Coachella Valley Conservation Commission

February 1, 2012

Coachella Valley Multiple Species Habitat Conservation and Natural Community Conservation Plan

# Desert Wetlands Communities and Species Monitoring Protocols

Prepared by the University of Riverside Center for Conservation Biology
for the Coachella Valley Conservation Commission

# Coachella Valley Multiple Species Habitat Conservation & Natural Community Conservation Plan

## Desert Wetlands Communities and Species Monitoring Protocols

**Natural Communities**
**Mesquite Hummocks**
**Mesquite Bosque**
**Desert Saltbush Scrub**
**Desert Sink Scrub**
**Southern Arroyo Willow Riparian Forest**
**Sonoran Cottonwood Willow Riparian Forest**
**Southern Sycamore-Alder Riparian Forest**
**Freshwater Marsh**
**Cismontane Alkali Marsh**
**Desert Fan Palm Oasis Woodland**
**Arrowweed Scrub**

**Listed Species**
**Arroyo Toad (*Bufo microscaphus*)**
**California Black Rail (*Laterallus jamaicensis*)**
**Crissal Thrasher (*Toxostoma crissali*)**
**Desert Pupfish (*Cyprinodon macularius*)**
**Least Bell's Vireo (*Vireo bellii pusillus*)**
**Southern Yellow Bat (*Lasiurus ega*)**
**Southwestern Willow Flycatcher (*Empidonax traillii extimus*)**
**Summer Tanager (*Piranga rubra*)**
**Yellow Warbler (*Dendroica petechia*)**
**Yellow-Breasted Chat (*Icteria virens*)**
**Yuma Clapper Rail (*Rallus longirostris yumanensis*)**

These Protocols are subject to future revision as deemed necessary by the CVMSHCP's adaptive management process – this version was last updated on February 1, 2012.

U.C. Riverside Center for Conservation Biology

**CONTENTS**

INTRODUCTION…… ………………………………………………………………………………..3
COMMUNITY DESCRIPTIONS ........ 3
INITIAL RESEARCH QUESTIONS (TO BE ADDRESSED WITH MONITORING DATA) ........ 7
Community-Level Questions: ........ 7
Community Level Monitoring Objectives: ........ 8
Species-Scale Research Questions and Monitoring Objectives: ........ 10
DESESRT WETLAND BIRDS ........ 11
Questions: ........ 13
Objectives: ........ 14
SOUTHERN YELLOW BAT ........ 15
Questions: ........ 16
Objectives: ........ 16
ARROYO TOAD ........ 16
Questions: ........ 17
Objectives: ........ 17
DESERT PUPFISH ........ 18
Questions: ........ 19
Objectives: ........ 19
SOIL/WATER SALINITY - WATER CHEMISTRY - GROUNDWATER DEPTH ........ 21
Questions: ........ 21
Objectives: ........ 21
PERENNIAL-WOODY PLANTS ........ 22
Questions ........ 22
Objectives: ........ 23
ARTHROPODS ........ 24
Questions: ........ 24
Objectives: ........ 24
DATA ANALYSES ........ 24
LITERATURE CITED ........ 27
APPENDIX 1. POINT COUNT DATA FORM: RIPARIAN BIRDS ........ 29

## INTRODUCTION

There are two aspects of the monitoring framework presented here that are unique among conservation plans elsewhere. First, this framework is explicitly science-based. In addition to providing abundance and occurrence data, our approach focuses on hypothesis driven questions that assess the risk stressors pose to meeting conservation objectives (Barrows et al. 2005). The effectiveness of this framework requires an experimental design that examines the performance of populations with or without a particular stressor, and long-term data sets that establish the temporal influence of stressors along with the resilience of populations when a stressor's impact is reduced. This approach leads to the identification of cause and effect relationships for population dynamics, allowing the separation of typical changes in populations from those beginning a trajectory toward local extinction (Barrows and Allen 2007b).

Second, this framework embraces the multiple species – community basis for the conservation design and goals of the Coachella Valley MSHCP-NCCP. This approach creates efficiency, but more importantly develops a view of the impacts of environmental stressors and management options across the breadth of biodiversity and multiple scales at which stressors can have impacts within designated conservation areas (Barrows et al. 2005).

Compliance with specific monitoring criteria and tasks of the Coachella Valley MSHCP-NCCP are detailed in a separate document (Monitoring Framework).

## COMMUNITY DESCRIPTIONS

Desert wetland communities covered under the Coachella Valley's Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan (the Plan, or MSHCP/NCCP) include mesquite hummocks, mesquite bosque, desert saltbush scrub, desert sink scrub, southern arroyo willow riparian forests cottonwood willow riparian forest, southern sycamore-alder riparian forest, freshwater marsh, cismontane alkali marsh, desert fan palm oasis woodland, and arrowweed scrub. The distribution of wetland communities within the Plan are shown in Figure 1. The position of each of these communities within the Plan area depends on the interaction of water supply (surface or groundwater, perennial or ephemeral surface flow, flow rates, and whether the surface flows are confined to a narrow channel or spread over a broader area) and levels of salinity. Many of these communities are associated with earthquake fault zones. A conceptual model of how water supply and salinity interaction gradients result in defined communities is shown in Figure 2.

A model of covered community-species relationships is shown in Figure 3. Individual community-specific descriptions (Holland 1986, Coachella Valley Mountains Conservancy 2000), roughly in order of their salinity tolerances, include:

*Desert Sink Scrub*

High salinity, high groundwater table soils with *Allenrolfea occidentalis* and *Sueda torreyana* as dominant shrubs. *Atriplex* can be a minor component. Flat-tailed horned lizards, *Phrynosoma* *mcallii,* may occur in this community in the Dos Palmas area, but the soils can be too salty for their primary prey, harvester ants.

*Desert Saltbush Scrub*

This community occurs in areas with a high groundwater table but no regularly occurring surface water. Soil salinity levels range from 0.2-0.7%. *Atriplex polycarpa* is a typical dominant shrub, with *A. canescens* as a common associated species. Covered species that occur within this community include flat-tailed horned lizards, and Le Conte's thrasher, *Toxostoma lecontei*.

*Arrowweed Scrub*

This scrub type occurs on wet soils with high salinity, often adjacent to palm oases and/or cismontane alkali marsh communities. Dominated by *Pulchea sericea,* Crissal thrashers, *Toxostoma crissali*, and yellow-breasted chats, *Icteria virens,* sometimes use this community.

