Abiotic Drivers

- Cold temperature
- Climate (cool and wet versus hot and dry)
- Lightning (cause of death, resulting from weather)
- Precipitation (monsoon, snowpack)
- Low nutrient, dolomite soil

Biotic Drivers

- Mycorrhizae
- Dead-wood for recruitment and habitat for other species (microhabitat provides shelter and retains moisture)
- Avian and rodent seed predation

3.1.6.4 Ecosystem Health Threats

The Bristlecone Pine ecosystem is threatened by climate change (Lanner, 2007). Barber's (unpublished data) recent field study in the White Mountains, California, indicates that bristlecone pines are growing slowly, with increasing number and density, upward into Alpine ecosystem as the climate warms. The influence of this change for the Bristlecone Pine ecosystem may be critical, because although the species recruits well with warmer temperatures the climate may warm sufficiently to eliminate the cooler temperatures that are required for the pine to grow slowly and live longer. This may result in a more rapid attrition rate than at present, with associated reduction in what is now thought of as mature stands, and the ecosystem services they provide.

Additionally, a warmer and wetter climate may create conditions whereby organisms in this ecosystem are more susceptible to disease and insect invasion. Blodgett and Sullivan (2004) reported the first white pine blister rust (*Cronartium ribicola*) infection in the Rocky Mountains bristlecone pine (*P. aristata*). The Great Basin bristlecone pine, which also belongs to the white pine group, is a potential host for white pine blister rust (Kliejunas and Adams, 2003) The mountain pine beetle (*Dendroctonus ponderosae*) may also become an important factor because it may breed more rapidly and cause more damage to bristlecone pines in warmer climates. Dense forest caused by warmer weather plus deadwood caused by bark beetles may create conditions that are conducive to burning and may change future fire regimes. Recreational collection and use of bristlecone pine wood for campfires are other threats to this ecosystem. Harvesters collect wood from both dead trunks and live trees, which affects growth and seed production and the quantity of microhabitat necessary for recruitment. Camp fires may cause fires and burn trees. Although there is no sign of invasion of non-native species in this ecosystem, introduction of non-native species is a potential threat that could alter the forb communities, impact animal fauna, and attract fires, especially under a warming climate.

Threats Summaries

Major Threats

- Climate change
- Recreation
  - Harvesting
  - Camping/fires

Minor and Potential Threats

- Bark beetles
- White pine blister rust
- Changing fire regime
- Introduction of non-native species

3.1.6.5 Ecosystem Health Indicators

The workshop participants suggested that the health of this ecosystem can be tracked by the following:

- Monitoring for changes in spatial and temporal variability in bristlecone populations by:
  - Monitoring and delineating the areal extent of young recruitment, adult mortality, and deadwood of bristlecone pine
  - Determining and tracking growth rates of trunks and foliage, and forest age structure. These tasks should occur in concert with environmental monitoring that tracks changes in climate, temperature, and precipitation, which will increase understanding of the relationship between forest demography and the environment
- Monitoring of air and snow chemistry to show changes occurring from factors such as atmospheric nitrogen deposition, acidity (ergo pH), and other pollutants
- Monitoring understory forb communities. This is important because they provide habitat for MSHCP covered plant and butterfly species. These communities also constitute the highest species richness of vegetation occurring in this ecosystem

Indicators Summary

Abiotic Indicators

- Temperature change
- Air/snow chemistry

- Precipitation dynamics

  Biotic Indicators

- Demography
  - Recruitment
    - Location, density
    - Frequency
  - Adult mortality
  - Growth rates
    - Trunk
    - Foliage
- Deadwood density
- Changes in forb community structure

3.1.7 Mixed Conifer Ecosystem

3.1.7.1 Distribution and Characteristics

In Clark County, the Mixed Conifer ecosystem consists of shrubs and conifers and occurs between 1,200 and 3,200 m (3,940 and 10,500 ft) in elevation. Annual precipitation is approximately 50 cm (20 in) from winter snow and summer storms. Mature trees are taller than 20 m (66 ft) and grow sufficiently close to one another to provide a canopy cover that ranges from 30% to 60% (Schoenherr, 1992). Species diversity of trees, shrubs, forbs, and animals is high because of the wide diversity of forest, shrub, and forb habitat in this ecosystem. As a consequence, this system supports a large number of covered species, including eight butterflies and 14 vascular plants that are endemic to the Spring Mountains. Low intensity fires are frequent in this system, and they are important for removing excess biomass from shrub assemblage, recycling nutrients into soils, and creating forest openings. High intensity (mega) fires also occur, typically covering greater areas and creating large open patches that fragment the uniform vegetation that characterizes a climax mixed conifer community. Low and high intensity fires create a heterogeneity of successional states and enhance species diversity.

There are three community types in the Clark County Mixed Conifer ecosystem (RECON, 2000). The white fir community is dominated by white fir *(Abies concolor*). It occurs in the Spring and Sheep mountains on north and east-facing slopes at elevations between 2,200 and 3,200 m (7,218 and 10,500 ft). Associated trees include bristlecone pine (*P. longaeva*) and limber pine (*P. flexilis*), at the higher elevations, and ponderosa pine (*P. ponderosa*) at lower elevations.

The ponderosa pine community encompasses the most extensive conifer forest in Clark County. This community ranges from 1,200 to 2,700 m (3,940 to 8,858 ft) and is dominated by ponderosa pine, which often occurs in nearly pure stands. Associated species are white fir, bristlecone pine, pinyon (*P. monophylla*), juniper (*Juniperus osteosperma*), limber pine, and mountain mahogany (*Cercocarpus* spp.).

The ponderosa pine/mountain shrub community is an extension of the conifer forest that is characterized by lower ponderosa pine canopy (less than 30 percent) and co-dominance with mountain shrubs, such as oak (*Quercus gambelii)*, mountain mahogany, snowberry (*Symphoricarpos albus*), and manzanita (*Arctostaphylos* spp.).

Characteristics Summary

Abiotic Characteristics

- High annual moisture/precipitation (> 50 cm, >20 in)
- Frequent small fires clear understory
- Infrequent large fires create mosaic of successional states

Biotic Characteristics

- Closed canopy (30-60%)
- Tall tree stands (> 20 m, > 66 ft)
- High diversity in trees, shrubs, forbs, and animals
- High butterfly diversity
- High endemism

3.1.7.2 MSHCP Covered Species

The Mixed Conifer ecosystem provides habitat for 34 MSHCP covered species (Table 10). They include Palmer's chipmunk, American peregrine falcon, western red-tailed skink, Sonoran lyre snake, three bats, eight butterflies, 18 vascular plants, and one dicranoweisia moss.

Table 10. Covered species found in the Mixed Conifer ecosystem.

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*
Charleston pussytoes	*Antennaria soliceps*
Dicranoweisia moss	*Dicranoweisia crispula*

3.1.7.3 Ecosystem Drivers

Relatively high precipitation, mild temperatures, long growing season, and fire frequency, intensity, and magnitude are the major natural abiotic drivers influencing the Mixed Conifer ecosystem. High moisture and mild temperatures provide for a long growing season (Smith and Knapp, 1990) and the relatively closed canopy maintains soil moisture and provides shade for relatively diverse understory shrub and forb communities. This diverse vegetation provides habitats for a high diversity of animal species. Frequent low intensity fires clear understory vegetation and infrequent high intensity fires create a mosaic of forest age classes (Battaglia and Shepperd, 2007). In addition, occasional avalanches also open patches where succession from shrub to coniferous forest may occur. There are several rodent and bird species that forage on seeds, but many of these species also cache seeds and facilitate seed dispersal and therefore conifer recruitment (Lanner, 1996).

Drivers Summary

Abiotic Drivers

- Moisture (high precipitation of snowfall/rainfall)
- Temperature, length of growing season
- Fire
    - Frequent small fires clean understory shrubs and recycles nutrients
    - Infrequent large fires remove old trees and create a mosaic of varying age stands
- Avalanches

Biotic Drivers

- Diverse vegetation supports high diversity of animal species
- Seed-dispersal by birds and rodents

3.1.7.4 Ecosystem Health Threats

The Mixed Conifer ecosystem is affected by many human activities. These include fire management, recreation, rural development, and water diversion. Past fire management has altered the natural fire regime and allowed increased forest density and biomass accumulation. This has resulted in decreasing low intensity, small fires and increasing incidence of high intensity fires that burn large areas and are more destructive of habitat (Battaglia and Shepperd, 2007). Rural development has covered portions of this ecosystem with impervious surfaces (e.g., homes, roads, drainage systems, etc.), which also eliminate habitat and fragment natural areas, and has altered water flow patterns and volume. Fragmentation degrades this ecosystem by inhibiting wildlife movement, providing avenues for introduction of invasive plants, and increasing exposure of wildlands to fire. Changing water flow patterns and volume typically reduces water for this ecosystem, which may influence the composition of plant and animal communities. Non-native plants, usually understory species such as puncture vine (*Tribulus terrestris*), also affect mixed conifer systems by competing with native species and enhancing conditions that create large and frequent fires. Non-native animals such as the house cat (*Felix catus*) and burro (*Equus asinus*) may predate native species, graze vegetation, and compete with native species for food resources. Grazing may reduce native vegetation and open spaces potentially suitable for establishment of invasive species. Recreation may stress wildlife, create erosion, and degrade water quality. The small mining operations that also occur in the Mixed Conifer ecosystem may affect the system by introducing pollutants and disturbing surface areas, which may alter vegetation communities and encourage the spread of invasive species. Air pollution may also increase ozone concentrations, which may threaten this system.

Threats Summary

Major Threats

- Change of fire regimes by past fire management (fire suppression)
    - Mega fires
    - Forest densification
- Rural development
    - Impervious surfaces
    - Fragmentation
- Water diversion
- Recreation
- Non-native invasive species

Minor and Potential Threats

- Non-native species (animals and plants)
- Pollution (ozone)

- Mining

3.1.7.5 Ecosystem Health Indicators

The following are suggested to assess health of the Mixed Conifer ecosystem in Clark County:

- Monitor precipitation, one of the major drivers of this ecosystem, and temperature, and determine amount and pattern of precipitation (snow and rain)
- Delineate fire history and determine the intensity and frequency of ground and crown (mega) fires
- Quantify forest and understory plant community structure and species diversity
- Integrate information from biotic and abiotic monitoring to determine salient environmental factors that affect these forest and understory biotic metrics
- Monitor spatial and temporal variability in demography and distribution of MSHCP covered species
- Monitor air and snow chemistry for airborne pollutants that may affect this ecosystem

Indicators Summary

Abiotic Indicators

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

Biotic Indicators

- Forest structure and species composition
- Understory species richness and composition
- Abundance and distribution of MSHCP covered species

3.1.8 Pinyon Juniper Ecosystem

3.1.8.1 Distribution and Characteristics

The Pinyon Juniper ecosystem is characterized by an open woodland of low, round crowned, evergreen, bushy trees (Lanner, 1975). The trees are well spaced and range from 10-15 m (33-50 ft) in height (Küchler, 1977; Tueller and Clark, 1975). Individual tree crowns rarely touch and canopy cover is generally less than 50 percent (Larson, 1980). When these groves of overstory trees are open they can have a dense to open layer of shrubs reaching heights of 1.5 m (5 ft) with low herbaceous plants (Küchler, 1977). Once trees dominate the site, these understory species are largely lost (Miller and Tausch 2001). In Clark County, the Pinyon Juniper ecosystem is distributed within elevational bands ranging from 1,500 to 2,500 m (4,920 to 8,200 ft) around the Spring Mountains, Sheep Mountains, and Virgin Mountains with an island community in the McCullough Mountains (RECON, 2000). 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 elevations, Utah juniper (*Juniperus osteosperma*) dominates, with Rocky Mountain juniper (*J. scopulorum*), western juniper (*J. occidentalis*) and shrub species such as rabbitbrush (*Chrysothamnus spp.*) and blackbrush (*Coleogyne ramosissima*) being present depending on location. Single leaf pinyon and Utah juniper co-dominate at middle elevations and sagebrush (*Artemisia* spp.) co-exists with pinyon-juniper at all elevation levels.

Stand structure varies depending on site quality, elevation, and disturbance history. Dense pinyons and junipers occur on suitable sites with little disturbance, while the distance between trees increases and tree size decreases on drier sites (Lanner, 1975). Pinyon-juniper stands are rather open at lower elevations and dense at higher elevations (Zarn, 1977). Studies have shown that there are three types of pinyon-juniper stands (Tausch and Hood, 2007; Miller et al., 2008). Sparse and relatively dense stands with diverse age-class distributions are old, pre-settlement growth, and dense stands with relatively even age-class distributions are relatively young and established following European settlement. The change in fire regimes, introduction of livestock grazing, and climatic conditions after European settlement may have caused an expansion of even age-class stands in the Pinyon Juniper ecosystem resulting in a structural and functional change that has affected the system's carrying capacity for fire (Miller and Tausch 2001; Tausch and Hood, 2007; Miller et al., 2008). Pinyon pines and junipers are not fire-resistant and are very flammable. Factors such as fires and avalanches clear old stands and create a mosaic of stands with different densities and diversify the associated perennial grass, forb, and shrub assemblages.

3.1.8.2 MSHCP Covered Species

The Pinyon Juniper ecosystem provides habitat for 33 MSHCP covered species (Table 11). They are similar to species in the Mixed Conifer ecosystem with the addition of lower altitude species and seven reptiles. The plant list includes 10 vascular and four non-vascular species. The animal species includes Palmer's chipmunk, American peregrine falcon, three bats, seven reptiles, and seven butterflies. Peregrine falcons forage and nest in this habitat.

Table 11. Covered species found in the Pinyon Juniper ecosystem.

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 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*
Charleston grounddaisy	*Townsendia jonesii* var. *tumulosa*
Limestone violet	*Viola purpurea* var. *charlestonensis*
Anacolia menziesii	*Anacolia menziesii*
Claopodium whippleanum	*Claopodium whippleanum*
Dicranoweisia crispula	*Dicranoweisia crispula*
Syntrichia princeps	*Syntrichia princeps*

3.1.8.3 Ecosystem Drivers

Distribution of the Pinyon Juniper ecosystem is limited by the combination of precipitation, temperature, soil, and topography. Pinyon and juniper grow on gently rolling hills to steep mountain slopes, rocky canyons, and narrow ridges (Bradley and Deacon, 1967) where precipitation ranges between 17 cm and 50 cm (7 in and 20 in), (West et al., 1975), and where soils are shallow typically rocky, coarse, porous, and well drained (Fowells, 1965). Elevation of this ecosystem is between 1,500 m to 2,500 m (4,920 ft to 8,200 ft) with pinyon pines at higher elevations than junipers. Disturbances caused by fires can vary in frequency and intensity (Miller and Tausch, 2001). Avalanches can locally facilitate the successional cycle and create a mosaic of woodland, shrub, and forb plant communities in this ecosystem. Seed predators, such as jays, nutcrackers, and chipmunks play an important role in seed dispersal and young recruitment for pinyon-juniper (Lanner, 1996). Johnson et al. (1990) suggested that increasing atmospheric CO_2 levels may contribute to expansion of pinyon-juniper woodlands.

Drivers Summary

Abiotic Drivers

- Climate
    - Temperature
    - Precipitation (drought, monsoon)
- Soil depth
- Slope (topographic position)

- Frequent low intensity fire
- Avalanche
- Atmospheric CO_2 level

Biotic Drivers

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

3.1.8.4 Ecosystem Health Threats

Studies in the Great Basin suggest that changes in fire regime (Tausch and Hood, 2007; Miller et al., 2008) and invasion of cheatgrass (*Bromus tectorum*) (Pellant, 1990; 1996) are the major factors that threaten the Pinyon Juniper ecosystem. Pinyon and juniper are very flammable and weakly resistant to fire because of their thin bark. Under existing conditions, most of this ecosystem bears little resemblance to historic conditions (conditions established during history and existing before influences of modern man) (Miller and Tausch 2001). Stand density is unusually high and woodlands are susceptible to intense, hot fires that scorch and sterilize soils and retard natural succession. Under these conditions, cheatgrass invades and the incidence of fire increases because cheatgrass is a species that rapidly covers the ground with highly flammable material. In addition, once dead, cheatgrass plants can have low palatablity for sheep and other livestock (Rummell, 1946). Native plants can be over-grazed where cheatgrass prevails. However, cheatgrass in Clark County may not be as hazardous to this ecosystem as it is in the Great Basin because summer moisture in Southern Nevada may diminish the incidence of fire in the region. As the climate dries and becomes warmer (Seager et al., 2007), the incidence of fire may increase in Southern Nevada, resulting in more dynamic conditions in this and surrounding ecosystems.

Unlike pinyon-juniper woodlands in many other regions, livestock grazing does not occur in this ecosystem in Clark County. Minor and potential threats to this ecosystem are rural and water (ergo spring) development, recreation, bark beetles, pine blister rust, and air pollution. Rural development and recreation also alters vegetation communities and fragments natural habitats. These activities may also increase the incidence of human-induced fire, erosion, and non-native species. Bark beetle and pine blister rust have occurred in the Pinyon Juniper ecosystem for many years, and they are currently not threats. They may become major threats if water availability in this ecosystem is decreased by water diversion or climate change and trees are weakened and more vulnerable to bark beetles and blister rust. Increasing global CO_2 concentration may also influence the expansion of pinyon-juniper woodlands.

Threats Summary

Major Threats

- Climate change
- Expansion of dense woodlands

- Changing fire regimes
- Increase in cheatgrass (invasive species)

Minor and Potential Threats

- Rural development
    - Homes
    - Roads
- Recreation
    - Fire
    - Erosion
    - Introduction of weeds
- Effects of past livestock grazing
- Bark beetles
- Pinyon pine blister rust
- Air chemistry: CO_2 concentration

3.1.8.5 Ecosystem Health Indicators

A healthy Pinyon Juniper ecosystem is composed of woodlands with a diversity of age classes and an understory of native shrubs and forbs. Health of this ecosystem is represented by plant community composition and vegetation structure, and can be monitored by:

- Periodically delineating the distribution of trees (pinyon and juniper) and shrubs from aerial photography and remote sensing technology to track tree density and cheatgrass cover
- Periodically conducting field surveys to determine and track the density, assemblage composition, and demography of trees, shrubs, and forbs
- Assessing the physiognomic structure of vegetation, such as shrub height and width, tree height, canopy size and cover
- Measuring understory biomass, which indicates the capability of vegetation to carry ground fires
- Surveying for invasive species such as cheatgrass and damage from bark beetle and blister rust
- Tracking changes in the fire regime by delineating the distribution and schedule of historic fires using aerial photographs

Indicators Summary

Abiotic Indicators

- Fire history: change of fire regimes

Biotic Indicators

- Tree, shrub, and forb density
- Vegetation community structure and demography
- Vegetation physiognomic structure
- Understory biomass
- Cheatgrass cover

3.1.9 Sagebrush Ecosystem

3.1.9.1 Description and Distribution

Sagebrush is a collective term applied to shrubby members of the genus *Artemisi,a* and in Clark County, that includes big sagebrush (*A. tridentata*), low sagebrush (*A. arbuscula*), Bigelow sagebrush (*A. bigelovii*), silver sagebrush (*A. cana*), and black sagebrush (*A. nova*). The dominant sagebrush species differs in response to local characteristics of topography, soil composition, and moisture (see Ecosystem Drivers for detail). 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, has a life span of 20 to 200 years, usually has a single, short, thick stem that branches into a nearly globular crown (Welch, 2005). Plant height ranges from 0.5 m to 3 m (1.6 ft to 10 ft) 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 system of lateral roots that are near the soil surface, that exclude most competing plants in an area that is up to three times the crown area. These adaptations may produce stands with shrubs of uniform size and spacing (Neal, 1988). A fire interval of 35 years to 40 years is a natural disturbance in this ecosystem (Kitchen and McArthur, 2007). In Clark County, this ecosystem typically ranges in elevation from 1,500 m to 2,800 m (4,920 ft to 9,200 ft) in the Spring, Sheep, and Virgin mountains (RECON, 2000).

Big sagebrush may occur in pure stands and it is commonly mixed with mountain mahogany (*Cercocarpus ledifolius*) and Utah juniper (*Juniperus osteosperma*) (Clokey, 1951). It is also associated with pinyon (*Pinus monophylla*) and ponderosa pine (*Pinus ponderosa*). Other associated shrubs include rabbitbrush (*Chrysothamnus* spp.), snakeweed (*Gutierrezia sarothrae*), blackbrush (*Coleogyne ramosissima*), shadscale (*Atriplex confertifolia*), spiny hopsage (*Grayia spinosa),* and bitterbrush (*Purshia tridentata*). Associated grass species include perennial bunchgrasses (*Agropyron* spp.), bluegrass (*Poa* spp.), needlegrass (*Stipa* spp.), fescues (*Festuca* spp.), galleta (*Pleuraphis jamesii*), and the introduced cheatgrass (*Bromus tectorum*). Grasses usually make up less than 25 percent of the ground cover in this ecosystem.

3.1.9.2 MSHCP Covered Species

The Sagebrush ecosystem provides habitat for 20 covered species (Table 12). Animal species include American peregrine falcon, two bats, six reptiles, and five butterflies. The list of plants includes five vascular and one non-vascular species. The dark blue butterfly (*Euphilotes enoptes purpurea*) occurs exclusively in this ecosystem.

Table 12. Covered species found in the Sagebrush ecosystem.

Common 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*

3.1.9.3 Ecosystem Drivers

Topography, soil composition, and moisture are the major physical factors driving the Sagebrush ecosystem (Neal, 1988; Welch, 2005). Low sagebrush dominates on low flats where soils are shallow and black sagebrush dominates where soils are high in gravel and carbonates. Fire, a natural disturbance, influences the population dynamics of sagebrush and the natural succession of communities in this ecosystem (Wright and Bailey, 1982). Big sagebrush, the dominant plant species, has beneficial effects, such as soil building, water conservation, and seed germination for other plant species (Welch, 2005), and it can be considered a biological driver.

Drivers Summary

Physical Drivers

- Temperature
- Precipitation (moisture regime)
    - Quantity

    - Capacity availability
- Soil types
- Topoclimate (orographic effects: topographical location of precipitation)
- Fire regimes (natural disturbance)

Biotic Drivers

- Big Sagebrush (beneficial effects for other plants)
    - Soil building
    - Water conservation
    - Seed germination of other species

3.1.9.4 Ecosystem Health Threats

The Sagebrush ecosystem has been identified as the most endangered ecosystem in the United States (Welch, 2005; Chambers, 2001; 2008). Threats to this ecosystem include invasive plants, pinyon-juniper woodland expansion, altered fire regimes, and excessive livestock grazing (Welch, 2005; Chambers, 2001; 2008). Cheatgrass has been replacing sagebrush and other associated plant species throughout the Great Basin and its presence facilitates an increase in fire frequency. Cheatgrass also greens up early, which reduces early season soil moisture and sagebrush recruitment. Pinyon and juniper are expanding into this ecosystem due to the cumulative effects of climate change, overgrazing, and fire suppression. The increase in woody fuels results in greater fire size and severity in the Sagebrush ecosystem. Excessive livestock grazing also alters the composition and structure of vegetation in the Sagebrush ecosystem and facilitates establishment of invasive annual grasses. An increase in biomass of these invasive species increases fire frequency. Large areas of sagebrush systems in Southern Utah have been invaded by pinyon-juniper woodlands. Increasing CO_2 may be contributing to these changes (Tausch and Hood, 2007). In addition, cheatgrass has replaced sagebrush over the past several decades, which has serious implications for changes in fire regime (Chambers et al. 2007). Although, in Clark County, it does not appear that these threats are as severe as they are in the Great Basin. The possibility of similar structural and functional changes in communities occurring in Clark County is of considerable concern.

Additional threats in Clark County include global climate change, air pollution, rural development, recreation, and military activities in this region. A warming climate may affect this ecosystem by decreasing sagebrush at lower elevations and moving it into higher elevations. Air pollution (NO_X and CO_2) may influence plant growth and cause changes in plant community composition. Rural development, recreation, and military activities may destroy plants, harden the soil surface, and prevent establishment of new plants. Sagebrush is widely distributed and the group includes many subspecies and genotypes. During restoration programs, it is essential that the correct genotype is selected to avoid introducing mal-adapted genotypes into local sagebrush ecosystems (Mahalovich and McArthur, 2004).

Threats Summary

Major Threats

- Cheatgrass (competes for water, affects fire regimes)
- Change of fire regimes: mega fires
- Pinyon-juniper expansion
- Over-grazing
- Introduction of maladapted genotypes

Minor and Potential Threats

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

3.1.9.5 Ecosystem Health Indicators

Sagebrush ecosystem health can be determined by tracking sagebrush density and composition of the plant community. These can be determined by monitoring:

- The distribution and density of sagebrush to determine trends in its population dynamics (e.g., recruitment and mortality)
- The distribution and density of pinyon-juniper woodlands to determine their expansion into the Sagebrush ecosystem
- The floristic composition and physiognomic structure of vegetation communities
- The coverage of cheatgrass and other invasive species to inform invasive species management programs
- Ant communities that may indicate healthy and degraded sagebrush systems
- Cryptobiotic crusts. Cryptobiotic crusts are beneficial associations of cyanobacteria, mosses, and lichens. They hold soils in place and protect the underlying sediments from erosion. They are also an important pioneer stage in ecological succession of bare ground that facilitates the establishment of grasses and forbs

Indicators Summary

Biotic Indicators

- Sagebrush distribution and density
- Big sagebrush recruitment and mortality
- Distribution and density of pinyon-juniper woodlands

- Plant community composition
- Distribution and density of cheatgrass
- Ant community structure
- Presence and abundance of cryptobiotic crust

3.1.10 Blackbrush Ecosystem

3.1.10.1 Description and Distribution

The Blackbrush ecosystem is a woody evergreen shrubland dominated by blackbrush (*Coleogyne ramosissima*), with associated plant species including Mormon tea (*Ephedra* spp.), wolfberry (*Lycium* spp.), hopsage (*Grayia spinosa*), and grasses (Brooks et al., 2007). Blackbrush canopy cover ranges from 20 to 50 percent, height ranges from 0.25 m to 2.5 m (0.82 to 82 ft), and longevity is up to 300 years. In Clark County, the Blackbrush ecosystem occupies coarse, rocky soils on upper bajadas, slopes, and valleys between 1,200 and 1,800 m (3,940 and 5,900 ft) elevation. Blackbrush prefers fine textured vesicular aridisols. Density is highest in late seral stands on shallow sandy soils that overlay strong petrocalcic (caliche) horizons, which severely limit water infiltration and movement. Plant density is lowest on deeper, silty soils, and at its upper and lower elevation boundaries. The relatively impervious petrocalcic horizon occurs near the surface and prohibits growth of new blackbrush and other plants. Ground dwelling animal species, such as pocket mice and kangaroo rats and insects, create holes that facilitate water infiltration and seedling growth.

Juniper (*Juniperus osteosperma*) is the primary tree in this system. Associated shrubs include spiny hopsage (*Grayia spinosa*), Mormon tea (*Ephedra* spp.), shadscale (*Atriplex confertifolia*), desert thorn (*Lycium* spp.), snakeweed (*Gutierrezia sarothrae*), creosote bush (*Larrea tridentata*), Joshua tree (*Yucca brevifolia*), and yucca (*Yucca* spp.). Blackbrush is very flammable and poorly adapted to fire. After burning, reestablishing the natural condition (ergo a condition that maintains ecosystem functions and viable biotic populations of native species) of this system may require centuries because of low blackbrush recruitment and growth rates (Webb et al., 1987).

3.1.10.2 MSHCP Covered Species

There are 10 covered species in the Blackbrush ecosystem of Clark County (Table 13). All of the seven animals are reptiles and the remaining species are vascular plants.

Table 13. Covered species found in the Blackbrush ecosystem.

Common Name	Scientific Name
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*
Mojave green rattlesnake	*Crotalus scutulatus scutulatus*
Spring Mountains milkvetch	*Astragalus remotus*
White-margined beardtongue (penstemon)	*Penstemon albomarginatus*
White bearpoppy	*Arctomecon merriamii*

3.1.10.3 Ecosystem Drivers

Distribution of the Blackbrush ecosystem is influenced by moisture, temperature, and soils. Blackbrush density is greatest at higher elevations where soil moisture and organic matter are high. Its density is lowest at sites with high soil temperature and compaction (Lei and Walker, 1997) and at upper and lower ecotones. Presence of a petrocalcic horizon near the surface prohibits growth and recruitment of new blackbrush and other plants, although the influence of this horizon on plants is ameliorated by burrowing animals that break the horizon, which also allows water to percolate more deeply and be more available to plants over longer periods. The blackbrush system is one of the most flammable native plant assemblages in the Mojave Desert. Fires burn plants to ground level and kill most seeds in the soil seedbank (Brooks et al., 2007). Since recruitment is low for all plants in this ecosystem, it commonly takes centuries for it to recover following fire (Webb et al., 1987; Minnich, 2003). Blackbrush and associated shrubs act as traps for wind-blown materials such as leaves, fruits, and dead insects which are deposited under their canopies, providing food sources for animals living under the shrubs (e.g., rodents and ants).

