# Adaptive Management and Monitoring Plan

**Prepared for:**

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## Acronyms and Abbreviations

| | |
|---|---|
| AMMP | Adaptive Management and Monitoring Plan |
| BCCE | Boulder City Conservation Easement |
| BGO | Biological Goals and Objectives |
| CFR | Code of Federal Regulations |
| CM | Conservation Measures |
| CMR | Capture-mark-recapture |
| DCP | Desert Conservation Program |
| HCP | Habitat Conservation Plan |
| LPI | Line-point Intercept |
| MSHCP | Multiple Species Habitat Conservation Plan |
| USFWS | United States Fish & Wildlife Service |

## Units

| | |
|---|---|
| ha | hectare |
| km | kilometer |
| $km^2$ | square kilometer |
| m | meter |
| $mi^2$ | square mile |

# Section 1.0 Introduction

This document is the Adaptive Management and Monitoring Plan (AMMP) developed as part of implementing the Multiple Species Habitat Conservation Plan (MSHCP; Clark County 2000) administered by the Clark County, Nevada Desert Conservation Program (DCP). This document is composed of three parts: 1) an introductory explanation of the need and overall purpose of adaptive management and monitoring in Clark County; 2) a description of on-the-ground species and habitat-level monitoring activities; and 3) a description of the adaptive management process, including direction on how monitoring results and periodic analysis can be used to determine success in achieving the Biological Goals and Objectives (BGOs) and ultimately in improving the populations and habitats of MSHCP-covered species.

## 1.1 Authorization and Need for the Adaptive Management and Monitoring Plan

Development of a monitoring plan is an explicit requirement for Habitat Conservation Plans (HCP) under the current US Fish & Wildlife Service (USFWS) *Habitat Conservation Planning and Incidental Take Permit Processing Handbook*, Chapter 3.B.4 (USFWS 1996). Guidance for development of a monitoring plan is to periodically estimate the rate of take, determine species status in the MSHCP-covered project area or associated mitigation areas, and to produce progress reports on achieving mitigation requirements. The existing MSHCP does not require estimates of take but does require biennial progress reports on success in achieving the specific mitigation requirements outlined in the MSHCP.

This AMMP uses additional guidelines from the USFWS (USFWS 1996, Chapter 3.B.4) for developing a monitoring plan. The focus of monitoring is on quantifying the status of MSHCP-covered species and their habitats within the reserve system. The monitoring data will be used in the adaptive management process to quantify the continuing success of the conservation actions in achieving the BGOs and in maintaining or improving the populations and habitats of MSHCP-covered species.

The Clark County MSHCP outlines the general role that adaptive management is to serve throughout the lifetime of the permit. Specifically, Chapter 2.8.2 of the MSHCP (Clark County 2000) states that:

"*The Clark County MSHCP will implement an AMP [Adaptive Management Process] designed to provide an objective, quantitative evaluation of the effectiveness of (a) management actions in attaining program goals and (b) inventory, monitoring, and research results and interpretation. The AMP is intended to provide a scientifically sound approach, which is preferred by many resource managers when funding and scientific resources are available. The AMP is intended to provide resource managers with objective scientific data and analysis upon which to base management decisions as well as scientifically valid evaluation of management actions.*"

This AMMP has been developed to provide the technical direction for collecting and assessing monitoring data and determining the success of the suite of conservation actions in achieving the BGOs and maintaining or enhancing MSHCP-covered species and their habitats. The MSHCP currently discusses the conceptual and policy needs of adaptive management; the AMMP is the technical roadmap detailing the monitoring actions and walkthroughs for conducting the adaptive management process. The adaptive management process is conducted at regular intervals to determine the success of conservation actions in achieving the biological objectives and ensuring that the suite of conservation actions as a whole is successfully maintaining or improving populations and habitats of MSHCP-covered species.

## 1.2 Integration of Monitoring and Adaptive Management

The foundational component of adaptive management is the incorporation of relevant and quantitative data and information obtained through regular monitoring. This information is then used in the periodic evaluation of conservation success, with a key focus on using the information to learn from past actions and make necessary changes, thus monitoring and adaptive management are complementary – neither can be successfully achieved without the other. The Monitoring Plan section of this AMMP describes which data to collect and the Adaptive Management Plan section describes how to use the data to evaluate two categories of criteria: the BGOs themselves and the species and habitat-level monitoring data. Many of the BGOs are not associated with specific MSHCP-covered species and conversely, many of the covered species are not directly associated with a BGO. This is the result of two separate goals. The BGOs were developed to guide development and assessment of conservation actions given the larger goals of the MSHCP. Monitoring and assessment of species and habitats was developed to "keep a finger on the pulse" of species and habitats directly to ensure maximum realized benefit of the conservation actions. Combined, applying monitoring and adaptive management to both categories of criteria provides a comprehensive evaluation of both internal (the BGOs) and external (species populations and habitats) metrics and of how well the suite of conservation actions are performing. Integral to this process is the strong quantifiability of actions and impacts and a recursive timeline to guide both the monitoring and adaptive management activities. This document unifies the monitoring methods and adaptive management assessment of the suite of conservation actions as a whole and ties them back to the BGOs and species and habitats.

## 1.3 Definitions

The scientific literature on adaptive management is often full of ambiguity (Rist et al. 2013). This section includes operational definitions specific to the intent and use of each term within the Clark County AMMP.

- Adaptive management – A formal mechanism to alter management actions in response to information gained from previous actions. The focus is on learning from past actions and independent monitoring data to strive for increased realized benefits from conservation actions.
- Biological goal - Biological goals are the broad, guiding principles for implementing conservation actions under the MSHCP. Biological goals are intentionally broad and general as they describe the desired future state of a species or biological system, and because of their descriptive nature they are not directly quantifiable.
- Biological objective - A biological objective is the specific, concrete, and quantifiable aim that leads to achieving the biological goal. Biological objectives are achieved via conservation measures.

- Conservation action – A specific project or action conducted as part of implementing the MSHCP.
- Conservation measure - Conservation measures are the themes or categories of actions that are implemented on-the-ground, such as specific monitoring techniques and schedules, restoration projects, etc.
- Ecological resilience – The capacity of a system to withstand acute and diffuse stressors without experiencing widespread negative regime changes, such as species extirpation or a fundamental loss of ecosystem function. Ecological resilience can be increased by increasing spatial resiliency through maintaining spatial connectivity, spatiotemporal variability in ecological processes, and adaptive management (Gunderson 2000, Kondoh 2012, Allen et al. 2016, Quinlan et al. 2016).
- Habitat-based surrogate – habitat attributes that are used as proxies for the presence, abundance, or diversity of particular elements (e.g., animal species, vegetation structure or composition) of the biota at both site- and landscape-levels (Lindenmayer et al. 2014).
- Indicator species – subsets of species which are representative of multiple species or aspects of the environment. These include umbrella, focal, keystone, indicator, and flagship species. Indicator species are commonly used for comprehensive planning that supports multiple species and habitats within a defined landscape or geographic area (USFWS 2015).
- Performance period – The time period over which success at achieving a biological objective is to be evaluated.
- Performance criteria – The quantitative measure used to determine whether a biological objective is successfully being achieved.
- Reserve system - Those lands over which the DCP has direct control of management activities, including via direct acquisition, easements, or future cooperative management agreements.
- Species occupancy – Whether or not a MSHCP-covered species is present in appropriate habitat during part or all of the year.

## 1.4 Biological Goals and Objectives

Biological goals are the broad, guiding principles for the operating conservation actions of the MSHCP. Goals are intentionally broad and general as they describe the desired future state of a species or biological system. They provide rationale for the conservation actions needed to minimize and mitigate adverse effects on MSHCP-covered species to the maximum extent practicable. Biological objectives are specific, concrete, and quantifiable aims that lead to achieving biological goals. Objectives are achieved through implementation, evaluation, and adaptive refinement of conservation actions that are generally grouped into categories of conservation measures. Together, the BGOs (Table 1), provide the rationale behind the MSHCP's terms and conditions, guide monitoring, and, when appropriate, inform adaptive management.

The BGOs are included in this document because they serve as guidance for developing future conservation actions and because they provide a relevant metric against which to compare the realized benefits resulting from conservation actions. The adaptive management section describes how to determine if the BGOs are being achieved and how to proceed if they are not being met. See DCP (2016) for a thorough discussion of the development of the BGOs.

**Table 1. Biological Goals and Objectives for the MSHCP**

| |
|---|
| **Goal R 1: Maintain, improve, and expand habitat for the MSHCP-covered species on riparian reserve system lands** |
| Objective R 1.1: *Monitor MSHCP-covered species occupancy* |
| Objective R 1.2: *Maintain and/or increase suitable breeding habitat for MSHCP-covered birds* |
| Objective R 1.3: *Incorporate elements of natural riparian processes into restoration design and implementation* |
| Objective R 1.4: *Inventory, remove, and control invasive and non-native plant species* |
| Objective R 1.5: *Reduce habitat fragmentation and/or improve connectivity and habitat quality through restoration design and implementation* |
| **Goal R 2: Maintain stable or increasing populations of federally-listed threatened and endangered (T&E) species on riparian reserve system lands** |
| Objective R 2.1: *Monitor and adaptively manage for breeding bird populations* |
| **Goal R 3: Foster community and stakeholder engagement to benefit covered species** |
| Objective R 3.1: *Collaborate with other stakeholders on project/mitigation work (e.g., agencies, permittees)* |
| Objective R 3.2: *Promote responsible recreation (e.g., signage, education)* |
| **Goal R 4: Promote ecological resiliency on riparian reserve system lands** |
| Objective R 4.1: *Identify critical uncertainties and address these through planning and adaptive management, when feasible (land use changes, catastrophic events–fire, climate change)* |
| Objective R 4.2: *Identify critical connectivity corridors for covered species, prioritize acquisition and/or conservation where feasible* |
| **Goal D 1: Maintain, improve, and expand habitat for MSHCP-covered species on desert upland reserve system lands** |
| Objective D 1.1: *Monitor MSHCP-covered species occupancy* |
| Objective D 1.2: *Maintain existing intact functioning habitat and restore degraded habitat (D 1.1 determines degree of habitat functionality)* |
| Objective D 1.3*: Protect and conserve habitat for covered plants and physically protect plants with specific requirements* |
| Objective D 1.4: *Inventory, remove, and control invasive and non-native plant species* |
| Objective D 1.5: *Reduce habitat fragmentation and/or improve connectivity through restoration design and implementation* |
| **Goal D 2: Maintain stable or increasing populations of Federal T&E-listed species on desert upland reserve system lands** |
| Objective D 2.1: *Monitor and adaptively manage for desert tortoise populations* |
| Objective D 2.2: *Augment populations through translocation programs when appropriate* |
| **Goal D 3: Foster community and stakeholder engagement to benefit covered species** |
| Objective D 3.1: *Collaborate with other stakeholders on project/mitigation work (e.g., agencies, permittees)* |
| Objective D 3.2: *Promote responsible recreation (e.g., signage, education)* |
| Objective D 3.3: *Provide law enforcement within reserve system* |
| Objective D 3.4: *Educate project proponents and construction personnel about procedures for reporting desert tortoises that occur on project sites and provide a mechanism for collection and relocation of tortoises in collaboration with USFWS* |
| **Goal D 4: Promote ecological resiliency on desert upland reserve system lands** |
| Objective D 4.1: *Identify critical uncertainties and address these through planning and adaptive management, when feasible (land use changes, catastrophic events–fire, climate change)* |
| Objective D 4.2: *Identify critical connectivity corridors for covered species, prioritize conservation and/or acquisition of corridors, and increase permeability for species movement where feasible* |

## 1.5 Conservation Measures

Within the HCP framework, conservation measures (CMs) are themes or categories of actions that may be implemented by the Permittee and other Participants to achieve the BGOs and to minimize, mitigate, and monitor the impacts of take of species covered by the MSHCP (Clark County 2000). The CMs guide the development of new projects and serve as a link between conservation projects and the BGOs. A single conservation project can support multiple CMs and a single CM can cover multiple projects. Over 650 specific actions were identified in the original MSHCP (Clark County 2000), including those to be implemented by local, state, and Federal agencies participating in the MSHCP. The MSHCP groups these actions into seven categories of CMs, which are used in this document and are described in the following sub-sections:

1. Public information and involvement
2. Research
3. Inventory
4. Monitoring
5. Protective measures
6. Habitat restoration and enhancement
7. Land-use policies and actions

### *1.5.1 Conservation Measure Details*

#### 1.5.1.1 CM 1: Public Information and Involvement

Activities associated with this CM are associated with public information, education, and outreach. Specific actions include, but are not limited to: "Mojave Max" appearances, contests, educational programs, and livestream camera; expenditures used to develop and produce multimedia advertisements regarding responsible use of reserve lands and other recreational areas; promotional material and giveaways; support for OHV registration program; and, development and delivery of informational materials via brochures, meetings, social media, and videos that inform users of reserve lands about authorized activities, habitat conservation, and species protection.

#### 1.5.1.2 CM 2: Research

This CM encompasses integrated research on MSHCP-covered species and associated habitats that informs and supports the DCP and implementation of the MSHCP. Specific research activities are implemented as needed to address data gaps and uncertainties as determined by DCP staff, the Science Advisor Panel, and other stakeholders.

#### 1.5.1.3 CM 3: Inventory

This CM includes, but is not limited to: baseline surveys of MSHCP-covered species and/or associated suitable habitat; baseline surveys of priority invasive species; analysis of inventory data; and, development of associated reports and databases.

#### 1.5.1.4 CM 4: Monitoring

Activities associated with this CM are monitoring MSHCP-covered species, associated habitats, and other elements of the DCP and MSHCP. Specific actions include, but are not limited to: planning and implementation of monitoring protocols for MSHCP-covered species, associated habitats, priority invasive species, habitat restoration and enhancement projects; public information, education, and outreach activities; analysis and evaluation of monitoring data with adaptive management frameworks; creating and maintenance of monitoring databases; and, reporting.

#### 1.5.1.5 CM 5: Protective Measures

Activities associated with this CM are physical protection of MSHCP-covered species and associated habitats. Specific actions include, but are not limited to: repair and maintenance of existing fences, barriers, and desert tortoise guards; installation of new desert tortoise exclusionary fencing; installation of new fencing to protect other MSHCP-covered species and habitats; and, desert tortoise protection and translocation.

#### 1.5.1.6 CM 6: Habitat Restoration and Enhancement

Activities associated with this CM focus on habitat restoration, invasive species control, and related activities. Specific actions include, but are not limited to: planning, implementation, and evaluation of habitat restoration projects; repair and maintenance of existing restoration sites; and, treatment of priority invasive species both as a part of routine, nondiscretionary reserve land management and discretionary situations such as treating unanticipated outbreaks of existing or new priority invasive species in more remote areas of reserve lands.

#### 1.5.1.7 CM 7: Land-use Policies and Actions

Actions associated with this CM are nondiscretionary reserve land management, land-use planning and property acquisition, and resiliency planning. Routine, nondiscretionary management of reserve lands includes such activities as law enforcement; removal of trash and other debris; repair and maintenance of kiosks, fences, barriers, viewing ramadas, groundwater pumps, irrigation systems, roads, trails, fire breaks, cattleguards, and desert tortoise guards; treatment of invasive species along roadsides; management of water rights; review of project applications that affect reserve lands; responding to permittee questions regarding allowable activities; reviewing and updating reserve management plans; and, coordinating with Participants, adjacent landowners, and other stakeholders. Land-use planning and property acquisition activities focus on expanding existing reserve lands through acquisition of property from willing sellers or through various agreements, but also include analyses of habitat conversion to balance acquisition and evaluations of habitat fragmentation/connectivity. Resiliency planning activities also include evaluations of habitat connectivity and corridors for MSHCP-covered species, as well as identification and evaluation of critical uncertainties (e.g., land-use changes, fire and other disturbances, demographic changes, and climate change) that have the potential to affect the DCP and MSHCP at broad spatiotemporal scales.

### *1.5.2 Relationship Between Conservation Measures*

While representing distinct categories of management actions, the seven types of CMs intentionally overlap to some degree to reflect connections between different management actions as well as opportunities for collaboration. For example, actions associated with CM 7 (Land-use policies and actions) will include outreach to the public regarding reserve rules and regulations, thus overlapping with actions associated with CM 1 (Public information and involvement).

### *1.5.3 Relationship of Conservation Measures to Biological Goals and Objectives*

The purpose of implementing the seven types of CMs is to achieve the BGOs. Each conservation measure has multiple associated biological objectives, often spanning both desert upland and riparian reserve lands (Table 2). All biological objectives, and thus all goals as well, have at least one associated conservation measure.