*Mesquite Bosque*

This community is defined by high groundwater, seasonal wetting, high to moderate salinity soils and is dominated by dense or open stands of screwbean mesquite, *Prosopis pubescens*. Crissal thrashers utilize this community.

*Desert Fan Palm Oasis Woodland*

This community occurs on moderately saline, very wet soils that may include surface water. The desert fan palm, *Washingtonia filifera* is a major component, often in homogeneous stands, or sometimes associated with Fremont cottonwood, *Populus fremontii*, willow species, *Salix* spp. and mesquite, *Prosopis* spp. Palms tolerate fire, however fire results in substantial loss of wildlife habitat value when the palm skirts are removed, and an overall loss in woody plant species richness. Southern yellow bats, *Lasiurus ega*, are believed to be somewhat if not wholly restricted to palms with intact skirts. When cottonwoods and willows are present this community provides habitat for the suit of covered riparian birds as well.

*Mesquite Hummocks*

Occurs in areas of low to moderately saline, high groundwater or where groundwater is forced to near the surface along earthquake fault lines as clumps of honey mesquite, *Prosopis glandulosa*. Crissal thrashers, along with round-tailed ground squirrels, *Spermophilus tereticaudus*, can find habitat within this community.

*Cismontane Alkali Marsh*

This community occurs when moderately saline, low gradient surface water flow is not confined to a narrow channel, and emergent sedges and rushes can form a dense mass of vegetation up to 2 m in height. Yuma clapper rail (*Rallus longirostris yumanensis*) and California black rail (*Laterallus jamaicensis*) find preferred habitats in this community. Desert pupfish (*Cyprinodon macularius*) can be present when this habitat is contiguous with deeper water habitats.

*Coastal and Valley Freshwater Marsh*

Similar to the cismontane marsh except water is less saline and vegetation is taller, up to 4-5 m. Yuma clapper rail and California black rail find preferred habitats in this community. Desert pupfish (*Cyprinodon macularius*) can be present when this habitat is contiguous with deeper water habitats.

*Sonoran Cottonwood Willow Riparian Forest, Southern Arroyo Willow Riparian Forest, and Southern Sycamore-Alder Riparian Forest*

These three similar community types functionally differ primarily in the composition of dominant tree species. These communities have the least salt tolerances of any of the wetland group. All can provide habitat for arroyo toads (*Bufo microscaphus*), least Bell's vireos (*Vireo bellii pusillus*), southwestern willow flycatchers (*Empidonax traillii extimus*), summer tanagers (*Piranga rubra*), yellow warbler (*Dendroica petechia*), and yellow-breasted chats (*Icteria virens*), although the arroyo toad and tanager are more likely to occur in the southern sycamore-alder community.