Divers Summary

Abiotic Drivers

- Precipitation (timing, amount)
- Temperature
- Topography: elevation
- Soil: sandy shallow soil with high moisture and organic matter
- Petrocalcic soil horizon limits recruitment and growth
- Infrequent fire: slow recovery from disturbance
- Aeolian deposition

Biotic Drivers

- Rodent density, small mammal and insect burrowing

3.1.10.4 Ecosystem Health Threats

Fire, invasive species, grazing, pesticide application, land development, and recreation are the greatest threats to the Blackbrush ecosystem. Since blackbrush is very flammable and recovery is slow after fire, fire creates vacant areas that are well suited to colonization of invasive species such as cheatgrass (*Bromus tectorum*). These species may adversely affect native plant recruitment and increase fire frequency by producing large quantities of dry biomass that frequently burns and changes the natural fire regime. Establishment of non-native vegetation after fire may increase an area's suitability for grazing, which may in turn retard the recovery of blackbrush as livestock grazing tends to create openings in the vegetation and facilitate invasion of brome and other non-native species. Blackbrush is unpalatable and a natural blackbrush ecosystem is therefore poorly suited to livestock grazing. Traffic by foot, bike, and off-road vehicles, and trampling by livestock may also cause removal and compaction of top soils and reduce plant recruitment. Moreover, areas of this ecosystem are replaced by impervious surfaces, roads, and trails that are associated with rural and urban development and cause habitat fragmentation.

Additional factors that potentially threaten the Blackbrush ecosystem are pesticides, climate change, air chemistry, and fire ants *(Solenopsis* spp.). Application of pesticides near developed areas may reduce burrowing insects and rodents, which will affect plant growth and recruitment. An increase in atmospheric CO_2 concentration that will accompany climate change may affect this system in many ways, such as encouraging growth of non-native plants (Smith et al., 2000). Other potential threats of changing climate are changing soil moisture and warming temperatures which may alter the fauna and flora of this ecosystem. The spread of fire ants can affect this ecosystem by excluding other ant species, burrowing insects, and small animals that dig burrows that improve plant recruitment by breaking the petrocalcic soil horizon.

Threats Summary

Major Threats

- Fire
- Invasive plant species
- Rural and urban development (roads, impervious surfaces)
- Livestock grazing and trampling
- Recreational activities (foot traffic, OHVs)
- Decreased recruitment

Potential Threats

- Pesticides
- Climate change
- Air chemistry (CO_2 enhancement)
- Fire ants

3.1.10.5 Ecosystem Health Indicators

The health of the Blackbrush ecosystem can be tracked by monitoring:

- Blackbrush demography, plant density and canopy cover, and the distribution of young, mature, and dead blackbrush stands. This information will provide insight into blackbrush population dynamics and demographic differences between blackbrush in healthy and degraded conditions
- Spatial distribution of the Blackbrush ecosystem to determine if it is expanding, contracting, or being fragmented
- Spatial and temporal variability in the species composition and physical structure of vegetation in the Blackbrush ecosystem to determine characteristics of healthy and degraded communities in the Blackbrush ecosystem
- Soil hydraulic conductivity in the blackbrush community to determine relationships between water penetration and plant recruitment
- Burrowing activity by insects and rodents by determining the density of active burrows. This may provide insight into the amount of water penetrating the petrocalcic soil horizon and the potential of an area for successful plant recruitment
- Kangaroo rat and pocket mouse populations because these species are important burrowers that disperse blackbrush seeds
- Presence of invasive species, particularly *Bromus* spp. and fire ants

Indicators Summary

Abiotic Indicators

- Soil hydraulic conductivity
- Habitat fragmentation

Biotic Indicators

- Blackbrush demographics (cover, size, age, class distribution, recruitment and mortality)
- Burrowing activity of insects and rodents
- Kangaroo rat and pocket mouse populations (related to seed dispersal)
- Vegetation survey
    - Community composition
    - Physiognomic structure
- Invasive species (both plants and animals)

3.1.11 Mojave Desert Scrub Ecosystem

3.1.11.1 Characteristics and Distribution

The Mojave Desert Scrub ecosystem is characterized by widely spaced shrubs, 0.5 to 3 m (1.6 to 10 ft) tall, on well-drained secondary soils covering slopes, fans, and valleys

(Schoenherr, 1992). This ecosystem, which occurs below 1,200 m (3,940 ft) elevation, is arid and the most widespread among the 11 ecosystems in Clark County. Productivity, biomass, and species richness are comparatively low in this ecosystem. This ecosystem encompasses a wide variety of distinctive landforms and substrates, including alluvial fans, bajadas, washes, sand dunes, rock outcrops, and gypsum soil. Its plant and animal communities are structured by relationships between the hydrologic cycle, elevation, substrate, and landform.

Bajadas cover most of this ecosystem and its vegetation community is dominated by creosote bush (*Larrea tridentata*), which may occur in relatively pure stands. White bursage (*Ambrosia dumosa*), a dwarf shrub, co-dominates with creosote bush on valley bottoms and mildly sloped lowlands. Desert thorn (*Lycium andersonii*), blader sage (*Salazaria mexicana*), indigo bush (*Psorothamnus fremontii*), blackbrush (*Coleogyne ramosissima*), brittlebush (*Encelia farinosa*), and burro bush (*Hymenoclea salsola*) also occur on bajadas. Other landforms, such as sand dunes, gypsum soils, cliff/rock outcrops, and steep slopes are isolated patches with distinctive plant and animal communities that include several rare species. Dominant vegetation in these patches includes Joshua tree (*Yucca brevifolia*), prickly pear cactus (*Opuntia basilaris*), yucca (*Yucca* spp.), cholla (*Opuntia* spp.), and hedgehog cactus (*Echinoceres* spp.).

Bajadas occur in arid and semi-arid regions and form by the lateral merging and blending of alluvial fans that are created at the base of mountains by the episodic flow of silt-laden water from higher elevations. Small bajadas are formed by single basins and large bajadas are created by coalesence of adjacent fans. The bajada surface is uneven due to washes created by ephemeral scouring streams that carry sediment-laden water in channels whose paths migrate from one side of the fan to another. Sides of some washes are covered by a caliche capstone that stabilizes the soil and creates suitable conditions for burrowing animals such as desert tortoise (*Gopherus agassizii*), burrowing owls (*Athene cunicularia hypugaea*), and gila monster (*Heloderma suspectum cinctum*). Areas between washes are relatively flat, stable, and covered by desert pavement. Bajadas are the main habitat for desert tortoise, a federal endangered species.

Sand dunes are formed by aeolian processes and they require sources of sand and a prevailing wind. In the Mojave Desert Scrub ecosystem, they are often associated with playas, remnant lakes of arid lowland basins, and intermittent watercourses. Dunes are occupied by highly specialized plants and animals that are adapted to living on porous soils where there is a paucity of water, including several rare species, such as the white-margined beardtongue (*Penstemon albomarginatus*), Threecorner milkvetch (*Astragalus geyeri* var. *triquetrus*), desert kangaroo rat (*Dipodomys deserti*), sidewinder (*Crotalus cerastes*), and many insect species. Thin layers of sand occur in some areas, which are habitat for some rare species, such as the white margined penstemon (*Penstemon albomarginatus*).

Several types of gypsum soil occur in this ecosystem. Some are a weathered layer of parent material containing sponge gypsum that lies over deposits of rock gypsum, others consist of gypsum that is thinly bedded in limestone, mudstone, or shale, and saline gypsum occurs where salt-charged groundwater is near the surface. The surface of gypsum soils is typically hard and it may support a cryptogamic crust. Gypsum soils support sparse vegetation and fewer annual plants than bajadas. Vegetation on saline gypsum soils includes a few short-lived species and almost no annuals. However, gypsum soils are characterized by a suite of endemic species restricted to these edaphic conditions, such as the 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 rock formations appear above the surface of the surrounding soils. They provide habitat for the western chuckwalla (*Sauromalus obesus*), Great Basin collared lizard (*Crotaphytus insularis bicinctores*), and speckled rattlesnake (*Crotalus mitchelli*).

Characteristics Summary

Abiotic Characteristics

Elevations below 1,200 m (3,940 ft)

- Low precipitation
- Abiotic conditions attributed to interrelation of hydrologic cycle, elevation, substrate, and landform
- Landform (please refer to the biotic characteristics)
    - Bajadas
        - Alluvial fans
        - Washes (caliche capstone, other kinds)
        - Desert pavement
    - Sand dunes
    - Gypsum soils
    - Cliff/rock outcrops

Biotic Characteristics

- Low productivity
- Specialized species associated with landform type, as shown in Table 14.

Table 14. Specialized species found in the different Mojave Desert Scrub landforms.

a) Bajadas	
<u>Alluvial fans</u>	
Desert tortoise	*Gopherus agassizii*
Southern desert horned lizard	*Phrynosoma platyrhinos calidiarum*
Large-spotted leopard lizard	*Gambelia wislizenii wislizenii*
Mojave green rattlesnake	*Crotalus scutulatus*
Washes (caliche capstone, other kinds)	
i) Caliche capstone	
Banded Gila monster	*Heloderma suspectum cinctum*
Desert tortoise	*Gopherus agassizii*
Western burrowing owl	*Athene cunicularia hypugaea*
Other burrowing animals	
ii) Other types of wash	
Pinto beardtongue	*Penstemon bicolor roseus*

Common zebra-tailed lizard	*Callisaurus draconoides draconoides*
Desert tortoise	*Gopherus agassizii*
Mojave green rattlesnake	*Crotalus scutulatus scutulatus*
Sidewinder	*Crotalus cerastes*
Other snakes	
Thrashers	*Toxostoma spp.*

<u>Desert pavement</u> *(possibly include this with alluvial fans)*

Alkali phacelia	*Phacelia neglecta*

b) <u>Sand (d=species only on dunes, s= species only on thin sheets of sand)</u>

White margined penstemon (s)	*Penstemon albomarginatus*
Threecorner milkvetch	*Astragalus geyeri* var. *triquetrus*
Sticky buckwheat	*Eriogonum viscidulum*
Beaver dam breadroot	*Pediomelum castoreum*
Scorpions	Order Scorpiones
Bees	Superfamily Apoidea
Scarab beetles (d)	Superfamily Scarabaeoidea
Zebra-tailed lizard	*Callisaurus draconoides*
Sidewinder	*Crotalus cerastes*
Desert kangaroo rat	*Dipodomys deserti*
Desert pocket mouse	*Chaetodipus penicillatus*

c) <u>Gypsum</u>

Las Vegas bearpoppy	*Arctomecon californica*
White bearpoppy	*Arctomecon merriamii*
Las Vegas buckwheat	*Eriogonum corymbosum* var. *nilesii*
Sticky Ringstem	*Anulocaulis leisolenus*
Silverleaf sunray	*Enceliopsis argophylla*
Nakedstem sunray	*Enceliopsis nudicaulis*
Palmers phacelia	*Phacelia palmeri*
Parry's sandpaper plant	*Petalonyx parryi*
Lancaster milkvetch	*Astragalus preussii* var. *laxiflorus*
Bees	Superfamily Apoidea

d) <u>Cliff/rock outcrops</u>

Ringtail cat	*Bassariscus astutus*
Cliff goldenbush	*Ericameria cuneata*
Barrel cactus	*Ferocactus cylindraceus* var. *lecontei*
Red spotted toad	*Bufo punctatus*
Great Basin collard lizard	*Crotaphytus bicinctores*
Banded Gila monster	*Heloderma suspectum cinctum*
Speckled rattle snake	*Crotalus mitchelli*
American peregrine falcon	*Falco peregrinus anatum*
Prairie falcon	*Falco mexicanus*
Golden eagle	*Aquila chrysaetos*
Bats	Order Chiroptera
Desert woodrat	*Neotoma lepida*
Desert bighorn sheep	*Ovis canadensis nelsoni*

3.1.11.2 MSHCP Covered Species

The Mojave Desert Scrub ecosystem provides habitat for 22 covered species (Table 15), comprising 13 reptiles and nine vascular species.

Table 15. Covered species found in the Mojave Desert Scrub ecosystem.

Common Name	Species Name
Desert tortoise	*Gopherus agassizii*
Banded gecko	*Coleonyx variegatus*
Desert iguana	*Dipsosaurus dorsalis*
Great Basin collared lizard	*Crotaphytus insularis bicinctores*
Large-spotted leopard lizard	*Gambelia wislizenii wislizenii*
California (common) king snake	*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)	*Penstemon albomarginatus*

3.1.11.3 Ecosystem Drivers

The Mojave Desert Scrub ecosystem includes a number of landforms that are characterized by their soil, erosional features, slope, aspect, and high temperature. Relationships between the hydrological cycle (frequency, duration, and timing of precipitation), soil type, sediment deposition, and erosion create different landforms/habitats that include sand dunes and sites thinly covered with sand, gypsum soils, cliff/rock outcrops, and bajadas (including alluvial fans, washes, and desert pavement). Some species occupy several habitat types and some only occur in one. Sand dunes, gypsum soils, and cliff/rock outcrops comprise a small percentage of this ecosystem but they support high rates of endemism. Precipitation and temperature are important factors that regulate the density and size of creosote bush and associated shrubs (Beatley, 1975; Barbour et al., 1977). Wildfires are a major disturbance.

Drivers Summary

Abiotic Drivers

- Climate
    - Precipitation (quantity, frequency, timing, duration)
    - High temperature
- Topography (elevation, slope, and aspect)
- Landform type
- Soils
- Wildfires
- Erosion

3.1.11.4 Ecosystem Health Threats

The Mojave Desert Scrub ecosystem is the most extensive of the 11 ecosystems in Clark County and has a wide range of potential threats and stressors. This lowland ecosystem provides primary habitat for desert tortoise, comprising over one-half of its range and the majority of Critical Habitat. Primary threats and stressors to this ecosystem are urbanization, invasive species, roads and utility corridors. Urbanization converts natural habitat into impervious surfaces (e.g., buildings, roads, etc.), and increases human recreational activity, predation by feral cats and dogs, and illegal activities (such as collecting, hunting, and dumping). Invasive species displace native vegetation and often increase the frequency of wildfires. Roads and utility corridors increase access to wilderness, are a vector for dispersal of invasive species, and fragment natural areas. Other small-scale threats include grazing by cattle and feral animals as well as human activities that increase soil compaction, erosion, and dust. These localized threats become significant when they affect small landform patches such as sand dunes, gypsum soils, and cliff/rock outcrops.

Threats Summary

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
- Altered air quality (primarily increasing dust)

- Wildfires

Minor and Potential Threats

- Feral cat and dogs predation
- Grazing
- Mining
- Desert dumping
    - Pollution
    - Increased predation (by feral animals, ravens, and foxes)
- Collecting and hunting

3.1.11.5 Ecosystem Health Indicators

The health of the Mojave Desert Scrub ecosystem may be inferred from species composition community and vegetation structure, and monitored by:

- Change in vegetation such as percent cover, physical structure, and species composition (including invasive species) (James and Shugart, 1970)
- Species composition and abundance of animal species
- Species richness
- Disturbance (i.e., soil compaction, erosion, stability)
- Delineating habitat loss attributed to road networks and habitat fragmentation. These surveys should be applied to all four landforms but they may be particularly important for locally distributed, specialized species. The timing and use of unique survey methods may be critical to assess short-lived species

Abiotic Indicators

- Disturbance (erosion, soil compaction and stability)
- Fragmentation
- Road network

Biotic Indicators

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

3.1.12 Salt Desert Scrub Ecosystem

3.1.12.1 Description and Distribution

The Salt Desert Scrub ecosystem is an open to moderately dense shrubland that is characterized by one or more *Atriplex* species in a mosaic with creosote bush (*Larrea tridentata*) and white bursage (*Abrosia dumosa*) communities. Canopy cover ranges from 0% to 35%, vegetation height from 25 to 150 cm (10 to 59 in), and the lifespan of most shrubs is less than 100 years, except for creosote bush. In Clark County, salt desert scrub covers approximately 208,600 acres (84,417 ha) between 900 and 1,800 m (2,950 and 5,900 ft) elevation on valley bottoms adjacent to dry lake beds (playas), or in localized depressions with poorly drained alkaline or saline soils. Soils are fine textured aridisols (water deficient soils with a low concentration of organics that form in arid or semi-arid climates) with high salt concentrations (RECON, 2000) often with white encrusted salt deposits (Schoenherr, 1992).

Other common shrub species in this ecosystem include shadscale (*Atriplex confertifolia*), desert holly (*Atriplex hymenelytra*), greasewood (*Sarcobatus vermiculatus*), desert thorn (*Lycium* spp.), Torrey saltbush (*Atriplex torreyi*), winterfat (*Krascheninnikovia lanata*), bursage, fourwing saltbush (*Atriplex canescens*), Mormon tea (*Ephedra* spp.), horsebrush (*Tetradymia canescens*), and snakeweed (*Gutierrezia sarothrae*). This ecosystem provides food and cover for wildlife, primarily during winter.

3.1.12.2 MSHCP Covered Species

There are 17 MSHCP covered species in this ecosystem (Table 16). They include two bats, 10 reptiles, and five vascular plants. Among them, Parish's phacelia (*Phacelia parishii*) is exclusively in this ecosystem, and forked (Pahrump Valley) buckwheat (*Eriogonum bifurcatum*) is only in this ecosystem and the Mesquite Catclaw Acacia ecosystem.

Table 16. Covered species found in the Salt Desert Scrub ecosystem.

Common Name	Scientific Name
Silver-haired bat	*Lasionycteris noctivagans*
Long-eared myotis	*Myotis evotis*
Desert tortoise	*Gopherus agassizii*
Desert iguana	*Dipsosaurus dorsalis*
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*
Sidewinder	*Crotalus cerastes*
Speckled rattlesnake	*Crotalus mitchelli*
Sticky ringstem	*Anulocaulis leisolenus*
Las Vegas bearpoppy	*Arctomecon californica*
White bearpoppy	*Arctomecon merriamii*
Forked (Pahrump Valley) buckwheat	*Eriogonum bifurcatum*
Parish's phacelia	*Phacelia parishii*

3.1.12.3 Ecosystem Drivers

The Salt Desert Scrub ecosystem occurs on valley floors, adjacent to playas, and in localized depressions where years of erosion have deposited soil from the surrounding terrain. The major driver of this ecosystem is soil salinity, which is formed when silt-laden water flows into localized, internally drained depressions and salts accumulate as water evaporates. The chemical composition of soils in each basin is a function of geological characteristics of the surrounding mountains, and the spatial extent of this ecosystem in a valley is influenced by the relationship between hydrology and sediment transported into the basin. All plant species in this ecosystem are halophilic (tolerant of high salt concentrations) and adapted to relatively harsh conditions. Soil moisture is low during summer and higher during winter or rainy periods. Summer temperatures are high compared to other locations at similar elevation, but cold air settles into the basins occupied by this ecosystem during winter, creating inversions that trap cold air. As a consequence, winter minimum temperatures on the basin floors are often lower than the surrounding terrain.

Drivers Summary

Abiotic Drivers

- Watershed characteristics
    - Topographic isolation, setting, position
    - Hydrology
    - Geology (soils, mining potential, characteristics)
    - Sediment transport
- Moisture patterns (high range of soil moisture)
- Soil salinity and moisture
- Temperature patterns (relatively hot summer and cold winter)

3.1.12.4 Ecosystem Health Threats

This ecosystem is associated with lower elevation flats that are altered by a number of human activities and is threatened by urban and rural development, modification of surface hydrology, recreational off-road vehicle activity, and livestock grazing. Approximately three percent (6,203 acres, 2,510 ha) of this ecosystem has been converted to urban land use since 2001, which is the highest percentage loss among the 11 MSHCP ecosystems. It has been replaced by impervious surfaces associated with urban development, and also modifies hydrology, water availability, sediment and saline transport processes in this ecosystem. Recreational vehicle activity impacts this ecosystem by disturbing soil surface structure and stability and subsequent water infiltration. Livestock grazing impacts are similarly negative, though less devastating relative to the total removal of communities by urban development. Consequently, grazing and recreational vehicle use may adversely affect covered species and other wildlife. The Salt Desert Scrub ecosystem is also threatened, although less significantly, by invasive species, mining, pollution attributed to illegal dumping, and future development for military activities and solar panel construction.

Threats Summary

Major Threats

- Urban/rural development
- Change of surface hydrology (flood control, altering water use and sediment transport)
- Recreation (OHV activity)
- Grazing (domestic, feral)

Minor and Potential Threats

- Pollution (dumping, contaminated runoff)
- Invasive species
- Potential military development
- Future mining
- Solar panel array construction

3.1.12.5 Ecosystem Health Indicators

Health of the Salt Desert Scrub ecosystem can be determined by assessing change in several biotic communities. This can be accomplished during monitoring programs that:

- Quantify community structure, including spatial and temporal variation in canopy cover, canopy gap, the number and extent of young and mature shrubs, and the density of dead stands of shrubs
- Quantify community diversity, including temporal variability in the floristic diversity
- Quantify the extent and coverage of biological crusts. Crusts are associations of cyanobacteria, mosses, and lichens that hold soils in place, protect the underlying sediments from erosion, and enable grasses and herbs to become established. Therefore, their status may be a useful indicator of salt desert scrub health
- Track the percent cover of invasive species, which may compete with and displace native vegetation

Health of this ecosystem may also be assessed by monitoring three abiotic indicators that:

- Quantify changes in patch fragmentation
- Determine changes in the areal extent of impermeable surface
- Quantify changes in surface hydrology and determine their influence on soil salinity and sediment deposition

Indicators Summary

Abiotic Indicators

- Habitat fragmentation

- Area of impermeable surface
- Surface hydrology
    - Sediment transport
    - Soil moisture

Biotic Indicators

- Vegetation demography
    - Canopy cover, canopy gap
    - Recruitment and mortality (young, mature, and dead stands)
- Vegetation survey
    - Floristic composition
    - Physiognomic structure
- Crust extent and density
- Invasive species cover

3.1.13 Mesquite Catclaw Acacia Ecosystem

3.1.13.1 Description and Distribution

The Mesquite Catclaw Acacia ecosystem in Southern Nevada covers an estimated 36,000 acres (1,457 ha) in patches that range in size from 2 acres (0.8 ha) to more than 2,500 acres (1,012 ha) along large rivers and perennial streams, in scattered clumps on valley floors, and near desert springs (Crampton et al., 2006). It generally occurs below 1,200 m (3,940 ft) elevation in Clark County, and adjacent portions of southern Nye and Lincoln counties, which is the northern extent of its range. This ecosystem is characterized by woody shrubs or trees on gravel, sand, clay, loam, silt, or gypsum soils where perennial groundwater is not more than 10 m (33 ft) from the surface (Schoenherr, 1992). Dominant tree species including screwbean mesquite (*Prosopis pubescens*), honey mesquite (*P. glandulosa*), catclaw acacia (*Acacia greggii*), and smoke tree (*Psorothamnus spinosa*) (which is rare in Clark County) are freeze intolerant and are members of the pea family, Fabaceae (Clokey, 1951; Crampton et al., 2006). Associated shrubs in this system 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*).

In a landscape that is dominated by desert scrub, these woodland patches provide important breeding, foraging, and resting places for more than 40 plant and animal species (Crampton et al., 2006). Traits of a healthy Mesquite Catclaw Acacia ecosystem are variable and may be specific for individual patches. For example, many patches support hemiparasitic desert mistletoe (*Phoradendron californicum*), an important food for Phainopepla (*Phainopepla nitens*), which Crampton et al. (2006) identified as a model species for the ecosystem. For reasons that are poorly understood, mistletoe is absent from other patches that appear to be otherwise healthy. A Mesquite and Acacia Conservation Management Strategy was prepared by Crampton et al. (2006) for the Las Vegas District Office of the US Bureau of Land Management. This strategy contains detailed descriptions of this ecosystem, management issues, and metrics that can be used to assess ecosystem health. This presentation summarizes salient elements of this conservation strategy. Krueger (1998) also contributed greatly to increasing knowledge of this ecosystem in Southern Nevada.

Characteristics Summary

Abiotic Characteristics

- Northern extent of ecosystem distribution
- Near perennial access to shallow groundwater from association with streams, rivers, dry lakes, and springs
- Associated with gravel, sand, clay, loam, silt, and gypsum soils
- Generally in elevations below 1200 m (3,940 ft)

Biotic Characteristics

- Isolated woodland patches
- Mistletoe serves important role
- Phainopepla is a model species for ecosystem
- Vegetation community variable across landscapes (associated species, density and structure)
- Freeze intolerant woody species (acacia more so than mesquite)

3.1.13.2 MSHCP Covered Species

The Mesquite Catclaw Acacia ecosystem is occupied by 10 covered species (Table 17). They include two bats, two birds, five reptiles, and one rare vascular plant. In Clark County, the Phainopepla occurs only in this ecosystem and forked (Pahrump Valley) buckwheat occurs exclusively in Mesquite Catclaw Acacia and Salt Desert Scrub ecosystems.

Table 17. Covered species found in the Mesquite Catclaw Acacia ecosystem.

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*
Great Basin collared lizard	*Crotaphytus insularis bicinctores*
Western red-tailed skink	*Eumeces gilberti rubricaudatus*
Sidewinder	*Crotalus cerastes*
Forked (Pahrump Valley) buckwheat	*Eriogonum bifurcatum*

3.1.13.3 Ecosystem Drivers

Temperature and access to groundwater are the two most important factors influencing distribution of the Mesquite Catclaw Alpine ecosystem. All woody species in this system are weakly tolerant of freezing temperatures, which limits them to lower elevations. This ecosystem also occurs on gravel, sand, clay, loam, silt, and gypsum soils, but only where adequate water is provided by groundwater, transient flow (e.g., in washes), or lateral seepage from streams or rivers. Mesquite is generally more sensitive to low water availability than catclaw and smoke trees, and work by Stromberg et al. (1992) showed that increased honey mesquite mortality is correlated with distance to the water table. Brown and Archer (1999) also suggested that mesquite distribution may be influenced by low recruitment attributed to seed dispersal rates and patterns. Dispersal by mammals and birds is important because seeds of these species are encased in hard shells that require scarification to maximize germination. Mistletoe is an important component of these woodlands. It is a primary food source for Phainopepla, which is responsible for disseminating mistletoe seeds (Krueger, 1998). Stands that support mistletoe also have greater species richness, which suggests that it may be an indicator of patch biodiversity. Recruitment, survival, and growth of mistletoe rely on adequate water availability and suitable temperatures (ergo frost-free). Mistletoe abundance is also correlated with tree size and age (Crampton et al., 2006). Fire, air temperature, water availability, grazing, and firewood cutting may also be stressors that affect growth form, which may reduce its value as wildlife habitat.

Drivers Summary

Abiotic Drivers

- Temperature
- Water availability
    - Groundwater hydrology
    - Precipitation
- The presence of gravel, sand, clay, loam, silt, and gypsum soil

Biotic Drivers

- Mistletoe: increasing species richness
- Phainopepla use
- Seed dispersal rate and pattern

3.1.13.4 Ecosystem Health Threats

This ecosystem faces three main problems, habitat loss and fragmentation, degradation of habitat quality, and lack of recruitment (Crampton et al., 2006). Habitat loss and fragmentation are mostly attributed to urban and agricultural development, the presence of invasive plants, fire, and water diversion. Urban, rural, and agriculture development have covered many of these woodlands and degraded habitat quality by introducing invasive species, increasing the frequency of fire, and fragmenting habitats with roads and right-of-ways. As in other ecosystems, the presence of invasive non-native plant species (e.g., *Tamarisk* spp. and *Bromus* spp.) may alter the ecosystem through competition with native vegetation for water, and by increasing the frequency of fires. The presence of invasive species may also affect ecosystem health by decreasing biodiversity. Excessive diversion of surface and ground waters affects this ecosystem by decreasing water availability and killing and stunting trees. Tree viability is also decreased by unpermitted wood cutting to supply firewood for homes and recreation. Livestock and feral animal grazing appear to be minor threats to this ecosystem. Recreation activities are suspected of adversely affecting this ecosystem by compacting soil, increasing sapling mortality, etc., but these impacts are not documented.