**Table 2. Crosswalk Between Conservation Measures and Biological Objectives***

| Conservation Measure | CM # | Associated Biological Objectives |
|---|---|---|
| *Public information and involvement* | **1** | Objectives associated with outreach and education (R 3.2; D 3.1, D3.4)<br><br>Objectives that could be accomplished in part by collaborating with public/stakeholders (R 1.1, R 1.2, R 1.4, R 2.1, R 3.1; D 1.1, D 1.4, D 1.5, D 2.1, D 2.2, D 3.1, D 3.4) |
| *Research* | **2** | Objectives associated with past, present, or potential integrated research (R 1.1, R 4.1; D 1.1, D 2.1, D 2.2, D 4.1) |
| *Inventory* | **3** | Objectives associated with species inventory (R 1.1, R 1.4, R 2.1; D 1.1, D 1.4, D 2.1) |
| *Monitoring* | **4** | Objectives associated with species monitoring (R 1.1, R 1.4, R 2.1; D 1.1, D 1.3, D 1.4, D 2.1, D 2.2)<br><br>Objectives associated with habitat monitoring (R 1.2, R 1.5; D 1.2, 1.5) |
| *Protective measures* | **5** | Objective D 1.3 (*Protect and conserve habitat for covered plants*)<br><br>Objective associated with desert tortoise relocation and fencing (D 2.1, D 2.2, D 3.4) |
| *Habitat restoration and enhancement* | **6** | Objectives associated with non-native/invasive species control and habitat restoration (R 1.3, R 1.4, R 1.5; D 1.2, D 1.4, D 1.5) |
| *Land use policies and actions* | **7** | Objective D 3.3 (*Provide law enforcement within upland reserve system*)<br><br>Objectives associated with property acquisition (R 1.6, R 4.2) and resiliency planning (R 1.5, R 4.1, R 4.2; D 1.5, D 4.1, D 4.2) |

*Conservation Measures are from the MSHCP and Biological Objectives were developed by DCP staff and the independent Science Advisor Panel in May, 2016.

# Section 2.0 Monitoring Plan

Monitoring serves as the fundamental basis of adaptive management and is a critical component of any large-scale and long-term applied conservation program. It serves as a source of information for making management decisions and it provides a benchmark for determining conservation success or failure. The following subsections describe the scale and type of monitoring that should be conducted and provide guidance on which components of the ecosystem should be monitored, including methods for field data collection and data analysis. Appendix A provides additional details related to the suggested monitoring methods and includes a discussion regarding alternative methods.

## 2.1 Scales of Monitoring

Monitoring of species and habitats must occur at scales relevant to the scale of management interest and at scales relevant to individual species. The MSHCP applies to all private land and land that may become private within Clark County, Nevada. In contrast, many conservation projects associated with implementation of the MSHCP occur only on lands where the DCP can ensure durability, which are specific areas of land not impacted by private development. Thus it is important to define the scale and location at which monitoring should occur.

Ideally, monitoring would occur in relevant habitats throughout Clark County. This is useful for two reasons: 1) it gives a larger picture of how species and their habitats are faring at the scale of the MSHCP (i.e., private lands across the entire county); and 2) it allows for assessment of the benefits of conservation actions conducted on reserve lands to species and habitats aside from regional trends in those species' populations and habitats. For example, large-scale climate and weather patterns can drive temporal changes in species' populations and habitats, and it would be useful to determine if the reserve system is providing additional benefits to species and habitats aside from regionally-driven trends.

The DCP, however, cannot be guaranteed consistent county-wide land access. This uncertainty is combined with the fact that money spent on monitoring is not directly spent on mitigation and conservation actions. Therefore, in practice, widespread monitoring across the county is neither feasible nor necessarily desirable.

As a compromise the DCP will perform monitoring at two scales. First, consistent monitoring of species and habitat will be conducted within the reserve system. Second, if triggers are met (i.e., populations are declining), monitoring will be initiated off the reserve system to determine if the trigger was met due to factors within (e.g., declines in habitat quality within the reserve system) or outside of the ability of the DCP to impact (e.g., regional population declines). The on- and off-reserve comparison can be made using DCP data along with data collected by other entities (e.g., Bureau of Land Management) or newly collected by the DCP itself.

## 2.2 Types of Monitoring

The successful implementation of the MSHCP and adaptive management requires that two types of monitoring be conducted: 1) species and habitat monitoring and 2) effectiveness monitoring.

Species and habitat-level monitoring is a broad level of monitoring conducted on reserve system lands in riparian and desert upland habitats in Clark County (see section 2.1) and is not tied to the results of any specific conservation project. The goal of species and habitat-level monitoring is to determine whether the conservation projects in aggregate are maintaining or improving the habitats and populations of MSHCP-covered species (i.e., creating additionality). Direct benefits to MSHCP-covered species are not a requirement of HCPs (USFWS 1996 Chapter 3.B.3.b.) and monitoring at this broad level is a value-added component in addition to the required actions under the MSHCP.

Effectiveness monitoring is designed and conducted for individual conservation projects. It is intended to quantify the conservation outcomes and benefits of each conservation project. The timeline and methods for effectiveness monitoring are highly variable between projects, and some projects may not require effectiveness monitoring. For example, acquiring a riparian property is a required action under the MSHCP, but does not lend itself to long-term effectiveness monitoring. In contrast, a restoration project may require both short- and long-term monitoring (e.g., 5-20 years) to determine project efficacy and benefits to the ecosystem. For projects that do not involve medium- or long-term effectiveness monitoring, post-project quantification of conservation benefits is still a requirement (and can be thought of as zero-term effectiveness monitoring). Effectiveness monitoring is a fundamental and critical part of the biennial reporting process as well as the biological objective-specific adaptive management process. See Appendix B for examples and more detailed discussion on conducting effectiveness monitoring. The remainder of the monitoring section of the main document will discuss species and habitat-level monitoring only.

## 2.3 Monitoring Phases

New HCPs often delineate three phases for conducting monitoring: baseline data collection, targeted study phase, and long-term monitoring and adaptive management. However, these phases do not directly translate to this document because the DCP has been implementing the MSHCP (and the specific requirements therein) since 2001. Periodic monitoring has already been conducted for a subset of MSHCP-covered species; several targeted studies have been completed or are ongoing; and the adaptive management process has been applied to relevant projects and, to a lesser extent, the suite of conservation actions as a whole. Ultimately, development and conservation actions conducted since 2001 have potentially impacted MSHCP-covered species. Thus any true baseline data would need to have been collected prior to 2001.

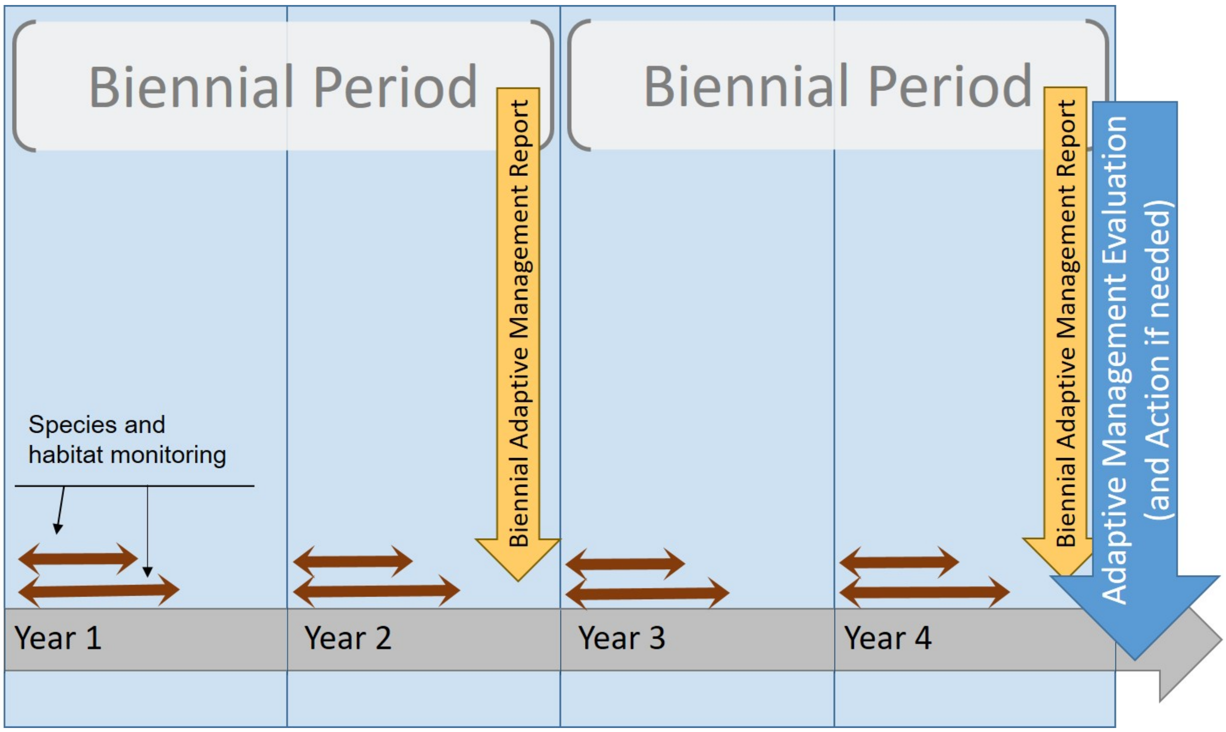
## 2.4 Data and Reporting

Monitoring data will be collected by either DCP staff or external contractors. Specific details on data collection methods will be determined at the beginning of the monitoring effort. Future modifications to the monitoring methods should be made if necessary and should be done in consultation with DCP staff and the independent Science Advisor Panel to ensure continuity of monitoring results.

All data will be stored by the DCP and will be available to other MSHCP Participants. The analysis of monitoring results for reporting purposes can occur at any time, but at a minimum will be conducted every two years as part of the Biennial Adaptive Management Report to serve as a benchmark for conservation progress. This is not a new feature of the Biennial Adaptive

Management Report but it is one whose importance deserves emphasis here. Additionally, the regular quantification and reporting of project-level progress can inform how well biological objectives are being achieved as part of the adaptive management process that occurs every four years (Figure 1). Analysis and reporting of monitoring results for the adaptive management process will occur as described in the Adaptive Management section (Section 3.3 below) and will be conducted every four years.

**Figure 1. Monitoring and Adaptive Management Evaluation Timeline**




## 2.5 Species Monitoring

A species-specific monitoring plan may include a variety of different methods to measure species occupancy and population trends. Some species (e.g., threatened and endangered species) have specific survey protocols that must be followed to accurately assess occupancy and trends. Several species (or groups of species) may be monitored simultaneously using a single survey method. The following sections describe recommended methods for inventory and monitoring MSHCP-covered species and Table 3 categorizes them by whether they are indicator species, the general habitat they occupy, and the monitoring method used.

The MSHCP uses the concept of indicator species to efficiently implement the MSHCP for all 78 MSHCP-covered plant and animal species. Indicator species are defined in the MSHCP as:

*"surrogates of population or ecosystem processes of concern. They can be species or ecosystem components or characteristics that are easy to measure and exhibit dynamics and responses that parallel those of more difficult to measure population or ecosystem processes of concern. Indicator species are selected because they demonstrate low natural variability but respond measurably to environmental change at reasonable cost. Indicators will include population sizes*

*and distributions of select species, physical and biotic variables associated with ecological communities, and vegetation types readily assessed by remote methods." (MSHCP, pg. 182)*

The AMMP uses a hybrid indicator species and comprehensive species approach to monitoring and adaptive management. Several species are designated as indicator species and require sufficient monitoring to inform adaptive management. This includes all federally-listed species. The remaining MSHCP-covered species are considered "non-indicator" because they are highly cryptic, are of less conservation concern, do not occur on private land within Clark County, and/or have distributions or habitat requirements insufficiently understood to design a monitoring plan. The monitoring methods developed for the indicator species were designed to simultaneously survey for non-indicator species where possible. Thus, the aim for the monitoring plan is to measure the population and habitat status of all MSHCP-covered species. Only indicator species, however, require a full, and potentially additional, survey effort to gather sufficient data to achieve the monitoring goals. Analysis of monitoring results for non-indicator species should occur where possible to most fully inform the adaptive management process for the entire suite of conservation actions.

**Table 3. Summary of Monitoring Methods and Status for 78 MSHCP-covered Species*.**

| Common Name | Scientific Name | Monitored | Habitat | Indicator spp | Monitoring method |
|---|---|---|---|---|---|
| **Birds** | | | | | |
| Yellow-billed cuckoo | *Coccyzus americanus* | X | Riparian | X | Protocol survey[a] |
| Southwestern willow flycatcher | *Empidonax traillii extimus* | X | Riparian | X | Protocol survey[b] |
| American peregrine falcon | *Falco peregrinus anatum* | X | Desert upland | - | Targeted survey |
| Blue grosbeak | *Guiraca caerulea* | X | Riparian | - | Point count |
| Phainopepla | *Phainopepla nitens* | X | Both | - | Point count |
| Summer tanager | *Piranga rubra* | X | Riparian | - | Point count |
| Vermillion flycatcher | *Pyrocephalus rubinus* | X | Riparian | - | Point count |
| Arizona Bell's vireo | *Vireo bellii arizonae* | X | Riparian | - | Point count |
| **Mammals** | | | | | |
| Silver-haired bat | *Lasionycteris noctivagans* | X | Both | - | Passive acoustic |
| Long-eared myotis | *Myotis evotis* | X | Both | - | Passive acoustic |
| Long-legged myotis | *Myotis volans* | X | Both | - | Passive acoustic |
| Palmer's chipmunk | *Neotamias palmeri* | - | - | - | - |
| **Amphibians** | | | | | |
| Relict leopard frog | *Rana onca* | - | - | - | - |
| **Reptiles** | | | | | |
| Glossy snake | *Arizona elegans* | X | Desert upland | - | Occupancy survey |
| Banded gecko | *Coleonyx variegatus* | X | Desert upland | - | Occupancy survey |
| Sidewinder | *Crotalus cerastes* | X | Desert upland | - | Occupancy survey |
| Speckled rattlesnake | *Crotalus mitchellii* | X | Desert upland | - | Occupancy survey |
| Mojave green rattlesnake | *Crotalus scutulatus scutulatus* | X | Desert upland | - | Occupancy survey |
| Great Basin collared lizard | *Crotaphytus bicinctores* | X | Desert upland | - | Occupancy survey |
| Desert iguana | *Dipsosaurus dorsalis* | X | Desert upland | - | Occupancy survey |
| Large-spotted leopard lizard | *Gambelia wislizenii wislizenii* | X | Desert upland | - | Occupancy survey |
| Desert tortoise | *Gopherus agassizii* | X | Desert upland | X | Occupancy survey |
| California kingsnake | *Lampropeltis getulus californiae* | X | Desert upland | - | Occupancy survey |
| Western leaf-nosed snake | *Phyllorhynchus decurtatus* | X | Desert upland | - | Occupancy survey |
| Western red-tailed skink | *Plestiodon gilberti rubricaudatus* | - | - | - | - |
| Western long-nosed snake | *Rhinocheilus lecontei lecontei* | X | Desert upland | - | Occupancy survey |
| Sonoran lyre snake | *Trimorphodon biscutatus lambda* | X | Desert upland | - | Occupancy survey |
| **Invertebrates** | | | | | |
| Spring Mountains acastus checkerspot | *Chlosyne acastus robusta* | - | - | - | - |
| Dark blue butterfly | *Euphilotes ancilla purpura* | - | - | - | - |
| Morand's checkerspot butterfly | *Euphydryas anicia morandi* | - | - | - | - |
| Spring Mountains comma | *Hesperia colorado* | - | - | - | - |
| Spring Mountains icariodes | *Icaricia icarioides* | - | - | - | - |
| Mt. Charleston blue butterfly | *Icaricia shasta charlestonensis* | - | - | - | - |