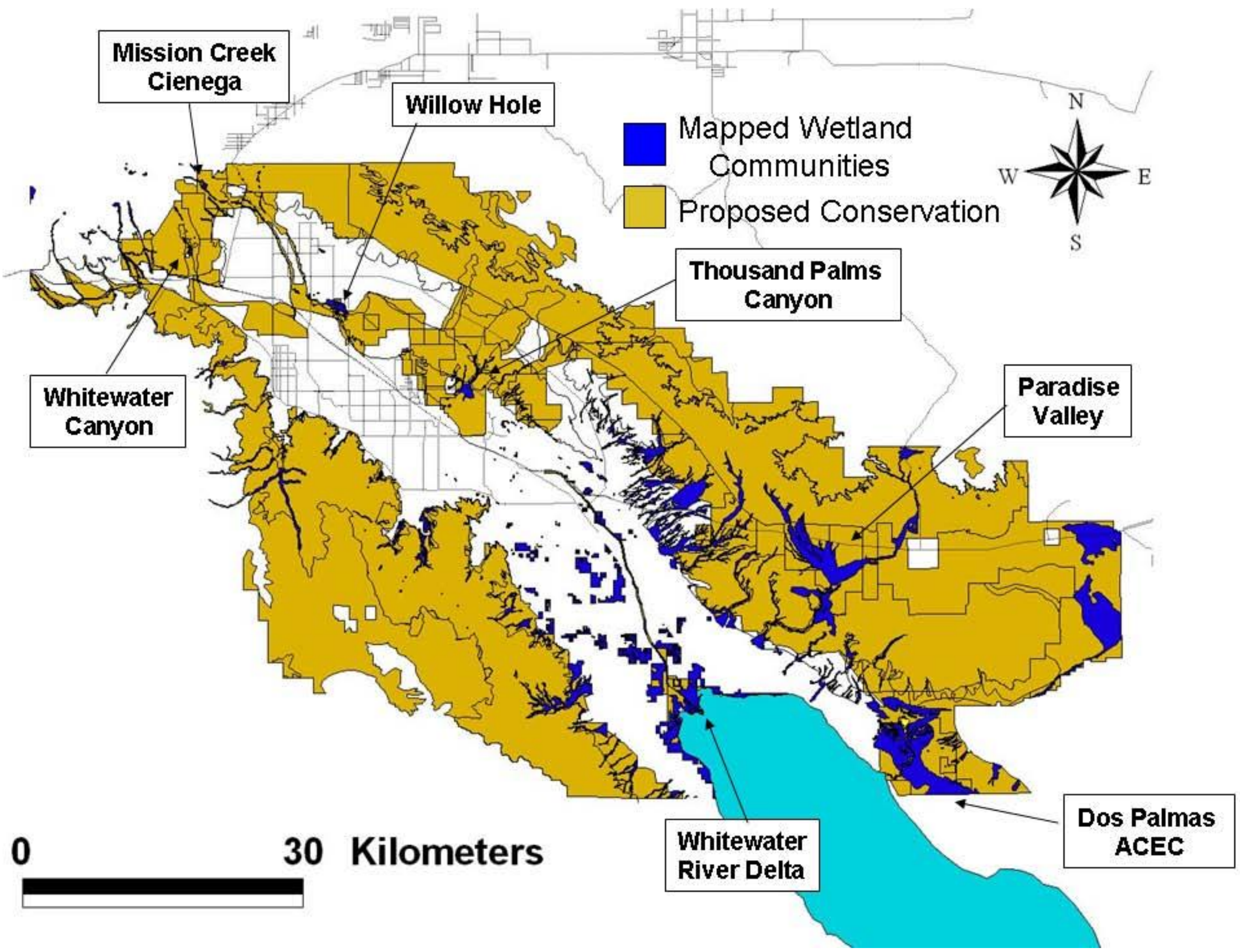



**Figure 1.** Mapped Wetlands occurring within the Coachella Valley MSHCP.

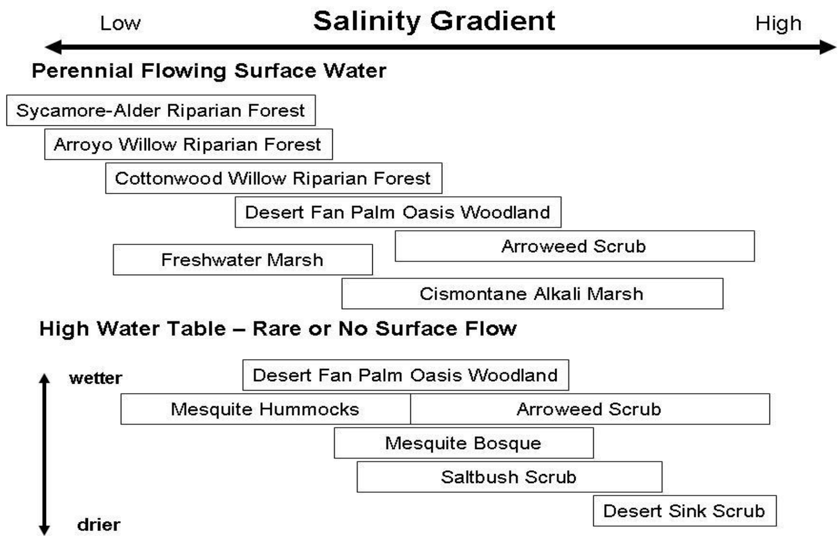



**Figure 2.** Conceptual model depicting the how gradients of moisture and salinity may distinguish which of the 11 natural communities covered in this protocol.

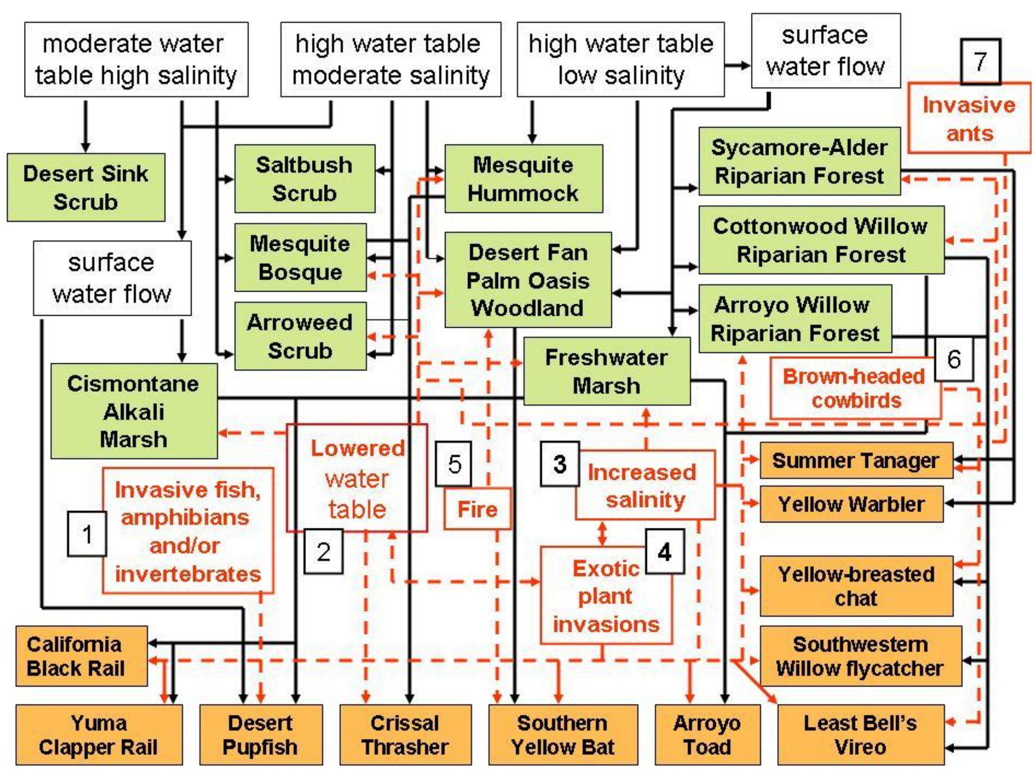



**Figure 3.** Water/salinity impacts on community type and species-community associations along with potential stressors (red boxes and red, dashed connecting lines). Numbers align with research questions and monitoring objectives.

## INITIAL RESEARCH QUESTIONS (TO BE ADDRESSED WITH MONITORING DATA)

The following research questions are aimed at assessing the risk that potential stressors pose to the integrity and sustainability of the desert wetland communities and associated species covered under the MSHCP/NCCP. Typical monitoring approaches have at best identified population trends, but have not included corollary data to answer whether those trends warrant management action and what management actions would improve that population's persistence (Barrows and Allen 2007). The objective here is to identify and distinguish the effects of typical community and population dynamics from the influence of anthropogenic stressors that may become the focus of management actions. Answers to these questions may require an adequate literature search if previous research has been sufficient and is applicable to this region or the answers will result from specifically designed monitoring strategies. Whatever the source, the objective is to identify, prioritize and direct appropriate management responses. Numbers align with stressors identified in the conceptual model (Fig. 3) but do not denote level of priority.

*Community-Level Questions:*

- **(2&3)** Salinity and availability of water dictate which of the desert wetland communities occur at a given location and thus what species will be able to find suitable habitat there. What are the spatial extents of each of the desert wetland communities? How dynamic and what is the trajectory of those distributions?

- **(2&3)** What is the range of salinity and groundwater depths characterizing each community?

- **(2&3)** What are the thresholds or tipping points of salinity and groundwater depth when communities begin to shift in character from one wetland community to another?

- **(2&3)** What is the source of change in salinity or groundwater that could bring a community to the tipping point of shifting from on community to another? To what extent does the lining of the Coachella canal, changing agricultural practices, tectonic shifts in fault zones, reduction of the Salton Sea, salt cedar densities, and/or climate change (precipitation inputs) impact salinity and groundwater levels?