Threats Summary

Major Threats

- Urban and agricultural development
    - Fragmentation
    - Replacement
- 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)

3.1.13.5 Potential Ecosystem Health Indicators

Traits characterizing the health of mesquite-catclaw woodlands appear to be site specific because of natural variability in soils, water availability, mistletoe, and recruitment. Crampton et al. (2006) suggested that healthy woodlands may have mixed age structure, single stemmed trees, and adequate recruitment. Mistletoe should also be present at a minimum level in a minimum percentage of stands (these levels have not been determined). The following monitoring programs are suggested to assess these factors:

- Develop predictive demographic models of healthy and degraded woodlands by monitoring the density of young (new recruits), mature, and dead mesquite and catclaw

- Determine changes in plant community composition and physiognomic structure by monitoring vegetation community structure and mesquite and catclaw height, growth form, and density
- Monitor for changes in animal abundance and species diversity. The diversity and abundance of animals is responsive to changes in vegetation, which may be a good indicator of ecosystem change
- Survey mistletoe density and Phainopepla populations. These two species are important components of this ecosystem, and their viability in a woodland may be indicative of its health and species richness. Declines in their abundance may indicate a decrease in woodland health
- Monitor depth to groundwater. The reliance of this ecosystem on access to adequate groundwater supplies suggests that this monitoring program may provide important information to assess ecosystem health
- Determine relationships between depth to groundwater and plant stress to identify threshold levels of adequate water availability. Determine if catclaw uses groundwater or only surface flows
- Monitor potential specialist pollinators of mistletoe and mesquite.

Indicators Summary

Abiotic Indicators

- Groundwater hydrology
  - Depth to groundwater
  - Adequate water supply
  - Precipitation and temperature regimes, especially major climate change
- Water stress

Biotic Indicators

- Recruitment and mortality
- Vegetation structure
  - Height
  - Growth form
  - Density
  - Age class structure
- Species diversity
- Desert mistletoe abundance
- Phainopepla abundance

3.1.14 Summary

Models of ecosystem health for the 11 MSHCP ecosystems presented above represent the first attempt to express hypothesized relationships among salient biotic and abiotic characteristics, describe threats to their ability to function as healthy systems, and suggest potential indicators of change in each ecosystem's health. The next stage in model development is to compile monitoring information and information from past research for each system and assess its efficacy in determining ecosystem health. Examination of historic data may also provide insight into the metrics that most effectively and efficiently indicate ecosystem health. It may be that linkages between biotic and abiotic components of each system can be illustrated by diagramming, which may result in a refinement of indicator selection, development of monitoring strategies, and rethinking of management priorities as part of an AMP (Atkinson et al., 2004). There are differences in the amount of historic information available for each ecosystem and it is important to prioritize future work and focus efforts on maintaining the health of the most degraded ecosystems (ergo ecosystems whose functional characteristics no longer exist and viable biotic populations of occupying native species are absent). Additionally, many of these ecosystems may have key or umbrella species – such as the Phainopepla for mesquite-catclaw – for which there is likely to be a body of information to guide model development (cf. Atkinson et al., 2004).

3.1.15 Recommendations

As the above models are more fully developed, a synergistic approach to integrating assessments of abiotic and biotic drivers and threats is strongly recommended to maximize the utility of ecosystem health models to guide management activities. In addition, future monitoring or research activities for these ecosystems and their components should have clearly stated objectives that improve understanding of the hypothesized relationships among model components, and the ability to better manage the species and habitats within these ecosystems.

3.2 Covered Species Habitat Loss by Ecosystem Tracking System

3.2.1 Introduction

The AMP also tracks covered species habitat loss by ecosystem to determine the impacts of the MSHCP's ITP (USFWS, 2001) on the 78 covered species. As described in chapter 2, data are available to document the number of acres permitted for habitat loss to date under the ITP and the spatial extent of actual habitat loss to date during the term of the ITP. There are also data available to document the spatial extent of the ecosystems described in the MSHCP and used in the MSHCP and USFWS analysis of the MSHCP as surrogates for the distribution of the covered species expected to rely upon each ecosystem for habitat (RECON, 2000; USFWS 2001b). Recall that as described in chapter 1, when habitat loss occurs, it is assumed to be a permanent and complete loss of habitat values for all covered species.

The MSHCP and USFWS's analysis of the potential impacts of issuing the ITP (the Biological Opinion) defined 11 ecosystem categories (Figure 14) based upon vegetation communities and described which of the covered species' habitats occurred within each of the ecosystems (RECON, 2000; USFWS 2001) These relationships are shown in Table 18. Few updates to the narrative conceptual models of species' habitat requirements found in the MSHCP and the Biological Opinion have been received to date, and those received are of a preliminary nature, thus no revisions have been made. Verification of updates to species' habitat conceptual models are anticipated in two years as the result of several interlocal agreements between Clark County and Federal Agencies and other contracts.

The below analyses are focused solely on habitat loss to date under the MSHCP's ITP (USFWS, 2001) and do not attempt to address larger questions regarding changes to ecosystem quality, function, or health from the impacts of this habitat loss or other anthropogenic or natural sources, nor does this section and analyses extend to assessments of species status or changes in species status. This section highlights those ecosystems and species' habitats that have been directly impacted by habitat loss to date, and makes recommendations for additional analyses of ecosystem health and species status.

3.2.2 What is the Spatial Extent of MSHCP Habitat Loss by Ecosystem?

As described in chapter 2, in August 2007, the first spatial analysis was conducted of habitat loss that had occurred to date during the term (March 2001 to September 2006) and within the geographic extent of the ITP (Clark County, 2007b). This analysis was recently updated using available imagery for the period of March 2001 to March 2007 (Clark County, 2008b) and showed that during this time period, 56,512 acres of habitat loss had actually occurred. Data are also available on the spatial extent of the ecosystems and management area categories defined in the MSHCP, and these data are compared to the above habitat loss data set.

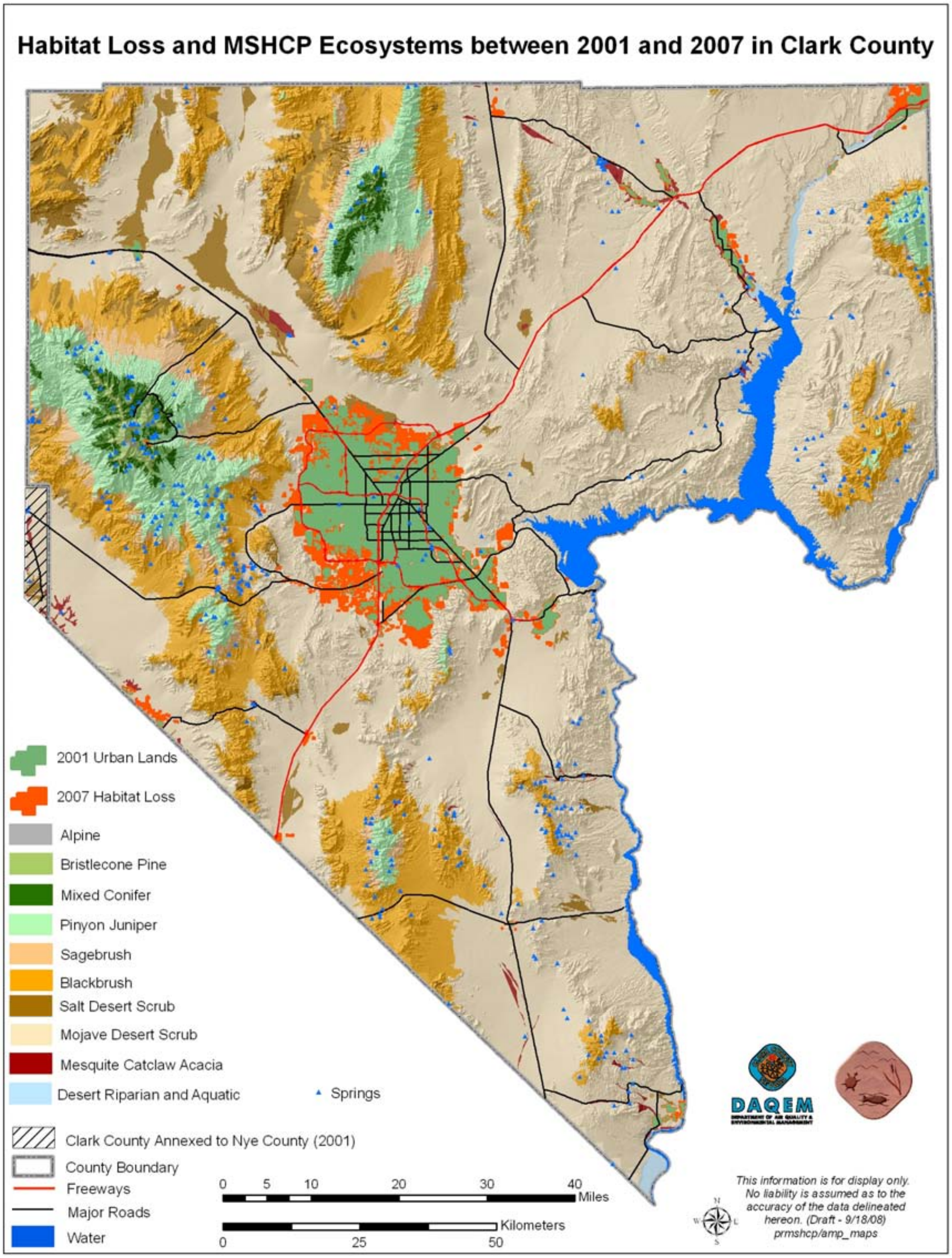

Figure 14. Map of habitat loss and MSHCP ecosystems between 2001 and 2007 in Clark County, Nevada.

Table 18. Acres of habitat loss (number of springs) within each MSHCP ecosystem in Clark County, Nevada.

ECOSYSTEM	County Total	2001 Urban	2007 Urban	Acres of Habitat Loss	% Ecosystem Extent Lost
Alpine	479 (194 ha)	0	0	0	0
Bristlecone Pine	15,856 (6,417 ha)	0	0	0	0
Mixed Conifer	56,413 (22,830 ha)	5 (2 ha)	6 (2 ha)	1 (0.4 ha)	0.002
Pinyon Juniper	281,695 (113,998 ha)	52 (21 ha)	53 (21 ha)	1 (0.4 ha)	0.000003
Sagebrush	138,949 (56,231 ha)	0	0	0	0
Blackbrush	831,531 (336,509 ha)	0	23 (9 ha)	23 (9 ha)	0.003
Salt Desert Scrub	208,565 (84,403 ha)	7,472 (3,024 ha)	14,171 (5,735 ha)	6,699 (2,711 ha)	3.21
Mojave Desert Scrub	3,467,118 (1,403,093 ha)	186,333 (75,406 ha)	234,573 (94,928 ha)	48,240 (19,522 ha)	1.39
Mesquite Catclaw Acacia	34,466 (13,948 ha)	6,727 (2,722 ha)	7,674 (3,106 ha)	947 (383 ha)	2.75
Desert Riparian and Aquatic	21,599 (8,741 ha)	3,451 (1,397 ha)	4,053 (1,640 ha)	602 (244 ha)	2.79
Spring	754	16	16	0	0
	Total Acres of Habitat Loss	56,512 (22,870 ha)			

As described above, the intent of this analysis was to spatially analyze MSHCP habitat loss by ecosystem between March 2001 and March 2007 within Clark County. For the purpose of this analysis, the 2001 and 2007 land use data sets created under the Land Use Trends Tracking System (chapter 2) and the RECON ecosystem data set were used (Table 18).

A total of 16 springs were known from lands where land disturbance (habitat loss) ocurred prior to the term of the MSHCP's ITP, and it is assumed that the habitat values of those springs are permanently lost. Of the 16 springs previously lost, 13 were located within Mojave Desert Scrub, one in Salt Desert Scrub, and one in Desert Riparian and Aquatic ecosystems. No additional springs were lost during the term examined in this analysis. Results of this spatial comparison of habitat loss with the ecosystem extent data set indicates that the majority of habitat loss (48,240 [19,522 ha] of a total of 56,512 acres [22,870 ha] of habitat loss) has occurred in the Mojave Desert Scrub ecosystem, and those acres represent 1.39% of that ecosystem's distribution within Clark County. The ecosystem that incurred the largest percentage loss (3.21%) was Salt Desert Scrub with 6,699 (2,711 ha) of 208,564 acres

(84,403 ha) of that ecosystem lost. Species with habitats described within the Mojave Desert Scrub and Salt Desert Scrub ecosystems are shown in Tables 1 and 15.

3.2.3 What is the Spatial Extent of Habitat Loss by Ecosystem within MSHCP Mitigation Reserve System Categories?

The habitat loss by ecosystem analyses results were also compared to the MSHCP management area categories data set. Table 19 shows the percent of total habitat loss in each management area category for each ecosystem from March 2001 to March 2007 for all of Clark County.

Table 19. Acres (number of springs) and percentage (%) of habitat loss in MSHCP ecosystems and MSHCP mitigation reserve system management area categories between March 2001 and March 2007, in Clark County, Nevada.

	Acres (Number of Springs) of Habitat Loss				
MSHCP ECOSYSTEM	IMAs	LIMAs	MUMAs	UMAs	% Ecosystem Extent Lost
Alpine	0	n/a	n/a	n/a	0
Bristlecone Pine	0	0	n/a	0	0
Mixed Conifer	0.2 (0.08 ha)	0	n/a	0.7 (0.3 ha)	0.002
Pinyon Juniper	0	0	0	0.8 (0.3 ha)	0.000003
Sagebrush	0	0	0	0	0
Blackbrush	0	0	0	23 (9.3 ha)	0.003
Salt Desert Scrub	0.2 (0.08 ha)	0	1,644 (665 ha)	5,055 (2,046 ha)	3.21
Mojave Desert Scrub	463 (187 ha)	79 (32 ha)	17,753 (7,184 ha)	29,946 (12,119 ha)	1.39
Mesquite Catclaw Acacia	1 (0.4 ha)	n/a	361 (146 ha)	585 (237 ha)	2.75
Desert Riparian and Aquatic	58 (23 ha)	n/a	91 (37 ha)	453 (183 ha)	2.79
Spring	0	0	0	0	0
Total Habitat Loss	523 (212 ha)	79 (32 ha)	19,849 (8,033 ha)	36,063 (14,594 ha)	

A comparison of the losses in each ecosystem within the four MSHCP management area categories showed that losses appear to be taking place within the areas anticipated by the USFWS analysis of the potential impact of the MSHCP's ITP (USFWS, 2000). The results of the spatial habitat loss by ecosystem in Management Area categories analysis show habitat loss occurring primarily within UMAs and MUMAs (36,063 acres [14,594 ha] and 19,849 acres [8,033 ha], respectively). The losses of habitat within the Mojave Desert Scrub and Salt Desert scrub ecosystems are each less than the anticipated potential losses of 4% and

10% respectively (Table 20), as described in the USFWS analysis of the potential impact of the MSHCP's ITP (USFWS, 2000). In addition, several (602) acres (244 ha) of habitat loss has occurred within areas designated as IMAs (523 acres [212 ha]) and LIMAs (79 acres [32 ha]).

Table 20. Expected potential percentage (%) of habitat loss in MSHCP ecosystems and expected potential acreages (number of springs) of ecosystem loss in MSHCP management area categories during term of the ITP (USFWS, 2000)

	Potential Acres (Number of Springs) of Habitat Loss in Each Category				
MSHCP ECOSYSTEM	IMAs	LIMAs	MUMAs	UMAs	Overall Potential % Ecosystem Extent Loss
Alpine	0	0	0	0	0
Bristlecone Pine	0	0	0	1,000 (405 ha)	6.3
Mixed Conifer	0	0	0	1,500 (607 ha)	2.6
Pinyon Juniper	0	0	0	4,200 (1,700 ha)	<1.0
Sagebrush	0	0	0	900 (364 ha)	<1.0
Blackbrush	0	0	0	8,700 (3,521 ha)	1.0
Salt Desert Scrub	0	0	0	19,800 (8,013 ha)	10.0
Mojave Desert Scrub	0	0	0	145,000 (58,679 ha)	4.0
Mesquite Catclaw Acacia	0	0	3,035 (1,228 ha)	5,000 (202 ha)	37.0
Desert Riparian and Aquatic	0	0	0	2700 (1,093 ha)	16.0
Spring	0	0	0	78 (32 ha)	16
Total Acres of Potential Habitat Loss	0	0	3,035* (1,228 ha)	188,800* (76,405 ha)	*up to a maximum of 145,000 (58,679 ha) in any category

It was not possible with the available data to determine how many of these acres were in areas disposed of by Federal agencies (thus changing their Management Area category to UMA), or how many of these acres were in areas that experienced a change in management designation that may have caused a reclassification of the MSHCP Management Area category. As previously described, the BLM has just completed an analysis of MSHCP Management Area changes, including the updated Clark County boundary, but the data were not available for this analysis. Recommendations are made in chapter 2 for future uses of those data.

3.2.4 Summary

This analysis shows that as anticipated in the MSHCP (RECON, 2000) and Biological Opinion (USFWS 2000), the majority of habitat loss occurred within the Mojave Desert Scrub ecosystem. No ecosystem experienced habitat loss in excess of that anticipated in the Biological Opinion (USFWS, 2000). The USFWS analysis of the ITP and MSHCP (USFWS, 2000) did not identify potential habiat losses among MUMA acres available for disposal outside of the mesquite catclaw acacia ecosystem. However, this USFWS analysis and the MSHCP clearly show that the USFWS anticipated MUMAs would experience land use designation changes through disposal of some of these Federal lands, thus changing their status to UMA.

3.2.4.1 Recommendation: Use newly available species habitat requirement and distribution data in future habitat loss by ecosystem analyses.

The MSHCP's goal is to ensure no net unmitigated loss or fragmentation of covered species habitats (RECON 2000). To provide a more direct analysis of each covered species' habitat losses, data on species occurrence, more detailed habitat parameters, and species viability could be assessed to evaluate the status of each affected species and extrapolate the impacts of the present habitat loss under the MSHCP. Available species occurrence data have been compiled and should be assessed for their applicability in such analyses. A few current MSHCP projects include creation and refinement of conceptual or predictive habitat models for several covered species, and within two years those refined models will be available to provide a more robust analysis of species habitat and test the ecosystem-as-habitat-surrogates for those species as described in the MSHCP (RECON, 2000). No species viability assessments are planned to date, but could be initiated if any species are shown to be experiencing a greater loss of habitat than predicted by the ecosystem analysis.

3.2.4.2 Recommendation: Refine vegetation classification used for habitat loss by ecosystem trends analysis.

An additional recommendation would be to refine and update the 1998 RECON Vegetation and Ecosystem data set used in the MSHCP (RECON, 2000). Since 1998, several new vegetation (SWReGAP, USGS/EPA and LANDFIRE, USGS) data sets have been completed. SWReGAP (http://fws-nmcfwru.nmsu.edu/swregap/) is a regional update to the Gap Analysis Program's assessment of species distribution, vegetation and land use. It produced a seamless map of vegetation across the states of Colorado, Arizona, New Mexico, Utah and Nevada. LANDFIRE (http://www.landfire.gov/) is another large scale analysis of vegetation that also includes wildland fuel load and fire regime data. Refining the RECON data set with new vegetation data sets and with newer satellite and aerial imagery data sets could create a more accurate vegetation and ecosystem data set.

3.2.4.3 Recommendation: Compare the results of this analysis to mitigation action project data in the future.

In order to address the MSHCP goal of no net loss or fragmentation of species habitat (RECON, 2000), the results of this habitat loss by ecosystem analysis should be compared with mitigation and conservation actions implemented by the MSHCP. A database of implementation actions funded by the MSHCP and a comprehensive GIS geodatabase depicting the locations of those actions are being developed. Many of the early MSHCP projects did not collect spatial data, and the metadata associated with most projects implemented prior to 2007 are of poor quality. Current projects are required to submit detailed data management plans for approval prior to implementation, and these data management plans meet minimal guidelines for metadata (Clark County, 2008c). When the MSHCP implementation database (described in chapter 4) and GIS geodatabase are completed, a spatial analysis should be performed of the spatial extent of habitat loss by ecosystem and species habitat, and compared to the spatial extent of implementation actions funded to mitigate the impacts of that habitat loss.

3.2.4.4 Recommendation: Integrate habitat loss by ecosystem analyses with an application to provide on-the-fly landscape analysis.

A possible improvement to this Habitat Loss by Ecosystem Tracking System would be a customized GIS or Internet based application that would perform on-the-fly landscape analysis. The ideal application would allow a user to input various GIS data sets along with land use/land cover data sets and have the ability to run and summarize various landscape metrics. Having the ability to generate and output maps and summary data such as land use proportion, patch analysis, and fragmentation metrics within a custom application would enable non GIS users to generate output data and maps effectively and efficiently.

There are a number of software packages that claim to have some of these capabilities. A few of the software packages that have been identified are Habitrak (http://www.dfg.ca.gov/nccp/habitrak/), ATtiLA (http://rmgsc.cr.usgs.gov/latp/tools.shtml), Fragstats (http://www.umass.edu/landeco/research/fragstats/fragstats.html), Patch Analyst (http://flash.lakeheadu.ca/~rrempel/patch/), NatureServe (http://www.natureserve.org/), and IDRISI Andes (http://www.clarklabs.org/products/). A few of these packages are free or can be purchased at a low cost but others may be expensive and would need significant upgrades. Habitrak has been integrated with the California Department of Fish and Game web site and shows a lot of promise. A comprehensive software search and cost assessment was recommended in the 2007 Habitat Loss by Ecosystem Tracking System report (Clark County, 2007b), but has not yet been completed to identify various software packages that would meet the MSHCP needs.

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CHAPTER 4. SPECIES STATUS TRACKING

4.1 Introduction

As part of activity focused on ecosystem health, and based on available data, Clark County asked DRI to develop a database management template to compile past and future population data for 12 of covered species. This data repository could then be used by researchers and managers to assess temporal and spatial changes in the abundance and distribution of these species. It could also be used periodocially to review, update and analyze available data and suggest refinement of the MSHCP biological goals and objectives as appropriate. At this time, little work has been accomplished on developing this tracking system, and the following discussion is relatively brief and incomplete. A more complete summary and description of the project will occur in a draft document and database that will be completed by December 31, 2008.

In June 2007, the County provided DRI with all available species data in ArcMap personal geodatabase format. This database contained sensitive data and there was agreement that it would not be externally circulated or made available to any other organization or person other than DRI staff working on the project. Other data provided by Clark County at this time included a snails database, the Virgin River data, and ArcGIS files containing reference data.

Several projects are currently underway that will provide updated data on both species population attributes and habitat needs of several covered species. However, as described in chapter 3, few updates to the narrative conceptual models of species' habitat requirements found in the MSHCP and the Biological Opinion have been received to date, and those received are of a preliminary nature, thus no revisions have been made to these relationships between species habitat and ecosystems. Verification of these and additional preliminary updates to species habitat conceptual models are anticipated in two years as the result of several interlocal agreements between Clark County and Federal Agencies and contracts with not-for-profit organizations. Recommendations are made regarding future use of these data.

There was considerable discussion relating to the selection of the 12 covered species for which the functional prototype will be developed. Although work on other components could have been initiated, DRI and Clark County agreed that taking time in the early stages of this task to set it up correctly would save time later and result in products that more closely address County needs. A "painting the room" analogy was made – the effort to remove furniture, mask woodwork and fittings, and prepare corners and edges is time-consuming, but pays off long-term.

4.2 Background

Implementation of the covered species tracking system will involve meeting with the scientific community, compiling existing information, creating databases, and executing the design. Databases for each covered species will include ecological information relevant to status, demographic, and habitat factors as determined from existing monitoring programs and consultation with the scientific community.

A pilot test for 12 species will be performed to test overall implementation of the linkage between the relational database and the GIS. The querying capabilities of the system will be tested with preset queries developed to assess spatial and temporal variability. The final test will determine the linkage between the queried values and the GIS. Once implementation has been tested, the compilation of data for other covered species will commence.

As monitoring programs are implemented or additional monitoring data are compiled, the tracking program will ultimately address all covered species. The tracking system will expand in concert with monitoring programs, and database structure will be closely linked to information compiled during monitoring programs for each species in each patch. Databases will be structured for use in the field so data can be digitally cataloged into field data loggers and downloaded directly into the database tracking system.

4.3 Methods

The following criteria were used by Clark County, in consultation with DRI, to select the 12 species for the prototype tracking system (these criteria were not weighted during the selection process):

- The list should include a taxonomic diversity of taxa
- Species for which there is sufficient demographic and distributional knowledge to design an effective monitoring program
- Species whose demography and habitats can be easily sampled
- Species that occupy discrete, readily quantified habitat
- Species that are rarest, most vulnerable to extirpation, and that could be most readily conserved by implementing a rigorous tracking system
- Species that are listed under Federal or State statute and are therefore most important to agency activities.

<u>Selected Species (not listed in priority order)</u>

Desert tortoise (*Gopherus agassizii*)
Southwestern willow flycatcher (*Empidonax traillii extimus*)
Phainopepla (Phainopepla nitens)
Relict leopard frog (*Rana relictus*)
Mt. Charleston blue butterfly (*Icaricia shasta charlestonensis*)
Southern Nevada springsnail (*Pyrgulopsis turbatrix*)
Whipple’s clapodium moss (*Claopodium whippleanum*)
Las Vegas bearpoppy (*Arctomecon californica*)
Threecorner milkvetch (*Astragalus geyeri* var. *triquetrus*)
White margined beardtongue (*Penstemon albomartinatus*)
Western burrowing owl (Speotyto cunicularia hypugaea)
Las Vegas Valley buckwheat (Eriogonum corymbosum var. nilesii)

4.4 Discussion

While the final decision on which species to include was made by Clark County, the options were discussed during two face-to-face meetings and several biweekly conference calls between the County and DRI. The owl and buckwheat are not covered, but are considered highly desirable. There is no mammal on this list, but Clark County decided that the value of the information that the prototype would provide to the permittees for the above 12 outweighed the value of including a mammal species in the prototype.

There was no activity on the species status tracking component of this task between October 2007 and June 2008 as the focus shifted to organization of ecosystem health workshops, synthesis of workshop results and development of the first iteration conceptual models for the 11 MSHCP ecosystems (see chapter 3, section 3.1, this report).

A pilot database including the 12 selected species will be drafted by December 31, 2008. It will be tested for potential expansion to include all covered species after it is complete in March 2009.

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CHAPTER 5. IMPLEMENTATION STATUS TRACKING

5.1 Introduction

In order to improve tracking of mitigation action projects implemented through the MSHCP, Clark County requested DRI develope a tracking system including a template for future projects and a prototype system to be tested with County staff. In July, 2007, the County made the previous two MSHCP Implementation Databases in FileMakerPro available to DRI. One dated from July 2005, and the other from December 2005. In addition to the existing databases, Clark County sent 1,513 files comprising proposal materials, awarded contracts/interlocal agreements, and final reports to DRI which comprise the available material for implementation analysis. This chapter describes progress in development of the implementation status tracking system.

5.2 Database Objectives

The objective of this task is to develop a mitigation action status tracking system that can better inform effectiveness monitoring and other adaptive management program tasks, including an analysis of the balance between habitat loss and mitigation actions (chapter 3). Initial efforts focused on refining the intended use of the database and identifying the best possible database structure to meet Clark County's needs. Through close collaboration and several meetings between the County and DRI, it became apparent that the objectives for the database needed refinement. The fundamental purpose of the database is to help Clark County identify, track, and account for implemented mitigation activities. Thus, it was determined that the database should focus on projects that were actually funded and implemented, with opportunities to describe how projects changed from the original proposal to actual implementation. The database will also allow the County to assess compliance with the ITP, but only when used in conjunction with other data sources (i.e. information on habitat loss).

In order to produce a database that provides an optimal level of performance under constraints in available data, Clark County provided a "wish list" of potential questions which could be answered by the final database. The general structure of the database was produced by identifying salient trends in the questions and comparing information needs with available data. The following list of example questions was provided by Clark County to DRI:

- What are the terms and conditions/requirements completed by the project?
- For inventory/monitoring projects:
    - Species status report components produced
    - Where looked
    - Where not looked
    - What looked for
    - What not looked for
- For research projects:
    - Number of publications
    - Number of management decisions impacted
    - Species status report components produced

- Were conservation management strategies/other plans developed
- What was done, where and when?
- Where have you cleaned up "weed species"?
    - number of project
    - Locations where cleaned up "weed species"
- Number of springs/riparian areas fenced
- Amounts/locations of water rights
- Easements (conservation easements)
- How many acres have we restored at some point in time (even if outcome is not permanent)?
- How many acres have we purchased?
- How many purchased acres were managed (property management, not for conservation benefit)?
- How many grazing allotments (acres) were purchased? Closed?
- How many miles of desert tortoise (DT) exclosure fencing were installed, retrofitted, inspected, maintained or repaired?
- How many DTs were picked up? How many of those were "wild"? What are the dispositions of those DTs, how many translocated?
- How many Public Information and Education events, how many people reached, how many products produced?
- How many miles of roads designated, closed?
- How many weeds or acres of weeds were removed / treated?
- How many acres were patrolled by Law Enforcement, number of citations, number of contacts?
- How many management decisions were impacted by this project (Adaptive Management Program, research, effectiveness monitoring projects)?
- Total cumulative number of projects, number of projects active at any point or period of time?
- Total approved funding per biennial Implementation Plan and Budget?

Maximum flexibility was maintained throughout database development because not all potential questions will be directly answerable by the database, and not all potential questions can be identified in advance.