| Common Name | Scientific Name | Monitored | Habitat | Indicator spp | Monitoring method |
|---|---|---|---|---|---|
| Nevada admiral | *Limenitis weidemeyerii* | - | - | - | - |
| Spring Mountains springsnail | *Pyrgulopsis deaconi* | - | - | - | - |
| Southeast Nevada springsnail | *Pyrgulopsis turbatrix* | - | - | - | - |
| Carole's silverspot butterfly | *Speyeria zerene carolae* | - | - | - | - |
| **Plants** | | | | | |
| No common name | *Anacolia menziesii* | - | - | - | - |
| Rough angelica | *Angelica scabrida* | - | - | - | - |
| Charleston pussytoes | *Antennaria soliceps* | - | - | - | - |
| Sticky ringstem | *Anulocaulis leiosolenus* | X | Desert upland | - | Species-specific[c] |
| Las Vegas bearpoppy | *Arctomecon californica* | X | Desert upland | - | Species-specific[c] |
| White bearpoppy | *Arctomecon merriamii* | X | Desert upland | - | Species-specific[c] |
| Rosy king sandwort | *Arenaria kingii* ssp. *rosea* | X | Desert upland | - | Species-specific[c] |
| Clokey milkvetch | *Astragalus aequalis* | - | - | - | - |
| Threecorner milkvetch | *Astragalus geyeri* var. *triquetrus* | X | Desert upland | - | Species-specific[c] |
| Clokey eggvetch | *Astragalus oophorus* var. *clokeyanus* | - | - | - | - |
| Spring Mountains milkvetch | *Astragalus remotus* | - | - | - | - |
| Alkali mariposa lily | *Calochortus striatus* | X | Riparian | - | |
| Clokey paintbrush | *Castelleja martinii* var. | - | - | - | - |
| Clokey thistle | *Cirsium clokeyi* | - | - | - | - |
| No common name | *Claopodium whippleanum* | - | - | - | - |
| Blue Diamond cholla | *Cylindropuntia multigeniculata* | X | Desert upland | - | Species-specific[c] |
| No common name | *Dicranoweisia crispula* | - | - | - | - |
| Jaeger whitlowgrass | *Draba jaegeri* | - | - | - | - |
| Charleston draba | *Draba paucifructa* | - | - | - | - |
| Inch high fleabane | *Erigeron uncialis* ssp. *conjugans* | - | - | - | - |
| Forked (Pahrump Valley) buckwheat | *Eriogonum bifurcatum* | X | Desert upland | - | Species-specific[c] |
| Sticky buckwheat | *Eriogonum viscidulum* | X | Desert upland | - | Species-specific[c] |
| Clokey greasebush | *Glossopetalon clokeyi* | - | - | - | - |
| Smooth pungent (dwarf) greasebush | *Glossopetalon pungens* var. *glabrum* | - | - | - | - |
| Pungent dwarf greasebush | *Glosspetalon pungens* var. *pungens* | - | - | - | - |
| Red Rock Canyon aster | *Ionactis caelestis* | - | - | - | - |
| Hidden ivesia | *Ivesia cryptocaulis* | - | - | - | - |
| Jaeger ivesia | *Ivesia jaegeri* | - | - | - | - |
| Hitchcock bladderpod | *Lesquerella hitchcockii* | - | - | - | - |

| Common Name | Scientific Name | Monitored | Habitat | Indicator spp | Monitoring method |
|---|---|---|---|---|---|
| Charleston pinewood lousewort | *Pedicularis semibarbata* var. *charlestonensis* | - | - | - | - |
| White-margined beardtongue | *Penstemon albomarginatus* | X | Desert upland | - | Species-specific[c] |
| Charleston beardtongue | *Penstemon leiophyllus* var. *keckii* | - | - | - | - |
| Jaeger beardtongue | *Penstemon thompsoneae* var. *jaegeri* | - | - | - | - |
| Parish's phacelia | *Phacelia parishii* | - | - | - | - |
| Clokey mountain sage | *Salvia dorrii* var. *clokeyi* | - | - | - | - |
| Clokey catchfly | *Silene clokeyi* | - | - | - | - |
| Charleston tansy | *Sphaeromeria compacta* | - | - | - | - |
| Charleston kittentails | *Synthyris ranunculina* | - | - | - | - |
| No common name | *Syntrichia princeps* | - | - | - | - |
| Charleston grounddaisy | *Townsendia jonesii* var. *tumulosa* | - | - | - | - |
| Limestone violet | *Viola purpurea* var. *charlestonensis* | - | - | - | - |

[a]See Halterman et al. (2016) for survey protocol details.
[b]See Sogge et al. (2010) for survey protocol details.
[c]Species-specific methods for monitoring plant populations depends on each species. See Appendix A for discussion.
* Some species not monitored because they do not occur on private land within Clark County or are covered by other regulatory mechanisms.

### 2.5.1 Desert Tortoise (*Gopherus agassizii*)

Agassiz's desert tortoises (*Gopherus agassizii*) range across the southwest United States, found northwest of the Colorado River (Murphy et al. 2011). It is a species in decline despite significant conservation and management efforts since it was federally-listed as threatened in 1990 (USFWS 1990, USFWS 2011). This species is threatened by the concomitant effects of habitat loss (Heaton et al. 2008, Darst et al. 2013), disease (Jacobson et al. 1991, Jacobson 1994), and predation (Boarman et al. 2006), all of which may vary spatially and temporally.

Various methods have been used to sample desert tortoise populations across their range. Sampling desert tortoises, however, is challenging due to their low capture probability as related to their fossorial life history, cryptic nature, and patchy spatial distribution. Previous desert tortoise survey methods include belt transects, occupancy (Zylstra and Steidl 2009, Zylstra et al. 2010), study plots of varying size (1 $mi^2$, 1 $km^2$, 1 ha) (Keith et al. 2008), and line-distance sampling (Anderson et al. 2001, Averill-Murray and Averill-Murray 2005).

Occupancy modeling determines the proportion of habitat within an area that contains evidence of a focal species (MacKenzie et al. 2002). It uses detection/non-detection data to estimate species occurrence, and explicitly recognizes that the probability of detection on a single survey may be less than one. The advantages to using occupancy to sample desert tortoise are that it has been previously used in this region and there is an established method and data set to compare to. It is inexpensive when compared to other sampling methods (e.g., line distance sampling, 100% coverage plots), and can provide both abundance/density and presence/absence data. Previous research on occupancy indicates that it had sufficient power to detect moderate levels of population change within 20 years' time (Zylstra et al. 2010, Erb et al. 2015). Occupancy monitoring is also useful in that it measures the most important state variable for a population – whether or not a species occurs in part of the landscape. Finally, occupancy can include ecological or management covariates (e.g., vegetation, soil type, invasive species control, and closing roads) within the plot design. The disadvantages of using occupancy are that there are statistical challenges when detection probability is extremely low, and it generally provides only a coarse level of inference (e.g., it does not provide robust demographic information, although it can provide abundance/density estimates). Nonetheless, we recommend developing a robust occupancy monitoring plan given its efficiency, and focus on a fundamental population state variable. See Appendix A for further background and discussion on occupancy monitoring for desert tortoise and a discussion of capture-mark-recapture and line distance sampling.

A series of 4 ha sample units (preferentially including those that were sampled during the pilot occupancy study on the BCCE, where feasible; DCP 2011) will be sampled annually (Table 4). Sample size should be determined based on the detection and occupancy rate results obtained in the pilot study. Guillera-Arroita & Lahoz-Monfort (2012) provide an overview of power analysis for determining sample size for occupancy monitoring studies.

Surveyor(s) should walk 10 m belt transects across the entire plot in an effort to complete a 100% coverage. Surveyor(s) are expected to investigate all vegetation and burrows for presence of live tortoises, active tortoise burrows, and tortoise sign within each 4-ha sample unit, and each sample unit will be surveyed seven times during the season (between March 1 – May 15). The low detection probability of tortoises requires an increased number of sampling events than were initially proposed in the pilot study. Desert tortoises will be marked using current acceptable methods upon detection and given a visual health assessment. Additional information will be recorded, including sex, midline carapace length, tortoise ID, location, and behavior. Information on desert tortoise burrows will also be recorded, including burrow width, substrate type, burrow location, and any tortoise sign associated with the burrow.

Statistical analysis should follow the equations and methods originally outlined in MacKenzie et al. (2002) and detailed in numerous subsequent papers and books. A variety of statistical programs can be used, including Program R, MARK, PRESENCE, and E-SURGE. Results from the pilot study can be used to determine which level of modeling complexity will be required for the monitoring data and the most appropriate statistical software can then be chosen. Appropriate weather or date covariates should be used in the estimation of detection probability.

### *2.5.2 Yellow-Billed Cuckoo (Coccyzus americanus)*

The Western Distinct Population Segment of yellow-billed cuckoo is a federally-listed threatened species inhabiting riparian habitats. Yellow-billed cuckoos are difficult to detect during traditional avian surveys; therefore, protocol-level surveys must be conducted to adequately detect the species. The USFWS-approved survey protocol (Halterman et al. 2016) consists of surveying a minimum of four times during the breeding season: once between June 15 – July 1, twice between July 1 – July 31, and once between July 31 – Aug 15. There is a minimum of 12 and a maximum of 15 days between surveys at a site. Surveys are conducted using call-playback methods in suitable or potentially suitable cottonwood-willow habitat. A survey station should be established in each patch of potentially suitable habitat > 5 ha and >300 m from the nearest other patch. The total number of stations depends on the number and size of patches of potentially suitable habitat. Multiple stations should be surveyed in large patches. The number of survey stations depends on the amount of potentially suitable breeding habitat, but should be high enough to allow for robust statistical inference on the proportion of occupied survey sites on riparian reserve system lands. Station locations should be determined prior to June 15 and the same survey stations should be surveyed in consecutive years, where possible. Surveys for the yellow-billed cuckoo and southwestern willow flycatcher may not be conducted simultaneously (i.e., each species requires a separate survey effort). Surveyors must attend a training session and be approved by USFWS to conduct the surveys. See Halterman et al. (2016) for survey protocol details.

### *2.5.3 Southwestern Willow Flycatcher (Empidonax traillii extimus)*

Surveys for the federally-listed endangered southwestern willow flycatcher, a riparian specialist, must follow the USFWS-approved survey protocol (Sogge et al. 2010). Surveys consist of a minimum of three surveys during the breeding season: once between May 15 – May 31, once between June 1 – June 24, and once between June 24 – July 17. Surveys must occur a minimum of 5 days apart. Surveys should occur in suitable or potentially suitable breeding habitat and should be conducted from within, rather than adjacent to, the patch of potentially suitable habitat. The number of survey sites depends on the amount of potentially suitable breeding habitat, but should be high enough to allow for robust statistical inference on the proportion of occupied survey sites on riparian reserve system lands. Surveys for yellow-billed cuckoos and southwestern willow flycatchers may not be conducted simultaneously (i.e., each species requires a separate survey effort). Surveyors must attend a training session and be approved by USFWS to conduct the surveys. Surveyors should be experienced at differentiating calls and appearance of similar species, such as other *Empidonax* flycatchers. Consult Sogge et al. (2010) for additional details on survey methods and descriptions of potentially suitable habitat.

### 2.5.4 American Peregrine Falcon (Falco peregrinus anatum)

The American peregrine falcon was delisted due to recovery of the species in 1999 and a monitoring plan was developed to detect declines in territory occupancy, nest success, and productivity (USFWS 2003). There are no suitable peregrine falcon nesting substrates within the current reserve system and no known nests adjacent to the reserve system. The BCCE, however, may serve as foraging habitat for peregrine falcons. Monitoring and maintaining high-quality upland desert habitat (Section 2.6.2) will be considered a surrogate for monitoring peregrine falcon populations directly.

### 2.5.5 Other MSHCP-Covered Bird Species

Other MSHCP-covered bird species that occur in riparian habitats include the summer tanager (*Piranga rubra*), vermillion flycatcher (*Pyrocephalus rubinus*), Arizona Bell's vireo (*Vireo bellii arizonae*), phainopepla (*Phainopepla nitens*), and blue grosbeak (*Passerina caerulea*). These species occur in cottonwood-willow habitat and associated desert washes composed of shrubby woodland habitat, such as mesquite, oak, and non-native tamarisk.

Surveys for these MSHCP-covered bird species should be conducted annually according to standard point count survey methods (Ralph et al. 1995, Rosenstock et al. 2002, MacKenzie 2006) in suitable or potentially suitable habitat. Point count stations should be established in riparian habitat, spaced a minimum of 250 m apart. Point count methods allow for the estimation of species occupancy or abundance/density estimation (e.g., distance sampling, count regression models, N-mixture modeling incorporating imperfect detection [Royle 2004]). A sufficient number of point count stations should be determined on reserve system lands to allow for robust statistical inference. Multiple visits, separated by a minimum of 5 days, should be made to each station during the general bird breeding season (early-mid April through mid-June). Because of the specific habitat and high attention requirements of federal protocols for surveying for southwestern willow flycatcher and yellow-billed cuckoo, other MSHCP-covered bird species must be surveyed separately.

### 2.5.6 Bats

All three MSHCP-covered bat species (silver-haired bat [*Lasionycteris noctivagans*], long-eared myotis [*Myotis evotis*], and long-legged myotis [*Myotis volans*]), may use riparian areas for foraging, day roosts, and maternity roosts. Silver-haired bats may also use riparian areas for hibernacula as they are known to hibernate under sloughing bark in low elevation, xeric habitats. Two of the species (long-eared myotis and long-legged myotis) may use desert upland areas for foraging and roosting habitat and may hibernate in surrounding caves, abandoned mines, cliff crevices, and rocky outcrops.

All three bat species would be most efficiently monitored using an occupancy approach via passive acoustic monitoring during summer (i.e., during the breeding season; Weller 2008). They all also have the potential to hibernate within Clark County and use the reserve system lands prior to, after, and potentially during winter so it may be advantageous to conduct surveys in late fall or early spring to document their use of reserve system lands during these seasons in addition to the breeding season survey. Passive acoustic bat call recorders should be used (e.g., Anabat SD2 Active Bat Detector). These detectors can be coupled with battery power sources and left in the field during surveys. The results are stored on the unit and can be downloaded for species assessment of each recorded call using the Analook software. It may be useful to align bat survey methods with the North American Bat Monitoring Program (Loeb et al. 2015) for data-sharing capabilities.

A series of fixed sampling stations has been found to be more effective at estimating spatial heterogeneity in bat species occurrence than continuous walking surveys (Stahlschmidt & Brühl 2012, Loeb et al. 2015). Thus a series of fixed-location stations should be set up within the riparian and desert upland reserve systems. By surveying the same locations in multiple years, comparisons of changes in occupancy can be made while removing the effect of noise derived from sample site variability. Sampling stations should be located randomly or systematically random such that the entire reserve system is sufficiently sampled and all acoustic detectors are at least 2 km apart. There is also the potential that grid cells (10 km x 10 km) selected by the North American Bat Monitoring Program (Loeb et al. 2015) fall within Clark County reserve lands and could be used as sampling stations to monitor bats across multiple years. The added benefit of using these grid cells is that the data collected would be added to a larger database that is monitoring bat species nationwide (Loeb et al. 2015).

The number of sampling stations should consider the costs of purchasing, deploying, and analyzing the survey results balanced with the conservation value of detecting the MSHCP-covered bat species. Additionally, a single passive acoustic recorder can be deployed at multiple sample sites. Recent research at the Ash Meadows National Wildlife Refuge found that 2-5 survey nights were needed to detect 40-60% of bat species that occurred at a single sample station (Skalak et al. 2012). Thus, for example, 5 acoustic recorders could be deployed for 5 nights at each sample station over a period of four weeks, leading to 20 sample stations each surveyed for 5 nights. Acoustic recorders should be deployed for the entire night in order to capture “rare” species that only call or forage during a narrow nightly window (e.g., just before dawn; Skalak et al. 2012). Acoustic recorders should be deployed for 2-5 nights at each sample station to balance capturing more “common” species with the cost of exhaustively sampling for rare species (e.g., 32 nights; Skalak et al. 2012). Analysis of acoustic recorder data should follow standard occupancy analysis methods that account for imperfect detection (e.g., package ‘unmarked’ in Program R). Environmental covariates (e.g., temperature, moon phase, wind speed, etc.) and date should be considered as potential covariates on detection probability.

### 2.5.7 Other Reptiles

There are 12 additional reptiles on the MSHCP-covered species list in addition to the desert tortoise. Three of these are expected to be encountered using the same monitoring protocol as for desert tortoise (Great Basin collared lizard [*Crotaphytus bicinctores*], desert iguana [*Dipsosaurus dorsalis*], and large-spotted leopard lizard [*Gambelia wislizenii wislizenii*]). At a minimum, these species should be surveyed concomitantly with the desert tortoise occupancy monitoring. Detections of these MSHCP-covered reptile species during desert tortoise surveys should be noted by field crews and, where sufficient data are available for each of these species, the appropriate occupancy analyses should be conducted. Additional surveys for these species could be conducted using the same sample design framework, except that survey timing or methods are altered (e.g., nocturnal surveys, season of survey, method of search within sample plots, etc.). Funnel traps and drift fences are another appropriate method for surveying reptile populations and would be an appropriate method for more surveys on these additional reptiles (Belnap et al. 2008). The remaining lizard (banded gecko [*Coleonyx variegatus*] and eight snake species (glossy snake [*Arizona elegans*], sidewinder [*Crotalus cerastes*], speckled rattlesnake [*Crotalus mitchellii*], Mojave green rattlesnake [*Crotalus scutulatus scutulatus*], California kingsnake [*Lampropeltis getulus californiae*], western leaf-nosed snake [*Phyllorhynchus decurtatus*], western long-nosed snake [*Rhinocheilus lecontei lecontei*], and Sonoran lyre snake [*Trimorphodon biscutatus lambda*]) are highly cryptic and are unlikely to be encountered using the desert tortoise sampling protocol. Therefore, monitoring and ensuring high-quality desert upland habitat (Section 2.6.2) will be used as a surrogate for directly monitoring these nine species.