- **(1&7)** Where are the occurrences and the spatial extent of invasive animal species within the desert wetland communities? Those invasive species include red fire ants, *Solenopsis invicta*, Argentine ants, *Linepithema humile*, crayfish, *Procambarus clarkii*, bullfrogs *Rana catesbeiana*, leopard frogs, *R. berlandieri*, various exotic fish species, exotic snails, and other snail species, including, but not limited to, quilted melania (*Tarebia granifera*) and channeled applesnail (*Pomacea canaliculata);* Red rim melania (*Melanoides tuberculatus*) and the quilted melania are particularly abundant in the drains and in some pupfish habitats. Mud snails, ramshorn snails and possibly others may also be present in some habitats. There is also the Asian clam (*Corbicula fluminea)* abundant in the drains and in some refuges. Also spiny softshell turtles (*Apalone spinifera*). Additionally native species which have benefited by anthropogenic habitat changes, such as raccoons, (*Procyon* *lotor)*, may be considered here. How dynamic are those distributions? What variables influence those dynamics?

- **(1)** What distances from source areas serve as barriers to colonization by invasive animal species? What are the vectors of new "inoculations" of invasive species?

- **(1)** What is the effectiveness of control methods (time/effort/cost/success/recurrence time) for these invasive species?

- **(2&3)** How does salinity and groundwater depth impact the success of restoration efforts of native plant community composition? – Do they affect patterns of native vegetation recruitment?

- **(2, 3&4)** How does salinity and groundwater depth impact invisibility?

- **(2, 3&4)** Do invasive plant species impact salinity and groundwater depths?

- **(4)** Where do non-native invasive plant species occur within the wetland communities and what is their spatial extent? Those invasive species include but are not limited to, salt cedar, *Tamarisk ramossisima*, giant reed, *Arundo donax*, fountain grass, *Pennisetum setaceum*, Bermuda grass, *Cynodon dactylon,*

- **(4)** What are the trajectories in the occurrence and abundance of invasive species in each of the wetland communities?

- **(4)** How does disturbance frequency and intensity (ie: from flooding, fires, and ORV trespass) impact the ability of invasive plant species to become established in wetland communities?

- **(4&5)** To what extent do invasive species impact the occurrence of fire in these wetland communities and how does fire impact the invisibility of those exotics?

- **(5)** What is the recolonization rate by native species into wetland communities after fire?

*Community Level Monitoring Objectives:*
MSHCP/NCCP goals include protecting the sustainability of the desert wetlands along with populations of covered species that find suitable habitats within those communities. Monitoring objectives need to provide data to support that goal by answering the research questions listed above.

In order to fully understand the risk that stressors (Fig.2) pose to the conservation goal, monitoring objectives should include the following (numbers align with those in Figure 2 and in the research questions):

- **(1, 2 & 3)** For sites being managed for desert pupfish or arroyo toads, water depth, flow rate and salinity will be additional metrics measured. Collecting data for each of these metrics will occur at permanent plots located randomly within the community types, the number of plots will be based on within community heterogeneity as determined through preliminary sampling. These variables will initially be re-sampled on each of the plots the same month every year; the time between repeated surveys will be adjusted based on the rates of change measured (high rates of change would call for more frequent surveys, low variance would call for less frequent surveys). For restoration and active management efforts, the same variables should be measured, but repeated annually until the perennial plant cover and composition within the restoration sites are within the range of values measured within intact portions of that community.

- **(2&3)** Create a baseline map of the current condition and extent of the wetland communities. This can be accomplished using current high resolution satellite imagery coupled with ground-truthing. Accurate polygons depicting the location and extent of each of the communities will be defined as GIS layers. This shall be repeated with new/current satellite imagery initially every three years; the time between repeated mapping should be adjusted based on the rates of change measured (high rates of change would call for more frequent mapping).

- **(2&3)** Groundwater levels and salinity are likely to change within the plan area due to many stressors, ranging from groundwater over drafting, tectonic activity, eliminating leakage along the Coachella canal, changing irrigation practices due to reduced water availability and higher costs, climate change, fire, and the effect of invasive species such as salt cedar (Fig 2). Even though the effects may be similar, the management response, if any, will differ based on the source stressor. Within each community, on randomly located plots, or centrally located within a cluster of permanent plots, depth to groundwater, groundwater salinity, and soil salinity and water stable isotope signatures will be quantified the same month every year; the time between repeated surveys will be adjusted based on the rates of change measured (high rates of change would call for more frequent surveys, low variance would call for less frequent surveys). .

- **(1)** Create a baseline GIS map of the current extent of exotic, invasive animal species within the MSHCP/NCCP conserved areas. Those invasive species include red fire ants, *Solenopsis invicta*, Argentine ants, *Linepithema humile*, crayfish, *Procambarus clarkii*, bullfrogs *Rana catesbeiana*, leopard frogs, *R. berlandieri*, various exotic fish species, exotic snails, and other snail species, including, but not limited to, quilted melania (*Tarebia granifera*) and channeled applesnail (*Pomacea canaliculata).*Red rim melania (*Melanoides tuberculatus*) and the quilted melania are particularly abundant in the drains and in some pupfish habitats. Mud snails, ramshorn snails and possibly others may also be present in some habitats. There is also the Asian clam (*Corbicula fluminea)* abundant in the drains and in some refuges. Also spiny softshell turtles (*Apalone spinifera*). Additionally native species which have benefited by anthropogenic habitat changes, such as raccoons, (*Procyon lotor).* Surveys to create this map shall be repeated initially every three years; the time between repeated mapping should be adjusted based on the rates of change measured (high rates of change would call for more frequent mapping).

- **(2, 3&4)** On permanent, randomly located plots located in each of the wetland communities, woody-perennial plant species richness and cover will be quantified every three years. For restoration/management plots, surveys will occur annually until species richness and cover values are within the variances measured on the undisturbed communities.

- **(4)** Create a baseline GIS map of the current extent of exotic, invasive plant species within the MSHCP/NCCP conserved areas. Those invasive species include but are not limited to, salt cedar, *Tamarisk ramossisima*, giant reed, *Arundo donax*, fountain grass, *Pennisetum setaceum*, Bermuda grass, *Cynodon dactylon,* Surveys to create this map shall be repeated initially every three years; the time between repeated mapping should be adjusted based on the rates of change measured (high rates of change would call for more frequent mapping). These data will also feed into the objectives of the low desert weed management area (NRCS).