5.3 Data Fields and Format

The database format evolved over time based on regular interactions between Clark County and DRI and refinement of database needs and objectives. The interface at the time this document was produced is shown in Figure 15. The database developers have attempted to maintain a high level of both user-friendliness and flexibility while meeting the intended purpose of the database. Both metadata regarding database structure and a users' manual will be prepared and provided to the County with the implementation status tracking system.

The current data entry form has several sections for specifying project information. The first section contains basic contract information including the project name, number, and funding details. A radio-button tab has been included to indicate whether the project is active or complete and whether it has been amended since its award. The sections on the right include dropdown boxes that describe species, ecosystems addressed, threats addressed, and conservation actions.

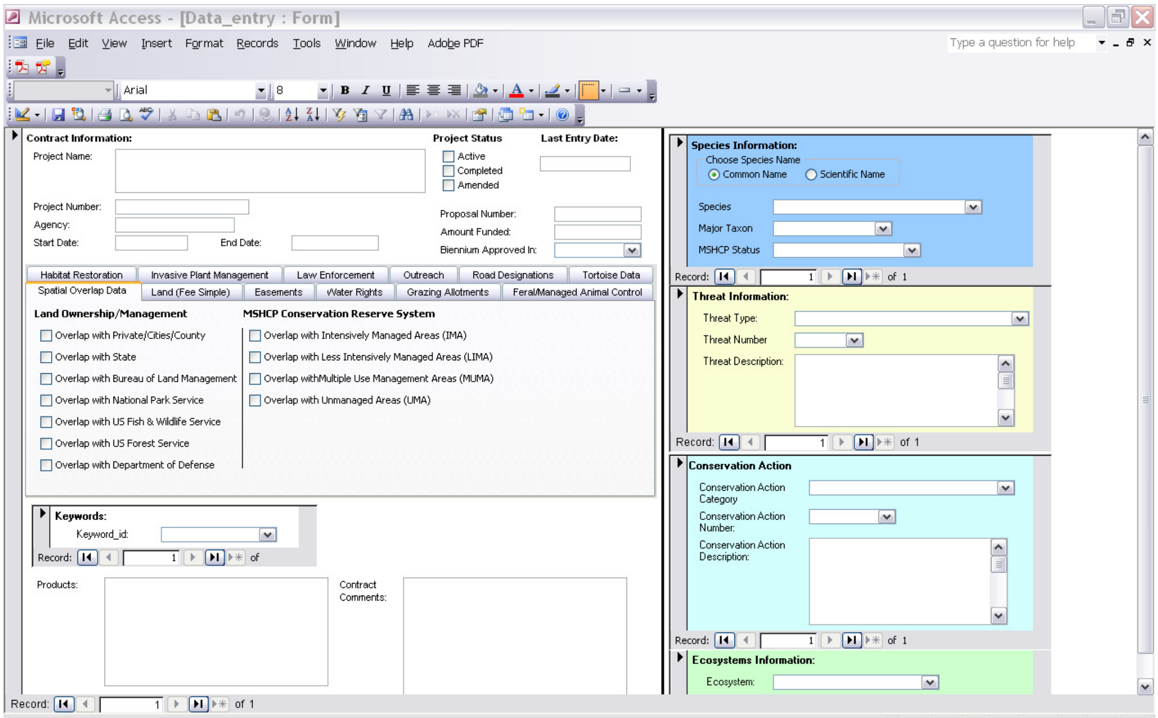


Figure 15. Current prototype database data entry form.

The dropdown menus were populated with tables provided by Clark County. In October 2007, the County provided DRI with a series of documents to be considered in database development including:

- A species list including scientific and common names, taxonomic categories, and the MSHCP status of each species
- A list of all DCP databases under development that might provide information or eventually be linked to the implementation database
- A mitigation actions list with proposed categories to be used in the implementation database
- A list of database requirements/needs/wants generated by the DCP senior management team (approximately 50 items)

In cooperation with Clark County, DRI proposed a grouping of activities with common elements. The center section of the data entry form contains tabs for each of these categories. Screenshots for each category are given in Figures 16 through 27 below. These categories were developed in cooperation with the County and have been refined based on a meeting held with the DCP senior management team in March 2008. The meeting included a complete demonstration of the prototype database's structure, capabilities, limitations, data entry fields, and reporting options. Clark County provided valuable feedback including the request to include a keywords function to allow for easy sorting based on commonly requested project information, which has since been added to the database.

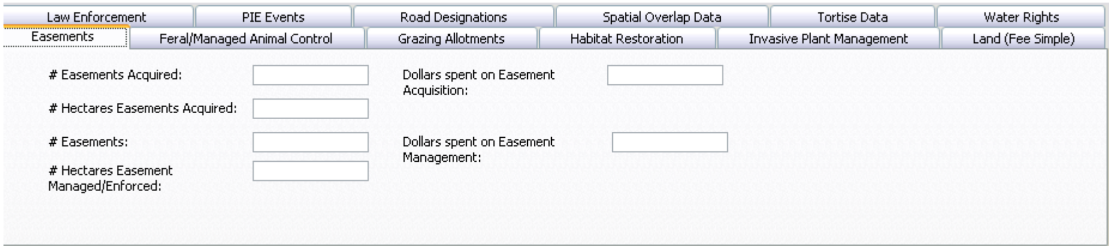


Figure 16. Easement data entry form.

Figure 17. Animal control data entry form.

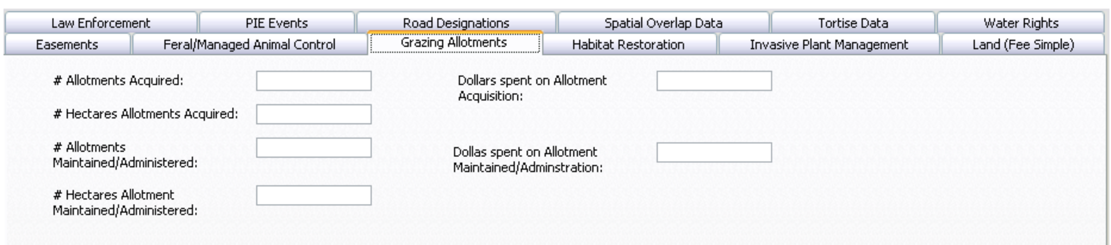


Figure 18. Grazing allotment data entry form.

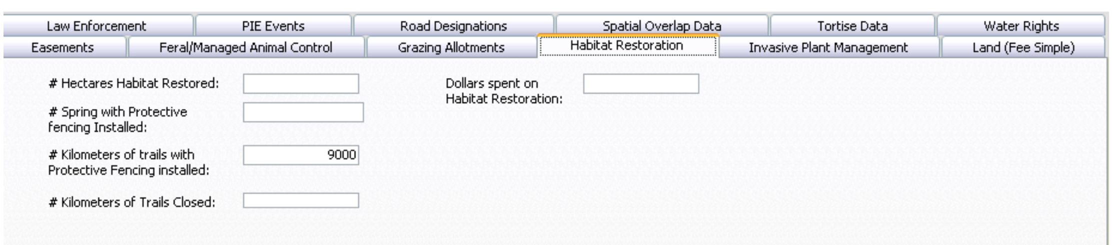


Figure 19. Habitat restoration data entry form.

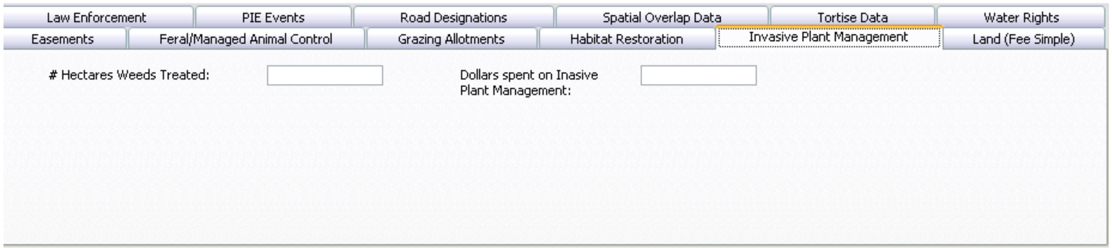


Figure 20. Invasive plant management data entry form.

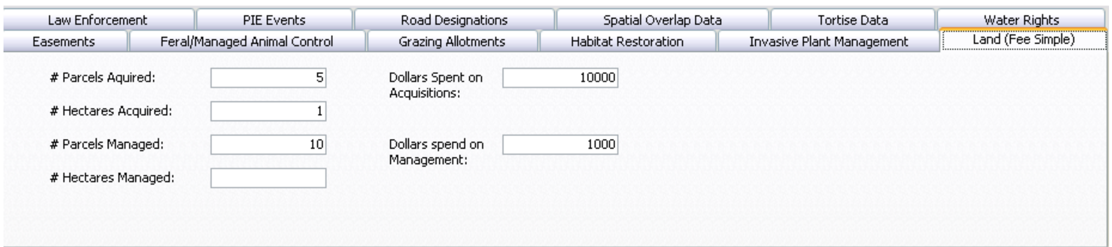


Figure 21. Land data entry form.

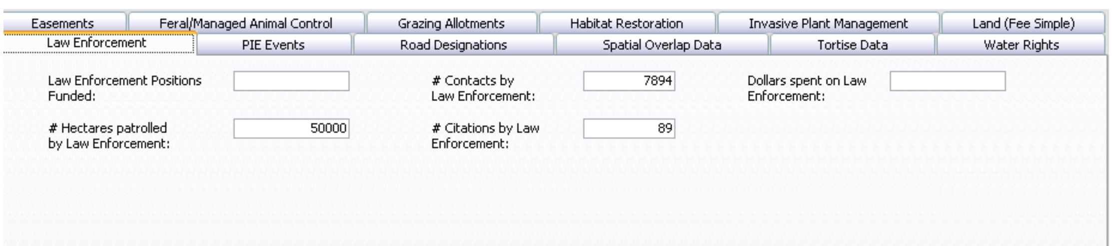


Figure 22. Law enforcement data entry form.

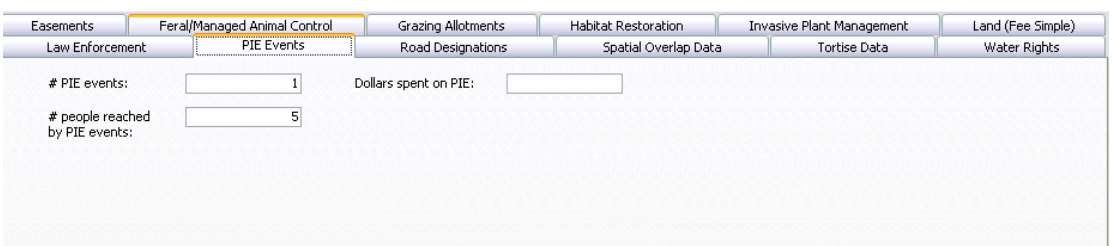


Figure 23. Public information events data entry form.

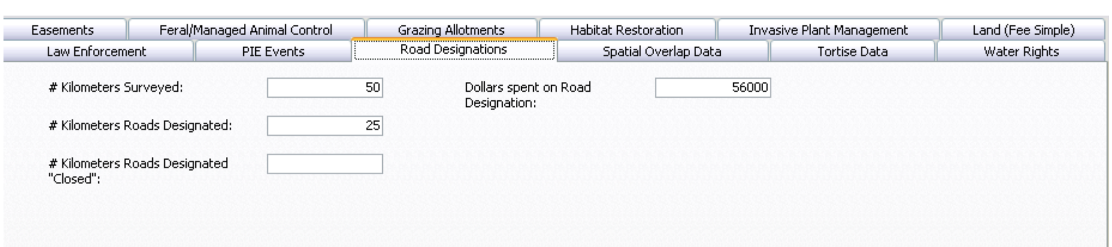


Figure 24. Road designations data entry form.

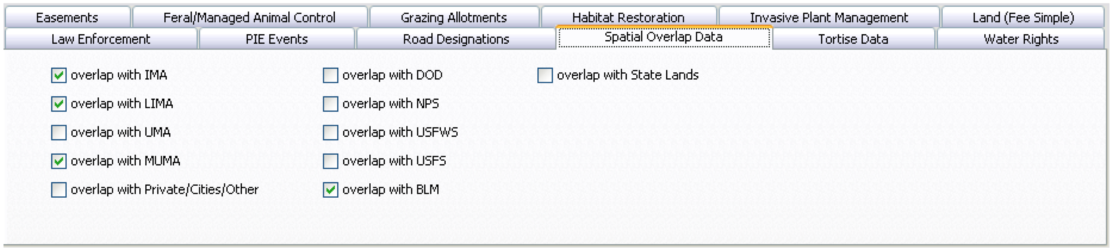


Figure 25. Spatial overlap data entry form.

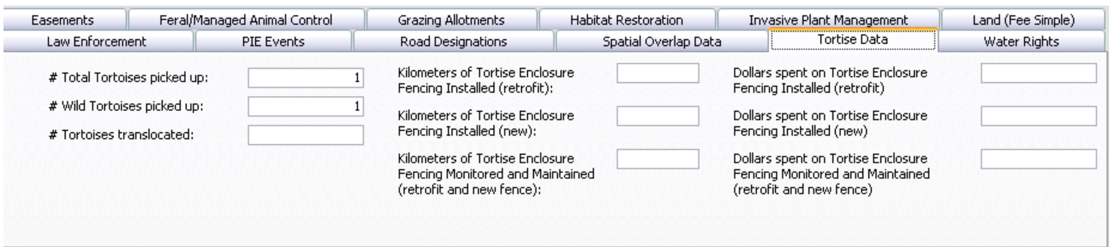


Figure 26. Tortoise data entry form.

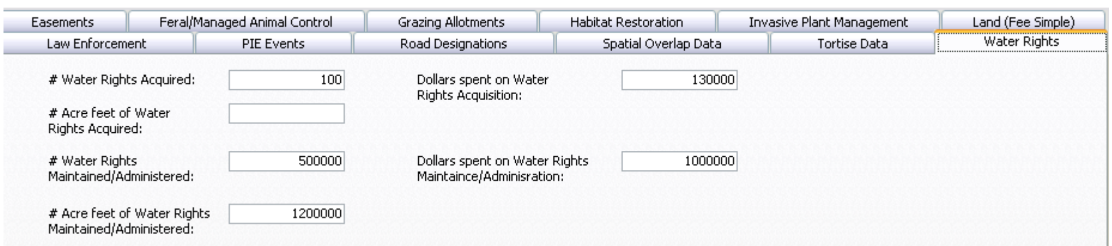


Figure 27. Water rights data entry form.

The data displayed in Figures 16 through 27 are hypothetical and were provided to DRI by the County to serve as test data for the prototype database. The test data provided a broad range of potential data that could potentially result from MSHCP mitigation action projects. Once the prototype database is completed, the entry of actual project data will commence. Clark County recently provided DRI with a mapping file to correlate data fields from the old Filemaker Pro database (now in Excel worksheets) to the new database.

5.4 Standard Reports and Querying Form

In order to provide a user friendly interface while allowing for flexibility, two options will be supported for querying data. First, the County provided DRI with the following list of 11 standard reports that are desired for the database:

1. Program status (for a user specified timeframe)
2. Public information and education events
3. Real estate, easement, grazing allotments and water rights acquisition and management (either one report or four separate reports)
4. Tortoise exclosure fencing

5. PickUp, holding and translocation of desert tortoises
6. Law enforcement
7. Road designation
8. Feral/managed animal control
9. Invasive plant management
10. Habitat restoration
11. Research/inventory/monitoring

Each requested report included a list of categories of data to be produced. An example report (Land Fee Simple) was produced and shared with Clark County and the County's feedback has been included for the final 11 standard reports. The search form and a resulting hypothetical report are shown in Figures 28 and 29. Again, the data shown here have been generated solely for testing purposes. The database was tested by Clark County on two occasions and the County provided DRI with a detailed list of comments, recommendations, and potential errors. All of the County's feedback was addressed before population of the database.

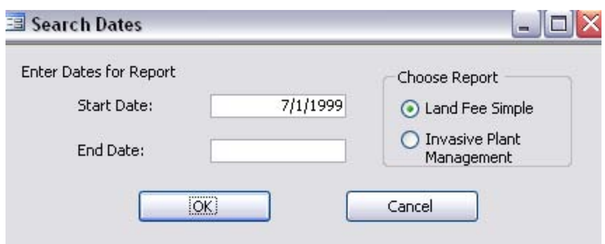
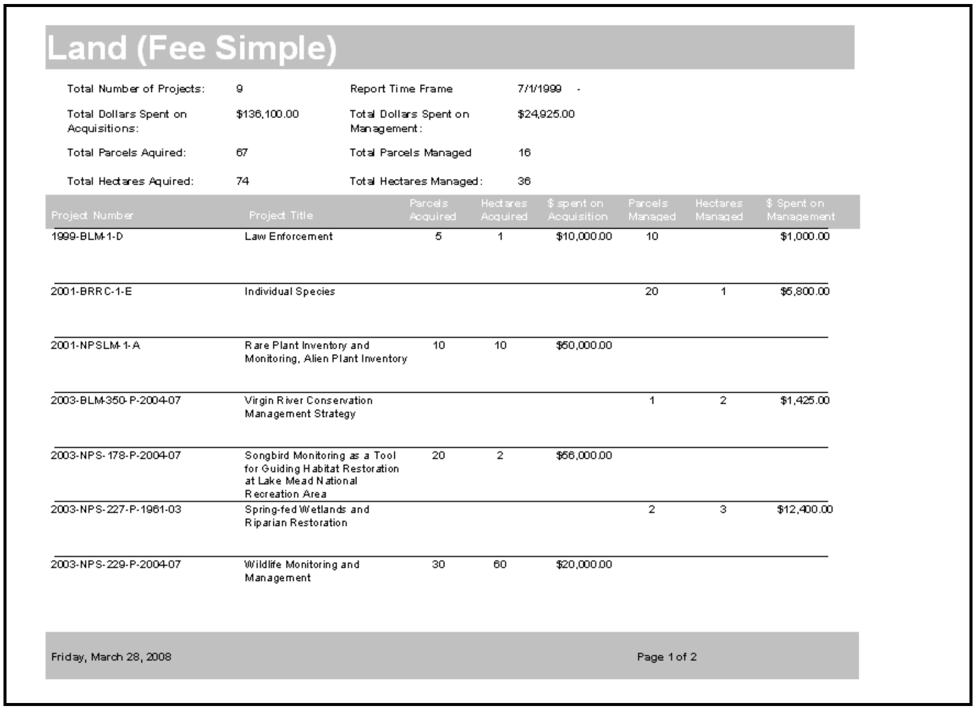


Figure 28. Prototype search form for standard reports.



Land (Fee Simple)

Total Number of Projects:	9	Report Time Frame	7/1/1999 -
Total Dollars Spent on Acquisitions:	$136,100.00	Total Dollars Spent on Management:	$24,925.00
Total Parcels Aquired:	67	Total Parcels Managed	16
Total Hectares Aquired:	74	Total Hectares Managed:	36

Project Number	Project Title	Parcels Acquired	Hectares Acquired	$ spent on Acquisition	Parcels Managed	Hectares Managed	$ Spent on Management
1999-BLM-1-D	Law Enforcement	5	1	$10,000.00	10		$1,000.00
2001-BRRC-1-E	Individual Species				20	1	$5,800.00
2001-NPSLM-1-A	Rare Plant Inventory and Monitoring, Alien Plant Inventory	10	10	$50,000.00			
2003-BLM-350-P-2004-07	Virgin River Conservation Management Strategy				1	2	$1,425.00
2003-NPS-178-P-2004-07	Songbird Monitoring as a Tool for Guiding Habitat Restoration at Lake Mead National Recreation Area	20	2	$56,000.00			
2003-NPS-227-P-1961-03	Spring-fed Wetlands and Riparian Restoration				2	3	$12,400.00
2003-NPS-229-P-2004-07	Wildlife Monitoring and Management	30	60	$20,000.00			

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Figure 29. Example standard report generated with the prototype database.

The second method for extracting data from the database will be through a querying form. Figure 30 contains an initial draft of a querying form containing sections for administrative details, species and ecosystem information, project status, and spatial overlaps. Discussions with Clark County revealed that more detailed spatial queries were not feasible given the availability of data and other user constraints. Such queries will be performed outside of the database as needed, but the database can serve as an initial screening tool.

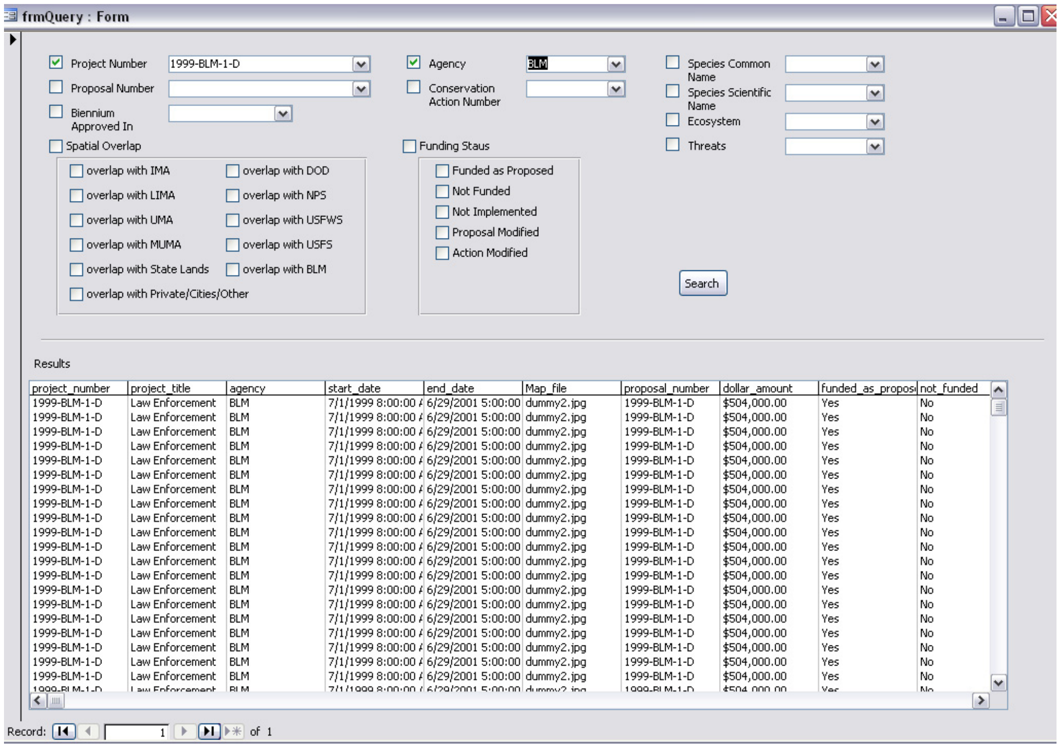

Figure 30. Example querying form for the prototype database.

5.5 Summary

Consistent progress has been made in the development of an MSHCP implementation tracking system. This effort has involved close collaboration between DRI and Clark County in order to assure that the final tool meets the County's needs. Regular communication through phone calls, emails, project management meetings, and database demonstration meetings have assured the smooth flow of information between both parties. At this point, the prototype database has been tested by the County and all concerns have been addressed by DRI. Clark County has provided DRI with a mapping file to correlate fields from the prior databases to the new database. The next stage of this task will be to enter available data for existing and completed MSHCP funded projects.

5.5.1 Recommendation: Compare the output of this mitigation action implementation status tracking system to habitat loss by ecosystem analysis results.

Queries on the mitigation action implementation database will highlight those mitigation action projects that should be further examined for their potential to balance habitat loss. Analyses such as these should, however, also be combined with mitigation action project effectiveness information generated by the MSHCP, partner agencies, or found in the literature.

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CHAPTER 6. PROGRAMMATIC EFFECTIVENESS FRAMEWORK AND STRATEGY

6.1 Introduction

In order to determine whether or not the MSHCP implementation actions are having their intended success at reaching general MSHCP measurable biological goals, Clark County asked DRI to develop an MSHCP Programmatic Implementation Effectiveness Monitoring Strategy that describes methods for monitoring the effectiveness of the MSHCP from both a programmatic and project level perspective. For this report, "monitoring" is defined as: The process of checking, observing, or keeping track of something for a specified period of time or at specified intervals; and "effectiveness monitoring" as: Determining the degree to which the biological system responds to management activities as expected. The two perspectives – programmatic and project - are important biologically and administratively, and monitoring is usually designed to address multiple factors. The inherent dynamism and spatial heterogeneity of natural systems considerably complicates the recognition of significant change (Mulder et al., 1999) and it is not always straightforward determining whether change is a result of management decisions or external forces.

Biologically, the information from individual projects provides species- and ecosystem-level data on status, trend and condition which facilitates assessment of structure, function, and provision of ecosystem services that are critical to human well-being. Management and/or administrative variables, often expressed by phrases such as "how many" or "how much", are also components of individual project monitoring programs. However, almost inevitably, some aspects of project-level monitoring require "scaling up" both biologically and administratively to address programmatic goals (Mulder et al., 1999). This is a complicated and difficult task, which Clark County and the MSHCP is in the initial stages of addressing. A collaborative approach, transparency, rigorous goal setting and a long-term perspective will be of considerable importance as this process moves forward.

The MSHCP stated goals are to "a.) allow no net unmitigated loss or fragmentation of habitat in Intensively Managed Areas and Less Intensively Managed Areas (or Multiple Use Managed Areas where they represent the majority of habitat for the species); and b.) maintain stable or increasing population numbers."

DRI prepared a framework document describing effectiveness monitoring drawing upon examples of other programs, and used this document as material for a workshop with MSHCP Implementing Agreement signatory agencies organized and hosted by DRI (which took place on August 5, 2008). Clark County and USFWS decided upon the desired outcome of the workshop, which was a draft plan of what could be measured and how (not including metrics at this stage), to which DRI added that a buy-in and sense of commitment from permittees was also important.

Based on workshop results, recommendations for project-level and programmatic-level effectiveness monitoring were made by DRI (DRI, in review), who worked with the Clark County DCP staff to design a programmatic effectiveness tracking system. The final report for this task (DRI, in review) presents the results of the workshop and includes recommendations for project and programmatic level effectiveness monitoring, and design recommendations for a programmatic effectiveness tracking system.

The workshop was designed to consider programmatic effectiveness at a conceptual level, make recommendations on what would be measured and how (but not include establishing mitigation metrics for offset of take), and share lessons from other programs. The monitoring program components, both in advance of the workshop and as part of the workshop itself, were clearly defined and addressed.

The conceptualization of programmatic effectiveness monitoring becomes clearer when it is examined in the context of, and linked to the conceptual models for, the 11 MSHCP ecosystems (chapter 3), which are both a precursor and a part of planning in the classic adaptive management "donut" shown in Figure 31. Ultimately, implementation status tracking (chapter 5) will be used as part of the evaluation and revision processes, as will programmatic effectiveness monitoring. Further study of these links might make the linkages and the strategy itself clearer and more useful.

When completed, the results of ecosystem health model development for the 11 MSHCP ecosystems will be used by permittees, agencies, and science advisors to address/refine MSHCP goals and will, in the long-term, be part of programmatic effectiveness monitoring. The goals themselves, together with the models, are critical parts of the early stages in planning and provide a framework for formulating a monitoring strategy. Programmatic effectiveness monitoring is unproductive unless there is a mechanism to effect change. This involves an analysis of the "scores", what can and cannot be controlled, and what might be done differently to improve the scores (the "Revise" point of the process of adaptive management shown in Figure 31). The analysis and assessment of the scores, though, must lead to the mechanism to effect change.

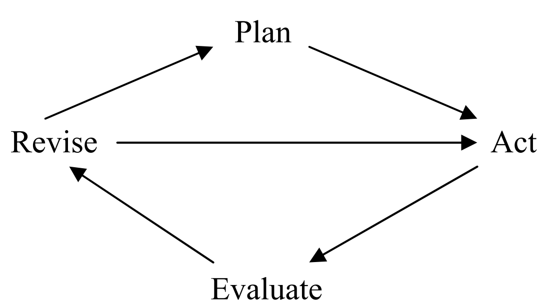

Figure 31. A simple schematic of the adaptive management process.

6.2 Progress

The goals of the MSHCP are of fundamental importance toward developing a programmatic effectiveness strategy as they provide the context in which progress (effectiveness) is measured. However, at a meeting between Clark County, the USFWS and DRI in late November 2007, it was acknowledged that participants in the MSHCP have different goals, or at least different priorities within the general framework of the stated goals, and this is part of an ongoing discussion between the USFWS and the County, initiated at the request of DRI. Consensus on the program goals will benefit all aspects of the MSHCP process, enhancing stakeholder commitment, strengthening program image, providing a "crisp and succinct" framework for agency and organizational science, and increasing cost effectiveness in terms of personnel and finances.