### *2.5.8 Plants (10 plants)*

The status of MSHCP-covered plant species populations should be monitored. There are 10 MSHCP-covered plants that may occur on private land within Clark County. These include sticky ringstem (*Anulocaulis leiosolenus*), Las Vegas bearpoppy (*Arctomecon californica*), white bearpoppy (*Arctomecon merriamii*), rosy king sandwort (*Arenaria kingii* ssp. *rosea*), threecorner milkvetch (*Astragalus geyeri* var. *triquetrus*), alkali mariposa lily (*Calochortus striatus*), Blue Diamond cholla (*Cylindropuntia multigeniculata*), forked [Pahrump Valley] buckwheat (*Eriogonum bifurcatum*), sticky buckwheat (*Eriogonum viscidulum*), and white-margined beardtongue (*Penstemon albomarginatus*). At this time little is known about the location or ecological needs of these plant populations within Clark County, although upcoming project work includes extensive surveys. If and when these populations are located, whether on or off of reserve system lands, quantitative methods such as those described in Appendix A should be developed. It is critical that flexibility and care be used in developing the monitoring plan, as several MSHCP-covered species are likely to occur in sensitive areas (e.g., high coverage of biological crusts), thus monitoring methods may require a light footprint. For example, low-level drone surveys may be sufficient to map the areal extent of populations of MSHCP-covered plant species. Useful quantitative methods include line-point intercept, canopy gap intercept, and multi-scale quadrats. Qualitative methods could include photo points and general indicators of desert upland ecosystem health.

## 2.6 Habitat Monitoring

### *2.6.1 Suitable Breeding Habitat for MSHCP-covered Birds*

Suitable breeding habitat is a prerequisite for supporting breeding populations of MSHCP-covered bird species. The rivers and streams of the Mojave Desert provide a riparian habitat oasis relative to an otherwise dry landscape. This lowland riparian community is comprised of a cottonwood overstory, a mesquite/willow midstory, and an herbaceous understory, all of which riparian-associated MSHCP-covered species rely on as breeding habitat and nonbreeding habitat (i.e., migratory stopover and overwintering habitat) during various parts of the year. While there are no MSHCP-covered bird species that explicitly breed in the upland desert reserves, this area does provide important foraging habitat for the American peregrine falcon because of its proximity to suitable nesting habitat (cliffs). Suitable breeding habitat may remain unoccupied over short timespans due to larger fluctuations in bird population size, irruptive dispersal patterns, and microclimate variability that influences prey resources, yet it remains critical for bird populations over long time spans. Monitoring changes in the extent and quality of breeding habitat, therefore, can complement species surveys of breeding populations. Several well – studied species (e.g., yellow-billed cuckoo, southwestern willow flycatcher, and Arizona Bells' vireo) have specific habitat suitability requirements (e.g., patch size, vegetation species composition, etc.), while specific guidelines and benchmarks that define habitat suitability for lesser-studied species are not always available (GBBO 2010, Sogge et al. 2010, Halterman et al. 2016), however, the general habitat associations for MSHCP-covered bird species are known and these variables are presented in Appendix A (Table A.1). The quality and extent of suitable breeding bird habitat should be monitored every two years (Table 4) and the amount of suitable habitat, including metrics on suitable patch sizes (for species for which this information exists) should be reported separately for each species.

### *2.6.2 Desert Upland Ecosystem Function*

Vegetation monitoring within the desert upland reserve system should be designed and implemented to provide timely information on the status and trends of key attributes of ecosystem components and functions. These include a) biotic integrity, (b) soil and site stability, and c) hydrologic function (see Appendix A; Miller 2005, Belnap et al. 2008, Herrick et al. 2009a & b). Monitoring should measure biotic indicators such as foliar cover and species diversity, and also include measures of soil resistance to erosion such as the amount of soil surface armored against erosion by rocks, litter, and biological soil crusts. These data can be collected either quantitatively or qualitatively and should be collected concurrently with vegetation monitoring. Since it will be desirable to compare the status and trends on reserve lands with those on lands managed by other agencies, it would be advantageous to adopt methods that would allow these comparisons (e.g., MacKinnon et al. 2011, Toevs et al. 2011a & 2011b). Belnap et al. (2008) describes methods, responses, and interpretation of surveys designed to monitor Mojave desert ecosystems.

### *2.6.3 Habitat Fragmentation and Connectivity*

Baseline connectivity and fragmentation metrics should be calculated for each reserve unit in order to prioritize and assess effects of invasive species removal, habitat restoration, and land acquisition projects. Standard landscape analysis methods, such as the widely-used Landscape Fragmentation Tool (http://clear.uconn.edu/tools/lft/lft2/index.htm), provide straightforward means to calculate fragmentation of a specified habitat type, such as riparian forest. The distribution of habitat types can be determined by classifying vegetation using aerial photography or other remotely-sensed data, coupled with ground-truthing to verify classifications.

Landscape metrics should be recalculated for reserve units at least every 4 years to monitor changes in habitat fragmentation and connectivity, especially in reserve units in which restoration projects have been implemented. This type of monitoring could also be implemented at smaller scales (e.g., parcel, subunit) with reserve units in order to evaluate species-specific objectives related to patch size or configuration, or at broader scales to prioritize acquisition of new parcels that may increase connectivity with existing reserve units.

# Section 3.0 Adaptive Management Plan

The concept of adaptive management for natural resources was formalized by Holling (1978) and Walters (1986) as a method to incorporate and systematically reduce the uncertainty in management actions and outcomes that are inherent in natural resource management. A common theme among the varying applications of adaptive management since the formulation by Holling (1978) and Walters (1986) has been a focus on learning, in that adaptive management is used as a formal mechanism to alter management actions in response to information gained from previous actions (Rist et al. 2013). Contrary to many conceptual or programmatic formulations of adaptive management (Williams et al. 2007, Rist et al. 2013), this document formulates adaptive management as a technical roadmap for the learning process of improving the efficacy and desired impact of specific conservation actions at the level of the entire suite of conservation actions. A key component of adaptive management as defined herein is the collection, incorporation, and assessment of species and habitat-specific monitoring data in relation to conservation targets and triggers. This allows for an objective assessment of the success of the entire suite of conservation actions in meeting both specific (i.e., achieving the BGOs) and general goals (e.g., improving the populations and habitats of MSHCP-covered species).

## 3.1 Adaptive Management Scope

Adaptive management can be applied in numerous ways, ranging from program-wide to project specific, and with a scope ranging from philosophical and conceptual to flowcharts and checklists. There are several challenges to implementing adaptive management, many of them resulting in a laissez-faire approach (Keith et al. 2011). To avoid this pitfall, this adaptive management plan for implementing the MSHCP was developed from a technical standpoint, with the scope being limited to continual required application of adaptive management to ensure two components of success: 1) determining if and how well the suite of conservation actions are achieving the BGOs, and 2) measuring whether the suite of conservation actions as a whole are sustaining or improving the populations and habitats of MSHCP-covered species. This document could also be described as a roadmap for collecting monitoring data followed by a walk-through of applying adaptive management to the suite of current and alternative conservation projects in response to the monitoring and project success data. The use of adaptive management in making changes to how the MSHCP is implemented or to the MSHCP itself is outside of the scope of this document. The application of adaptive management to individual conservation projects is also outside of the scope of this document (but see Appendix B).

## 3.2 Performance Criteria, Targets, and Triggers

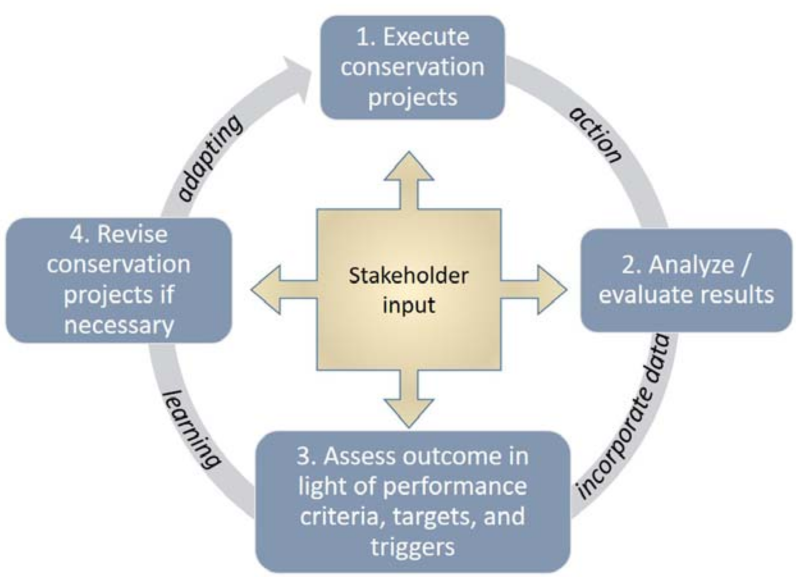
Incorporating specific ecological conditions into the adaptive management framework is integral to ensuring the suite of conservation actions are effectively meeting their goals. In this document there are three types of specific ecological conditions: performance criteria, targets, and triggers. Performance criteria are the explicit, quantifiable conditions associated with each biological objective. Achieving the performance criteria for a given objective indicates that the suite of conservation actions being undertaken are successfully contributing to the BGOs. Targets and triggers are associated with the species and habitat-specific monitoring results. Targets are the explicit and quantifiable desired state of MSHCP-covered species populations and their habitats.

Successfully achieving targets means the suite of conservation actions have been thoroughly successful at improving the populations of MSHCP-covered species and their habitats. Triggers are the explicit and quantifiable undesired state of MSHCP-covered species populations and their habitats (e.g., population declines). If the monitoring results show that there is widespread failure to maintain or increase populations of MSHCP-covered species and their habitats, the adaptive management action process must be enacted. Note that increasing populations of MSHCP-covered species is neither a specific requirement of the MSHCP nor of habitat conservation plans in general (USFWS 1996 Chapter 3.B.3.b.) and, therefore, it is not an indication of successful compliance with the conditions of the MSHCP. Rather, the performance criteria, targets, and triggers are used to measure the conservation success and net benefit of the entire suite of conservation actions above and beyond the legal requirements and expected outcomes detailed within the MSHCP (USFWS 1996 Chapter 3 B.3.b.).

## 3.3 Adaptive Management Process

Traditionally, adaptive management is broken down into six iterative steps: 1) assess the problem, 2) design a solution, 3) implement the action, 4) monitor the results, 5) evaluate results in light of the problem, and 6) adjust the solution (adapted from Williams et al. 2007 and Rist et al. 2013). These steps were designed to be applied at a high level with a focus on reducing uncertainty surrounding management actions. Alternatively, adaptive management can be formulated as a process that explicitly incorporates learning from past actions to improve the outcome of those actions. Reducing uncertainty in action outcomes can be linked with improving those outcomes, although the link is not inherent. Therefore, it should be emphasized that the adaptive management process outlined in this document was designed with a clear focus on improving the outcomes of conservation actions on MSHCP-covered species and their habitats. Figure 2 shows the conceptual overview of applying adaptive management as a process to ensure that fundamental conservation goals are being met. In Figure 2, blue boxes are actions and the gray arrow is the underlying process that is achieved by completing the previous action.

**Figure 2. Conceptual Overview of Adaptive Management**



Adaptive management, as an umbrella term, covers monitoring-data compilation, data analysis, evaluation of targets and triggers, and where necessary, the adaptive management action sub-routine. The adaptive management action sub-routine is enacted when analysis identifies that specific biological objectives or species or habitat-specific triggers have been met and is the mechanism that ensures formal improvement and changes in light of undesired conditions. More specifically, the adaptive management process will be applied to two general classes or performance criteria: BGOs and the status of MSHCP-covered species' populations and habitats. The goal of applying adaptive management to the BGOs is to provide quantitative rigor in ensuring that the conservation actions are successfully achieving the BGOs and, if they are not, how management actions should change in order to fully achieve them. The goal of applying adaptive management to the status of MSHCP-covered species' populations and habitats is to ensure that, even when all BGOs are being successfully achieved, the desired benefits to MSHCP-covered species are also being realized. In this sense the adaptive management framework both ensures that the suite of conservation actions are successful both in achieving their own internal metrics (the BGOs) and the realized external metrics (populations of MSHCP-covered species).

In the formulation presented here, the adaptive management process is broken into two parts: the adaptive management evaluation process and the adaptive management action process. The adaptive management evaluation process is a regular, systematic, recurring process to be performed every 4 years. It involves assessing the performance criteria, targets, and triggers associated with the BGOs and MSHCP-covered species monitoring data using the compiled results from individual conservation actions and the ongoing monitoring plan. If the determination is that the BGOs are being met and that the MSHCP-covered species triggers are not being met, the adaptive management evaluation process is complete. If the determination is that some of the BGOs performance criteria are not being achieved or some of the MSHCP-covered species population and habitat triggers are being met, the adaptive management action process is initiated and continued until all BGOs are achieved and no triggers are met. Therefore, the adaptive management evaluation process occurs every 4 years without exception but the adaptive management action process only occurs when necessary, beginning at the 4-year evaluation interval and continuing until the actions have proven successful.

### *3.3.1 Adaptive Management Regarding the BGOs*

In 2016 the independent Science Advisor Panel and DCP staff developed new draft BGOs to provide a more rigorous framework for guiding and evaluating implementation of the MSHCP. Applying the adaptive management analysis and evaluation process to the biological objectives ensures that the suite of conservation actions are meeting the biological objectives and, by proxy, the biological goals. Ensuring successful achievement of the biological objectives is a critical part of ensuring that conservation actions are meeting their own internal metrics. The biological objectives and associated performance criteria are detailed in Table 4.

**Table 4. Performance Periods and Performance Criteria for each BGO**

| Goals and Objectives | Relevant Conservation Measure(s) | Performance Period(s) | Performance Criteria |
|---|---|---|---|
| **Goal R 1: Maintain, improve, and expand habitat for the MSHCP-covered species on riparian reserve system lands** | | | |
| Objective R 1.1: *Monitor MSHCP-covered species occupancy* | CM 4: *Monitoring*<br>CM 3: *Inventory*<br>CM 2: *Research*<br>CM 1: *Public information* | Monitor MSHCP-covered species occupancy in suitable habitat every _1_ year(s)<br><br>Evaluate progress towards objective using Adaptive Management (AM) framework every _4_ years | Demonstrate that MSHCP-covered species are monitored every _1_ year(s) |
| Objective R 1.2: *Maintain and/or increase suitable breeding habitat for MSHCP-covered birds* | CM 4: *Monitoring*<br>CM 1: *Public information* | Monitor changes in suitable breeding habitat across riparian reserve lands every _2_ year(s)<br><br>Evaluate progress towards objective using AM framework every _4_ years | Demonstrate stable or increasing acreage of suitable breeding habitat across riparian reserve lands for all MSHCP-covered birds<br><br>Demonstrate stable or increasing patch size of suitable breeding habitat across riparian reserve lands for all MSHCP-covered birds |
| Objective R 1.3: *Incorporate elements of natural riparian processes into restoration design and implementation* | CM 6: *Habitat Restoration and enhancement* | Evaluate progress towards objective using AM framework every _4_ years | Riparian restoration projects plans demonstrably include elements of natural riparian processes as appropriate<br><br>Riparian restoration projects demonstrate functionality after _6_ years or as established during project initiation |
| Objective R 1.4: *Inventory, remove, and control invasive and non-native plant species* | CM 6: *Habitat restoration and enhancement*<br>CM 3: *Inventory*<br>CM 4: *Monitoring*<br>CM 1: *Public information* | For locations where non-native and invasive species have been treated, monitor every 1 year until 2 consecutive years indicate no remaining individuals. Then monitor every 4 years, at a minimum<br><br>For locations where nonnative and invasive species are located but not treated, monitor every _1_ year(s) to ensure no expansion into surrounding area.<br><br>Evaluate progress towards objective using AM framework every _4_ years | Demonstrate effective control or reduction (as appropriate) of invasive and non-native species at treated locations across desert upland reserve lands<br><br>Demonstrate reduction of invasive species across desert upland reserve lands |
| Objective R 1.5: *Reduce habitat fragmentation and/or improve connectivity and habitat quality through restoration design and implementation* | CM 6: *Habitat restoration and enhancement*<br>CM 7: *Land use policies*<br>CM 4: *Monitoring*<br>CM 1: *Public information* | Monitor riparian reserve units every _4_ years<br><br>Evaluate progress towards objective using AM framework every _4_ years | Riparian restoration projects demonstrably reduce fragmentation/increase connectivity when feasible and as identified during project initiation<br><br>Demonstrate upward trend in habitat connectivity and downward trend in habitat fragmentation across riparian reserve lands |
| Objective R 1.6: *Acquire riparian property at an equivalent rate as take (i.e., habitat conversion)* | CM 7: *Land use policies* | Evaluate progress towards objective using AM framework every _4_ years | Demonstrate acquisition of riparian habitat and function at an equivalent rate as take over life of Permit |