*Species-Scale Research Questions and Monitoring Objectives:*

Research Questions

- **(1, 2, 3, 4, 5, 6 & 7)** What resources or stressors drive population dynamics of species occurring within desert wetland communities? This is the key to understand and partition the sources of variance resulting from the identified stressors 2.

- (**4&7**) What effect do exotic species (plants or animals) have on the occupancy and reproductive success of covered species? If there is an effect, is it through the depletion of native arthropod prey, through ant predation on young, nest parasitism?

- **(5)** How does fire impact the occurrence of covered species?

Monitoring Objectives

- **(1, 2, 3, 4, 5, 6 & 7)** Document patterns of occurrence and abundance for each of the covered wetland species**.** Create a baseline map of the current occupancy and relative abundance at each conserved wetland site. Initially conduct annual re-surveys, but if there is little or no annual change shift survey frequency to every 3-5 yrs.

- **(4&7)** Document patterns of occurrence for invasive animal and plant species in each of the covered wetland sites**.** Create a baseline map of the current occupancy and relative abundance for invasive species at each conserved wetland sites. Initially conduct annual re-surveys, but if there is little or no annual change shift survey frequency to every 3-5 yrs.

With the data generated through these monitoring objectives each of the key community questions should then be able to be addressed, protection goals for the wetland communities should be able to be quantified, and land managers will have the information necessary to carry out tasks aimed at reducing the source and/or effect of stressors.

**DESESRT WETLAND BIRDS**

Circular plots are a well-established technique for surveying birds (Reynolds et al. 1980, DeSante 1981, Ralph et al. 1993). Several of the bird species to be monitored under this protocol are listed as endangered, so appropriate permits may be needed to conduct surveys. Circular plots will be conducted in mesquite and palm oases for crissal thrasher (*Toxostoma crissali*), and in riparian habitats for least Bell's vireo (*Vireo bellii pusillus*), southwestern willow flycatcher (*Empidonax traillii extimus*), summer tanager (*Piranga rubra*), yellow warbler (*Dendroica petechia*), and yellow-breasted chat (*Icteria virens*). Plot center-points will be distributed within the identified community type either regularly (after beginning at a random point), separated at a sufficient distance so as not to count the same individuals from adjacent points. The number of points will vary with the size of the community polygon and the detection distance of the species being surveyed. Center-points of circular plots will also serve as the center of the permanent vegetation and arthropod survey plots (described below).

At each point a surveyor will stand quietly for at least one minute before initiating the count. After the one minute rest period the surveyor can then begin counting all birds for a 15 minute count period, identifying birds in relation to a map (Appendix 1) and distance from the observer. In marsh habitat surveying for the rail species, recorded playbacks of both of the rails' calls will be played for one minute at the beginning and at the 10 minute mark of the 15 minute count period. Because using tapped calls to solicit responses is an "active" rather than passive detection approach, surveyors will need to acquire any needed federal or state permits. Surveyors need to be adept at identifying all local species by sight, by song and by call notes. They need to also be able to accurately estimate distances to a singing/calling bird. To assess and improve bird survey skills, a mandatory 1-2 week training period should proceed each count period. For determining detectability for each species, the count period can be divided into intervals, with each species and each individual tallied separately for each period. Also, a second surveyor can count the same points, separated from the first count by at least 30 minutes. This time separation provides independence between the counts and ensures that the observers are not using each other's behavior or expertise to identify individuals that they may have otherwise missed. By incorporating a second observer in this manner a more accurate estimate of detectability can be made which then allows a better estimate of the number of visits required to accurately determine occupancy and/or relative abundance. Data collected for each count at each point should include the number of individuals and their estimated distance from the survey point for all bird species. Each point should be surveyed four times during the birds' breeding season. The timing of breeding varies considerably, with hummingbirds breeding is in January-March, other resident species breed from March through May, earlier migrants breeding from April through June, and late migrants, such as the southwestern willow Flycatcher, don't arrive until late May or June. Consequently counts need to be staggered to overlap with peak activity/and or detectability for each species; one round of counts in March, April, May and in June should suffice.

For Yuma clapper rail (*Rallus longirostris yumanensis*) and California black rail (*Laterallus jamaicensis*) surveys will follow the guidelines of the 2005 National Marsh Bird Monitoring

Program. By using these protocols the data generated will be comparable to and incorporated into a national network for marsh bird monitoring. Data sheets are standardized and available from the National Marsh Bird Monitoring Program. The protocol for rails will include permanent points along a predetermined route, each point being at least 400 m apart. Each rout and survey point should be resurveyed annually and repeated at least three times with each year between March 15 and May 31. At each point the surveyor will use recorded calls for each of the rails (and so Federal and State permits will be required), starting at first light and not to exceed two hours after sunrise using the following protocol:

- The broadcast CD should be obtained from the National Marsh Bird Monitoring Program Coordinator. The CD is composed of 1 track which contains 5 minutes of silence followed by 30 seconds of broadcast and 30 seconds of silence for each of 4 marsh bird species (Black Rails, Least Bitterns, Virginia Rails, and Clapper Rails).
- Speakers should be placed on the ground or on the bow of the boat as close to the wetland interface as possible, facing into the center of the wetland.
- The broadcast CD should be played at a volume of 80-90 db measured 1 meter from the speakers

The objectives for wetland bird monitoring are to both detect bird occupancy levels as well as identify correlates of occupancy or absence such as cowbird parasitism, invasive plant species, invasive ant species, insect abundance and species richness, vegetation structure and composition. These variables are of particular interest because they can be manipulated to achieve management and conservation goals, but understanding the influence they have in driving species' occupancy is a critical first step. Landscape variables should also be included in multivariate correlation analyses. Landscape variables are less subject to management manipulation but may have an over-riding influence on the occurrence of wetland community birds. Such variables include the extent of the community type within set distances of the survey point, the width and/or edge character of the community at the survey point, and the distance to water. These variables can be quantified from satellite image-GIS analyses. The data from the surveys prescribed above can be used to develop models capable of identifying which of these variables correlate with occupancy and abundance (see data analysis; Royle and Dorazio 2008).

UC Riverside's Center for Conservation Biology conducted a pilot study of riparian community bird occurrences within the Plan area from 2002-2004. Over that three year period 18 separate riparian community sites were surveyed and 116 points were surveyed (averaging slightly more than six points per site). Survey points were spaced approximately 200 m apart. The following is a description of the methods used in that study:

"Point counts were conducted between sunrise and 0900 hours. During point counts, observers stood quietly on or near the location of a point and recorded detections of the target species (identifications by sight or sound) during a 15-minute count period. Non-target species were also noted before, during, or after the counting period; however, detection of non-target species was a secondary goal because of its potential interference with the detection of target species.