A framework document was developed describing effectiveness monitoring in the context of similar programs. Clark County and DRI discussed the utility of the framework document, and are in agreement that it will guide development of future monitoring plans, and it also provided material for discussion at the workshop. From the County's perspective, in the long-term, it will also guide the crafting of new goals and/or objectives for the amended MSHCP. The overall relevance of the framework document is for programmatic effectiveness. Therefore, as the County discusses and rethinks its goals for the MSHCP and in the context of preparing for the framework document and workshop, an understanding of the development (including goals) of other programs is of interest.

The Coachella Valley, Western Riverside County, and East Contra Costa County MSHCPs were used as the primary examples for discussion at the workshop, with limited reference to the Chesapeake Bay Program (CBP), Chesapeake Bay Foundation (CBF) and Lake Tahoe Pathway process.

The Western Riverside County MSHCP has three goals, one each in biologic, economic and social contexts, as follows (quoted from: http://www.rctlma.org/mshcp/index.html):

- In the MSHCP Plan Area, Conserve Covered Species and their Habitats.
- Improve the future economic development in Clark County by providing an efficient, streamlined regulatory process through which development can proceed in an efficient way. The MSHCP and the General Plan will provide the County with a clearly articulated blueprint describing where future development should and should not occur.
- Provide for permanent open space, community edges, and recreational opportunities, which contribute to maintaining the community character of Western Riverside County.

A measure of programmatic effectiveness would therefore involve all three contexts.

By comparison, the Coachella Valley MSCHP is a relatively new program, as the final version of their MSHCP is dated September 2007. The broadest goals of their plan (http://www.cvmshcp.org/Plan_Documents.htm) which are biologically and management oriented, include:

- Represent native ecosystem types or natural communities across their natural range of variation in a system of conserved areas.
- Maintain or restore viable populations of the species included in the Plan so that Take Permits can be obtained for currently listed animal species and non-listed animal species can be covered in case they are listed in the future.
- Sustain ecological and evolutionary processes necessary to maintain the viability of the conserved natural communities and habitats for the species included in the Plan.
- Manage the system adaptively to be responsive to short-term and long-term environmental change and to maintain the evolutionary potential of lineages.

The East Contra Costa County MSHCP is newly approved, and therefore untested. Its Mission Statement defines the Plan's guiding principles as follows (quoted from: http://www.co.contra-costa.ca.us/depart/cd/water/HCP/documents.html):

The East Contra Costa Habitat Conservation Plan/Natural Community Conservation Plan will provide comprehensive species, wetlands, and ecosystem conservation and contribute to recovery of endangered species within East Contra Costa County while:

- Balancing open space, habitat, agriculture, and urban development
- Reducing the cost and increasing the clarity and consistency of federal and state permitting
- Consolidating and streamlining these processes into one, locally controlled plan
- Encouraging, where appropriate, the multiple use of protected areas, including recreation and agriculture
- Sharing the costs and benefits of the habitat conservation plan as widely and equitable as possible; and
- Protecting the rights of private-property owners.

As reflected in the statements above, the East Contra Costa County plan recognizes the fact that the area is experiencing rapid urban growth, together with associated infrastructure.

Although HCP examples had the most relevance for the framework document and workshop, DRI felt that it would be of interest to the workshop group to briefly consider the efforts of the CBP and CPF, largely as an example of what is not working (or is only marginally successful). The 1987 Chesapeake Bay Agreement between partnership Federal and State agencies comprising the CBP contains goals and priority commitments for living resources, water quality, population growth and development, public information, education and participation, public access, and governance (CBP, 1987). Despite this broad spectrum of environmental and social categories, the focus of the program has been reduction in nitrogen and phosphorus in Bay waters (CBP, 1992). In the context of both Chesapeake and Lake Tahoe, Jim Karr (personal communication, 2008) argues that a narrow focus on pollutants is misguided and is a waste of an opportunity to consider the functioning of the ecological system as a whole. Karr (2008) also commented that, in his opinion, the CBP is overly driven by models. Observations made by DRI are that it involves limited feedback to management and policy changes to improve effectiveness.

The CBF is a private sector organization with a 2006 goal (quoted from CBF, 2006) to:

- Increase CBF's Health Index from 27 to 40 by 2010 as a first step toward reaching a saved Bay with a Health Index of 70 by 2050.

With a quantitative goal such as this, measuring programmatic effectiveness may be as deceptively simple as "in 2008, how close is the Bay's Health Index to 40?" However, there are 12 indicators in three major categories (pollution, habitat, and fisheries) which make up the index (http://omalley.3cdn.net/1857d3b7f96ee13e1f_02m6bhe5j.pdf) which makes it a far more complex assessment, the results of which most likely expresses considerable spatial variability.

6.2.1 Clark County Goals

Phase I of the Clark County MSHCP specifies goals and objectives for the following components of the program (RECON, 2000 Section 1.2.3): Methodology; Species and Habitats; GIS; Library of Laws, Rules, and Regulations; AMP; Stressors and Threats; Analyze Laws, Rules, and Regulations; Conservation Measures; Stakeholders; Implementation Plan; Coordination; Listed Species; Species Not Currently Listed; Permits and Agreements; Prioritize Evaluation Species; and Measureable Biological Objectives.

However, and in the context of this report, the relevant goals that are applicable to programmatic effectiveness (and are currently under discussion as mentioned above) are:

- No net unmitigated loss or fragmentation of Intensively Managed Areas (IMA) or Less Intensively Managed Areas (LIMA) (or some Multiple Use Managed Areas (MUMA)) or mitigate and minimize the proposed incidental take to the maximum extent practicable (RECON, 2000: section 1 page 8; section 2 pages 7, 24, 152-172)
- Maintain stable or increasing populations of covered species in IMA and LIMA (and some MUMA) (RECON, 2000: section 1 page 8; section 2 pages 8, 152-172)
- Not appreciably reduce the likelihood of the survival and recovery of the species in the wild (RECON, 2000: section 1 page 8; section 2 page 24)
- Maintain healthy ecosystems and the species supported by them (RECON, 2000: section 2 pages 56, 179)
- Recovery of listed species and conservation of unlisted Covered Species (RECON, 2000: section 2 page179)

Assessing the effectiveness of the program's ability to meet these goals has been challenging for Clark County, partly due to the need for an understanding of the term "programmatic effectiveness." In addition, the low level of County control over the trends of the various impacting activities handicaps their ability to revise and re-plan (in the adaptive management "donut" shown in Figure 31) and thereby for management actions to result in improvement. Thus, these potential candidate goals for effectiveness assessment have been constrained by the County, and a decision was made in late March 2008 that a programmatic mitigation goal of "Net Neutral or Positive Impact Resulting from Take" will be the MSHCP goal to be addressed by programmatic effectiveness monitoring. The implications of this recent decision have not been explored, but DRI feels that it is a realistic goal, which will result in the outlining and future development of a viable strategy to meet County needs.

6.3 Summary

The framework document and design recommendations report (DRI, in review) will guide development of future monitoring plans, and the former also provided material for discussion at the August 2008 workshop. From Clark County's perspective, in the long-term, these reports will also guide the crafting of new goals and/or objectives for the amended MSHCP.

6.3.1 Recommendation: Use a collaborative approach to design components of the programmatic effectiveness monitoring strategy.

The advantages of forming partnerships and working in collaboration was mentioned several times during the August 2008 workshop and there are specific tasks that need to be completed before a programmatic effectiveness monitoring strategy is implemented, all of which would benefit from the collaborative approach. Clear objectives must be defined, and this could be accomplished by a small working group that would "report" to the larger stakeholder community. A similar method could be employed for the definition of indicators – for the MSHCP itself, and for non-MSHCP indicators targeting bigger picture information. Species, the program, and adaptive management may require individual indicators, depending on selection of metrics.

6.3.2 Recommendation: Incorporate an AMP effectiveness monitoring program in the MSHCP programmatic effectiveness monitoring strategy.

As part of thinking beyond the currently contracted activity, and to ground it in the long-term program objectives, programmatic effectiveness monitoring can best be assessed in the context of evaluating an AMP through a series of questions and associated nested metrics. The following is a suggested array:

- Level 1 – How effective is the program? (e.g., number of acres of habitat gained or lost; % change +/-)
- Level 2 – How much has the AMP contributed to achieving overarching MSHCP goals? (e.g., how much of the outcome is as a result of the AMP? Qualitative)
- Level 3 – How much has each AMP element contributed to the AMP's effectiveness? (e.g., a subjective assessment of the importance of each element toward achieving overall AMP goals)
- Level 4 – How complete is each AMP element? (e.g., a given AMP element/task is X% complete).

The first stages in developing a programmatic effectiveness monitoring strategy for the Clark County MSHCP have been approached in a thoughtful manner, with investment of considerable time spent in discussion between all involved. The authors are confident that this strategy will result in development and implementation of a viable and cost-effective program that may possibly serve as an example to other HCPs in the region.

CHAPTER 7. PROJECT-LEVEL, PRIORITIZED RECOMMENDATIONS FOR THE 2009-2011 IMPLEMENTATION PLAN AND BUDGET

7.1 Introduction

Every two years, the MSHCP develops a new two-year Implementation Plan and Budget (IPB). As described in the MSHCP (RECON, 2000), this process requires the following major steps:

- Solicit project ideas from the Implementing Agreement signatories,
- Receive science-based input on these project ideas and a recommendation from the Adaptive Management Program,
- Receive public stakeholder input on these project ideas, and
- Make a recommendation to the Clark County Board of County Commissioners to approve the subject IPB.

For the recommendations on the 2009-2011 biennial IPB, the Implementing Agreement signatories were invited by Clark County to participate in a workshop, organized by Clark County, to design an *a priori* decision support tool. This tool was subsequently used by the DRI science advisor team to evaluate and rank discretionary (non-permit conditions) conservation action projects proposed for possible funding by the implementing agencies. The permittees determined that the science advisor team would not rank the non-discretionary project concepts, as they were requirements of the permit. The overall process to develop the IPB for 2009-2011 is provided in Appendix 4.

There are six parts to this chapter, the first two of which are summarized below and were prepared by Clark County. They are presented in detail in Appendix 4. The remaining four parts to this chapter were prepared by the DRI science advisor team:

- A description of a workshop to design a Decision Support System
- Details of the project concept solicitation
- A summary of discussions among the DRI science advisor team regarding the scoring strategy for project concepts using the Decision Support System
- A description of the results of the scoring and ranking process
- The Decision Support System matrix showing project concept scores
- Summary

7.2 Decision Support System Workshop

A workshop was held in late February 2008 with the goal of developing a list of science-based criteria that could be used to evaluate non-MSHCP permit condition project concepts. There were 19 participants in the workshop, from Federal, State and permittee agencies, plus the three-person DRI science advisor team, and two facilitators. Everyone participated in discussion, which was lively and productive.

The workshop opened with an overview of the MSHCP 2009-2011 IPB process (Appendix 4) and introduction to workshop objectives. Breakout groups evolved naturally and their discussion resulted in 48 ideas for possible proposal evaluation criteria (Appendix 4), which the whole group sorted into 12 topic areas based on the MSHCP context – with no mention or discussion of their relevance to the AMP. Of these 12, four were excluded from consideration based on participant agreement on their non-science focus. The group voted against bonus points, but decided that inclusion of any of the four non-science topics might be considered as the DRI science advisor team wrote up their notes on the ranking (see Results of Scoring and Ranking Project Concept Papers by DRI below).

Following a brief summary of potential data availability, the group agreed on the following four criteria, which were selected based on perceptions of the MSHCP's goals, objectives, and current priorities, rather than the program's role in Clark County's AMP:

- *Criterion 1*: Priority Species: Is the project key to population sustainability of a priority species?
- *Criterion 2*: Priority Habitats/Species/Ecosystems: Does the project benefit impacted priority ecosystems/habitat or species? Explain.
- *Criterion 3*: Pick one of the following two depending on type (information gathering / implementation) of project concept:
- *Criterion 4*: Effectiveness Likelihood/Method: How likely is the project concept to be effective at meeting its stated goal?

The workshop concluded with discussion of ranking and weighting, and the forthcoming project concept solicitation (Appendix 4)

7.3 DRI's Decision Support System Scoring Strategy

The DRI science advisor team on this task consists of three members, with diverse backgrounds. All meetings, conference calls, emails, and face-to-face discussions on criteria, sub-criteria, scoring strategy, and reporting occurred in advance of any team member looking at any of the project concept papers. DRI consulted with Clark County during this "strategy development" phase to clarify points raised during the February 28, 2008 workshop, and to make sure the scoring strategy options and decisions were compliant with group perceptions and preferences. Written records of all interactions were made, and the following sections are excerpts.

7.3.1 Criterion 1: Is the project key to population sustainability of a priority species?

Addressing five species is not necessarily better than addressing one. If there is no reference at all to a species, the score would be zero. Indirect reference (for example, the proposal was really for trail improvement but the author justified it by saying that better trails would result in people not damaging off-trail areas and species 'x', which was growing/living there) would likely not get the top score on this criterion, but if the concept paper were well-written it might make up for it on other criteria.

The team agreed that descriptions for four possible scoring categories were as follows:

- Fully, and well, shows that the project would benefit a key species. (score 8-10)
- Shows that the project would, or would somewhat, benefit a key species. (score 6-7)
- Partially, or rather weakly, or indirectly, shows that the project would benefit a key species. (score 3-5)
- Does not show, or scarcely shows, that the project would benefit a key species, or does not refer to any species. (score 0-2)

7.3.2 Criterion 2: Does the project benefit impacted priority ecosystems/habitat or species? Explain.

The phrasing on the scoring categories will basically be the same as for Criterion 1, but addressing habitats. Concept papers that do not provide any explanation here would score very low (score 0-10).

7.3.3 Criterion 3: Habitat/species benefit type or, knowledge/information to inform management.

The team remembered the struggle the workshop participants had with this, and that 3A is "information gathering", versus "implementation" for 3B. However it was thought likely that criteria 2 and 3A may score similarly for some of the project concepts.

It was noted that during the workshop there was considerable discussion concerning the relative merits of habitat enhancement, versus restoration or protection and participants were undecided about which was "most important/beneficial." The discussion concluded when it was suggested that the DRI science team would rank the implementation type (enhance, restore, protect). DRI discussed this subsequently, and agreed that as workshop participants had requested a formal ranking this would be done. Consensus among the DRI team was that protection was most beneficial (important), followed by enhancing and restoring in that order. The fact that a really good or large scale restoration project is very valuable and might be "better" than one that provides an intermediate protection was recognized, but a decision was made that even an exceptionally good restoration project concept paper will only score 8 (maximum); similarly, an enhancing project might score a 9, but potentially a protection project could score 10, thereby recognizing the relative importance of these activities in the broader contexts of adaptive management and ecosystem health.

7.3.4 Criterion 4: How likely is the project concept to be effective at meeting its stated goal?

This is the connection between project and goal. So to be scored high, goal and concept must be really clear, explicit, and well referenced. It will score low if it has unjustified assumptions, or a high level of uncertainty of outcome (i.e. dependent on weather). Again the wording of the descriptive phrases detailed under Criterion 1 will be appropriate, with minor adjustments for the topics.

During the workshop, participants were asked it they felt any of the criteria were "tie makers/breakers." Initially it appeared that Criterion 4 would be allocated this status, but although participants agreed that if a project had no chance of success, it should not be funded; the tie-breaker concept did not receive approval from the workshop participants. The DRI team was somewhat surprised at this, and agreed that such a project would score low and probably be ranked last.

7.3.5 DRI's Discussion of Strategy and Possible Issues

The DRI science advisor team discussed the score range of 0 to 10, which was probably a greater resolution than necessary. However, it means that each of the four "score brackets" would cover a range of two to three score points and this was considered advantageous. The team developed a set of sub-criteria, which comprised factors that would be taken into consideration during scoring (Table 21). The team decided that some of these sub-criteria (e.g., "Is project likely to be successful at meeting its goals?" under criterion 4) were absolutely critical (marked AC in second column from the left on the Table 21 spreadsheet), others critical (marked C in the second column from left), while others (with no notation in second column from left) were for reviewer guidance and consideration during scoring. It was agreed that the "set" of sub-criteria that comprises each criteria will receive the score, not individual sub-criteria. For example, population dynamics might be critical for some species, but not in the case of, say, the desert tortoise. What is being scored is what the project SAYS it is going to accomplish, but all agreed that if everyone thought something should be added that is not mentioned, it would be noted but probably would not affect the score. The team wondered how explicit notes would need to be on this process, and discussed again the importance of professional experience. Team members will inevitably use professional opinion for big picture issues, and this is acceptable.

The first stage is for the three people on the DRI science advisor team for this task to score independently and then meet and see how closely their scores correspond. In some cases, even if one project concept scores high, it might rank lower if it were carelessly written. The question of whether to ask other DRI researchers to score too was discussed, but it was decided that the three-person team was adequate, especially as everyone had participated in the February 28th workshop and knew the issues, system, etc. It was agreed that if results from the three science advisor team reviewers were significantly inconsistent, the concept papers affected would need careful discussion. It is possible that someone might miss something, and decide to change their score after/during discussion. In that case, a record of the initial score would be kept and the change justified.

7.4 Results of Scoring and Ranking Project Concept Papers by DRI

The DRI science advisor team members were in general agreement on the project concept papers, and were pleased that all authors had complied with requests on formatting and inclusion of citations and a location map.

In general, it was not clear from most of the papers whether their proposed activity would fall under "implementation" or "information gathering" (Criteria 3A and 3B respectively). The DRI team members compared notes on their individual decision for this criterion during their first meeting, which resulted in three adjustments from 3B to 3A, and one from 3A to 3B. There were no major changes in score as a result of these adjustments, and the two categories with associated scores are shown in Table 22. One of the DRI team members scored the paper "Gypsum Habitat Restoration Methods and Associated Species Research for Lake Mead National Recreation Area (National Park Service)" substantially higher than the other two on criterion 1, but in discussion with the other team members, agreed that this should be lowered, as the paper relates primarily to habitat.

Table 21. Science advisor project concept criteria 2009-2011 biennium.

			Project Concept by Title						
Criterion	**Topics for evaluator consideration. AC = absolutely critical, C=critical**		**A**	**B**	**C**	**D**	**E**	**F**	**G**
1: Priority species	**AC**	Addresses issues relating to a priority species							
		Addresses issues relating to an impacted species							
		Concerns population dynamics							
	C	Reflects understanding of sustainability issues for species in question							
		Benefits multiple species							
2: Priority habitats		Benefits priority impacted ecosystem, or							
		Benefits impacted habitat, or							
	AC	Benefits impacted species							
		Shows understanding of ecosystem-species relationship							
		Provides explanation of project relevance							
Either 3A: Implementation	**AC**	Relates to mitigating impacts or threats							
	AC	Specifies whether protecting, enhancing (max =/<9) or restoring (max =/<8)							
		Shows understanding of, or at least refers to differences in duration/intensity and cause-effect							
	AC	What % of species distribution is targeted, or does proposed work have broad significance for entire species distribution?							
Or 3B: Information	**AC**	Is a priority goal, objective or information gap identified?							
	AC	Contributes new or missing knowledge/data							
	AC	Clear link to management need included							
4: Methods	**AC**	Goal explicitly stated							
	AC	Methods provided							
	AC	Is project likely to be successful at meeting its goals?							
		Is a steep learning curve involved before project will be operational?							
	C	Does area to be studied match with intensity of effort/cost?							
	C	Is adequate time allowed for?							

Table 21. Science advisor project concept criteria 2009-2011 biennium (continued).

			Project Concept by Title						
Criterion	**Topics for evaluator consideration. AC = absolutely critical, C=critical**		**A**	**B**	**C**	**D**	**E**	**F**	**G**
Required		Is location map provided, or location adequately described?							
		Are citations and/or references to documents included, if applicable?							
General		**No score - but may be acknowledged in reviewer comments**							
		Are concepts thought through and proposal clearly written?							
		If appropriate, are other issues (e.g., sustainable development) mentioned?							
		Is an education component mentioned?							
		Is it relatively easy to see how the effectiveness of the proposed activity could be measured?							
		Is activity likely to be dependent on weather or other uncontrollable factors?							

Table 22. Science advisor project concept scoring 2009-2011 biennium.

	Project Concept by Title																				
	A Post-fire rehab			**B Leopard frog**			**C Mesquite acacia**			**D DT monitoring**			**E Restoration DT/gyp**			**F OHV education**			**G Gypsum restoration**		
Criterion	***MS***	***JL***	***DM***	***MS***	***JL***	***DM***	***MS***	***JL***	***DM***	***MS***	***JL***	***DM***	***MS***	***JL***	***DM***	***MS***	***JL***	***DM***	***MS***	***JL***	***DM***
1: Priority species	8	6	8	8	9	7	5	7	4	7	6	6	5	8	6	5	6	4	4	2	4
2. Priority habitats	9	8	8	7	8	7	6	8	7	8	5	6	5	5	6	7	7	5	7	8	5
3A. Implementation	9	8	7	7	4	8							7	7	6	7	3	5			
3B. Information							7	8	8	8	8	7							5	8	5
4: Methods	8	7	8	8	8	9	8	8	6	7	5	6	5	6	4	8	7	5	5	8	4
Total	34	29	31	30	29	31	26	31	25	30	24	25	22	26	22	27	23	19	21	26	18
Total for all Reviewers			94			90			82			79			70			69			65
Rank			1			2			3			4			5			6			7

The seven project concept papers were discussed in alphabetical order after the science advisor team members had completed their reviews. A number of scientific papers and documents were consulted as part of the evaluation process (Anderson et al., 2001; Heaton et al., 2008; USFWS, 2007; Clark County, 2007c-g; Provencher and Andress, 2004; TNC, 2007) as sources of specific and background information.

The following sections comprise reviewer comments on each of them in order of priority, starting with the paper that ranked highest. Scores are shown in Table 22.

7.4.1 An Assessment of Post-Fire Rehabilitation of Desert Tortoise Habitat in Clark County, Nevada

The proposed work builds on two years of monitoring following wildfires which occurred in 2005. The monitoring effort will improve information regarding restoration of post-fire sites with desert tortoise as benefitted species. Although the monitoring area is relatively small, the new information will be valuable to land managers in and outside of the study areas. The work will complement related work by the USGS on monitoring tortoise behavior in burnt habitat.

The concept paper is well written with appropriate references and a clear and informative map. The authors provided adequate information for the reviewers to understand the larger context of modified fire regimes and the associated impacts on priority habitat for the desert tortoise. An appropriate level of detail was given to provide the reviewers with confidence that the proposed work will be thoroughly and effectively completed. As a continuation of ongoing work, the monitoring effort is likely to be successful. The project addresses a priority species, desert tortoise, but indirectly by monitoring habitat rehabilitation.

7.4.2 Relict Leopard Frog Conservation

This is a good and comprehensive project concept paper with an informative map and a list of pertinent citations. A priority species is clearly identified and population sustainability is directly addressed. How and to what extent the project will address priority habitat is not easy to assess. Study sites are already known, which increases confidence in the successful outcome of the effort. The proposed project will build upon ongoing activity described in the concept including vegetation removal and breeding pool improvement. Threats and stressors are identified. It is, however, challenging to assess whether the concept was an implementation or information gathering project.

The project description and methods are sufficiently detailed for review. The proposed activity would address several management actions recommended in the Conservation Assessment and Strategy for the frog, and would seem to benefit other species (such as springsnails) in the process of removing exotic fish species. The goal is ambitious, but the proposed activity has a good chance of meeting it successfully.

7.4.3 Mesquite and Acacia Woodland Assessment, Monitoring, Restoration and Management for Lake Mead National Recreation Area (National Park Service)

This is a good project concept paper, with a clear map and some citations. Although priority species are not directly addressed, clear connections are made to priority habits and species including the Phainopepla, vermilion flycatcher, and several other species. The authors did a good job of describing the ecological benefit of the proposed activity,which is set in the bigger picture context of patch integrity, threats and stressors, and human impacts. The project is likely to meet at least some of its stated goals.

The methods section is clear and in sufficient detail. The approach appears to be comprehensive and viable, and likely to meet the project goals and produce useful results. Several recommended management actions would be implemented by this effort.

7.4.4 Desert Tortoise Monitoring 2010-2011

The proposal is clearly written, with a stated goal of providing viable evidence toward delisting of desert tortoise. The proposed work would continue ongoing monitoring efforts of desert tortoise. However the benefit to the species (criterion 2) is not stated, nor is the link between management action and benefit to species. The project goal is exceedingly long-term, but the proposed activity will possibly contribute toward its success. The map does not have a legend (or scale), but it is presumed that the study areas are outlined in blue. Appropriate references are provided.

There is minimal "justification" for the proposed activity and selected methods. One reviewer felt the need to do additional reading to confirm sampling and data collection methods. The budget is substantial (much higher than the other proposals) and, unlike other concept papers, no basic break-down is provided. It also is not clear how the proposed work and budget fit into what is apparently a much larger overall monitoring program.

7.4.5 Restoration of Desert Tortoise and Gypsum Habitat

The stated project goal is restoration of desert tortoise and gypsum habitat. Although desert tortoise and five other species are identified as benefiting from the work, the proposed activity is basically habitat restoration, which may include: planting vertical mulch, seeding, transplanting live plants, ripping compacted soils with a bobcat, recontouring dump sites with a front-end loader, removing trash and large debris by hand or with heavy equipment, and installing fences or other barriers. This project concept paper does not provide thorough details in terms of activities and methods. Although not provided in a compelling manner, the proposed activity would likely achieve at least a portion of the project's stated objectives.

No new science is proposed and data gaps in knowledge identified which might be filled by the project is not identified. The explanation of benefit, required under criterion 2, is very minimal. As with any study involving human impacts, it is difficult to be sure that this proposed activity will meet project goals.

The project map shows IMA, LIMA, MUMA, and UMAs but study sites have not been identified, making it impossible to evaluate the portion of habitat addressed. The citations are limited. The impacts of the proposed work are clearly identified.

7.4.6 OHV Education

This is the "odd man out" among the project concept papers as it related to education rather than species and habitats. However, benefits to seven priority species are stated and some good ideas are presented. It is possible that this scored "low" because the criteria were developed for natural, not social, science issues and it is difficult to assess how the proposed activities will impact priority species and habitats.

The paper is clearly written, with a good map, and a list of citations. The methods section provides adequate detail and the cost breakdown was useful in helping the reviewers understand the project approach. Six conservation management strategies identify the need for improved habitat of the kind that would likely result from the successful implementation of the proposed activity. It is, however, difficult to predict how successful the proposed activity will be at meeting the stated goals.

7.4.7 Gypsum Habitat Restoration Methods and Associated Species Research for Lake Mead National Recreation Area (National Park Service)

This project concept paper is well written, with a good map and some references. The methods section is thorough. This is habitat rather than species-oriented, although two priority plant species and one priority impacted plant species would benefit. The project goal is well stated, so that it is moderately likely that the project would be at least partially successful. However, evaluating the extent to which priority species and habitats would benefit is very difficult.

The research appears solidly grounded, it relates to population sustainability, and addresses gaps in knowledge relevant to the bigger picture – fire, invasives, fragmentation. Project results are likely to have broader application for management.

7.5 Summary

This is the most transparent advice received to date from a Science Advisor consultant. In summary, the DRI science advisor team agreed that there were no “poor” project concepts submitted. The two relating to desert tortoise were unexpectedly weak, but were not ranked lowest due to their explicit potential benefit to a priority species. Benefit to species is implicit in the two lowest ranking project concept papers, and their respective educational and restoration focus, although highly commendable and potentially worthwhile, were not sufficient for their higher ranking in the context of the other papers reviewed. The top three were all interesting, worthwhile, would likely be successful,l and would provide information that would be directly of benefit to both management and species. There are many challenges in establishing and operating a habitat conservation plan, and most proposed activity would contribute to the potential success of the Clark County program.

7.5.1 Recommendation: Refine MSHCP goals.

A refinement of MSHCP goals, perhaps by making existing biological goals more specific and adding social and economic components, would result in projects that are closely focused and more easily assessed for project-level effectiveness (see chapter 6 in this report). An agreement on research priorities among the land management agencies with responsibilities in Clark County would streamline and probably greatly improve the quality of proposals and the evaluation process. In the long-term this effort will tie into AMP objectives and operation in a way that is at present not being addressed. In conclusion, it should be noted that final project prioritization was based on permittee decision, which took into account the results described in this chapter.

CHAPTER 8. SUMMARY AND RECOMMENDATIONS

Building upon ongoing work by Clark County to improve the structure of the AMP (chapter 1) and track land use change (chapter 2) and covered species habitat (chapter 3.2), this 2008 AMR includes results of activities on four tasks assigned to DRI in its capacity as Science Advisor to Clark County. DRI's work during the 2007-2009 biennium focused on providing advice and tools as required, was not driven by underlying research questions, and did not involve collection of new data.

Chapter 4 of this report summarizes the initial stages in development of a functional prototype of a covered species population tracking system and chapter 3.1 presents conceptual models for the 11 MSHCP ecosystems in the context of ecosystem health. Chapters 5, 6, and 7 report on development of a functional prototype of an implementation status tracking system, recommendations for a programmatic effectiveness monitoring strategy, and a decision support system for prioritizing future project funding, respectively. Results and recommendations are summarized below.