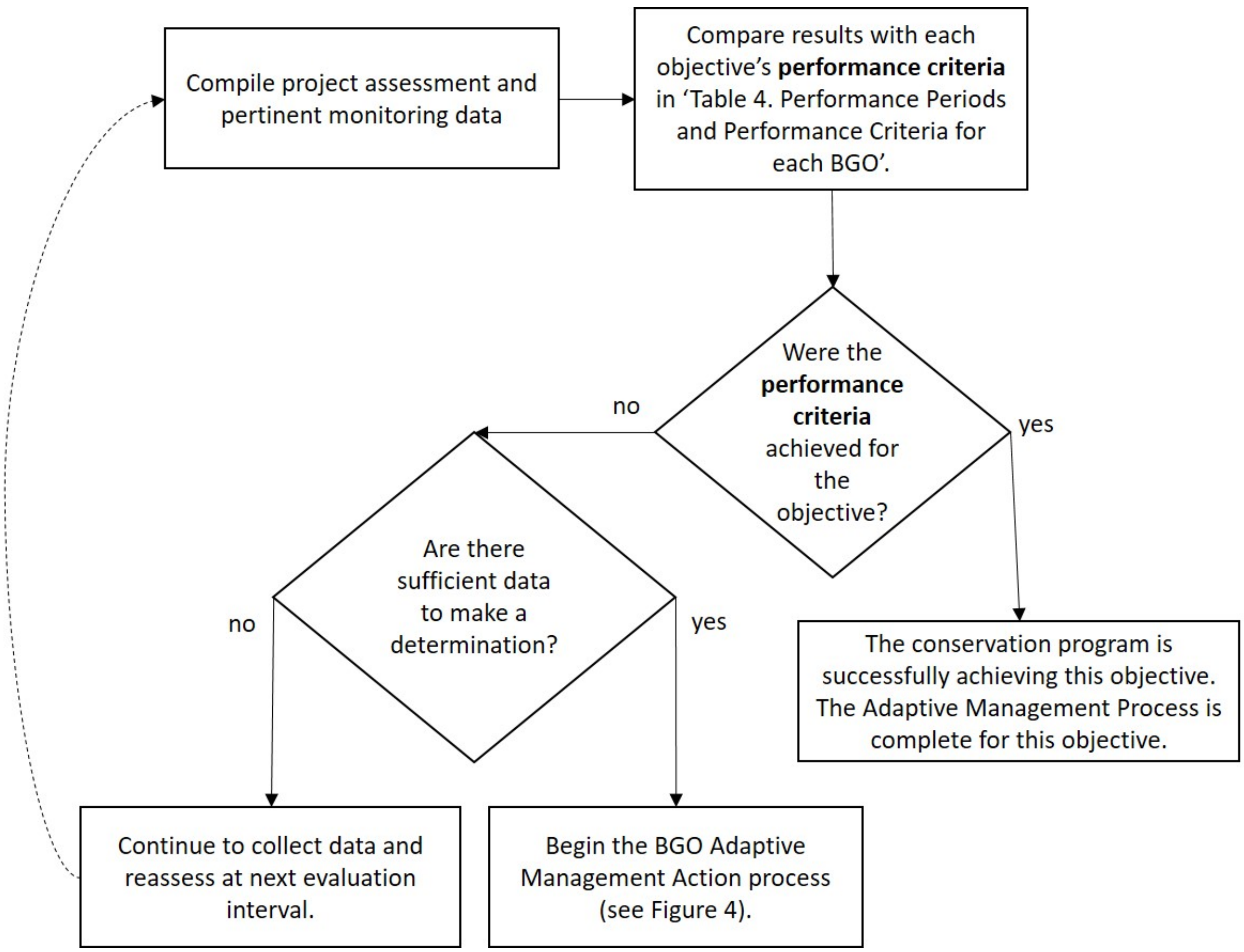
| Goals and Objectives | Relevant Conservation Measure(s) | Performance Period(s) | Performance Criteria |
|---|---|---|---|
| **Goal R 2: Maintain stable or increasing populations of federally-listed threatened and endangered (T&E) species on riparian reserve system lands** | | | |
| Objective R 2.1: *Monitor and adaptively manage for breeding bird populations* | CM 3: *Inventory*<br>CM 4: *Monitoring*<br>CM 1: *Public information* | Monitor T&E breeding bird populations in all suitable habitat every _1_ year(s)<br><br>Evaluate progress towards objective using AM framework every _4_ years | Demonstrate stable or increasing T&E breeding bird populations across riparian reserve lands |
| **Goal R 3: Foster community and stakeholder engagement to benefit covered species** | | | |
| Objective R 3.1: *Collaborate with other stakeholders on project/mitigation work* | CM 1: *Public information and involvement* | Evaluate progress towards objective using AM framework every _4_ years | Demonstrate a stable or increasing number of collaborators |
| Objective R 3.2: *Promote responsible recreation (e.g., signage, education)* | CM 1: *Public information*<br>CM 7: *Land use policies* | Evaluate progress towards objective using AM framework every _4_ years | Sign repair is completed within 60 days of damage reported<br><br>'Demonstrate a stable or decreasing number of negative law enforcement encounters per unit effort<br><br>Demonstrate a stable or increasing number of public engagement, such as presentations and brochure distribution |
| **Goal R 4: Promote ecological resiliency on riparian reserve system lands** | | | |
| Objective R 4.1: *Identify critical uncertainties and address these through planning and adaptive management, when feasible* | CM 7: *Land use policies*<br>CM 6: *Habitat restoration and enhancement*<br>CM 4: *Monitoring*<br>CM 2: *Research* | Evaluate progress towards objective using AM framework every _4_ years | An analysis of critical uncertainties at the scale of the riparian reserve lands is conducted every _4_ year(s) and as determined on a project-by-project basis during project initiation<br><br>Riparian projects demonstrably identify and address critical uncertainties during planning and implementation |
| Objective R 4.2: *Identify critical connectivity corridors for covered species, prioritize acquisition and/or conservation where feasible* | CM 7: *Land use policies*<br>CM 6: *Habitat restoration*<br>CM 4: *Monitoring*<br>CM 2: *Research* | Conduct comprehensive connectivity analysis of critical connectivity corridors for covered species at scale of riparian reserve lands every _4_ year(s) and when a land acquisition project is being considered<br><br>Evaluate progress towards objective using AM framework every _4_ years | An analysis of critical connectivity corridors for covered species at the scale of the riparian reserve lands is conducted every _4_ year(s)<br><br>Acquisition and conservation activities demonstrably consider connectivity enhancement during planning and implementation |

| Goals and Objectives | Relevant Conservation Measure(s) | Performance Period(s) | Performance Criteria |
|---|---|---|---|
| **<u>Goal D 1</u>: Maintain, improve, and expand habitat for MSHCP-covered species on desert upland reserve system lands** | | | |
| <u>Objective D 1.1</u>: *Monitor MSHCP-covered species occupancy* | CM 4: *Monitoring*<br>CM 3: *Inventory*<br>CM 2: *Research*<br>CM 1: *Public information* | Monitor MSHCP-covered species occupancy in suitable habitat every _1_ year(s)<br><br>Evaluate progress towards objective using AM framework after _4_ years | Demonstrate that MSHCP-covered species are monitored every _1_ year(s) |
| <u>Objective D 1.2</u>: *Maintain existing intact functioning habitat and restore degraded habitat* | CM 6: *Habitat restoration and enhancement*<br>CM 4: *Monitoring*<br>CM 2: *Research*<br>CM 1: *Public information* | Monitoring restoration projects annually for at least _5_ years.<br><br>Evaluate progress towards objective using AM framework every _4_ years | Demonstrate stable or increasing acreage of high-functioning habitat within the desert upland reserve |
| <u>Objective D 1.3</u>*: Protect and conserve habitat for covered plants* | CM 5: *Protective measures*<br>CM 4: *Monitoring* | Evaluate progress towards objective using AM framework every _4_ years | Demonstrate that known habitat for covered plant species is protected and conserved<br><br>Demonstrate that known covered plant species are physically protected |
| <u>Objective D 1.4</u>: *Inventory, remove, and control invasive and non-native plant species* | CM 6: *Habitat restoration and enhancement*<br>CM 3: *Inventory*<br>CM 4: *Monitoring*<br>CM 1: *Public information* | For locations where non-native and invasive species have been treated, monitor every 1 year until 2 consecutive years indicate no remaining individuals. Then monitor every 4 years, at a minimum<br><br>For locations where nonnative and invasive species are located but not treated, monitor every _1_ year(s) to ensure no expansion into surrounding area.<br><br>Evaluate progress towards objective using AM framework every _4_ years | Demonstrate effective control or reduction (as appropriate) of invasive and non-native species at treated locations across desert upland reserve lands<br><br>Demonstrate reduction of invasive species across desert upland reserve lands |
| <u>Objective D 1.5</u>: *Reduce habitat fragmentation and/or improve connectivity through restoration design and implementation* | CM 6: *Habitat restoration and enhancement*<br>CM 7: *Land use policies*<br>CM 4: Monitoring<br>CM 1: *Public information* | Evaluate progress towards objective using AM framework every _4_ years | Desert upland restoration projects demonstrably reduce fragmentation/increase connectivity when feasible and as identified during project initiation<br><br>Demonstrate upward trend in habitat connectivity and downward trend in habitat fragmentation across desert upland reserve lands |
| **<u>Goal D 2</u>: Maintain stable or increasing populations of Federal T&E-listed species on desert upland reserve system lands** | | | |
| <u>Objective D 2.1</u>: *Monitor and adaptively manage for desert tortoise populations* | CM 4: *Monitoring*<br>CM 3: *Inventory*<br>CM 2: *Research*<br>CM 1: *Public information* | Monitor desert tortoise populations in all suitable habitat every _1_ year(s)<br><br>Evaluate progress towards objective using AM framework every _4_ years | Demonstrate stable or increasing desert tortoise populations across desert upland reserve lands |
| <u>Objective D 2.2</u>: *Augment populations through translocation programs* | CM 4: *Monitoring*<br>CM 2: *Research*<br>CM 1: *Public information* | Evaluate progress towards objective using AM framework every _4_ years | Demonstrate positive contribution of translocated desert tortoise populations to the overall desert tortoise population across desert upland reserve lands |

| Goals and Objectives | Relevant Conservation Measure(s) | Performance Period(s) | Performance Criteria |
|---|---|---|---|
| **Goal D 3: Foster community and stakeholder engagement to benefit covered species** | | | |
| Objective D 3.1: *Collaborate with other stakeholders on project/mitigation work* | CM 1: *Public information and involvement* | Evaluate progress towards objective using AM framework every _4_ years | Demonstrate a stable or increasing number of collaborators |
| Objective D 3.2: *Promote responsible recreation (e.g., signage, education)* | CM 1: *Public information*<br>CM 7: *Land use policies and actions* | Evaluate progress towards objective using AM framework every _4_ years | Sign repair is completed within 60 days of damage reported<br><br>Demonstrate a stable or decreasing number of negative law enforcement encounters per unit effort |
| Objective D 3.3: *Provide law enforcement within reserve system* | CM 7: *Land use policies and actions*<br>CM 1: *Public information* | Evaluate progress towards objective using AM framework every _1_ year(s) | Demonstrate a stable or decreasing number of negative law enforcement encounters per unit effort<br><br>Demonstrate a stable or increasing number of positive law enforcement encounters |
| Objective D 3.4: *Educate project proponents and construction personnel…in collaboration with USFWS* | CM 1: *Public information*<br>CM 7: *Land use policies and actions* | Evaluate progress towards objective using AM framework every _4_ years | Demonstrate that desert tortoise reporting procedures are communicated to proponents and construction personnel for each project occurring on tortoise habitat<br><br>Demonstrate engagement with contractors (e.g., biological consultants, researchers) to ensure they are aware of reporting and tortoise disposition procedures when working desert upland reserve lands |
| **Goal D 4: Promote ecological resiliency on desert upland reserve system lands** | | | |
| Objective D 4.1: *Identify critical uncertainties and address these through planning and adaptive management, when feasible* | CM 7: *Land use policies and actions*<br>CM 6: *Habitat restoration and enhancement*<br>CM 4: *Monitoring*<br>CM 2: *Research* | Conduct comprehensive uncertainty analysis every _4_ year(s)<br><br>Evaluate progress towards objective using AM framework every _4_ years | An analysis of critical uncertainties at the scale of the desert upland reserve lands is conducted every _4_ year(s) and when a new project is initiated<br><br>Desert upland projects demonstrably identify and address critical uncertainties during planning and implementation |
| Objective D 4.2: *Identify critical connectivity corridors for covered species, prioritize conservation …increase permeability for species movement where feasible* | CM 7: *Land use policies and actions*<br>CM 6: *Habitat restoration and enhancement*<br>CM 4: *Monitoring*<br>CM 2: *Research* | Conduct comprehensive connectivity analysis of critical connectivity corridors for covered species at scale of desert upland reserve lands every _4_ year(s) or when a land acquisition project is being considered<br><br>Evaluate progress towards objective using AM framework every _4_ years | An analysis of critical connectivity corridors for covered species at the scale of the desert upland reserve lands is conducted every _4_ year(s)<br><br>Acquisition and conservation activities demonstrably consider connectivity enhancement during planning and implementation |

The adaptive management evaluation, with respect to the BGOs, is to be completed every 4 years. It is completed separately for each performance criteria relevant to each biological objective. This process for each performance criteria should involve the following steps: 1) compile all relevant data (both results from all individual conservation projects and monitoring data, where relevant, from the previous 4 years), 2) conduct appropriate statistical analysis where necessary, 3) compare compiled results with the associated performance criteria, and 4) if necessary, begin the adaptive management action process. Figure 3 provides a decision path outlining these actions and the required decisions.

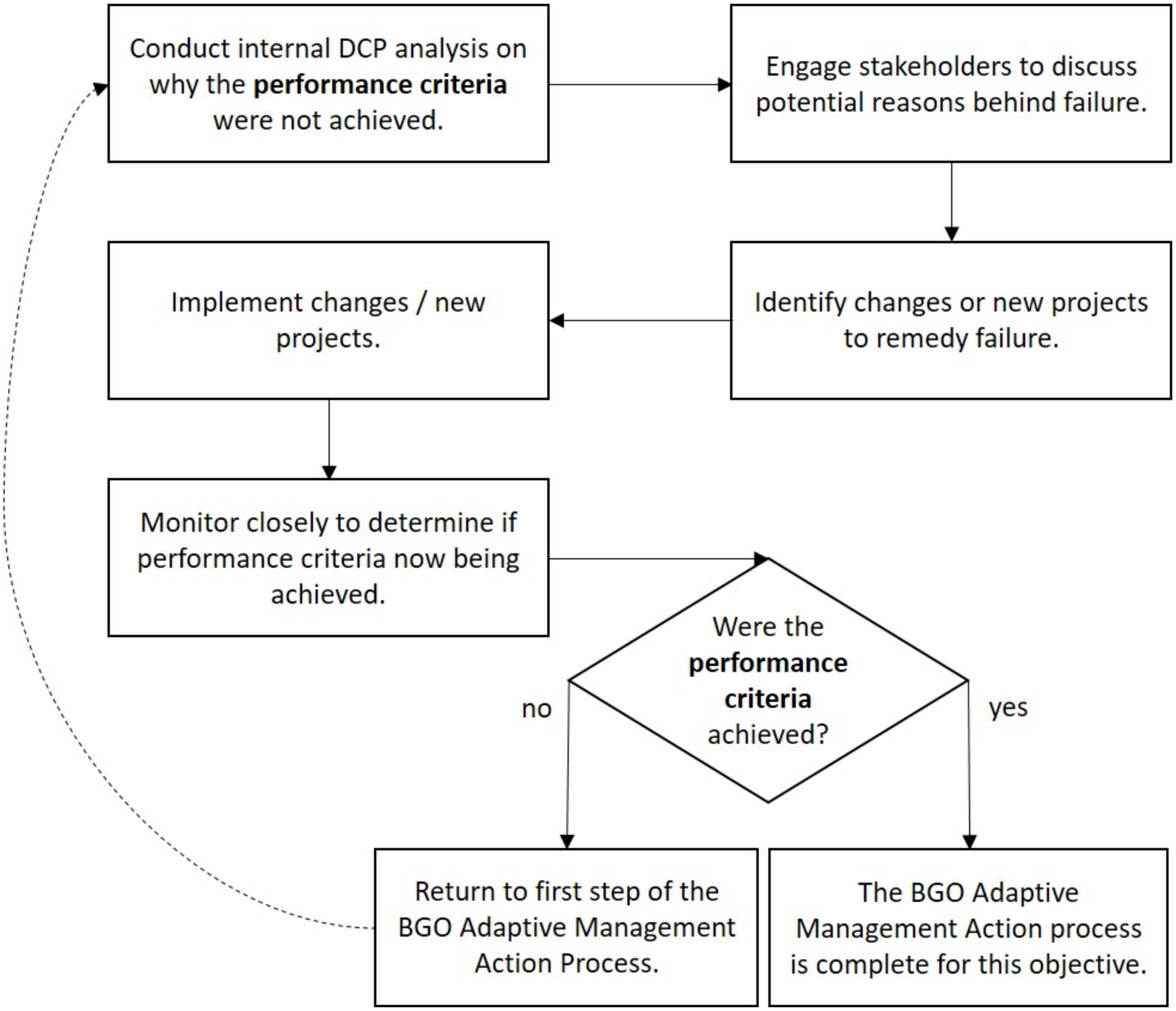
**Figure 3. Adaptive Management Evaluation Process for the BGOs.**




**Note: For Figure 3 through Figure 6, rectangles are actions and diamonds are questions. There is a "yes" and a "no" arrow leading from each question to the next action.*

If the adaptive management evaluation process determines that any BGOs are not being achieved, the adaptive management action process must be completed separately for each of those biological objectives. The basic steps in this process are to 1) determine why the objective is not being met, 2) identify changes or new projects designed to achieve the objective, 3) conduct the changes or new projects, and 4) monitor the results on a more frequent time frame than the 4-year adaptive management evaluation process. This process is intended to continue until all failing objectives are met. This is the process whereby changes to the conservation actions are made. Figure 4 provides a decision path outlining these actions and the required decisions.