We employed a double-observer method at all 15 sites. For the double-observer method, two observers conducted counts at each point count location on the same day but at slightly different times. The second count was conducted within 30 minutes of the first count. The first observer (Observer 1) went to Point 1 while the second observer (Observer 2) waited at a distance of approximately 200 m or more away from Point 1. When Observer 1 was finished counting at Point 1, he/she radioed to Observer 2 to progress to Point 1, and Observer 1 progressed to Point 2. The two observers progressed through all of the points in this manner, with Observer 2 trailing Observer 1. At the end of the survey, observers compared observations to estimate the total number of individual birds actually present at the site. For future statistical analyses of detectability of riparian birds using these counting methods, the 15-minute count period was divided into four intervals, and we recorded whether species were detected in the first (0-3:00), second (3:00-5:00), third (5:00-10:00), or fourth (10:00-15:00) interval. Additionally, we recorded the distance estimated to the nearest meter from the observer/point to each bird detected, and whether initial detection was made visually, or by call or song. Detection information and locations of target species relative to the point coordinates were documented on point count data forms." Summary results of that pilot study are shown below in Figure 4.

*Questions:*

- **(1, 2, 3, 4, 5, 6 & 7)** What resources/stressors drive population dynamics of bird species occurring within desert wetland communities? This is a key to understand and partition the sources of variance resulting from the stressors identified in Figure 2.

- **(1)** What distances from source areas serve as barriers to colonization by invasive animal species? What are the vectors of new "inoculations" of invasive species?

- (**7**) What effect do exotic ants have on the occupancy and reproductive success of nesting riparian birds or arroyo toads? If there is an effect, is it through the depletion of native arthropod prey, or through ant predation on nestlings?

- **(1)** What is the effectiveness of control methods (time/effort/cost/success/recurrence time) for these invasive species?

- **(2&3)** What are the thresholds or tipping points of salinity and groundwater depth when communities begin to shift in character from one wetland community to another?

- **4)** Where do non-native invasive plant species occur within the wetland communities and what is their spatial extent? Those invasive species include but are not limited to, salt cedar, *Tamarisk ramossisima*, giant reed, *Arundo donax*, fountain grass, *Pennisetum setaceum*, Bermuda grass, *Cynodon dactylon,*

- **(4)** To what extent do invasive plant species impact the occurrence of native bird species within the wetland communities?

- **(4)** How does disturbance frequency and intensity (ie: from flooding, fires, or ORV trespass) impact the ability of invasive plant species to become established in wetland communities?

- **(6)** What are the drivers and stressors of nesting success in riparian birds, including least Bell's vireos, summer tanagers, or yellow-breasted chats (the covered riparian birds that nest in the plan area)? Is the current level of brown headed cowbird nest parasitism impacting breeding success and recruitment?

- **(6)** Does cowbird trapping significantly reduce levels of nest parasitism?

*Objectives:*
Pertinent desert wetland birds research/monitoring questions and objectives (nos. correspond to Fig. 3):

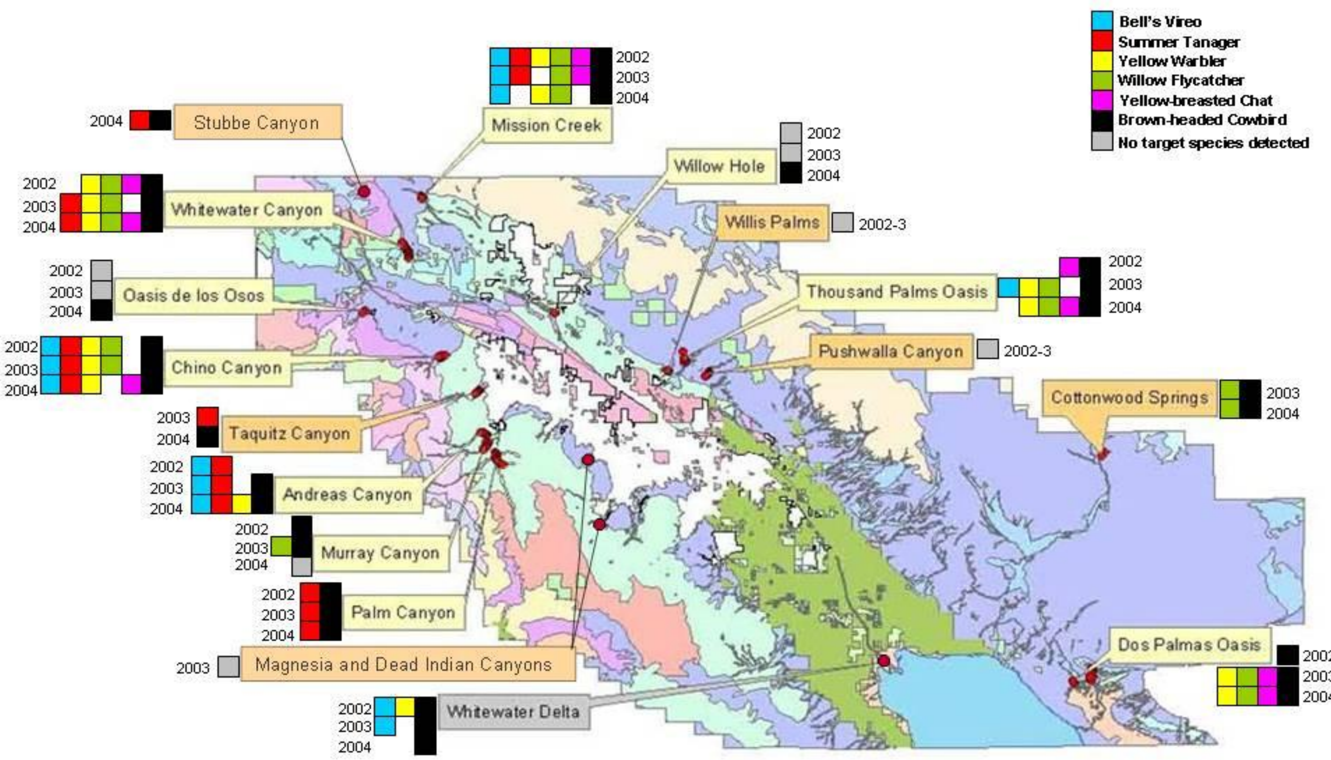
- **(1&6)** For sites being managed for desert wetland community birds, conduct surveys of avian species composition and arthropod community composition. For sites where exotic species control (including cowbirds) is undertaken, surveys should be annual and an assessment of reproductive success should occur. After three years, if there is small between-year variance, then surveys could be conducted every three years.