The development, use, and refinement of conceptual models are topics that are discussed in numerous places in this report. The first part of chapter 3 presents results of a three-day workshop, hosted by DRI, which was tasked with developing first iteration models of ecosystem health for the 11 MSHCP systems. As a result of the workshop, hypothesized relationships among salient biotic and abiotic characteristics of each system were suggested, threats to their ability to function as healthy systems were described, and suggestions were made for potential indicators of change in each ecosystem's health. Historical information on status and extent of the ecosystems may facilitate prioritizing future work to focus on maintaining the health of the most degraded ecosystems – those whose functional characteristics no longer exist and where viable biotic populations of occupying native species are absent. Diagramming biotic and abiotic components of the systems may be useful for indicator selection and development of monitoring strategies, as well as formulating and rethinking management priorities (Atkinson et al., 2004 and chapter 3, this report).

A topic that was discussed in many meetings between Clark County and DRI is a need to identify and take advantage of the links between the tasks assigned to DRI and the County's land use trends and species tracking programs, and how all these fit into an adaptive management framework. Synergy in these activities will avoid duplication of effort and reinvention of the wheel and will, ultimately, result in more rigorous hypothesis formulation and testing and appropriately focused management activity. As a part of this, evaluation of existing (possibly long-term) monitoring strategies may lead to significant changes, as it is possible that an ecosystem-centered rather than species-centered approach may be adopted. Communication and stakeholder commitment will be crucial to this process, as will be empowering personnel to make (and enforce) the necessary decisions.

Managers, researchers and other stakeholders recognize that change in land use, species extent and community structure, ecosystem function, and many other parameters is typically measured over time and at "appropriate" spatial scale. Determination of what is appropriate is something that lends itself to hypothesis testing in the AMP context and that may be facilitated and improved by GIS, which also lends itself to integration with remote sensing imagery. The spatial analysis of acres permitted for habitat loss during the term of the MSHCP ITP shows similar results to that of actual habitat loss for the same period (February through December 2007) and both losses are within a reasonable margin of difference from the habitat loss of 63,475 acres (25,287 ha which was anticipated by the County (chapter 2). Most of the habitat loss occurred in the Mojave Desert Scrub ecosystem (second part of chapter 3), potentially putting species found in this system at greatest risk. In addition, this system comprises the most variety and complexity in terms of landscape units (first part of chapter 3), which increases the challenge for management and makes the assessment of impacts, causes, and effects more difficult.

As recommended in the 2006 AMR, a thorough investigation of the opportunities for monitoring using remote sensing technology would be a worthwhile exercise (Clark County, 2006), recognizing that species-specific variables will be extrapolated from analyses of vegetation condition and/or extent. Examples of relevant work include studies conducted by Kepner et al. (2000), Jensen et al. (2000), and Jones et al. (2008). A prototype covered species status tracking system, which is currently in the early stages of development (chapter 4), will eventually provide a spatially explicit system to assist Clark County in answering many questions related to species distribution, population trend, and the effect of management decisions, with a greater level of confidence than is currently possible.

The prototype MSHCP implementation status tracking system (chapter 5) is another tool that will contribute to greater efficiency and accountability of the MSHCP as a whole. This database has been tested by the County and all concerns have been addressed. Fields from prior databases have been mapped to the new one, existing data have been successfully transferred, and new data will be entered in fall 2008. This database will enable the County to answer questions relating to location and duration of projects, management decisions impacted, species status reports produced, law enforcement activities, and public outreach, as well as issues relating to funding and project completion.

Timely completion of projects is only one component of "effectiveness," which Clark County is addressing at the programmatic level for the MSHCP (chapter 6). In this context, DRI hosted a programmatic effectiveness monitoring strategy workshop as part of a longer-term effort to answer questions of effectiveness, and to determine whether implementation actions are addressing biological goals. One of the first, and most basic, issues discussed was goals – should they only be biologic, or would the inclusion of social and economic goals also assist in programmatic effectiveness evaluation? Workshop participants discussed indicators and indices, assessment questions and analysis strategies, and the overarching question of ecosystem and species condition. Workshop discussion was led by six outside experts, and other HCPs and related programs were used as examples. The development of a future monitoring strategy and crafting of new goals/objectives for the amended MSHCP will be facilitated by workshop results and associated reports.

DRI participated in a workshop organized by Clark County to develop criteria for project-level prioritized recommendations for the 2009-2011 IBP, and then provided an assessment of seven project concept papers (chapter 7) as input for decisions on funding for the next biennium. There were no "poor" project concepts submitted, and many were considered worthwhile and would likely provide information that would directly benefit both management and species. One of the major recommendations resulting from this task was the refinement of MSHCP goals so that specific needs and requirements for future projects could be established. Other recommendations made throughout this report are shown in Table 23.

Table 23. A summary of recommendations made in this report.

Category	Recommendation section number	Recommendation
Refine analyses	2.6.1	Refine land cover classification used for land-use trends analysis.
Update data used in analyses	2.6.2	Use new Clark County boundary in future analyses.
Update data used in analyses	2.6.3	Use newly available land-use trend data in future analyses.
Update data used in analyses	3.2.4.1	Use newly available species habitat requirement and distribution data in future habitat loss by ecosystem analyses.
Refine analyses	3.2.4.2	Refine vegetation classification used for habitat loss by ecosystem trends analysis
Combine results with other analyses	3.2.4.3	Compare the results of this analysis to mitigation action project data in the future.
Refine analyses	3.2.4.4	Integrate habitat loss by ecosystem analyses with an application to provide on-the-fly landscape analysis.
Partnership development	6.3.1	Use a collaborative approach to design components of the programmatic effectiveness monitoring strategy.
Refine analyses	6.3.2	Incorporate an AMP effectiveness monitoring program in the MSHCP programmatic effectiveness monitoring strategy.
Refine MSHCP goals and/or objectives	7.5.1	Refine MSHCP goals.
Combine results with other analyses	5.5.1	Compare the output of this mitigation action implementation tracking system to habitat loss by ecosystem and project-level effectiveness analysis results.

In conclusion, there are specific issues that some of the recommendations and suggestions in this report will help to address. The advantages of forming partnerships and working in collaboration were mentioned during all of the workshops. Clear objectives for the MSHCP must be defined, and this could be accomplished by a small working group that would “report” to the larger stakeholder community. A similar method could be employed for the definition of indicators, for the MSHCP itself, and for non-MSHCP indicators targeting bigger picture information. Species, the program, and adaptive management may require individual indicators, depending on selection of metrics.

The process of indicator development and selection addresses the overall programmatic goal of “no net unmitigated loss.” As stated elsewhere, conceptual models and well thought out hypotheses related to habitat and species assemblages are used to identify appropriate indicators. These indicators together with their integration (as indices) are used to reconcile this overall goal.

It may be inherently “easier” to prioritize projects that are associated with low uncertainty and/or low risk actions. However, there may be limited lessons to be learned and less information for management generated as a result of the “safe” projects. In general, if conceptual models are used to set up questions and hypotheses, projects with higher risk and uncertainty will tend to generate more questions, which will, in turn, ensure that they are accorded priority.

Finally, there is currently no formal mechanism to report how the results of data collection – or effectiveness monitoring – are evaluated and used to impact future actions or decisions. The MSHCP process will be incomplete unless the adaptive management loop is closed by ensuring effective feedback to decision making, and empowerment of the personnel necessary for making changes.

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APPENDIX 1

COVERED SPECIES CONSERVATION EVALUATIONS

TABLE A-1
COVERED SPECIES CONSERVATION EVALUATIONS

Species	Conserved (IMAs, LIMAs)	Potential Indirect Impacts (MUMAs)	Potential Direct Impacts (UMAs)[1]	Management	Rationale for Coverage	Measurable Biological Goals
Silver-haired bat *Lasionycteris noctivagans*	93% of potential habitat	6% of potential habitat	2% of potential habitat	USFS SMNRA USFWS (DNWR) BLM Red Rock Cyn NCA	North American species, occurring in Clark Co. primarily at high elevations. 93% of primary habitat in IMAs and LIMAs; management actions in SMNRA through the CA and on DNWR.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Long-eared myotis *Myotis evotis*	97% of potential habitat	7% of potential habitat	1% of potential habitat	USFS SMNRA USFWS (DNWR) BLM Red Rock Cyn NCA BLM RMP	Western North American species, occurring in Clark Co. primarily at high elevations. 97% of primary habitat in IMAs and LIMAs; management actions in SMNRA through the CA and on DNWR.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Long-legged myotis *Myotis volans*	93% of potential habitat	6% of potential habitat	2% of potential habitat	USFS SMNRA USFWS (DNWR) BLM Red Rock Cyn NCA	Western North American species, occurring in Clark Co. primarily at high elevations. 93% of primary habitat in IMAs and LIMAs; management actions in SMNRA through the CA and on DNWR.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Palmer's chipmunk *Tamias palmeri*	97% of potential habitat	none	3% of potential habitat	USFS SMNRA	Spring Mtns endemic. 97% of habitat in IMAs and LIMAs; management actions in SMNRA through the CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
American peregrine falcon *Falco peregrinus anatum* **Endangered (delisted 8/99)**	60% of potential habitat	30% of potential habitat	<5% of potential habitat	BLM RMP NPS GMP NDOW (Overton WMA) USFWS (DNWR)	Southern North American species. 90% of habitat in IMA, LIMA, and MUMAs. Management and monitoring of eyries by USFWS and NDOW; with specific monitoring by NPS & USFS.	• Monitor and protect existing eyrie sites on private, state, and Federal lands • Maintain stable or increasing population numbers

TABLE A-1
COVERED SPECIES CONSERVATION EVALUATIONS (CONTINUED)

Species	Conserved (IMAs, LIMAs)	Potential Indirect Impacts (MUMAs)	Potential Direct Impacts (UMAs)[1]	Management	Rationale for Coverage	Measurable Biological Goals
Yellow-billed cuckoo *Coccyzus americanus*	24% of potential habitat	30% of potential habitat	46% of potential habitat	BLM RMP NPS GMP NDOW (Overton WMA)	Riparian dependent species of North America. Actions proposed for southwestern willow flycatcher will provide adequate management. Protection of additional suitable habitat on Virgin & Muddy Rivers and Las Vegas Wash.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Vermillion flycatcher *Pyrocephalus rubinus*	25% of potential habitat	29% of potential habitat	46% of potential habitat	BLM RMP NPS GMP NDOW (Overton WMA)	Riparian dependent species of southwestern US and Mexico. Actions proposed for southwestern willow flycatcher will provide adequate management. Protection of additional suitable habitat on Virgin & Muddy Rivers and Las Vegas Wash.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Phainopepla *Phainopepla nitens*	28% of potential habitat	48% of potential habitat	26% of potential habitat	BLM RMP NPS GMP NDOW (Overton WMA) USFWS (DNWR)	Northernmost edge of species range in southwestern US and Mexico. 10,200 ac (74%) of potential habitat in Clark Co. and all known key populations in IMAs or MUMAs (Newberry Mtns, Moapa, Corn Creek, Sandy Valley): BLM specific management plan for mesquite in MUMAs.	• No net unmitigated loss or fragmentation of habitat in IMAs & MUMAs • Maintain stable or increasing population numbers in key areas
Southwestern willow flycatcher *Empidonax traillii extimus* **Federal Endangered**	24% of potential habitat	30% of potential habitat	46% of potential habitat	USFWS BLM RMP NPS GMP NDOW (Overton WMA)	Riparian dependent species of southwestern US and northwestern Mexico. MSHCP provides mechanisms to protect and manage additional suitable habitat on the Virgin & Muddy Rivers and Las Vegas Wash as defined by the AMP.	• No net unmitigated loss or fragmentation of occupied habitat • Maintain stable or increasing population numbers

TABLE A-1
COVERED SPECIES CONSERVATION EVALUATIONS (CONTINUED)

Species	Conserved (IMAs, LIMAs)	Potential Indirect Impacts (MUMAs)	Potential Direct Impacts (UMAs)[1]	Management	Rationale for Coverage	Measurable Biological Goals
Summer tanager *Piranga rubra*	24% of potential habitat	30% of potential habitat	46% of potential habitat	BLM RMP NPS GMP NDOW (Overton WMA)	Riparian dependent species of southern US and Mexico. Actions proposed for southwestern willow flycatcher will provide adequate management. Protection of additional suitable habitat on Virgin & Muddy Rivers and Las Vegas Wash.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Blue grosbeak *Guiraca caerulea*	24% of potential habitat	30% of potential habitat	46% of potential habitat	BLM RMP NPS GMP NDOW (Overton WMA)	Riparian dependent species of southern US and Mexico. Actions proposed for southwestern willow flycatcher will provide adequate management.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers • Protection of additional suitable habitat on Virgin & Muddy Rivers & Las Vegas Wash
Arizona bell's vireo *Vireo bellii arizonae*	24% of potential habitat	30% of potential habitat	46% of potential habitat	BLM RMP NPS GMP NDOW (Overton WMA)	Riparian dependent species of south central US and Mexico. Actions proposed for southwestern willow flycatcher will provide adequate management.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers • Protection of additional suitable habitat on Virgin & Muddy Rivers & Las Vegas Wash
Desert tortoise *Gopherus agassizii* **Federal Threatened**	56% of potential habitat	33% of potential habitat	11% of potential habitat	BLM RMP NPS GMP USFWS (DNWR)	Mojave desert endemic. 90% of potential habitat in Clark Co. in IMAs, LIMAs (>2 million ac), or MUMAs (>1.4 million ac).	• Implementation of the DCP goals in IMAs, LIMAs, & MUMAs • Maintain stable or increasing population numbers
Banded gecko *Coleonyx variegatus*	56% of potential habitat; 37% of cited locations	33% of potential habitat; 53% of cited locations	11% of potential habitat; 11% of cited locations	BLM RMP NPS GMP USFWS (DNWR)	Southwestern desert endemic. 90% of potential habitat in Clark Co. (>3.6 million ac) and cited locations in IMAs, LIMAs, or MUMAs.	• No net unmitigated loss or fragmentation of habitat in IMAs, LIMAs, & MUMAs • Maintain stable or increasing population numbers

TABLE A-1
COVERED SPECIES CONSERVATION EVALUATIONS (CONTINUED)

Species	Conserved (IMAs, LIMAs)	Potential Indirect Impacts (MUMAs)	Potential Direct Impacts (UMAs)[1]	Management	Rationale for Coverage	Measurable Biological Goals
Desert iguana *Dipsosaurus dorsalis*	55% of potential habitat; 28% of cited locations	32% of potential habitat; 44% of cited locations	13% of potential habitat; 28% of cited locations	BLM RMP NPS GMP USFWS (DNWR)	Southwestern desert endemic. 87% of potential habitat in Clark Co (>3 million ac) in IMAs, LIMAs, or MUMAs.	• No net unmitigated loss or fragmentation of habitat in IMAs, LIMAs, & MUMAs • Maintain stable or increasing population numbers
Western chuckwalla *Sauromalus obesus*	57% of potential habitat; 23% of cited locations	33% of potential habitat; 69% of cited locations	11% of potential habitat; 9% of cited locations	BLM RMP NPS GMP USFWS (DNWR)	Southwestern desert endemic. 89% of potential habitat in Clark Co (>2 million ac) and 91% of cited locations in IMAs, LIMAs, or MUMAs.	• No net unmitigated loss or fragmentation of habitat in IMAs, LIMAs, & MUMAs • Maintain stable or increasing population numbers
Western red-tailed skink *Eumeces gilberti rubricaudatus*	92% of potential habitat	7% of potential habitat	1% of potential habitat	USFS SMNRA USFWS (DNWR) BLM Red Rock Cyn NCA BLM RMP	Eastern Mojave desert endemic. 92% of potential habitat in Clark Co. (>250,000 ac) in IMAs & LIMAs.	• No net unmitigated loss or fragmentation of habitat in IMAs, LIMAs, & MUMAs • Maintain stable or increasing population numbers
Large-spotted leopard lizard *Gambelia wislizenii wislizenii*	55% of potential habitat; 34% of cited locations	32% of potential habitat; 58% of cited locations	13% of potential habitat; 8% of cited locations	BLM RMP NPS GMP USFWS (DNWR)	Great Basin, southwestern desert endemic. 87% of potential habitat in Clark Co (>2.9 million ac) and 92% of cited locations in IMAs, LIMAs, or MUMAs.	• No net unmitigated loss or fragmentation of habitat in IMAs, LIMAs, & MUMAs • Maintain stable or increasing population numbers
Great Basin collared lizard *Crotaphytus insularis bicinctore*s	60% of potential habitat; 30% of cited locations	30% of potential habitat; 59% of cited locations	10% of potential habitat; 11% of cited locations	BLM RMP NPS GMP USFS SMNRA BLM Red Rock Cyn NCA USFWS (DNWR)	Great Basin, southwestern desert endemic. 90% of potential habitat in Clark Co (>2.9 million ac) and cited locations in IMAs, LIMAs, or MUMAs.	• No net unmitigated loss or fragmentation of habitat in IMAs, LIMAs, & MUMAs • Maintain stable or increasing population numbers

TABLE A-1
COVERED SPECIES CONSERVATION EVALUATIONS (CONTINUED)

Species	Conserved (IMAs, LIMAs)	Potential Indirect Impacts (MUMAs)	Potential Direct Impacts (UMAs)[1]	Management	Rationale for Coverage	Measurable Biological Goals
California (common) kingsnake *Lampropeltis getulus californiae*	55% of potential habitat; 38% of cited locations	32% of potential habitat; 57% of cited locations	13% of potential habitat; 5% of cited locations	BLM RMP NPS GMP USFWS (DNWR)	Southwestern desert and Pacific coast species. 87% of potential habitat in Clark Co (>2.9 million ac) and 95% of cited locations in IMAs, LIMAs, MUMAs.	• No net unmitigated loss or fragmentation of habitat in IMAs, LIMAs, & MUMAs • Maintain stable or increasing population numbers
Glossy snake *Arizona elegans*	55% of potential habitat; 57% of cited locations	32% of potential habitat; 23% of cited locations	13% of potential habitat; 20% of cited locations	BLM RMP NPS GMP USFWS (DNWR)	Southwestern desert endemic. 87% of potential habitat in Clark Co (>2.9 million ac) and cited locations in IMAs, LIMAs, or MUMAs.	• No net unmitigated loss or fragmentation of habitat in IMAs, LIMAs, & MUMAs • Maintain stable or increasing population numbers
Western long-nosed snake *Rhinocheilus lecontei lecontei*	55% of potential habitat; 20% of cited locations	32% of potential habitat; 68% of cited locations	13% of potential habitat; 11% of cited locations	BLM RMP NPS GMP USFWS (DNWR)	Southwestern desert endemic. 87% of potential habitat in Clark Co. (>2.9 million ac) and 89% of cited locations in IMAs, LIMAs, or MUMAs.	• No net unmitigated loss or fragmentation of habitat in IMAs, LIMAs, & MUMAs • Maintain stable or increasing population numbers
Western leaf-nosed snake *Phyllorhynchus decurtatus*	55% of potential habitat	32% of potential habitat	13% of potential habitat	BLM RMP NPS GMP USFWS (DNWR)	Southwestern desert endemic. 87% of potential habitat in Clark Co. (>2.9 million ac) in IMAs, LIMAs, or MUMAs.	• No net unmitigated loss or fragmentation of habitat in IMAs, LIMAs, & MUMAs • Maintain stable or increasing population numbers
Sonoran lyre snake *Trimorphodon biscutatus lambda*	60% of potential habitat	30% of potential habitat	10% of potential habitat	BLM RMP NPS DMP USFS SMNRA BLM Red Rock Cyn NCA USFWS (DNWR)	Sonora and east Mojave desert species. 90% of potential habitat in Clark Co. (>4.2 million ac) in IMAs, LIMAs, or MUMAs.	• No net unmitigated loss or fragmentation of habitat in IMAs, LIMAs, & MUMAs • Maintain stable or increasing population numbers

TABLE A-1
COVERED SPECIES CONSERVATION EVALUATIONS (CONTINUED)

Species	Conserved (IMAs, LIMAs)	Potential Indirect Impacts (MUMAs)	Potential Direct Impacts (UMAs)[1]	Management	Rationale for Coverage	Measurable Biological Goals
Sidewinder *Crotalus cerastes*	55% of potential habitat; 34% of cited locations	32% of potential habitat; 46% of cited locations	13% of potential habitat; 20% of cited locations	BLM RMP NPS GMP USFWS (DNWR)	Mojave desert endemic. 87% of potential habitat in Clark Co. (>2.9 million ac) in IMAs, LIMAs, or MUMAs.	• No net unmitigated loss or fragmentation of habitat in IMAs, LIMAs, & MUMAs • Maintain stable or increasing population numbers
Speckled rattlesnake *Crotalus mitchelli*	59% of potential habitat; 25% of cited locations	31% of potential habitat; 75% of cited locations	10% of potential habitat	BLM RMP NPS GMP USFWS (DNWR) USFS SMNRA BLM Red Rock Cyn NCA	Southwestern desert endemic. 90% of potential habitat in Clark Co. (>4.2 million ac) and all cited locations in IMAs, LIMAs, or MUMAs.	• No net unmitigated loss or fragmentation of habitat in IMAs, LIMAs, & MUMAs • Maintain stable or increasing population numbers
Mojave green rattlesnake *Crotalus scutulatus scutulatus*	56% of potential habitat; 64% of cited locations	33% of potential habitat; 21% of cited locations	11% of potential habitat; 14% of cited locations	BLM RMP NPS GMP USFWS (DNWR)	Southwestern desert endemic. 89% of potential habitat in Clark Co. (>4.2 million ac) and 86% of cited locations in IMAs, LIMAs, or MUMAs.	• No net unmitigated loss or fragmentation of habitat in IMAs, LIMAs, & MUMAs • Maintain stable or increasing population numbers
Relict leopard frog *Rana onca*	Both extant populations; 76% of cited locations	19% of cited locations	5% of cited locations	NPS GMP	Clark County/northwestern Arizona endemic. Both extant populations in Clark County managed by NPS.	• Increase the number of springs with populations through reintroduction in appropriate locations • Maintain stable or increasing populations at extant springs • Develop and implement relict leopard frog management plan
Dark blue butterfly *Euphilotes enoptes* ssp.	All known population and cited locations	none	none	USFS SMNRA	Spring Mtns endemic. Monitored and managed as part of the Spring Mtns CA.	• No net unmitigated loss of larval host plant or nectar plant species habitat in SMNRA • Maintain stable or increasing population numbers and host and larval plant species

TABLE A-1
COVERED SPECIES CONSERVATION EVALUATIONS (CONTINUED)

Species	Conserved (IMAs, LIMAs)	Potential Indirect Impacts (MUMAs)	Potential Direct Impacts (UMAs)[1]	Management	Rationale for Coverage	Measurable Biological Goals
Spring Mountains icarioides blue *Icaricia icarioides* ssp.	All known populations	none	none	USFS SMNRA	Spring Mtns endemic. All known habitat monitored and managed as part of the Spring Mtns CA.	• No net unmitigated loss of larval host plant or nectar plant species habitat in SMNRA • Maintain stable or increasing population numbers and host and larval plant species
Mt. Charleston blue butterfly *Icaricia shasta charlestonensis*	All known population and cited locations	none	none	USFS SMNRA	Spring Mtns endemic. All known habitat monitored and managed as part of the Spring Mtns CA.	• No net unmitigated loss of larval host plant or nectar plant species habitat in SMNRA • Maintain stable or increasing population numbers and host and larval plant species
Spring Mountains acustus checkerspot *Chlosyne acastus*	All known population and cited locations	none	none	USFS SMNRA	Spring Mtns endemic. All known habitat monitored and managed as part of the Spring Mtns CA.	• No net unmitigated loss of larval host plant or nectar plant species habitat in SMNRA • Maintain stable or increasing population numbers and host and larval plant species
Morand's checkerspot butterfly *Euphydryas anicia morandi*	All known population and cited locations	none	none	USFS SMNRA	Spring Mtns endemic. All known habitat monitored and managed as part of the Spring Mtns CA.	• No net unmitigated loss of larval host plant or nectar plant species habitat in SMNRA • Maintain stable or increasing population numbers and host and larval plant species
Carole's silverspot butterfly *Speyeria zerene carolae*	All known population and cited locations	none	none	USFS SMNRA	Spring Mtns endemic. All known habitat monitored and managed as part of the Spring Mtns CA.	• No net unmitigated loss of larval host plant or nectar plant species habitat in SMNRA • Maintain stable or increasing population numbers and host and larval plant species

TABLE A-1
COVERED SPECIES CONSERVATION EVALUATIONS (CONTINUED)

Species	Conserved (IMAs, LIMAs)	Potential Indirect Impacts (MUMAs)	Potential Direct Impacts (UMAs)[1]	Management	Rationale for Coverage	Measurable Biological Goals
Nevada admiral *Limenitus weidemeyerii nevadae*	All known population and cited locations	none	none	USFS SMNRA BLM Red Rock Cyn NCA USFWS (DNWR)	Southern Nevada endemic (Spring Mtns, Sheep Range). All known habitats monitored and managed as part of the Spring Mtns CA, BLM management actions for Red Rock Cyn, or USFWS management of the DNWR.	• No net unmitigated loss of larval host plant or nectar plant species habitat in SNRA or Sheep Range • Maintain stable or increasing population numbers and host and larval plant species
Spring Mountains comma skipper *Hesperia comma ssp.*	All known populations	none	none	USFS SMNRA BLM Red Rock Cyn NCA	Spring Mtns endemic. All known habitat monitored and managed as part of the Spring Mtns CA or BLM management actions for Red Rock Cyn.	• No net unmitigated loss of larval host plant or nectar plant species habitat in SMNRA • Maintain stable or increasing population numbers and host and larval plant species
Spring Mountains springsnail *Pyrgulopsis deaconi*	2 extant and 1 extirpated population	none	none	USFS SMNRA BLM Red Rock Cyn NCA	Southern Nevada endemic with 2 of 3 extant populations in Clark Co. within IMAs with specific management actions; only other population in Nye County.	• Increase number of springs with populations through reintroduction in Red Rock • Maintain stable or increasing populations at extant springs
Southeast Nevada springsnail *Pyrgulopsis turbatrix*	5 extant and 1 extirpated population	none	none	USFS SMNRA BLM Red Rock Cyn NCA	Red Rock endemic with 5 extant populations in IMA or LIMA lands managed by USFS and BLM.	• Increase number of springs with populations through reintroduction in Willow Springs • Maintain stable or increasing populations at extant springs
Clokey eggvetch *Astragalus oophorus* var. *clokeyanus*	93% of potential habitat; 13 of 14 cited locations	6% of potential habitat	1% of potential habitat	USFS SMNRA	Southern Nevada endemic with more than 99% of populations in SMNRA with specific management actions.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers

TABLE A-1
COVERED SPECIES CONSERVATION EVALUATIONS (CONTINUED)

Species	Conserved (IMAs, LIMAs)	Potential Indirect Impacts (MUMAs)	Potential Direct Impacts (UMAs)[1]	Management	Rationale for Coverage	Measurable Biological Goals
Blue Diamond cholla *Opuntia whipplei* var *multigeniculata* **State of Nevada Critically Endangered, Federal Candidate**	95% of known habitat	none	5% of known habitat	BLM Red Rock Cyn NCA	Blue Diamond Hills endemic. Approximately 95% of the habitat for this species will be on Federal land managed under the terms of a conservation agreement.	• No loss of Blue Diamond cholla in the management area • Maintain stable or increasing population numbers • Harvest and stockpile mature seeds to conserve a seed bank for propagation studies
Rough angelica *Angelica scabrida*	91% of cited locations	none	9% of cited locations	USFS SMNRA	Spring Mtns endemic with more than 90% of populations in SMNRA with specific management actions in the Spring Mtns CA.	• No net unmitigated loss of fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Sticky ringstem *Anulocaulis leisolenus*	22% of potential habitat	60% of potential habitat	17% of potential habitat	BLM RMP NPS GMP	Southwestern US. More than 80% of widespread habitat in IMA, LIMA, and MUMAs. Protection for the coextensive Las Vegas bearpoppy provides protection for this species.	• No net unmitigated loss or fragmentation of habitat in IMAs, LIMAs, & MUMAs • Maintain stable or increasing population numbers
Charleston pussytoes *Antennaria soliceps*	96% of cited locations		4% of cited locations	USFS SMNRA	Spring Mtns endemic with more than 96% of populations in SMNRA with specific management actions in the Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers

TABLE A-1
COVERED SPECIES CONSERVATION EVALUATIONS (CONTINUED)