**Figure 4. Adaptive Management Action Process for the BGOs.**




### *3.3.2 Adaptive Management Regarding MSHCP-covered Species' Populations*

Monitoring the status of populations and the habitats of MSHCP-covered species provides additional information on the benefits of conservation actions conducted as part of implementing the MSHCP. Additionally, it can serve as a safeguard against the possibility that MSHCP-covered species fare poorly in spite of successful implementation of the MSHCP. Thus the monitoring plan will be used to record and evaluate species' population and habitat trends, and potentially, to demonstrate a net benefit from the entire suite of conservation actions on the populations of MSHCP-covered species.

There are several caveats to consider when assessing the monitoring data. First, conservation projects conducted to-date occur at multiple spatial scales. Some projects only occur within the DCP reserve system, and their benefits are expected to be realized within the reserve system. Other projects occur without a specific spatial scale (e.g., public information and education) and their benefits may occur county-wide. Second, long term trends in habitat and populations of MSHCP-covered species are influenced both by local processes (e.g., development, restoration, etc.) and regional processes (e.g., long-term drought cycles). Thus, if a trigger is met, a critical component of the monitoring plan is the capacity to initiate assessment of the status of populations and habitats both within and outside the reserve system to quantify the impact of the conservation actions as nested within the larger impacts of regional factors. Third, both plant and animal populations can experience time lags in their response to conservation actions, particularly for long-lived species with low reproductive rates such as the desert tortoise, therefore, it is expected to take multiple years to see the realized benefits of conservation actions. Finally, fourth, the MSHCP was enacted in 2001. This means that there is a long history of both development and conservation actions that have occurred over the life of the permit, prior to this monitoring plan being instituted. Thus, the use of adaptive management with the monitoring data is not a true impact analysis and rather should be interpreted as a safeguard moving forward to ensure maintenance of populations of MSHCP-covered species.

The adaptive management evaluation with respect to the populations of MSHCP-covered species is to be completed every 4 years. It is completed separately for each target and trigger relevant to each monitoring survey method and species (Table 5). This process for each target and trigger should involve the following steps: 1) compile all relevant monitoring data, 2) conduct appropriate statistical analysis to compare trends and state variables within the reserve system, 3) compare results with the associated targets and triggers, 4a) if a target is achieved, no action is required, or 4b) if a trigger has been met, coordinate new data collection or inter-agency data sharing for that species or habitat off of the reserve system for an appropriate time period (e.g., 2-3 years), and 5) if a trigger is only met within the reserve system but not off the reserve system, begin the adaptive management action process. Figure 5 provides a decision path outlining these actions and the required decisions.

**Table 5. Adaptive Management Criteria for Species Monitoring**

| Monitoring survey | Covered species group | Species | Target | Target achieved? | Trigger | Trigger met? |
|---|---|---|---|---|---|---|
| Occupancy sampling | Desert upland reptiles[a] | **Desert tortoise** | Stable or increasing metric across desert upland reserve lands during the assessment period | | Decreasing metric across desert upland reserve lands during the assessment period | |
| | | Great Basin collared lizard | | | | |
| | | Desert iguana | | | | |
| | | Large-spotted leopard lizard | | | | |
| Federal protocol | - | **Yellow-billed cuckoo** | Stable or increasing metric across riparian reserve lands during the assessment period | | Decreasing metric across riparian reserve lands during the assessment period | |
| Federal protocol | - | **Southwestern willow flycatcher** | Stable or increasing metric across riparian reserve lands during the assessment period | | Decreasing metric across riparian reserve lands during the assessment period | |
| Point count | Riparian birds | Blue grosbeak | Stable or increasing metric across riparian reserve lands during the assessment period | | Decreasing metric across riparian reserve lands during the assessment period | |
| | | Phainopepla | | | | |
| | | Summer tanager | | | | |
| | | Vermillion flycatcher | | | | |
| | | Arizona Bell's vireo | | | | |
| Passive acoustic occupancy | Bats | Silver-haired bat | Stable or increasing metric across reserve lands during the assessment period | | Decreasing metric across reserve lands during the assessment period | |
| | | Long-eared myotis | | | | |
| | | Long-legged myotis | | | | |
| Species-specific | Desert upland plants | Sticky ringstem | Stable or increasing metric across reserve lands during the assessment period | | Decreasing metric across reserve lands during the assessment period | |
| | | Las Vegas bearpoppy | | | | |
| | | White bearpoppy | | | | |
| | | Rosy king sandwort | | | | |
| | | Threecorner milkvetch | | | | |
| | | Alkali mariposa lily | | | | |
| | | Blue Diamond cholla | | | | |
| | | Forked (Pahrump Valley) buckwheat | | | | |
| | | Sticky buckwheat | | | | |
| | | White-margined beardtongue | | | | |
| TBD[b] | Riparian | Habitat quality | Stable or increasing habitat quality across riparian reserve lands during the assessment period | | Decreasing habitat quality across riparian reserve lands during the assessment period | |
| TBD[b] | Desert upland | Habitat quality[c] | Stable or increasing habitat quality across desert upland reserve lands during the assessment period | | Decreasing habitat quality across desert upland reserve lands during the assessment period | |

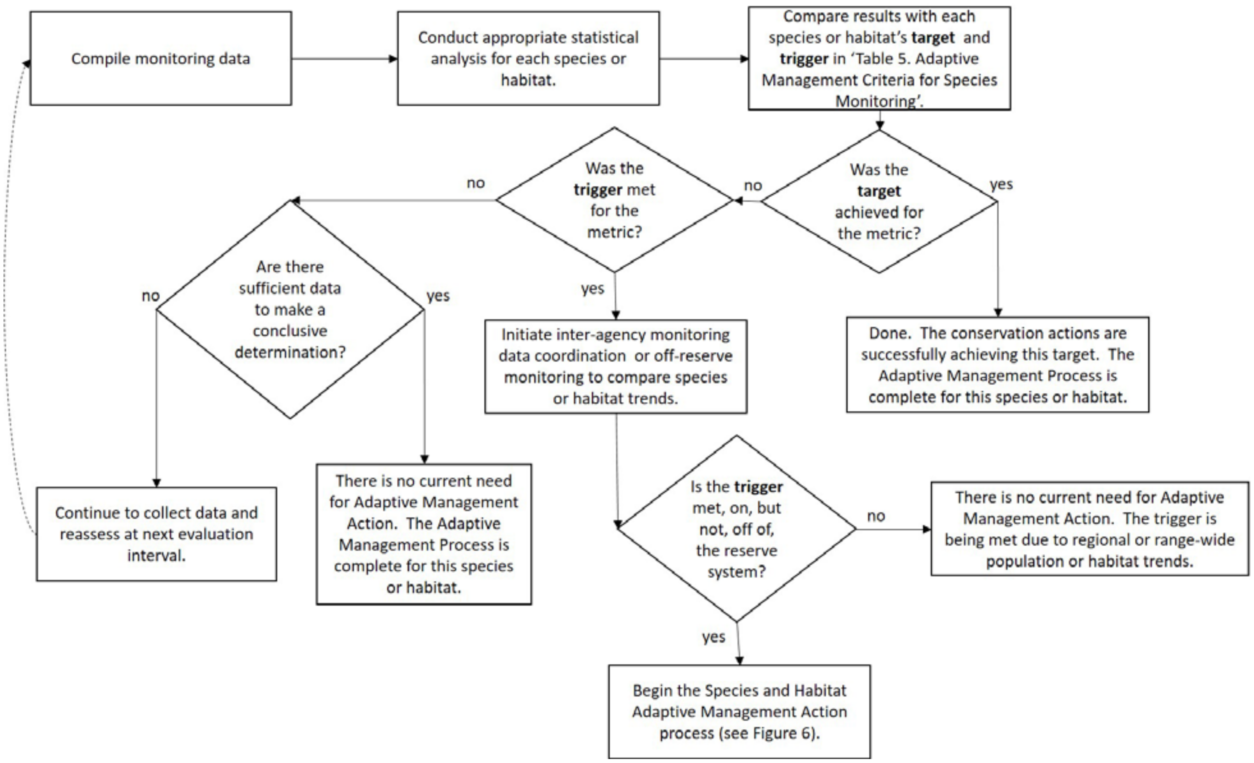
Note: Species in **bold** are indicator species and must be surveyed sufficiently for statistical analysis of status and trend.

[a]Other MSHCP-listed reptile species will be covered using 'desert upland habitat quality' as a surrogate

[b]To be decided: Appendix A outlines possible approaches; specific monitoring methods to be determined prior to initial survey

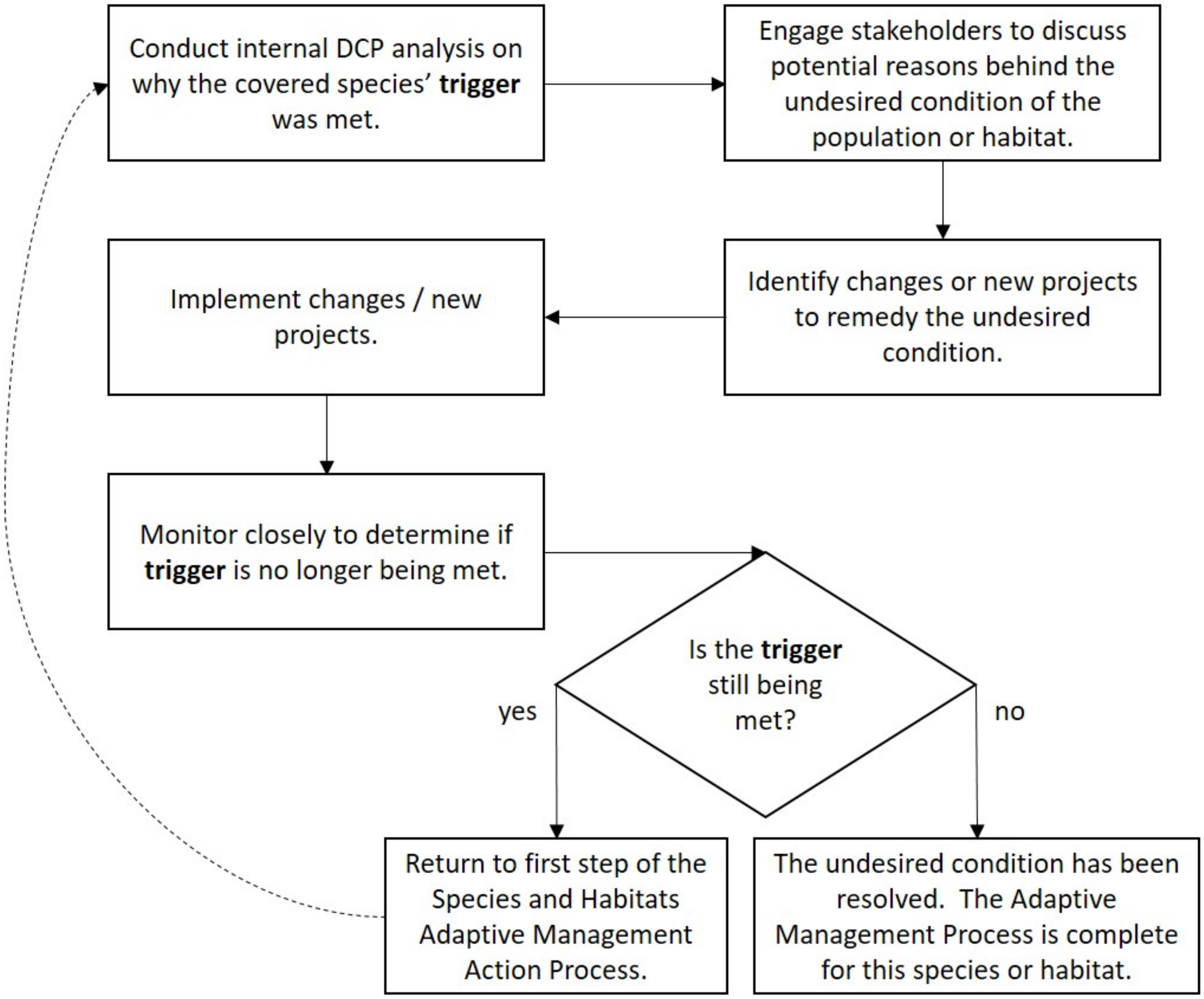
[c]Desert upland habitat quality also serves as surrogate for peregrine falcon and nine cryptic reptile species

**Figure 5. Adaptive Management Evaluation Process for Species and Habitats.**




If the adaptive management evaluation process determines that any triggers are being met, the adaptive management action process must be completed for those MSHCP-covered species. The basic steps in this process are to 1) determine why the trigger is being met, 2) identify changes or new projects designed to improve the population or its habitat, 3) conduct the changes or new projects, and 4) monitor the results on a more frequent time frame than the 4-year adaptive management evaluation process. This process is intended to continue until all species-specific triggers are no longer being met. This is the process whereby changes to the conservation actions are made. Figure 6 provides a decision path outlining these actions and the required decisions.

**Figure 6. Adaptive Management Action Process for Species and Habitats.**




## 3.4 Stakeholder Involvement

Regular constructive stakeholder involvement is critical to the success of both the monitoring and adaptive management portions of this plan. Stakeholders may have insight into species ecology, strengths and weaknesses of existing monitoring methods, or emerging monitoring methods. Stakeholders may also prove invaluable in the adaptive management process, particularly if the adaptive management action process must be initiated. They can identify causes of problems and potential projects and solutions to remedy undesired conditions of species and their habitats. Incorporating stakeholder involvement can thus improve the overall quality and effectiveness of the AMMP.

## 3.5 Comprehensive Adaptive Management

Monitoring and adaptive management should be an active and engaged process. This document has described a framework of monitoring methods, expected results, and an outline for assessing the efficacy of the entire suite of conservation actions in light of internal BGOs and external species and habitat data. In this sense, the AMMP can be considered comprehensive adaptive management. It actively collects independent monitoring data, it assesses system-wide success at achieving defined BGOs, and it quantifies potential additionality of the entire suite of conservation actions by assessing trends of MSHCP-covered species and habitats in relation to the reserve system. Ultimately, the AMMP is a living document to comprehensively monitor and manage implementation of the MSHCP.

# Section 4.0 Revisions to the Adaptive Management and Monitoring Plan

The purpose of this document is to function as a handbook for designing and implementing the MSHCP monitoring and adaptive management process. In the future, however, revisions to this Plan may be warranted. For example, new monitoring techniques or ecosystem indicators may be developed, additional species may need to be added to the monitoring plan, or the adaptive management evaluation or action processes may need to be revised. This document is therefore a ‘living document’ and should be reviewed, revised, and updated at least every four years as part of the adaptive management evaluation process (Section 3.0, above). Revisions to this Plan and the rationale behind such revisions should be documented in Appendix C.

The critical caveat altering this Plan is that any future modifications to the monitoring methods be incorporated in such a way that all previous monitoring data is directly comparable to the new monitoring data. For example, new methods should be conducted simultaneously with old methods for more than 1 year to allow for statistical adjustment of any method-dependent biases in the resultant data (e.g., a comparison of relative abundance). If cost prohibits full spatiotemporal overlap of old and new monitoring methods, however, it should be noted that newly observed patterns in the monitored metric may be due to methodology, underlying changes in the population, or a combination of both. Therefore it is strongly recommended that there is some temporal overlap, such as monitoring half of the sites using the old methodology and half of the sites using the new methodology for two years before using the new methodology at all sites. This will ensure continuity in the estimates of trends in species and their habitats.