- **(2&3)** Create a baseline map of the current condition and extent of the wetland communities. This can be accomplished using current high resolution satellite imagery coupled with ground-truthing. Accurate polygons depicting the location and extent of each of the communities will be defined as GIS layers. This shall be repeated with new/current satellite imagery initially every five years; the time between repeated mapping should be adjusted based on the rates of change measured (high rates of change would call for more frequent mapping).

- **(2&3)** Groundwater levels and salinity are likely to change within the plan area due to many stressors, ranging from groundwater over drafting, tectonic activity, eliminating leakage along the Coachella canal, changing irrigation practices due to reduced water availability and higher costs, climate change, fire, and the effect of invasive species such as salt cedar (Fig 2). Even though the effects may be similar, the management response, if any, will differ based on the source stressor. Within each community, on randomly located plots, or centrally located within a cluster of permanent plots, depth to groundwater, groundwater salinity, and soil salinity and water stable isotope signatures will be quantified.

- **(2, 3&4)** On permanent, randomly located plots located in each of the wetland communities, woody-perennial plant species richness and cover will be quantified every five years. For restoration/management plots, surveys will occur annually until species richness and cover values are within the variances measured on the undisturbed communities.

- **(4)** Create a baseline GIS map of the current extent of exotic, invasive animal species within the MSHCP/NCCP conserved areas. Those invasive species include but are not limited to, salt cedar, *Tamarisk ramossisima*, giant reed, *Arundo donax*, fountain grass, *Pennisetum setaceum*, Bermuda grass, *Cynodon dactylon*, Surveys to create this map shall be repeated initially every three years; the time between repeated mapping should be adjusted based on the rates of change measured (high rates of change would call for more frequent mapping). These data will also feed into the objectives of the low desert weed management area (NRCS).




**Occupancy patterns of target bird species in the Coachella Valley, 2002-2004**

**Figure 4.** Results of previous riparian bird surveys conducted by UC Riverside's Center for Conservation Biology.

## SOUTHERN YELLOW BAT

Southern yellow bats, *Lasiurus ega*, are associated with desert fan palm communities and are the only bat species covered under this conservation plan. As the effort to record the occurrence of this species along with any other bat species using that community is the same, we recommend conducting a community-level bat survey. Surveys for bats should follow the similar protocols described above for birds, including using the same survey points when they occur in desert fan palm oases woodland communities. Surveys could occur anytime throughout the warm months as long as winds are light. There are, however, a couple important exceptions; surveys will be conducted at night, and bat detections will be made via their ultrasonic-species specific vocalizations (eg. Weller 2008). There are several products available for detecting bat vocalizations such as “anabat” or “sonobat”. This technology (i.e. anabat/sonobat) lends itself to remote sensing where multiple recorders can be deployed throughout the selected sites and allowed to record all night.

Nocturnal mist netting may yield positive occurrence data when there are isolated pools or other water sources that focus bat activity and facilitate stretching nets across or near such features. However isolated open water does not occur at each potential site, and not catching a bat even when water is present is not equivalent to their being absent. Mist netting will also require a Scientific Collecting Permit from the California Department of Fish and Game. Pertinent southern yellow bat research/monitoring questions and objectives (nos. correspond to Fig. 3):

*Questions:*

- **(1, 2, 3, 4, 5&6)** What resources drive population dynamics of southern yellow bats as well as other bat species occurring within desert wetland communities? This is a key to understand and partition the sources of variance resulting from the stressors identified in Figure 2.

- **(4&5)** To what extent do invasive species impact the occurrence of fire in these wetland communities and how does fire impact the invisibility of those exotics?

*Objectives:*

- **(5)** Create a baseline assessment of the occurrence or southern yellow bats in palm oases within the MSHCP/NCCP conservation areas. Compare oases that have never burned with those that have a known burn history. Repeat every three years; the time between repeated surveys should be adjusted based on the rates of change measured (high rates of change would call for more frequent mapping).

## ARROYO TOAD

Arroyo toads, *Bufo microscaphus,* have a very limited range within the Plan area, recently known only from Whitewater Canyon, where its current occurrence needs verification. Survey protocols for arroyo toads can follow those described above for riparian birds, again using the same survey points whenever possible to use the same habitat and invasive species measurements to save time and money. As with the bat surveys the primary difference is the surveys would occur at night. Recommended USFWS survey protocols are available at the following link and should be adhered to: http://www.fws.gov/ventura/speciesinfo/protocols_guidelines/docs/arroyotoad/arroyotoad_surveyprotocol.pdf. Adult arroyo toads call in the spring when nighttime temperatures reach 12-14° C; for our area that would be March-April. The toads can be very sensitive to noise and disturbance so surveys along creeks, and movement between survey points should be done quietly, avoiding any direct contact with the water or the toads. Another method includes daytime surveys for tadpoles. The tadpoles are distinctive but not so much so that they can be positively identified without handling. Since this species is federally and state protected, no handling or disturbance can occur without appropriate permits. Pertinent arroyo toad research/monitoring objectives and questions (numbers correspond to Fig. 3):

*Questions:*

- **(1, 2, 3, 4, 5&6)** What resources drive population dynamics of arroyo toads? This is a key to understand and partition the sources of variance resulting from the stressors identified in Figure 2.

- **(1&7)** Where are the occurrences and the spatial extent of invasive animal species within the desert wetland communities? Those invasive species include red fire ants, *Solenopsis invicta*, Argentine ants, *Linepithema humile*, crayfish, *Procambarus clarkii*, bullfrogs *Rana catesbeiana*, leopard frogs, *R. berlandieri*, exotic snails, *Melanoides* spp. and various exotic fish species. How dynamic are those distributions? What variables influence those dynamics?

- **(1)** What effect do the exotic fish, amphibians and invertebrates have on arroyo toads? Does that effect change with different combinations of invasive species present?

- (1 & 7) What effect do exotic ants have on the occupancy and reproductive success of arroyo toads? If there is an effect, is it through the depletion of native arthropod prey, or through ant predation on young toads?