Species	Conserved (IMAs, LIMAs)	Potential Indirect Impacts (MUMAs)	Potential Direct Impacts (UMAs)[1]	Management	Rationale for Coverage	Measurable Biological Goals
Las Vegas bearpoppy *Arctomecon californica* **State of Nevada Critically Endangered**	22% of cited locations	60% of cited locations	17% of cited locations	BLM RMP NPS GMP	Southern Nevada and northeastern Arizona endemic. The majority (82%) of potential habitat, including 3 populations in Las Vegas Valley, will be managed under the terms of the Las Vegas Bearpoppy Memorandum of Agreement. In addition to designation of ACECs for the species, BLM will develop and implement a habitat management plan for the species on BLM land, including MUMAs.	• Conserve populations on the North Las Vegas Airport, NAFB Area 3, and SNWA North Well Field • No net unmitigated loss or fragmentation of habitat in IMAs, LIMAs, & MUMAs • Maintain and/or improve bearpoppy habitat in 4 BLM management areas: Sunrise, Lovell Wash, Bitter Spring, Gold Butte
White bearpoppy *Arctomecon merriamii*	84% of cited locations	3% of cited locations	13% of cited locations	USFS SMNRA USFWS (DNWR)	Mojave desert endemic. 83% of cited locations in IMAs and LIMAs; 60% of potential habitat on DNWR.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Rosy king sandwort *Arenaria kingii* ssp. *rosea*	88% of known locations	none	12% of known locations	USFS SMNRA	Spring Mtns endemic. 15 of 17 sites in IMA managed under terms of Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Clokey milkvetch *Astragalus aequalis*	96% of cited locations	none	4% of cited locations	USFS SMNRA	Spring Mtns endemic with more than 96% of populations in SMNRA with specific management actions in the Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Threecorner milkvetch *Astragalus geyeri* var. *triquetrus* **State of Nevada Critically Endangered**	18% of cited locations	82% of cited locations	<1% of cited locations	BLM RMP NPS GMP NDF NRS 527.270	Southeastern Mojave desert endemic with 99% of potential habitat in Clark Co. and all but 6 of 825 cited locations in IMAs, LIMAs, or MUMAs protected by NRS.	• No net unmitigated loss or fragmentation of habitat in IMAs, LIMAs, & MUMAs • Maintain stable or increasing population numbers

TABLE A-1
COVERED SPECIES CONSERVATION EVALUATIONS (CONTINUED)

Species	Conserved (IMAs, LIMAs)	Potential Indirect Impacts (MUMAs)	Potential Direct Impacts (UMAs)[1]	Management	Rationale for Coverage	Measurable Biological Goals
Spring Mountain milkvetch *Astragalus remotus*	98% of cited locations	none	2% of cited locations	USFS SMNRA	Spring Mtns endemic with more than 98% of populations in SMNRA with specific management actions in the Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Alkali mariposa lily *Calochortus striatus*	88% of cited locations	none	12% of cited locations	BLM Red Rock Cyn NCA	Eastern Mojave desert endemic. Almost 90% of cited locations in IMAs & LIMAs, primarily in Red Rock Cyn NCA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers • Develop an activities plan for the NCA including management for this species
Clokey paintbrush *Castelleja martinii* var. *clokeyi*	88% of cited locations	none	13% of cited locations	USFS SMNRA USFWS (DNWR)	Eastern Mojave desert mountains endemic with almost 90% of populations in SMNRA and DNWR with specific management actions in the Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Clokey thistle *Cirsium clokeyi*	88% of cited locations	none	13% of cited locations	USFS SMNRA	Spring Mtns endemic with almost 90% of populations in SMNRA with specific management actions in the Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Jaeger whitlowgrass *Draba jaegeri*	All cited locations	none	none	USFS SMNRA	Spring Mtns endemic with all known populations in SMNRA with specific management actions in the Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers

TABLE A-1
COVERED SPECIES CONSERVATION EVALUATIONS (CONTINUED)

Species	Conserved (IMAs, LIMAs)	Potential Indirect Impacts (MUMAs)	Potential Direct Impacts (UMAs)[1]	Management	Rationale for Coverage	Measurable Biological Goals
Charleston draba *Draba paucifructa*	All cited locations	none	none	USFS SMNRA	Spring Mtns endemic with all known populations in SMNRA with specific management actions in the Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Inch high fleabane *Erigeron uncialis* ssp. *Conjugans*	All cited locations	none	none	USFS SMNRA	Southern Nevada endemic with all known populations in SMNRA and DNWR with specific management actions in the Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Forked buckwheat *Eriogonum bifurcatum*	none	Unknown proportion of habitat	Unknown proportion of habitat	BLM RMP	Pahrump Valley (eastern Mojave desert) endemic. Most of the habitat for this ephemeral species appears to be on BLM land. BLM management should preclude further loss of habitat.	• No net unmitigated loss or fragmentation of habitat on public lands • Maintain stable or increasing population numbers on public lands • Develop inventory of extant populations in Pahrump and Sandy Valley
Sticky buckwheat *Eriogonum viscidulum* **State of Nevada Critically Endangered**	30% of cited locations	67% of cited locations	4% of cited locations	BLM RMP NPS GMP NDF NRS 527.270	Eastern Mojave desert endemic with 97% of potential habitat in Clark Co and all but 3 of 84 cited locations in IMAs, LIMAs, or MUMAs protected by NRS.	• No net unmitigated loss or fragmentation of habitat in IMAs, LIMAs, & MUMAs • Maintain stable or increasing population numbers
Clokey greasebush *Glossopetalon clokeyi*	All cited locations	none	none	USFS SMNRA	Spring Mtns endemic with all known populations in SMNRA with specific management actions in the Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers

TABLE A-1
COVERED SPECIES CONSERVATION EVALUATIONS (CONTINUED)

Species	Conserved (IMAs, LIMAs)	Potential Indirect Impacts (MUMAs)	Potential Direct Impacts (UMAs)[1]	Management	Rationale for Coverage	Measurable Biological Goals
Smooth pungent greasebush *Glossopetalon pungens* var. *glabra*	All cited locations	none	none	USFS SMNRA BLM Red Rock Cyn NCA USFWS (DNWR)	Eastern Mojave desert mountains endemic. All habitat for this species in IMAs and LIMAs managed by USFS (Spring Mtns CA), USFWS, and BLM (Bridge Mtn Monitoring Plan).	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Pungent dwarf greasebush *Glossopetalon pungens* var. *pungens*	All cited locations	none	none	USFS SMNRA BLM Red Rock Cyn NCA USFWS (DNWR)	Southern Nevada endemic. All habitat for this species in IMAs and LIMAs managed by USFS (Spring Mtns CA), USFWS, and BLM (Bridge Mtn Monitoring Plan).	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Red Rock Canyon aster *Ionactis caelestis*	All cited locations	none	none	BLM Red Rock Cyn NCA	Red Rock Cyn endemic. Single, remote population managed under the Red Rock Cyn NCA GMP.	• No loss or disturbance of habitat in Red Rock Cyn NCA • Maintain stable or increasing population numbers
Hidden ivesia *Ivesia cryptocaulis*	All cited locations	none	none	USFS SMNRA	Spring Mtns endemic with all known populations in SMNRA with specific management actions in the Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Jaeger ivesia *Ivesia Jaegeri*	95% of cited locations	none	5% of cited locations	USFS SMNRA BLM Red Rock Cyn NCA	Spring Mtns (NV) and Clark Mtns (CA) endemic. 95% of cited populations in SMNRA and BLM Red Rock Cyn NCA, with specific management actions in Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Hitchcock Bladderpod *Lesquerella hitchcockii*	93% of cited locations	none	7% of cited locations	USFS SMNRA USFWS (DNWR)	Nevada endemic with 95% of Clark Co populations in SMNRA and DNWR, with specific management actions in Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers

TABLE A-1
COVERED SPECIES CONSERVATION EVALUATIONS (CONTINUED)

Species	Conserved (IMAs, LIMAs)	Potential Indirect Impacts (MUMAs)	Potential Direct Impacts (UMAs)[1]	Management	Rationale for Coverage	Measurable Biological Goals
Charleston pinewood lousewort *Pedicularis semibarbata* var. *charlestonensis*	97% of potential habitat		3% of potential habitat	USFS SMNRA USFWS (DNWR)	Southern Nevada endemic with 97% of Clark Co populations in SMNRA and DNWR, with specific management actions in Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
White-margined beardtongue *Penstemon albomarginatus*	30% of cited locations	70% of cited locations	<1% of cited locations	BLM RMP	Eastern Mojave desert endemic. Less than 1% of populations on private lands. BLM is conducting experimental grazing exclosure study to evaluate grazing impacts to this species.	• No net unmitigated loss or fragmentation of habitat in IMAs, LIMAs, & MUMAs • Maintain stable or increasing population numbers • Implement modifications to grazing practices as indicated by exclosure study on Jean Lake and Hidden Valley
Charleston beardtongue *Penstemon leiophyllus* var. *keckii*	>90% of cited locations	none	<10% of cited locations	USFS SMNRA	Spring Mtns endemic with >90% of known populations in SMNRA with specific management actions in Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Jaeger beardtongue *Penstemon thompsoneae* var. *jaegeri*	All cited locations	none	none	USFS SMNRA	Southern Nevada endemic with all known populations in SMNRA with specific management actions in Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Parish's phacelia *Phacelia parishii*	>90% of cited locations	none	<10% of cited locations	USFWS (DNWR)	Mojave desert endemic with >90% of Clark Co. populations in IMAs and LIMAs on DNWR.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers

TABLE A-1
COVERED SPECIES CONSERVATION EVALUATIONS (CONTINUED)

Species	Conserved (IMAs, LIMAs)	Potential Indirect Impacts (MUMAs)	Potential Direct Impacts (UMAs)[1]	Management	Rationale for Coverage	Measurable Biological Goals
Clokey mountain sage *Salvia dorrii* var. *clokeyi*	All cited locations	none	none	USFS SMNRA BLM GMP USFWS (DNWR)	Southern Nevada endemic with all known populations in SMNRA with specific management actions in Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Clokey catchfly *Silene clokeyi*	96% of cited locations	none	4% of cited locations	USFS SMNRA	Spring Mtns endemic with >96% of known populations in SMNRA with specific management actions in Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Charleston tansy *Sphaeromeria compacta*	>90% of cited locations	none	<10% of cited locations	USFS SMNRA	Spring Mtns endemic with >90% of known populations in SMNRA with specific management actions in Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Charleston kittentails *Synthyris ranunculina*	All cited locations	none	none	USFS SMNRA	Spring Mtns endemic with all known populations in SMNRA with specific management actions in Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Charleston grounddaisy *Townsendia jonesii* var. *tumulosa*	>90% of cited locations	none	<10% of cited locations	USFS SMNRA BLM Red Rock Cyn NCA USFWS (DNWR)	Southern Nevada endemic. >90% of habitat for this species in IMAs and LIMAs managed by USFS (Spring Mtns CA), USFWS, and BLM (Bridge Mtn Monitoring Plan).	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers

TABLE A-1
COVERED SPECIES CONSERVATION EVALUATIONS (CONTINUED)

Species	Conserved (IMAs, LIMAs)	Potential Indirect Impacts (MUMAs)	Potential Direct Impacts (UMAs)[1]	Management	Rationale for Coverage	Measurable Biological Goals
Limestone violet *Viola purpurea* var. *charlestonensis*	All known locations	none	none	USFS SMNRA BLM GMP USFWS (DNWR)	Southwestern desert endemic with all known populations in IMAs and LIMAs with specific management actions in the Spring Mtns CA.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Anacolia menziesii	Only cited locations	none	none	BLM Red Rock Cyn NCA	West Coast species with single location in Nevada at Red Rock Cyn.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Claopodium whippleanum	Only cited locations	none	none	BLM Red Rock Cyn NCA	West Coast species with single location in Nevada at Red Rock Cyn.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Dicranoweisia crispula	Only cited locations	none	none	USFS SMNRA	Western North American species with single population in Lee Cyn.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers
Syntrichia princeps	Both cited locations	none	none	USFS SMNRA BLM GMP	West Coast species with two Nevada locations in Spring Mtns and Virgin Mtns.	• No net unmitigated loss or fragmentation of habitat in IMAs & LIMAs • Maintain stable or increasing population numbers

[1]In all cases, projected potential impacts represent the “worst case” analysis.

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APPENDIX 2

STATUS OF RECOMMENDATIONS MADE IN 2006 ADAPTIVE MANAGEMENT REPORT

Code	Page	Recommendation	DCP Response	2008 AMR §
AMR(2006) 1	**General Recommendations for All Projects**			
AMR(2006) 1.1	93	Data will be collected and transferred to the DCP in accordance with the Data Management Plan Development and Implementation Guidelines.	Contracting procedures require data management plan and annual, final data deliverables for all applicable projects.	1.4
AMR(2006) 1.2	93	Contracts that address permit conditions, monitoring or production of programmatic analyses for the AMP should include a deliverable schedule that accommodates subject-matter review of draft products.	Peer review time and responses to review in deliverables incorporated in contracts where applicable.	1.4
AMR(2006) 1.3	93	Monitoring project RFPs should require bidders to include the qualifications of each statistical or biometrician subject-matter expert that will be involved in the design of monitoring protocols.	Contracting procedures require qualifications of key staff and notification/approval of changes in key staff.	
AMR(2006) 1.4	94	The program should conduct a review of critical priorities prior to the next funding cycle to identify and define next actions and these should constitute the scopes of work for a directed call for proposal.	Done, see chapter 7.	7.1
AMR(2006) 1.5	94	The next funding cycles should emphasize information gathering projects for species or threats that appear most critical.	Done, see chapter 7.	7.1
AMR(2006) 1.6	94	Implementation actions without objective, independent effectiveness monitoring should be avoided.	Not implemented.	
AMR(2006) 1.7	94	Data delivered as Access databases or Excel spread sheets are not immediately GIS friendly and will require considerable time to make them so	Contracting procedures require data management plan.	1.4
AMR(2006) 1.8	94	More recent data from the federal land managers (weed data, restoration actions, and law enforcement patrol routes) appear to be very well documented.	No response needed.	
AMR(2006) 1.9	94	Knowledge of quality control procedures is required to make an assessment of usefulness of data.	Contracting procedures require data management plan.	1.4
AMR(2006) 1.10	94	Knowledge of the purpose and design of data collection is required to determine usefulness of the data.	Contracting procedures require data management plan.	1.4

Code	Page	Recommendation	DCP Response	2008 AMR §
AMR(2006) 1.11	94	Cleaning up data from multiple sources, and collected for multiple reasons without prior metadata specification, will be a long, involved and expensive process.	Contracting procedures require data management plan.	1.4
AMR(2006) 2	**General Recommendation for All Implementation Projects**			
AMR(2006) 2.1	94	As recommended in the draft Weeds Strategic Plan (NDOA 2005), implementation project methods should include best management practices to reduce the spread of invasive weed species during project activities.	Not implemented.	
AMR(2006) 3	**Specific Recommendations for Implementation Projects**			
AMR(2006) 3.1	95	The AMST recommends that the program continue on the current trajectory for implementation projects within programmatic categories used during the development of the 2005-2007 IPB.	Advisory Committee for 2007-2009 IPB received this recommendation and Board of County Commissioners adopted similar approach.	
AMR(2006) 3.2	95	This can be accomplished by using descriptions of the funded projects from 2005-2007 to guide creation of RFPs for similar implementation projects.	Advisory Committee for 2007-2009 IPB and Board of County Commissioners did not adopt this approach.	
AMR(2006) 3.3	95	The funding for implementation projects should be divided among project types in proportions equal to the 2005-2007 CFP categories (table 7).	Advisory Committee for 2007-2009 IPB received this recommendation and Board of County Commissioners adopted similar approach.	
AMR(2006) 3.4	95	This approach to implementation is reasonable only if it is combined with a strong commitment by the DCP to undertake a substantial effort to design and begin effectiveness monitoring to inform the AMP.	Not implemented.	
AMR(2006) 4	**General Recommendations for All AMP Projects**			
AMR(2006) 4.1	*Regular Reporting on Adaptive Management Tasks*			
AMR(2006) 4.1.1	98	Future Science Advisor contracts should include a specific schedule for submittal of draft designs of the AMP analyses recommended above.	Done and peer review incorporated where applicable.	1.4
AMR(2006) 4.1.2	98	These designs should be received by the DCP and reviewed by the AMST using clear acceptance criteria before they are considered acceptable deliverables.	Done and peer review incorporated where applicable.	

Code	Page	Recommendation	DCP Response	2008 AMR §
AMR(2006) 4.1.3	98	Similar review and acceptance criteria should be incorporated for the results of all major AMP analyses completed by the Science Advisor and other contractors.	Done and peer review incorporated where applicable.	1.4 & 1.5
AMR(2006) 4.1.4	98	In addition, the delivery of AMP analyses results and compilation of those results into the 2008 AMP by the Science Advisor contractor should be scheduled far enough in advance of the 15 March 2008 deadline to provide for response by the contractor to peer review of a final draft by the AMST.	*Done within amended schedule for completion of 2008 AMR.*	*1.5*
AMR(2006) 4.1.5	98	The response to this review and final AMR should be received by the DCP in advance of the 15 March 2008 deadline to allow for acceptance of the deliverable and transmittal by the DCP to the USFWS.	*Done within amended schedule for completion of 2008 AMR.*	
AMR(2006) 4.2	*Active Adaptive Management Recommendation*			
AMR(2006) 4.2.1	98	The DCP must increase its efforts to fully embrace the principles and techniques of active adaptive management.	Many principles and components of adaptive management have been incorporated into contracting procedures but active adaptive management not implemented for implementation projects with a reasonable level of certainty.	1.4
AMR(2006) 4.2.2	98	As was described in the 2004 AMR (UNR-BRRC), the DCP should prepare a detailed monitoring manual that provides contractors and agencies with suggested steps for designing and documenting monitoring plans.	Available literature made accessible and external expertise brought in to assist.	1.4
AMR(2006) 4.2.3	98	The solution is to not delay species or effectiveness monitoring, ----------- (2nd part of recommendation) and bring necessary resources to bear for design and technical review of the designs to ensure that monitoring data collection can begin as quickly as possible.	Available literature made accessible and external expertise brought in to assist.	1.4
AMR(2006) 4.2.4	99	However, they [other data] should be used to inform conceptual models and hypotheses regarding the status of species, ecosystem health, trends in threats and land use, and effectiveness of previously implemented actions.	Contracting procedures require conceptual models and monitoring methods to be delivered for peer review and possible modification annually.	1.4

Code	Page	Recommendation	DCP Response	2008 AMR §
AMR(2006) 4.2.5	99	The AMP should seek to enhance the scientific and technical resources available to inform the DCP.	Available literature made accessible and external expertise brought in to assist. Also incorporated peer review where practicable.	1.4
AMR(2006) 4.2.6	99	Independent experts should critically review the value to the DCP of continuing to seek indicators of species' status.	See chapters 3, 6.	3.2.4 & 6.1
AMR(2006) 4.2.7	99	Research and development of new technology projects must be responsive to uncertainties that impact land and natural resource management decisions ------------ (2nd part or recommendation) and should be subjected to review by independent experts with subject matter and adaptive management expertise.	No such projects were recommended for funding in the 2007-2009 or 2009-2011 IPBs.	
AMR(2006) 4.2.8	99	Research and development of new technology projects must be responsive to uncertainties that impact land and natural resource management decisions ------------ (2nd part or recommendation) and should be subjected to review by independent experts with subject matter and adaptive management expertise.	A duplicate recommendation, see response to AMR(2006) 4.2.7	
AMR(2006) 4.2.9	99	In addition, all such projects should contain an explicit description of how the data and results of the project will be used by managers to confirm or alter implementation of the MSHCP.	Contracting procedures now include objective statements and MSHCP elements addressed by the project.	1.4
AMR(2006) 4.2.10	99	Monitoring and research/development projects funded by the MSHCP must be informative to adaptive management of the DCP.	Requiring conceptual models as deliverables and updates to them to be considered annually.	1.4
AMR(2006) 4.2.11	99	In other words, monitoring should be designed to address key uncertainties about the species or effectiveness of actions in achieving goals and objectives of the MSHCP.	Requiring conceptual models as deliverables and updates to them to be considered annually. Monitoring methods required to address uncertainties in the models.	1.4
AMR(2006) 4.2.12	99	In addition, the monitoring should be rigorous enough to refute or support hypotheses to provide guidance for land and resource managers.	Requiring conceptual models and project methods as deliverables and updates to them to be considered annually. Peer review of methods incorporated into deliverable acceptance procedures.	1.4

Code	Page	Recommendation	DCP Response	2008 AMR §
AMR(2006) 4.2.13	101	For example, the completion of the Southwest Regional GAP effort provides an opportunity for the DCP to consider a multiple model hypothesis testing technique described in Shenk and Franklin (2001).	Not implemented.	
AMR(2006) 4.2.14	101	As this approach to experimental and monitoring design is relatively new, the AMP should identify and make available to the program subject-matter and statistical experts who are familiar with application of the multiple-hypothesis approach and the appropriate statistical techniques.	Not implemented.	
AMR(2006) 4.2.15	101	Experts who also have experience implementing this approach within a regulatory, adaptive management framework should be strongly considered.	Not implemented.	
AMR(2006) 4.2.16	101	These approaches to monitoring design and testing of multiple models or hypotheses can be applied to all AMP tasks and monitoring funded by the DCP.	Not implemented.	
AMR(2006) 5	**Specific Recommendations for AMP Projects**			
AMR(2006) 5.1	*Land-use Trends*			
AMR(2006) 5.1.1	101	As described in chapter 2, the direction for this AMP task is currently vague, and clarification should continue to be sought from the USFWS.	Clarification sought from USFWS and outcome is approach in chapter 2.	1.4 & 2.1
AMR(2006) 5.1.2	101	Once the direction is better understood, a design for implementing this AMP task should be included in the scope of work in the Science Advisor contract.	Clarification sought from USFWS and outcome is approach in chapter 2.	1.4 & 2.1
AMR(2006) 5.1.3	102	The design and results of this and all AMP analyses should be reviewed by the AMST and subject-matter experts as necessary.	DCP staff designed and implemented analysis. It was peer reviewed by Science Advisor and by external peer reviewers, modified as practicable.	1.4

AMR(2006) 5.2	*Habitat Loss by Ecosystem*			
AMR(2006) 5.2.1	102	This AMP task might be sufficiently accomplished by an estimate of potential disturbance under the section 10 take permit for the MSHCP using the boundaries of the disposal areas and private lands outside of those areas, as was done for the preliminary risk assessment conducted by UNR-BRRC as Science Advisor contractor during the 2003-2005 biennium.	Clarification sought from USFWS and outcome is approach in chapters 2 and 3.	1.4 & 2.1 & 3.2
AMR(2006) 5.2.2	102	The areas for which NDOT has coverage for take under the MSHCP should also be included.	Not implemented.	
AMR(2006) 5.2.3	102	The results of this [BLM] analysis will allow the DCP to prioritize conservation actions by the potential percentage of each ecosystem that might be disturbed under the section 10 take permit for the MSHCP.	Not implemented. Data from BLM analysis of management designations were not available for additional analyses at time of 2008 AMR preparation. See chapter 3 for current approach.	3.2.3 & 3.2.4
AMR(2006) 5.2.4	102	As described in chapter 3, more detailed spatial tracking of land disturbance under the section 10 take permit might be necessary if it is determined that the areas within disposal boundaries contain a majority of the habitat for a covered species.	Species data being organized and assessed. See chapter 4 for status. This analysis not yet implemented.	1.4 & 3.2.4 & 4.1
AMR(2006) 5.2.5	102	This would require a strategy to convert the data from disturbance permit reports from all permittees to a GIS compatible data layer, and may take considerable effort.	Clarification sought from USFWS on analysis of habitat loss and outcome is approach in chapter 3.	1.4 & 3.2
AMR(2006) 5.2.6	102	This information might also be inferred using new remote sensing technologies if an appropriate baseline dataset is available.	Clarification sought from USFWS on analysis of habitat loss and outcome is approach in chapter 3.	1.4 & 3.2
AMR(2006) 5.2.7	102	The priority for more detailed spatial tracking of this AMP task should be considered against the other priorities of the AMP.	Clarification sought from USFWS on analysis of habitat loss and outcome is approach in chapter 3.	1.4 & 3.2
AMR(2006) 5.2.8	102	In addition, the definitions of the 11 ecosystems used as surrogates for species habitat in the MSHCP may warrant refinement in light of currently available data, including the Southwest Regional GAP data currently available in provisional form.	Not yet implemented. See chapter 3 for current approach.	3.2.4

AMR(2006) 5.2.9	102	However, the refinement of the land-use and management data layers, use of a national vegetation classification system, incorporation of potential habitat models for terrestrial vertebrates (birds, reptiles, amphibians, mammals), and date of the remote sensing data layers used (1998) to produce the land-cover dataset are all strong arguments in favor of using this dataset to refine our models and hypotheses regarding the use of ecosystems as surrogates of potential species distribution within Clark County.	Not yet implemented. See chapters 3 and 4 for status.	3.2.4 & 4.1
AMR(2006) 5.2.10	103	Further evaluation of this approach should occur early in the 2005-2007 biennium.	DCP staff designed and implemented analysis. It was peer reviewed by Science Advisor and by external peer reviewers, modified as practicable.	1.4
AMR(2006) 5.3	*Species Status and Ecosystem Health*			
AMR(2006) 5.3.1	103	During the 2007-2009 biennium, the DCP should produce species' status reports for the third most at risk covered species as described in the 6 January 2006 letter to the USFWS.	Not yet implemented. A 2007-2009 IPB approved project to begin species status report production was not funded by Round 8 SNPLMA. See chapter 4 for status.	4.1
AMR(2006) 5.3.2	103	The monitoring of population status and trend for all "covered" MSHCP species and other species of concern, assessment of the amount, quality and occupancy of habitat, extent of habitat fragmentation, and actions to mitigate or minimize decrements need to be regularly reported in Species Status Reports.	Contracting procedures now require annual data deliverables. Additional species data not yet requested of other agencies. Currently available species data being organized and assessed see chapter 4 for status.	1.4 & 4.1

AMR(2006) 5.3.3	103	The species' status report for each species must at a minimum: • summarize the known distribution • review current taxonomic status • create a habitat model that predicts the possible distribution to guide inventory efforts • summarize known natural history and autecology of the species • analyze all available inventory, monitoring, and other data to describe population status and trend • summarize the known threats to the species • identify gaps in our knowledge of this species and propose projects to fill those gaps • summarize the conservation and other actions taken to benefit this species • identify needed actions to address threats • list and archive all information resources (published, peer-reviewed papers, reports, locality information, implementation project description, etc.)	Not yet implemented. A 2007-2009 IPB approved project to begin species status report production was not funded by Round 8 SNPLMA. See chapter 4 for the information to be contained in the species status information database.	4.1
AMR(2006) 5.3.4	103	The AMP should strengthen ties to the USFWS Desert Tortoise Recovery Office to ensure that data and recommendations from this office are clearly incorporated into the AMP.	Done to the extent that Recovery Office data were available and recommendations were specific enough to implement.	
AMR(2006) 5.3.5	104	The AMP should set aside funding to provide appropriate subject matter experts, such as those who anticipated, in the 2005 workshop, to assist in the design and review of those monitoring projects to ensure that learning for adaptive management is maximized during the 2005-2007 biennium, in preparation for development of species' status reports in 2007-2009.	Done for monitoring and survey projects. A 2007-2009 IPB approved project to begin species status reporting was not funded by Round 8 SNPLMA.	1.4 & 4.1
AMR(2006) 5.3.6	104	In addition, the DCP would benefit from a better mechanism for the AMP to learn from data generated outside the program.	Requests for data not funded by MSHCP have not yet been made of agencies and other sources.	
AMR(2006) 5.3.7	104	An effort to design a more efficient means of receiving more formal notice of these data is recommended for the 2005-2007 biennium.	Not implemented.	

AMR(2006) 5.3.8	104	The Science Advisor should identify and ensure the participation of appropriate scientific and other experts into a working committee for a Species Status Report Initiative that would use existing knowledge gap analysis, the Preliminary Risk Assessment and input from species and other experts to prioritize and create timelines for filling the knowledge gaps for covered species and other species of concern.	Not implemented, see status of species status information database in chapter 4.	4.1
AMR(2006) 5.3.9	104	Further, we believe this action <AMR(2006) 5.3.8> should occur in the next three months and the resulting priorities be incorporated into a directed actions request for proposal to fill critical knowledge gaps and emergency management actions where the failure to act may result in serious population impacts.	Not implemented, see status of species status information database in chapter 4.	4.1
AMR(2006) 5.3.10	105	Desert tortoise: continue to develop technologies to improve estimates in trends in population density from transect data. Consider using data only in "good years," and develop models of animal availability to be seen during monitoring as a means to provide more accurate estimates of density.	Experts and peer review for monitoring and survey projects method development was implemented.	1.4
AMR(2006) 5.3.11	105	Desert tortoise: continue to develop technologies to assess trends in habitat occupancy by live and dead tortoises. Consider using data only in "good years," and develop models of animal availability to be seen during monitoring as a means to provide more accurate estimates of density.	USFWS Desert Tortoise Recovery Office is the lead on tortoise issues. We trust that this recommendation was forwarded by USFWS HCP staff to the Recovery Office.	
AMR(2006) 5.3.12	105	Desert tortoise: develop means to assess stress in tortoises as a means to monitor at the individual scale.	USFWS Desert Tortoise Recovery Office is the lead on tortoise issues. We trust that this recommendation was forwarded by USFWS HCP staff to the Recovery Office.	
AMR(2006) 5.3.13	105	Desert tortoise: correlate stress and immune competence in tortoise as a means to give meaning to individual-scale monitoring.	USFWS Desert Tortoise Recovery Office is the lead on tortoise issues. We trust that this recommendation was forwarded by USFWS HCP staff to the Recovery Office.	
AMR(2006) 5.3.14	105	Desert tortoise: develop a spatially explicit model of areas in which tortoises are stressed to the point of being vulnerable to disease and assess temporal trends in vulnerability to disease.	USFWS Desert Tortoise Recovery Office is the lead on tortoise issues. We trust that this recommendation was forwarded by USFWS HCP staff to the Recovery Office.	