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# Appendix A

## Details of Monitoring Methods for MSHCP-Covered Species and their Habitats

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# Appendix A

# Details of Monitoring Methods for MSHCP-Covered Species and their Habitats.

This appendix provides additional discussion and explanation for selected species and habitat monitoring. The following sections expand discussions on monitoring activities for desert tortoise, suitable breeding bird habitat, and individual plant species. This appendix is supplementary only and should not be read, used, or cited without first consulting the main Adaptive Management and Monitoring Plan document.

## Section 1.0 Desert tortoise

### 1.1 Desert Tortoise Species Information

Agassiz's desert tortoises (*Gopherus agassizii*) range across the southwest United States, found northwest of the Colorado River (Murphy et al. 2011). It is a species in decline despite significant conservation and management efforts since it was federally-listed as threatened in 1990 (USFWS 1990, USFWS 2011). This species is threatened by the concomitant effects of habitat loss (Heaton et al. 2008, Darst et al. 2013), disease (Jacobson et al. 1991, Jacobson 1994), and predation (Boarman et al. 2006), all of which may vary spatially and temporally.

Desert tortoises are philopatric, establishing home ranges between 15 and 45 hectares (O'Connor et al. 1994, Harless et al. 2009), depending on region and local conditions. Home ranges and cover sites are associated with a wide range of desert scrub communities, and generally occur where robust perennial vegetation provides above-ground shelter (Todd et al. 2016), cover from predators, and presumably structure for underground burrows. Desert tortoise activity varies daily and seasonally where most activity occurs during the warmer months (March through October) and becomes crepuscular during the hottest times of the day or season (Nagy and Medica 1986, Agha et al. 2015). During the cooler winter months when tortoises brumate (November through February), above ground movement is very limited (Nagy and Medica 1986, Nussear et al. 2007).

### 1.2 Desert Tortoise Survey Options

Developing effective population monitoring plans for rare and cryptic species are essential to help guide monitoring and conservation efforts. The low number of individuals detected for such species, however, generally limits robust density or abundance estimates that can be used on more abundant animals.

Various methods have been used to sample desert tortoise populations across their range. Sampling desert tortoises is challenging, however, due to their low capture probability as related to their fossorial life history, cryptic nature, and patchy spatial distribution. Previous desert tortoise survey methods include belt transects, occupancy (Zylstra and Steidl 2009, Zylstra et al. 2010), study plots of varying size (1 $mi^2$, 1 $km^2$, 1 ha) (Keith et al. 2008), and line-distance sampling (Anderson et al. 2001, Averill-Murray and Averill-Murray 2005).

The goal of monitoring desert tortoise populations within and adjacent to the Boulder City Conservation Easement (BCCE) is to establish a baseline population for this region, and assess population trends over time on reserve lands compared to regional population trends. These trends can be used to develop triggers for management actions as needed, which may include an increased monitoring effort, predator control, or population augmentation through targeted translocation efforts. We do not discuss line-distance sampling further because this method is more appropriate for use with desert tortoise over very large scales (e.g., range-wide; Averill-Murray and Averill-Murray 2005). The following two proposed sampling methods—occupancy modeling and capture-mark-recapture—may be used concurrently, as each provides different information.

### *1.2.1 Option 1: Occupancy Modeling*

Occupancy modeling determines the proportion of habitat within an area that contains evidence of a targeted species (MacKenzie et al. 2002). It uses detection/non-detection data to estimate species occurrence, and explicitly recognizes that the probability of detection on a single survey may be less than one. In 2011 a pilot project was implemented to test the efficacy of using occupancy sampling to monitor desert tortoise populations. The BCCE occupancy monitoring protocol states "The use of occupancy sampling is based on the assumption that the status and change over time of a population can be assessed by changes in the proportion of the sample units that are occupied or used by the species….This approach assumes that the species will respond to changes in habitat, habitat alteration, or management practices by their occupancy or use of an area. For increases in the population or management success to be detected, tortoises would have to increase in their occupancy of the sample units, and alternatively, a decrease would only be measured by a reduction of sample units occupied by the species" (Desert Conservation Program 2011).

The advantages to using occupancy to sample desert tortoises at the BCCE are that it has been used previously in this region, it is an established method, and there are existing data with which to compare future monitoring data. It is inexpensive when compared to other sampling methods (e.g. line distance sampling, 100% coverage plots), and can provide both abundance/density and presence/absence data. Previous research on occupancy indicates that it had sufficient power to detect moderate levels of population change within 20 years' time (Zylstra et al. 2010, Erb et al. 2015). Occupancy monitoring is also useful in that it measures the most important state variable for a population – whether or not a species occurs in part of the landscape (MacKenzie et al. 2002). Finally, occupancy can include ecological or management covariates (e.g. vegetation, soil type, invasive species control, and closing roads) within the plot design. The disadvantages of using occupancy are that there are statistical challenges when detection probability is extremely low, and it generally provides only a coarse level of inference (e.g., it does not provide robust demographic information, although it can provide abundance/density estimates).

#### 1.2.1.1 Study Design and Methods

A series of randomly-selected 4-ha sampling units within two strata (i.e., east and west sections of BCCE; DCP 2011), which preferentially includes those units sampled during the pilot study during 2011 (DCP 2011), should be sampled annually. Final sample size should be determined based on the detection and occupancy rate results obtained in the DCP (2011) study. Guillera-

Arroita & Lahoz-Monfort (2012) provide an overview of power analysis for determining sample size for occupancy monitoring studies.

Surveyor(s) should walk 10 m belt transects across the entire plot in an effort to complete a 100% coverage. Surveyor(s) are expected to investigate all vegetation and burrows for presence of live tortoises, active tortoise burrows, and tortoise sign within each 4 ha sample unit, and each sample units will be surveyed three times during the season (between March 1 – May 15). Desert tortoises will be marked upon detection, and given a visual health assessment. Additional information will be recorded, including sex, midline carapace length, tortoise ID, location, and behavior. Information on desert tortoise burrows will also be recorded, including burrow width, substrate type, burrow location, and any tortoise sign associated with the burrow.

Statistical analysis should follow the equations and methods originally outlined in MacKenzie et al. (2002) and detailed in numerous subsequent papers and books. A variety of statistical programs can be used, including Program R, MARK, PRESENCE, and E-SURGE. Results from the pilot study can be used to determine which level of modeling complexity will be required for the monitoring data and the most appropriate statistical software can then be chosen. Appropriate weather or date covariates should be used in the estimation of detection probability. An additional benefit to using the occupancy approach is that if more than one desert tortoise is sometimes observed within a sample plot, the N-mixture method of Royle (2004) can be used to obtain density estimates accounting for imperfect detection (e.g., Kery et al. 2005).

### *1.2.2 Option 2: Capture-mark-recapture*

Capture – mark – recapture (CMR) is a commonly used approach for estimating population size and capturing demographic information of a targeted species, which is based on ratios of marked to unmarked individuals. In general, a portion of the population is captured, marked, and released. At a later time, a second (and potentially third) survey occurs, in which another portion is captured. The number of marked individuals within the sample is counted to return an estimated population size.

A CMR approach has the advantages of providing density estimates, demographic information, and can yield estimates of survival and recruitment rates. Plots of varying size (1 ha, 1 $km^2$, and 1 $mi^2$) have been used to assess tortoise populations, and there is potential to compare the BCCE population to other regions of study. Transect width may vary from 5 to 15 m depending on site conditions. The disadvantages of this sampling approach are that it can be expensive, time-consuming (e.g., 3 passes on a 5 m full-coverage survey of 1 $km^2$ plot will take approximately 60 person days to complete), and may be difficult to locate enough animals for robust demographic estimates.

There are numerous ways to analyze CMR data, and each has biological assumptions relating to the capture phase. For example, the simplest assumptions may be that all tortoises are located during survey effort, that the system is 'closed', mortality is same for marked and unmarked animals, and each survey captures a representative sample of various age categories within the population. It is therefore critical to understand the limitations of a chosen model, and account for how assumptions will be met during field surveys.

#### 1.2.2.1 Study Design and Methods

A series of 1 $km^2$ CMR plots will be sampled every 5 years. Sample size (i.e., the number of CMR plots) should be determined based on expected capture numbers from the literature to ensure sufficient captures to permit modeling. Surveyor(s) will aim to cover 100% of the site to identify all tortoises in all size classes; depending on vegetation cover and terrain, this effort may be 5 or 10 m belt transects across the entire plot. Surveyor(s) are expected to investigate all vegetation and burrows for presence of live tortoises, active tortoise burrows, and tortoise sign within each plot, and each plot will be surveyed three times (capture – mark – recapture ) during the season (between March 1 – May 15). Desert tortoises will be marked upon detection and given a visual health assessment. Additional information will be recorded, including sex, midline carapace length, tortoise ID, location, and behavior. Information on desert tortoise burrows will also be recorded, including burrow width, substrate type, burrow location, and any tortoise sign associated with the burrow.

There are a wide variety of statistical models to analyze CMR data, each dependent on different contingencies with the data and the objective to be met. Schwarz & Seber (1999) provide a good overview of the basic models; many advancements have been made since then and are available by consulting the current literature (e.g., Grimm et al. 2014).

# Section 2.0 Monitoring Methods for Suitable Breeding Habitat for MSHCP-Covered Birds

Vegetation monitoring within the riparian reserve system must be designed and implemented to provide timely information on the status and trends of suitable breeding habitat for MSCHP-covered species. This information can then be used to inform future habitat restoration or conservation efforts that would benefit these species. Monitoring should measure the overall habitat extent and configuration that characterizes suitable breeding bird habitat. The rivers and streams of the Mojave Desert provide a riparian habitat oasis relative to an otherwise dry landscape. This lowland riparian community is comprised of a cottonwood overstory, a mesquite/willow midstory, and an herbaceous understory, all of which riparian-associated MSHCP-covered species rely on as breeding habitat and nonbreeding habitat (i.e., migratory stopover and overwintering habitat) during various parts of the year. While there are no MSHCP-covered bird species that explicitly breed in the upland desert reserves, this area does provide important foraging habitat for the American peregrine falcon because of its proximity to suitable nesting habitat (cliffs).

The known habitat associations for MSHCP-covered bird species vary in their level of specificity. Some species have been well-studied (e.g., yellow-billed cuckoo, southwestern willow flycatcher, and Arizona Bells' vireo) and requirements for patch size and vegetation composition are known for these species (GBBO 2010, Sogge et al. 2010, Halterman et al. 2016), while specific guidelines and benchmarks that define habitat suitability for lesser-studied species is not always available at comparable levels of specificity. The information presented in Table A.1 represents the current and best available knowledge for the Mojave region and was constructed based on regionally relevant literature as referenced in the table.

Vegetation surveys should be conducted and species inventoried to collect sufficient data to describe avian-habitat associations (James and Shugart 1970, Noon 1981). These methods can be somewhat flexible in order to collect specific data that will directly measure variables of interest, and for example, may combine standard circular plot methods and line transect methods.  Surveys can include a combination of field vegetation and topographic measurements (e.g. vegetation structure, species composition, percent shrub cover, visual obstruction, distance to open water, etc.) and GIS-based analyses (e.g., average and maximum patch size, total shrub area, extent of canopy closure, etc.).  Field vegetation components of habitat monitoring can be conducted at the same point count stations used to monitor the avian species.  These methods should be repeated at a regular 2-year interval.  Appropriate statistical analyses include multivariate regression and other trend-based analyses.

**Table A1. Habitat Requirements of MSHCP-Covered Bird Species***

| Species | Habitat | Habitat Mosaic | Plant Density | Breeding Habitat Patch Size Requirements | Reference |
|---|---|---|---|---|---|
| **Southwestern willow flycatcher** | Lowland Riparian (Mojave and Great Basin), Springs, Marsh | Extensive thickets of willow or other riparian shrubs with saturated soils and nearby surface water | Dense riparian veg. >4 m high, >50% cover, tall canopy trees scattered/absent. | 2 acres (min) / >15 acres (optimal) | GBBO 2010<br>USFWS 2013 |
| **Yellow-billed cuckoo** | Lowland Riparian (Mojave and Great Basin), Springs | Large intact patches of riparian forest, or tall riparian shrub thickets, diverse vertical structure | High (>50% cover) with canopy heights varying from 5-30 m | >50 ac (min) / >200 ac (optimal) | GBBO 2010<br>USFWS 2014 |
| **Peregrine falcon** | Open environments with suitable nesting cliffs (ledges / holes on rocky cliffs) | Open environments including open water, desert shrub, and marshes, adjacent to suitable nesting cliffs | - | - | USFWS 2003, NVNHP 2016 |
| **Arizona Bell's vireo** | Lowland Riparian (Mojave Mesquite-Acacia), Springs | Structurally diverse habitat and saturated soils; currently in saltcedear, native trees increases habitat value | Dense shrub understory up to 3 m high; tree overstory relatively open / absent | >12 ac (min) / >49 ac (optimal) | GBBO 2010 |
| **Blue grosbeak** | Lowland Riparian (Mojave and Great Basin) | Shrubby woodland edges of riparian habitat | Open canopy, forest edges, shrubby and herbaceous understory. | | White 1998 |
| **Phainopepla** | Riparian, shrubland, woodland, and desert | Habitat with suitable structure, associated with desert trees bearing mistletoe | - | - | NDOW 2011, Crampton & Sedinger 2011 |
| **Summer tanager** | Lowland Riparian (Mojave and Great Basin) | Well-developed, continuous cottonwoood-willow stands | Dense canopies and <9m tall trees | 100 acres can support 20-30 birds | BLM 2016 |
| **Vermillion flycatcher** | Lowland Riparian (Mojave and Great Basin) | Riparian woodlands and adjacent scrublands | Open habitat with scattered trees, does not tolerate dense, shrubby understory or dense canopy | | BLM 2016 |

# Section 3.0 Monitoring Methods for Vegetation and Sensitive Plant Species on Desert Upland Reserve System Lands

Vegetation monitoring within the desert upland reserve system must be designed and implemented to provide timely information on the status and trends of key attributes of ecosystem components and functions. These include a) biotic integrity, b) soil and site stability, and c) hydrologic function (Miller 2005, Belnap et al. 2001, Herrick et al. 2009a & b). Biotic integrity is the capacity of a site to support characteristic functional and structural communities in the context of normal variability, to resist loss of this function and structure, and to recover following disturbance (Herrick et al. 2009b). Soil and site stability is the capacity of the site to limit redistribution and loss of soil resources (including nutrients and organic matter) by wind and water erosion (Herrick et al. 2009b). Hydrologic function is the capacity of the site to capture, store, and safely release water from rainfall, run-on, and snowmelt (Herrick et al. 2009b). Monitoring should measure biotic indicators such as foliar cover and species diversity, and also include measures of soil resistance to erosion. Since it will be desirable to compare the status and trends on reserve lands with those on lands managed by other agencies, it would be advantageous to adopt methods that would allow these comparisons (e.g., MacKinnon et al. 2011, Toevs et al. 2011a & 2011b).

In addition to monitoring desert upland ecosystem function, the status of MSHCP-covered plant species should be monitored. At the time of writing little is known about the location or ecological needs of these plant populations, although upcoming project work includes extensive surveys. If and when these populations are located, whether on or off of reserve system lands, quantitative methods such as those described below should be developed. It is critical that flexibility and care be used in developing the monitoring plan as several covered species are likely to occur in sensitive areas (e.g., high coverage of biological crusts) and thus monitoring methods may require a light footprint. For example, low-level drone surveys may be sufficient to map the areal extent of populations of MSHCP-covered plant species.

## 3.1 Quantitative Monitoring Methods

Three types of quantitative monitoring methods are described below that could be used for monitoring vegetation on desert upland reserve system lands.

- <u>Line-point intercept (LPI)</u> methods generate data on plant species foliar and basal cover, bare ground, and the amount of soil surface armored against erosion by rocks, litter, and biological soil crusts (Herrick et al. 2009a). Properly conducted, LPI has been shown to be among the least biased of methods and results in comparable data across changes in personnel (Elzinga et al. 2001). LPI generally, however, is best for documenting dominant vegetation and misses uncommon species. Trend detection is dependent on the precision of the foliar cover measurements, so it is important to ensure 200-400 points are collected at each location.
- <u>Canopy gap intercept</u> methods provide data on the proportion of the soil surface in large inter-canopy gaps, and thus generate an indicator for the potential for wind erosion, as well as susceptibility to weed invasion (Herrick et al. 2009a). The same transect used for the LPI method can be used to collect canopy gap data.