AMR(2006) 5.3.15	105	Desert tortoise: monitor trends in known threats to tortoise populations.	USFWS Desert Tortoise Recovery Office is the lead on tortoise issues. We trust that this recommendation was forwarded by USFWS HCP staff to the Recovery Office.	
AMR(2006) 5.3.16	105	Desert tortoise: monitor trends in quality of habitat for tortoise populations.	USFWS Desert Tortoise Recovery Office is the lead on tortoise issues. We trust that this recommendation was forwarded by USFWS HCP staff to the Recovery Office.	
AMR(2006) 5.3.17	105	Adaphic specialist plants: consider abandoning attempts to assess population densities of populations based solely upon numbers of plants insofar as this metric does not include all life stages of the species (e.g., it does not include dormant seeds).	Require edaphic plant conceptual habitat models as deliverables and updates to them to be considered annually. Monitor methods required to address uncertainties in the models. Experts and peer review for edaphic plant monitoring and survey projects method development was implemented.	1.4
AMR(2006) 5.3.18	105	Adaphic specialist plants: develop technologies to assess spatially-explicit trends in habitat occupancy by populations of adult plants and of seeds.	Require edaphic plant conceptual habitat models as deliverables and updates to them to be considered annually. Monitor methods required to address uncertainties in the models. Experts and peer review for edaphic plant monitoring and survey projects method development was implemented.	1.4 & 4.1
AMR(2006) 5.3.19	105	Adaphic specialist plants: begin program of monitoring seed banks of each species of plants.	Require edaphic plant conceptual habitat models as deliverables and updates to them to be considered annually. Monitor methods required to address uncertainties in the models. Experts and peer review for edaphic plant monitoring and survey projects method development was implemented.	1.4 & 4.1

AMR(2006) 5.3.20	105	Adaphic specialist plants: begin program of monitoring frequency of reproduction in populations of sensitive species, and correlate reproductive competence with habitat fragment size and proximity to threats to the species.	Require edaphic plant conceptual habitat models as deliverables and updates to them to be considered annually. Monitor methods required to address uncertainties in the models. Experts and peer review for edaphic plant monitoring and survey projects method development was implemented.	1.4 & 4.1
AMR(2006) 5.3.21	105	Adaphic specialist plants: monitor trends in known threats to populations including habitat fragmentation.	Require edaphic plant conceptual habitat models as deliverables and updates to them to be considered annually. Monitor methods required to address uncertainties in the models. Experts and peer review for edaphic plant monitoring and survey projects method development was implemented.	1.4 & 4.1
AMR(2006) 5.3.22	105	Adaphic specialist plants: monitor trends in quality of habitat (including threats to pollinators) for each species.	Require edaphic plant conceptual habitat models as deliverables and updates to them to be considered annually. Monitor methods required to address uncertainties in the models. Experts and peer review for edaphic plant monitoring and survey projects method development was implemented.	1.4 & 4.1
AMR(2006) 5.3.23	105	Adaphic specialist plants: do analysis to determine the smallest length of time required to achieve an estimate of trend in populations.	Not implemented.	
AMR(2006) 5.3.24	105	Rare butterflies: reconsider attempts to assess densities of populations based solely upon simple observations of adult insects, as this metric has not been calibrated to consistent measures of density that would permit estimates of population trends.	A 2005-2007 butterfly monitoring project was modified to include first-iteration habitat component descriptions and delineation. From this information, better monitoring of key attributes of population drivers could be developed.	4.1

AMR(2006) 5.3.25	106	Rare butterflies: develop means to assess spatially-explicit trends in habitat occupancy by populations of adult insects.	A 2005-2007 butterfly monitoring project was modified to include first-iteration habitat component descriptions and delineation. From this information, better monitoring of key attributes of population drivers could be developed.	4.1
AMR(2006) 5.3.26	106	Rare butterflies: monitor trends in known threats to populations including habitat fragmentation.	A 2005-2007 butterfly monitoring project was modified to include first-iteration habitat component descriptions and delineation. From this information, better monitoring of key attributes of population drivers could be developed.	4.1
AMR(2006) 5.3.27	106	Rare butterflies: monitor trends in quality of habitat (including threats to nectar sources and host plants) for each species.	A 2005-2007 butterfly monitoring project was modified to include first-iteration habitat component descriptions and delineation. From this information, better monitoring of key attributes of population drivers could be developed.	4.1
AMR(2006) 5.3.28	106	Rare butterflies: do analysis to determine the smallest length of time required to achieve an estimate of trend in populations	A 2005-2007 butterfly monitoring project was modified to include first-iteration habitat component descriptions and delineation. From this information, better monitoring of key attributes of population drivers could be developed.	4.1
AMR(2006) 5.3.29	106	Rare migratory birds: continue to monitor population sizes in Clark County for each species.	Require rare bird conceptual habitat models as deliverables and updates to them to be considered annually. Monitor methods required to address uncertainties in the models. Experts and peer review for rare bird monitoring and survey projects method development was implemented.	1.4 & 4.1

AMR(2006) 5.3.30	106	Rare migratory birds: develop models of habitat suitability as a means to identify suitable, but unoccupied, habitat.	Require rare bird conceptual habitat models as deliverables and updates to them to be considered annually. Monitor methods required to address uncertainties in the models. Experts and peer review for rare bird monitoring and survey projects method development was implemented.	1.4 & 4.1
AMR(2006) 5.3.31	106	Rare migratory birds: monitor trends in quality of habitat.	Require rare bird conceptual habitat models as deliverables and updates to them to be considered annually. Monitor methods required to address uncertainties in the models. Experts and peer review for rare bird monitoring and survey projects method development was implemented.	1.4 & 4.1
AMR(2006) 5.3.32	106	Rare migratory birds: develop means to assess population sizes of species in wintering grounds.	Require rare bird conceptual habitat models as deliverables and updates to them to be considered annually. Monitor methods required to address uncertainties in the models. Experts and peer review for rare bird monitoring and survey projects method development was implemented.	1.4 & 4.1
AMR(2006) 5.3.33	106	Rare migratory birds: monitor trends in known threats to populations including habitat fragmentation.	Require rare bird conceptual habitat models as deliverables and updates to them to be considered annually. Monitor methods required to address uncertainties in the models. Experts and peer review for rare bird monitoring and survey projects method development was implemented.	1.4 & 4.1
AMR(2006) 5.3.34	106	Rare migratory birds: monitor trends in quality of habitat.	Require rare bird conceptual habitat models as deliverables and updates to them to be considered annually. Monitor methods required to address uncertainties in the models. Experts and peer review for rare bird monitoring and survey projects method development was implemented.	1.4 & 4.1

AMR(2006) 5.3.35	106	Rare migratory birds: do analysis to determine the smallest length of time required to achieve an estimate of trend in populations.	Require rare bird conceptual habitat models as deliverables and updates to them to be considered annually. Monitor methods required to address uncertainties in the models. Experts and peer review for rare bird monitoring and survey projects method development was implemented.	1.4 & 4.1
AMR(2006) 5.4	*Effectiveness Monitoring*			
AMR(2006) 5.4.1	106	Before the designs of these data collection projects are finalized, it is recommended that a technical advisory group be convened to review the available implementation data and the programmatic and project-specific hypotheses to be tested by these monitoring projects.	Not implemented. See chapter 6 for status of programmatic-effectiveness monitoring. An alternative approach to project-effectiveness monitoring is recommended in the product resulting from the efforts described in chapter 6. This product will be a separate report produced concurrently with 2008 AMR.	6.1
AMR(2006) 5.4.2	107	Thus, it is cautioned that these data be used to formulate conceptual models and hypotheses to be tested rather than used to draw conclusions.	Will be considered when 2005-2007 effectiveness monitoring projects are completed.	
AMR(2006) 5.4.3	107	In January 2006, the AMST recommended that future IPBs include funding to initiate effectiveness monitoring for major categories of implementation actions.	Advisory Committee for 2007-2009 IPB and Board of County Commissioners did not adopt this approach.	
AMR(2006) 5.4.4	107	The AMST recommended that a matching fund for effectiveness monitoring be included in the 2007-2009 IPB for each category of implementation project to ensure that the program begins to design and implement monitoring for the effectiveness of implementation projects as soon as possible.	Advisory Committee for 2007-2009 IPB and Board of County Commissioners did not adopt this approach.	
AMR(2006) 5.5	*General Effectiveness Monitoring Project Recommendations*			
AMR(2006) 5.5.1	107	For each programmatic category of implementation action, the 2007-2009 IPB should allocate funding for development and execution of effectiveness monitoring for that implementation project category.	Advisory Committee for 2007-2009 IPB and Board of County Commissioners did not adopt this approach.	

AMR(2006) 5.5.2	107	The RFP for contractors to perform this work should be based upon the following schedule of tasks: Year 1 1. Compile existing data and with local resource and land management agency staff and subject-matter experts refine draft management objectives for the programmatic category and the implemented conservation actions. 2. If applicable, design analyses for retrospective study of the implementation. 3. Execute retrospective study, if applicable. 4. Design effectiveness monitoring study, including an explicit plan for those data to be gathered by the implementing parties. Year 2 1. Provide results of the retrospective study of the implementation, if applicable. 2. Implement effectiveness monitoring study to address management objectives. 3. Provide results of first year of effectiveness monitoring study, including recommendations for any changes in the effectiveness monitoring approach.	A similar approach is recommended in the product resulting from the efforts described in chapter 6. This product will be a separate report produced concurrently with 2008 AMR.	6.1
AMR(2006) 5.5.3	107	However, the AMP must be more specific if the AMP recommendations are to inform development of RFPs for specific effectiveness monitoring projects.	Not implemented.	
AMR(2006) 5.5.4	107	The USGS monitoring and adaptive management manual (USGS, 2004) provides a more detailed approach to designing monitoring for adaptive management, and could be referenced in the RFPs for effectiveness monitoring projects.	A similar approach is recommended in the product resulting from the efforts described in chapter 6. This product will be a separate report produced concurrently with 2008 AMR.	6.1

AMR(2006) 5.5.5	108	The current projects that are preliminary steps toward programmatic effectiveness monitoring, those that provide indirect measures of effectiveness, should be continued. They are: • Desert tortoise density monitoring • Reptile and amphibian distribution • Ecosystem Indicators • Effectiveness of Muddy River salt cedar and knapweed removal and native vegetation restoration • Virgin River restoration effectiveness research	A similar approach is recommended in the product resulting from the efforts described in chapter 6. This product will be a separate report produced concurrently with 2008 AMR.	6.1
AMR(2006) 5.6	*Specific Recommendation for Public Information and Education Effectiveness Monitoring*			
AMR(2006) 5.6.1	108	No additional monitoring of PIE is recommended unless the methods used to implement PIE are changed.	Implemented.	
AMR(2006)5.6.2	108	The Science Advisor recommends development of species' specific objectives for PIE and design of an effectiveness monitoring program to evaluate the conservation effectiveness of PIE activities.	Not implemented.	

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APPENDIX 3

ECOSYSTEM HEALTH WORKSHOP PARTICIPANTS AND THEIR PROFESSIONAL AFFILIATION

Clark County MSHCP Ecosystem Health Workshop Participants and Their Professional Affiliation on January 29, 2008 (Day 1).

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
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

CC = Clark County; NPS = U.S. National Park Service; NPS PLI = U.S. National Park Service; Public Lands Institute; EPA = 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.

Clark County MSHCP Ecosystem Health Workshop participants and their professional affiliation on January 30, 2008 (Day 2).

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

Clark County MSHCP Ecosystem Health Workshop participants and their professional affiliation on January 31, 2008 (Day 3).

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

APPENDIX 4

DECISION SUPPORT SYSTEM WORKSHOP FOR 2009-2011 IMPLEMENTATION PLAN AND BUDGET PROCESS

DECISION SUPPORT SYSTEM DESIGN WORKSHOP

The workshop was held on Thursday, February 28, 2008, from 8:30 am to 4:00 pm at the Clark County Government Center, Organizational Development Center, 500 Grand Central Parkway, Las Vegas, Nevada.

Workshop Purpose

To develop a list of science-based criteria that can be used to evaluate non-MSHCP permit condition project concepts.

Participants

Bureau of Land Management
- Carrie Ronning

City of Henderson
- Paul Andricopulos
- Michael Johnson

City of Las Vegas
- Eric Peters
- Cheng Shih

City of Mesquite
- Catherine Lorbeer

City of North Las Vegas
- Jan Schweitzer

Clark County
- Lee Bice
- Marci Henson
- John Tennert
- Sue Wainscott

Desert Research Institute (Science Advisor to DCP)
- Judith Lancaster
- Dave Mouat
- Mark Stone

National Park Service
- Ross Haley
- Alice Newton
- Kent Turner

Nevada Department of Transportation
- Julie Ervin-Holoubek
- James Murphy

Nevada Department of Wildlife
Cris Tomlinson
Nevada Division of Forestry
John Jones
Ruth Siguenza LLC (Facilitator and Student)
Ruth Nicholson-Siguenza
Heidi Bigler-Cole
U.S. Fish and Wildlife Service
Janet Bair

Opening and Introductions

Goals: To introduce meeting participants and their roles. To review the meeting purpose and agenda.

County staff and the facilitator opened the meeting. The County provided an overview of the MSHCP 2009-2011 IPB process (Appendix 2) and explained to the group how the day's workshop fit into that process.

Identify and Sort Project Evaluation Criteria

Goals: To list project evaluation criteria from all meeting participants. To separate scientific criteria from other criteria. To group major categories of criteria, as appropriate.

The group worked in small groups of two-five participants to produce a set of 48 ideas for possible criteria and placed them on the whiteboard. The facilitator guided the group in sorting the possible criteria into similar sets. These possible criteria and sets are listed in Table 1:

Table 1. Potential project evaluation criteria generated by participants.

Appropriate Mitigation	• Mitigate impacts of habitat loss under the permit on covered species • Is the project mitigating impacts to the habitat and ecosystems most impacted by the permit • Think of big picture
Enforcement	• Ability to enforce the regulations • Enforcement of the conserved area
Sustainable Development	• Impact on water resources • Effects on transportation (roads, trails) • Ability to continue development • Does the project account for impacts that result from construction of sustainable technology • Reinforces responsible planning/development
Education	• Reinforces responsible recreation
Edge Effect	• Reduces edge effects of development • Transition between developed areas and conservation areas
Priority Species	
	• Southwestern Willow Flycatcher (SWFL) • White-margined penstemon • Desert tortoise • Las Vegas bearpoppy • Las Vegas buckwheat • Relict leopard frog • Sticky buckwheat
Population Augmentation	• Augments populations of imperiled species • Augments populations of priority species • Augments populations of species at risk - where science is known
Priority Habitat	• Action that benefits multiple species • Protects habitat of high priority species • Does the project focus on most at-risk species/ecosystems
Habitat (protect, enhance, restore)	• Habitat enhancement or improvement • Protects and/or improves habitat for target species • Improve habitat quality (increase K: K=scientific notation for carrying capacity for a species) • Does project consider/address minimizing catastrophic fires • Projects that reduce habitat degradation • Protects habitat • Restores habitat of at risk species - where habitat is limiting e.g. SWFL • Habitat restoration
Knowledge and Information Gaps to Inform Management Decisions	• Does the project fill a high priority knowledge gap? Reduce uncertainty • Research on impacts to species • Will the project result in new information? Or will it tell us what we already know • Additional data on bearpoppy; i.e., growth in other soils, longevity, feasibility, etc. • Provides key data gap in understanding meta populations • More ground research for buckwheat • How much scientific data is available to use

Effectiveness	• How effective is tortoise fencing • Does project consider climate change • A value judgment on effectiveness of the proposed action or project • Project effectiveness should be measurable • Does project consider effectiveness monitoring
Methods	• Are the project methods scientifically defensible? Grounded in the literature • Is the research methodology sound

The group discussed each set and determined that several belonged in the Other (not-science) criteria board. These sets were: Enforcement, Sustainable Development, and Education. The group also determined that the set of Edge Effects contained possible project concept ideas, rather then possible criteria.

The group asked the DRI science advisor team and the DCP's AMP staff to discuss the remaining science-based criteria sets and report back after lunch on what data exist to inform scoring of project concepts.

Data Check

The County presented a proposal from the AMP staff and the DRI science advisor team regarding which criteria had available data, literature or expert opinion to support their use. DCP's AMP staff described the DCP geodatabase of species, habitat, ecosystem and land use data currently available to the program. Available information for the DRI science advisor team includes data sets, grey literature, published literature and expert opinion of DRI team members. The group discussed and clarified the proposed criteria and what information would need to be provided to DRI to assure a transparent and informed sorting of the project concepts.

The accepted modification of this proposal was:

Criterion 1: Priority Species: Is the project key to population sustainability of a priority species?

Priority Species are defined as: Federal listed species, State listed species, and Candidate Species Covered in MSHCP (Desert Tortoise, SW Flycatcher, LV Buckwheat, relict leopard frog, Las Vegas bearpoppy, sticky buckwheat, white-margined penstemon, yellow-billed cuckoo). (As per the actions list for this meeting, USFWS, the County and others determined the final list of priority species for this criterion for the 2009-2011 IPB process early the week of March 3.)

Criterion 2: Priority Habitats/Species/Ecosystems: Does the project benefit impacted priority ecosystems/habitat or species? Explain.

Priority Impacted Species are defined as: covered species directly impacted by direct take under permit. This list will be populated by the species hypothesized in Clark County's most recent habitat loss by ecosystem report (2008b) to be found in the three ecosystems most impacted by take under the permit to date: Desert Aquatic/Riparian, Catclaw Mesquite and Salt Desert Scrub.

Criterion 3: Pick One of the following two depending on type (information gathering / implementation) of project concept:

> 3A Habitat/Species Benefit Type: What does the proposed action do to benefit the species and its habitats by mitigating impacts and or threats? The group discussed at length whether any one of the following types of implementation projects was more important: Enhance, Protect, Restore. The group decided to allow the Science Advisor to rank the benefit of each type as well as incorporate the proportion of a species distribution addressed by the project concept with rationale that are defined up front, prior to Science Advisor assigning any scores to project concepts.
>
> 3B Knowledge/Information to Inform Management: Is the knowledge gap either (1) Cited in an assessment (need a list of documents) as a high priority, or (2) shown as a tight link of information to a management decision?

Criterion 4: Effectiveness Likelihood/Method How likely is the project concept to be effective at meeting its stated goal?

The DRI science advisor team emphasized to the group that project concepts should include information on each of these criteria in the narrative and provide copies of and citations to literature, grey literature and data sets that could be used in evaluating the project concept. During this portion of the meeting, several additional issues were raised and placed in the *Parking Lot*. These issues are listed below under Wrap Up and Closing.

<u>Ranking and Weighting Criteria</u>

The group assigned each criterion a possible rating of 0-10, higher number = higher priority. The group discussed different weighting of criteria, but declined to assign a higher or lower weight to any of the criteria. The scores are to be added across all applicable columns for each project concept, with a possible summary score range of 0 – 40. DRI's May 15 report will include a description of methods used for each criterion to assign scores and what information sources were used.

Project Concept Solicitation

Clark County staff developed a Project Concept form and provided it to each of the Implementing Agreement signatory agencies. Each agency was allowed to submit up to three project concepts for consideration. A total of seven project concept forms were submitted to Clark County by the deadline, and these were bundled and sent to DRI.

Clark County Desert Conservation Program
Multiple Species Habitat Conservation Plan
2009-2011 Implementation Plan and Budget (IPB) Process

2/11 – Implementing Agencies Conference Call

- ✓ Limited to the Required Section 10 expenditure
- ✓ Do not plan to request any Round 10 Southern Nevada Public Lands Management Act funds
- ✓ Plan Administrator, on behalf of the permittees, will prepare project concepts that meet permit conditions and operational requirements
- ✓ Implementing agencies are requested to submit individual, non-permit condition project concepts – limited to their top three priorities
- ✓ Issuing the call for project concepts on 3/3/08

2/28 – Science Advisor and Implementing Agencies craft a Decision Support System

3/3 – Issue call for project concepts to Implementing Agencies

- ✓ Only accepting the Agencies' top three priorities
- ✓ Accepting individual project concepts only - as opposed to programmatic concepts
- ✓ Most interested in projects related to priority species (those that are state or federally listed and those that are covered by the permit and impacted by direct take activities).
- ✓ Most interested in projects that mitigate for the direct impact of (habitat restoration, fencing, road designation, etc.) habitat loss (see 2008 Habitat Loss by Ecosystem Analysis and Land Use Trends Analysis)
- ✓ Most interested in concepts that will fit well into what is likely to be included in the permit and plan amendment

3/28 – Implementing agencies' project concepts due

4/1 – Non-permit condition project concepts to Science Advisor

4/23 – Send draft criteria to permittees for discussion at 5/7 meeting

5/7 – Determine final permittees criteria

5/9 – Send criteria and project proposals to permittees, highlighting that Science Advisor reviews are forthcoming

5/15 – Ranking of non-permit condition project concepts from Science Advisor

5/20 – Send Science Advisor reviews to permittees.

5/26 – Permittees' reviews due to Plan Administrator

6/4 – Permittees discuss reviews, rankings and draft IPB

6/30 – Hold Implementing Agency meeting on draft IPB, 1:30 – 4:30pm, Pueblo Room

7/15 – Publish Draft IPB

7/31 – Hold Public Meeting on Draft IPB and take input and comments, 6:30pm – 8:30pm, Pueblo Room

9/30 – Publish Revised IPB and respond to public comments

11/30 – Take Revised IPB to the Board of County Commissioners

12/31 – Submit IPB to the U.S. Fish and Wildlife Service

MULTIPLE SPECIES HABITAT CONSERVATION PLAN (MSHCP)

Desert Conservation Program (DCP)
Project Concept Summary Form: 2009-2011 Biennium
Due: March 28, 2008

Instructions, template form follows on last page.

General Guidance: Implementing Agencies are asked to prepare and submit their top three individual, non-permit condition project concepts using the form provided by close of business March 28. The permittees are most interested in funding projects that mitigate for the direct impact of habitat loss, largely as a result of development activities in the Las Vegas valley. The permittees are also most interested in funding projects benefiting priority species and priority impacted species listed below. The permittees will also be looking to fund projects that will fit well in the implementation of an amended incidental take permit and habitat conservation program.

Project concepts shall be no more than two (2) pages in length.

Project Name: Enter the name of your project.

Location of activities: Indicate the MSHCP Management Area (IMA/LIMA/MUMA/UMA) and land manager/owner. Briefly describe project location and provide a map of the project area no larger than 8.5 x 11 page as Attachment 1. ArcGIS compatible GIS files of the project location are appreciated.

Project Goal: State the goal and/or objective(s) of the project.

Project Description and Anticipated Benefit: Describe the project and what benefit the project would provide to priority or priority impacted species, habitats and/or ecosystems. Will the project benefit be achieved at the species, habitat or ecosystem level?

Priority Species

COMMON NAME	SCIENTIFIC NAME
Yellow-billed cuckoo	*Coccyzus americanus*
Southwestern willow flycatcher	*Empidonax traillii extimus*
Desert tortoise	*Gopherus agassizii*
Relict leopard frog	*Rana onca*
Las Vegas bearpoppy	*Arctomecon californica*
Las Vegas buckwheat	*Eriogonum corymbosum* var. *nilesii*
Sticky buckwheat	*Eriogonum viscidulum*
White-margined beardtongue	*Penstemon albomarginatus*

Priority Impacted Species

COMMON NAME	SCIENTIFIC NAME	TAXON GROUP	Salt Desert Scrub	Mojave Desert Scrub	Mesquite Catclaw Acacia
Phainopepla	*Phainopepla nitens*	Bird			Y
Vermillion flycatcher	*Pyrocephalus rubinus*	Bird			Y
Long-eared myotis	*Myotis evotis*	Mammal	Y		Y
Silver-haired bat	*Lasionycteris noctivagans*	Mammal	Y		Y
Banded gecko	*Coleonyx variegatus*	Reptile		Y	Y
California (common) king snake	*Lampropeltis getulus californiae*	Reptile	Y	Y	
Desert iguana	*Dipsosaurus dorsalis*	Reptile	Y	Y	Y
Desert tortoise	*Gopherus agassizii*	Reptile	Y	Y	
Glossy snake	*Arizona elegans*	Reptile	Y	Y	
Great Basin collared lizard	*Crotaphytus insularis bicinctores*	Reptile	Y	Y	Y
Large-spotted leopard lizard	*Gambelia wislizenii wislizenii*	Reptile	Y	Y	
Mojave green rattlesnake	*Crotalus scutulatus scutulatus*	Reptile		Y	
Sidewinder	*Crotalus cerastes*	Reptile	Y	Y	Y
Sonoran lyre snake	*Trimorphodon biscutatus lambda*	Reptile		Y	
Speckled rattlesnake	*Crotalus mitchellii*	Reptile	Y	Y	
Western leaf-nosed snake	*Phyllorhynchus decurtatus*	Reptile	Y	Y	
Western long-nosed snake	*Rhinocheilus lecontei lecontei*	Reptile	Y	Y	
Western red-tailed skink	*Eumeces gilberti rubricaudatus*	Reptile			Y
Alkali mariposa lily	*Calochortus striatus*	Plant		Y	
Blue Diamond cholla	*Opuntia whipplei var. multigeniculata*	Plant		Y	
Forked (Pahrump Valley) buckwheat	*Eriogonum bifurcatum*	Plant	Y		Y
Las Vegas bearpoppy	*Arctomecon californica*	Plant	Y	Y	
Parish's phacelia	*Phacelia parishii*	Plant	Y		
Spring Mountain milkvetch	*Astragalus remotus*	Plant		Y	
Sticky buckwheat	*Eriogonum viscidulum*	Plant		Y	
Sticky ringstem	*Anulocaulis leisolenus*	Plant	Y	Y	
Threecorner milkvetch	*Astragalus geyeri var. triquetrus*	Plant		Y	
White bearpoppy	*Arctomecon merriamii*	Plant	Y	Y	
White-margined beardtongue	*Penstemon albomarginatus*	Plant		Y	

Project Approach / Methods: Describe the methods of the project in sufficient detail for readers to be able to assess its likely effectiveness in achieving stated goal/objectives. Provide supporting data, literature (grey or published), or observations.

Estimated Project Cost: Provide the estimated cost of the project, rounded to the nearest $10,000.

For Information Gathering/Research-Related Projects: Describe how this project addresses a priority goal, objective or information gap described in a Conservation Management Strategy, Assessment, Conservation Agreement or other planning document?

(See below link for several such documents: http://www.accessclarkcounty.com/daqem/epd/desert/dcp_reports.html)

Indicate the goal/objective/gap, name and date of plan, and page number for goal/objective/gap.

Describe how the new information collected will inform specific management decisions.

Citations/Literature List: Provide a list of citations and other pertinent literature as Attachment 2.

Submittal Instructions:
Complete proposals must be submitted electronically via e-mail to Marci Henson at mhenson@co.clark.nv.us by 5:00 p.m., March 28, 2008. Proposals will not be accepted after this date and time. Hard copies of proposals will not be accepted.

Project concepts shall be no more than two (2) pages in length, excluding Attachment 1 – Map of the Project Location and Attachment 2 – Citations and Literature List. Concepts more than two pages and those that are incomplete or omit the information requested in this guidance will not be reviewed or considered for funding.

No more than three project concepts will be accepted per agency.

Multiple Species Habitat Conservation Plan (MSHCP)
Desert Conservation Program (DCP)
Project Concept Summary Form: 2009-2011 Biennium
Due: March 28, 2008

Project Name:

Location of activities, MSHCP Management Area (IMA/LIMA/MUMA/UMA) and land manager/owner (8.5x11 map attached as Attachment 1):

Project Goal:

Project Description and Anticipated Benefit:

Project Approach / Methods:

Estimated Project Cost:

For Information Gathering/Research-Related Projects: Does this project address a priority goal, objective or information gap described in a Conservation Management Strategy, Assessment, Conservation Agreement or other planning document?

Citations/Literature List (Attached as Attachment 2)