- Multi-scale quadrats are important for detecting the ephemeral herbaceous species that are the major component of ecosystem diversity in the Mojave Desert. Additionally, large plots (tens of square meters) will be critical for early detection of covered species colonization and occupancy in suitable habitats (Obj. D 1.1). Thus, the transect monitoring above should be augmented with a multi-scale quadrat approach (Stohlgren et al. 1995, Herrick et al. 2009b). The size and number of quadrats should be determined based on a) the expected spatial and temporal variance in vegetation cover, b) the amount of change to be detected, and c) the required confidence in any conclusion about whether any change has occurred (Elzinga et al. 2001). The vegetation data collected through the desert tortoise covariate monitoring project (Project # 2009-KLA-811H) can be used to make these determinations.

## 3.2 Qualitative Monitoring Methods

Two types of qualitative monitoring methods are described below that could be used for monitoring vegetation on desert upland reserve system lands.

- Photo points replicated over time are important for a visual record of each location, and are effective for illustrating the quantitative data.
- Indicators of rangeland health may precede, or subsequently augment, quantitative measurements. Site attributes to assess include rills (small erosional rivulets), water flow patterns, pedestals, gullies, areas with soil deposition or blowouts, soil compaction, soil stability, plant mortality, and evidence of reproduction and recruitment (flowers, fruits and seedlings). A standardized protocol for the assessment and interpretation of these range health indicators is readily available (i.e., Pellant et al. 2005).

## 3.3 Threat Monitoring

In many cases, the principle threats to habitats and populations of listed and covered plant species are known. These threats should be monitored so that any changes can be compared to changes in the target species. Measurements may include distance to roads and trails (or total linear disturbance within a fixed radius), distance to urban and residential development, evidence of livestock grazing, and changes in weed infestations. This monitoring may be completed using aerial imagery and updated periodically, or when new developments are noted.

## 3.4 Distribution and Number of Sampling Locations

The minimum number and size of transects and quadrats can be determined using existing data sets and following the approach of Elzinga et al. (2001) as noted above. The distribution of these sampling locations should largely be random, but should also be stratified based upon knowledge about the ecosystems of interest. For example, many covered plant species have specific substrate requirements (e.g., alkaline or gypseous soils, calcareous soils, deep sandy soils, salt flats, or silty alluvial fans). These areas should be mapped, and monitoring locations should be assigned to them even if they comprise a very small amount of the total reserve area.

## 3.5 Statistical Analysis

If permanent sampling locations are used, then a repeated-measures analysis may be most appropriate when multiple years of data are being compared. It may also, however, be appropriate to conduct multiple pair-wise comparisons using simple t-tests and adjust the threshold probability level using the Bonferroni adjustment (Elzinga et al. 2001). Caution must be used with regression or analysis of variance techniques to avoid losing or obscuring many of the fine differences among species composition, abiotic characteristics, and numerous covariates.

Vegetation community analysis may be better analyzed by calculating a similarity (or dissimilarity) index and then performing an appropriate ordination (McCune & Grace 2002) or temporal autocorrelation (Collins et al. 2000) analysis. These approaches can be used to identify locations with vegetation that differs from the typical ecosystem, and identify temporal trends toward or away from management desired conditions, and make use of all the species data collected over many years of monitoring.

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# Appendix B

## Effectiveness Monitoring for Individual Conservation Projects

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# Appendix B
# Effectiveness Monitoring for Individual Conservation Projects

## Section 1.0 Introduction

This appendix is supplementary only and should not be read, used, or cited without first consulting the main Adaptive Management and Monitoring Plan document.

Monitoring is a critical part of conducting conservation actions at multiple levels - from monitoring entire species, populations, and habitat at the level of the landscape down to monitoring the results of individual projects. This Appendix serves as a compliment to the AMMP in that while the AMMP describes the large-scale, landscape-level monitoring plan for MSHCP-covered species and their habitats, this Appendix describes the importance, rationale, and utility of project-level effectiveness monitoring.

Effectiveness monitoring is necessary to determine the realized benefits of an individual conservation project. At the level of a single project, it quantifies the success of that project. Effectiveness monitoring can ultimately be simplified to "quantifying the success of a project". How it is implemented and what variables are monitored can thus be viewed more broadly. Even clear-cut and/or short-term projects with no expected change over time involve instantaneous post-project "monitoring", which may simply be the quantification of project results. With this broad category of effectiveness monitoring and quantifying realized project outcomes, all projects conducted as part of implementing the MSHCP should require monitoring and evaluation.

The type of effectiveness monitoring that is conducted depends on the nature of the conservation action. For example, effectiveness monitoring for a public information and education project might involve tallies of website hits, estimates of video viewership, or follow-up surveys with the target audience. In contrast, effectiveness monitoring for a research project might involve assessment of the field effort and sample size, a compilation of management-oriented results, or counting the number of resultant peer-reviewed publications.

The timeline for conducting effectiveness monitoring also depends on the nature of the project. For example, a fencing project can have one period of "monitoring" immediately following construction (e.g., quantifying the distance of fence built) or multiple periods of effectiveness monitoring (e.g., revisiting the fence line 5 years later to determine structural integrity, leading to a distance-time quantified benefit, such as 5 fence mile-years for a 1-mile fence that stood for 5 years). In contrast, a restoration project requires a longer timeline, such as vegetation surveys at the time of restoration completion and again at 3 and 6 years post-restoration to determine plant survival and ecosystem process establishment. Thus a time period of "0 days" is still on a timeline. This allows for a consistent requirement of post-project quantification of success, whether the nature of the project only requires immediate quantification of success (e.g., number of kilometers of fence constructed) or delayed quantification of success (e.g., proportion of seedlings surviving 10 years post-planting).

# Section 2.0 Effectiveness Monitoring Linked to BGOs and Adaptive Management

All projects conducted as part of implementing the MSHCP are designed to support or accomplish one or more of the MSHCP Biological Objectives and also fall under at least one CM. Project-level effectiveness monitoring and documentation lends itself to an informal adaptive management approach. Lessons learned (or realized shortcomings) at the conclusion of a project should be used to improve study design and/or implementation of future projects that aim to achieve the same Biological Objectives and/or that fall within the same CM. In order to effectively quantify outcomes, project expectations including performance periods and performance indicators, should be set up during project inception and used as a measuring stick at the conclusion of the project (or at pre-determined milestones for a long-term project). To facilitate and thoroughly document project expectations and outcomes with respect to the BGOs, Worksheet B1 represents a version of the Performance Periods and Criteria Table that has been modified to apply to individual projects. This also applies to adaptively managing long-term projects with this process being conducted at pre-determined milestones.

Worksheet B1 is one of several effectiveness worksheets used during a project, from its inception to project close-out. It is designed to be complimentary to existing worksheets and to facilitate linkages between BGOs and measuring success of each objective. Pre-existing worksheets that are used throughout each project include:

- Project concepts and adaptive management guidelines that are identified during the IPB process (Worksheet B2). Worksheet B1 should be consulted during Worksheet B2 completion to identify which BGOs may be met with each project concept.
- Adaptive management project initiation form (Worksheet B3). Worksheet B1 should be partially-completed in concurrence with Worksheet B3 to identify project-specific performance indicators (further described in Section 2.1, below)
- Lessons learned that are documented at the conclusion of a project (Worksheet B4). Worksheet B1 should be completed in concurrence with Worksheet B4. Primarily, this includes documenting the performance indicator results (further described in Section 2.1, below).

Worksheets B1, B2, and B3 have explanations built into each question and are already in use by the DCP; therefore they are not discussed further in this appendix. All worksheets may be revised as described in Section 4.0 of the main Adaptive Management and Monitoring Plan document. Discussion for the project level performance period and performance indicator worksheet (Worksheet B1) is included in the next sub-section.

**Worksheet B1. Project-Level Performance Periods, Performance Indicators, and Indicator Results***

| Goals and Objectives | Project-Specific Performance Period(s) | Project-Specific Performance Indicators | Performance Indicator Results |
|---|---|---|---|
| **Goal R 1: Maintain, improve, and expand habitat for the MSHCP-covered species on riparian reserve system lands** | | | |
| Objective R 1.1: Monitor MSHCP-covered species occupancy | Assess every ___times/year for ___years using project-specific monitoring | Compare post-project monitoring data to already existing pre-project monitoring data (or go collect pre-data prior to construction)<br><br>After ___years, monitoring should demonstrate an ____increase or stable MSHCP-covered species occupancy within the restoration area. | [Report result--did the monitoring show the increase that was predicted in the Performance Indicator column?] |
| Objective R 1.2: Maintain / increase suitable breeding habitat for ...birds | Restoration area is predicted to reach full efficacy for <u>breeding habitat</u> in ____years. | After ___years, project-specific habitat and species monitoring should demonstrate a stable or increasing acreage of suitable breeding habitat for MSHCP-covered birds | [Not filled in because this is an example only] |
| Objective R 1.3: Incorporate elements of natural riparian processes into restoration design and implementation | Restoration area is predicted to reach full efficacy for <u>riparian processes</u> in ____years | The following specific elements of natural riparian processes are included in the restoration design:<br>-____acres of floodplain connectivity<br>-New materials placed in stream channel, banks, and floodplain will be modeled after reference reach substrate and habitat types.<br><br>After ___years, project specific monitoring should demonstrate that:<br>-___% of total floodplain acres are successfully connected;<br>-___Riparian restoration projects demonstrably include elements of natural riparian processes | [Not filled in because this is an example only] |
| Objective R 1.4: Inventory, remove, and control invasive and non-native plant species | Should result in [complete] removal of undesirable species immediately after construction and vegation establishment should reach full efficacy in ____years | Pre-data indicate ___acres of invasive / non-native plants within restoration footprint.<br><br>After ___years, demonstrate reduction of invasive species by at least ___% (or allow maximum of ___acres of undesirable species) on restoration site compared to baseline. | [Not filled in because this is an example only] |
| Objective R 1.5: Reduce habitat fragmentation … | [Not filled in because this is an example only] | [Not filled in because this is an example only] | [Not filled in because this is an example only] |
| **Goal R 2: Maintain stable or increasing populations of federally-listed threatened and endangered (T&E) species on riparian reserve system lands** | | | |
| Objective R 2.1: Monitor ... for breeding bird… | [Not filled in because this is an example only] | [Not filled in because this is an example only] | [Not filled in because this is an example only] |
| **Goal R 3: Foster community and stakeholder engagement to benefit covered species** | | | |
| Objective R3.1 Collaborate with other stakeholders… | NA because no collab with other stakeholders. | NA. This project does not contribute to this objective because Clark County is not collaborating with other stakeholders. | NA because no collab with other stakeholders. |
| Objective R3.2: Promote responsible recreation | NA because there is no public access. | NA. This project does not contribute to this objective because there is no public access. | NA because there is no public access. |

*This worksheet will be partially filled out during project inception and completed at the conclusion of each project. Categorizing each project by its CM helps determine which biological objectives apply to each project. Some projects may require only a portion of the table (i.e., are meant to achieve specific objectives) and the evaluation may be straightforward. **This table is an example only and is based on hypothetical expectations for a Muddy River Grading Plan Project (i.e., floodplain restoration).**

**Adaptive Management Questions to be Answered During Creation of IPB Project Concepts**

(Worksheet B2 in Appendix B of the AMMP)

**1)** What is the Fundamental Objective (Hint: Keep asking “why is that important” until you get to a “because it is” type of answer)?

**A)** Is the objective clear, defined and agreed upon?

**B)** Is the science behind this objective well understood (i.e. there is no uncertainty in how a management action will perform or that there is disagreement in how the problem should be tackled. Stop here if the answer is yes)?

**2)** Is this problem recurrent (does a decision occur on a regular basis or at least multiple times i.e. restoring many small areas where leaning can be applied to future projects)?

**3)** Is there structural uncertainty (are you unsure in any way how the management action will affect the system state or are there multiple methods available with uncertainty which will work the best)?

**4)** Is there a monitoring program that is sufficiently focused and precise to discriminate among alternative hypotheses/models (can we learn)?

**5)** Is there an ability to change management strategy in response to what is learned (can we adapt)?

(If A and B are yes then Structure Decision making is appropriate for this project. If B is no and 2 – 5 are Yes then Adaptive Management is correct.

## Adaptive Management Project Initiation Form

(Worksheet B3 in Appendix B of the AMMP)

**1)** What is the Fundamental Objective (taken from the project concept)?

**2)** What are the means objectives (how will you achieve the fundamental objective)?

**3)** List alternative actions (methods) that may allow you to achieve the objectives discussed in the previous questions.

**4)** Develop models based on each action discussed in question 3 to allow for looking at the consequences of each action. (this can be done through a table, decision tree, GIS models, or any other visual or mathematical representation).

**5)** Determine through optimization techniques which is the best alternative to implement at this point.

# AMP Lessons Learned

(Worksheet B4 in Appendix B of the AMMP)

**PROJECT #**:
**CONTRACTOR:**
**DATE OPENED:**
**DATE CLOSED:**
**ASSESSMENT DATES:**
**TITLE:**

**PROJECT OBJECTIVES/GOALS (bulleted list based on SOW)**
Goal 1:

Was the goal/objective adequately addresses Yes or No? (If no proceed to questions 1 otherwise skip to question 5)

1) Was the objective realistic? If not, why? How could the objective be improved?
2) Was the pre-existing data adequate for the objective? If not, why? What additional information could have been gathered prior to the project?
3) Was the study design adequate to meet this objective? If not, how could the study design be improved to meet this objective?
4) Did the objective require more resources than available/expected?
5) Could the results be obtained more efficiently with less time or money?

**STUDY DESIGN/DATA COLLECTION**

1) Was the data collected during this project useful to the MSHCP why or why not?
2) Was the data collected at the appropriate temporal scale?
3) Was the data collected at the appropriate spatial scale?
4) Is there a need for additional data analysis or expert interpretation?

**PROJECT RECOMMENDATIONS (from contractor)**

**AMP TAKEAWAY/LESSONS LEARNED**

1) How will these results be disseminated
2) What results from this study can be used to design or modify future studies
3) Does this project seem financially viable? Why or why not? Could actions be taken to make it more efficient?
4) Would this project be useful to complete again in the future? What modifications should occur in the future and at what interval?
5)

### 2.1 Description and Explanation for Worksheet B1

The *Project-Level Performance Periods, Performance Indicators, and Indicator Results Worksheet* (Worksheet B1) will be partially filled out at the beginning of each project and completed at the conclusion of each project. Categorizing each project by its CM can help determine which biological objectives apply. Some projects may only use a very small portion of the table (i.e., are meant to achieve only a few specific objectives) and the evaluation may be very straightforward (e.g., building fence). The worksheet is currently filled out for illustrative purposes only and is based on hypothetical expectations for a Muddy River Grading Plan Project (i.e., floodplain restoration). The following are descriptions and guidance for each column of the worksheet.

*Goals and Objectives Column:*

Each upcoming project begins with a new Performance Periods and Performance Indicator table, which includes the complete list of BGOs. The list of CMs and which biological objectives they apply to should be used to help determine which objectives the upcoming project has potential to achieve. Moving forward with the table, only those BGOs that are expected to be supported by the project should be retained or filled out.

*Project-Specific Performance Period Column:*

The performance period should be determined by the County during project inception and can be unique for each project as well as for each objective for the same project (i.e., for the same restoration project, the performance period for quantifying the final breeding habitat may be different than the timeframe for determining the success in reducing invasive plants). These can also be interim timeframes to evaluate milestone achievement of a project.

*Project-Specific Performance Indicators Column:*

The performance indicators should be determined by the County during project inception and should be based on prior knowledge, data, and/or predictions.

*Performance Indicator Results Column:*

The performance indicator results should be quantified / summarized once the timeframe (or interim timeframes) for the Performance Period has been met. Information in this column should succinctly and quantitatively report whether or not performance indicators were met. Follow-up discussion and documentation should be conducted as needed to apply informal adaptive management to upcoming projects, including topics such as: potential reasons performance indicators were or were not achieved, the appropriateness of the performance period—was it too short or too long?, what made the study design effective or not?, are there new methods or techniques that should be considered if a similar project is proposed in the future?, etc.

## Section 3.0 Reporting Project Effectiveness

All conservation projects should have a post-project effectiveness monitoring component, regardless of the timeline and project expectations, and outcomes should be documented in the project-level performance template (Worksheet B1). These quantified outcomes should be included in the Biennial Adaptive Management Report. Quantifying the outcome of projects is an opportunity to showcase and highlight the realized benefits of all conservation projects that have concluded or have monitoring data from the previous two years. It is also a chance to disseminate the species and habitat monitoring data and results on a more frequent basis than the 4-year Adaptive Management Evaluation period. Formal adaptive management is not part of this progress assessment. Quantifying project successes in the Biennial Adaptive Management Report is a place to disseminate species and habitat data and information gained from all post-project effectiveness monitoring actions.

# Appendix C
# AMMP Revision Documentation Table

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desert conservation PROGRAM

# Appendix C - AMMP Revision Documentation Table

| Version No. | **Date** | **Summary of Revisions** | **Rationale for Revisions** | **Revision Made / Approved By** |
|---|---|---|---|---|
| | | | | |
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