*Objectives:*

- **(1)** For sites being managed for arroyo toads, assess the occurrence toads along with invasive, non-native fish, amphibians, ants and snails annually.

- **(1)** Create a baseline GIS map of the current extent of exotic, invasive animal species within the MSHCP/NCCP conserved areas. Surveys to create this map shall be repeated initially every three years; the time between repeated mapping should be adjusted based on the rates of change measured (high rates of change would call for more frequent mapping).

- **(1, 2 & 3)** For sites being managed for arroyo toads, water depth, flow rate and salinity will be additional metrics measured. Collecting data for each of these metrics will occur at permanent plots located randomly within the community types. Plots will initially be re-sampled every three years; the time between repeated surveys should be adjusted based on the rates of change measured (high rates of change would call for more frequent surveys). For restoration and active management efforts, the same variables should be measured, but repeated annually until the perennial plant cover and composition within the restoration sites are within the range of values measured within intact portions of that community.

**DESERT PUPFISH**

Desert pupfish, *Cyprinodon macularius*, have been regularly surveyed by the California Department of Fish and Game within the southern Coachella Valley and surrounding the Salton Sea for over a decade. The survey methods presented here reflect their experience and expertise. Data derived from these methods result in an estimate of occupancy within a given body of water or reach of a flowing stream. The methodology will result in a measure of number of pupfish captured per effort, and so under controlled surveys (similar time of year, time of day, temperatures) may represent a relative abundance estimate.

The suggested survey protocol for desert pupfish includes using standard minnow traps. Standard Gee's minnow traps, recommend having 1/8 inch mesh as these are more effective than traps with ¼ inch mesh, are typically set for approximately two hours during the day, and the exact soak time is recorded to the nearest quarter-hour. The minnow traps need to be placed so that their openings are completely below the water surface. Traps are baited with fish-flavored canned cat food (about 1.5 ounces) placed in perforated plastic bags. The number of traps set in a particular water body depends on habitat size and heterogeneity, as well as accessibility; approximately one trap per five meters of accessible shoreline should suffice, however a higher density may be appropriate depending on site conditions. All captured fish and crayfish are identified, counted and released. The general size range of captured pupfish is recorded, as well as the sex ratio when possible and feasible. The presence of other species, such as nonnative snails, is recorded. In habitats where traps fail to capture pupfish, pupfish presence may be documented by observation and dip net. A YSI 85 instrument is used to record basic water quality parameters (temperature, dissolved oxygen, conductivity, specific conductivity, salinity). A Garmin GPS map 60Cx is used to document pupfish capture sites and/or observations.

Once the minnow trap is removed from the body of water being surveyed, the trap needs to be immediately submerged in a bucket filled with water from the same body of water being surveyed. Utmost care should be taken to limit the stress on any pupfish captured in the trap. The minnow trap should be opened while submerged in the bucket and removed leaving its contents in the bucket. The contents should first be visually inspected and quantified to the extent possible. If closer examinations are required to verify identifications, or if fish are too numerous to quantify otherwise, then fish should be carefully removed with a small dip net. After quantifying the trap contents, desert pupfish should be gently released back into the body of water being surveyed.

The entire contents of the minnow trap should be quantified to species or genus; crayfish and aquatic snails clinging to the minnow trap exterior should be included in the tally of species surveyed. Data from each trap should be recorded separately so that data can be summarized as mean/variance for each species/trap effort.

Pertinent desert pupfish research/monitoring objectives & questions (nos. correspond to Fig. 3):

*Questions:*

- **(1, 2, 3, 4, 5 & 6)** What resources drive population dynamics of desert pupfish populations? This is a key to understand and partition the sources of variance resulting from the stressors identified in Figure 2.

- **(1)** Where are the occurrences and the spatial extent of invasive animal species within the desert wetland communities? crayfish, *Procambarus clarkii*, bullfrogs *Rana catesbeiana*, leopard frogs, *R. berlandieri*, various exotic fish species, exotic snails, and other snail species, including, but not limited to, quilted melania (*Tarebia granifera*) and channeled applesnail (*Pomacea canaliculata).*Red rim melania (*Melanoides tuberculatus*) and the quilted melania are particularly abundant in the drains and in some pupfish habitats. Mud snails, ramshorn snails and possibly others may also be present in some habitats. There is also the Asian clam (*Corbicula fluminea)* abundant in the drains and in some refuges. Also spiny softshell turtles (*Apalone spinifera*).How dynamic are those distributions? What variables influence those dynamics?

- **(1)** What distances from source areas serve as barriers to colonization by invasive animal species? What are the vectors of new "inoculations" of invasive species?

- **(1)** What effect do the exotic fish, amphibians and invertebrates have on desert pupfish? Does that effect change with different combinations of invasive species present?

- **(1)** What is the effectiveness of control methods (time/effort/cost/success/recurrence time) for these invasive species?

- **(1)** For aquatic systems, a potential invasive species control method could be to temporarily dry wetlands where water management is possible. What is the effect on native species (pupfish, and rails) of temporarily drying wetlands?

- **(4)** What are the trajectories in the occurrence and abundance of invasive species in each of the wetland communities?

- **(2, 3&4)** How does salinity and groundwater depth impact invisibility?

- **(2, 3&4)** Do invasive plant species impact salinity and groundwater depths?

- **(4)** Where do non-native invasive plant species occur within the wetland communities and what is their spatial extent? Those invasive species include but are not limited to, salt cedar, *Tamarisk ramossisima*, giant reed, *Arundo donax*, fountain grass, *Pennisetum setaceum*, Bermuda grass, *Cynodon dactylon,*

*Objectives:*

- **(1)** For sites being managed for desert pupfish assess the occurrence of pupfish along with invasive, non-native fish, amphibians, ants and snails annually.

- **(1, 2 & 3)** For sites being managed for desert pupfish, water depth, flow rate and salinity will be additional metrics measured. Collecting data for each of these metrics will occur at permanent plots located randomly within the community types, the number of plots will be based on within community heterogeneity as determined through preliminary sampling. These variables will initially be re-sampled on each of the plots the same month every year; the time between repeated surveys will be adjusted based on the rates of change measured (high rates of change would call for more frequent surveys, low variance would call for less frequent surveys).. For restoration and active management efforts, the same variables should be measured, but repeated annually until the perennial plant cover and composition within the restoration sites are within the range of values measured within intact portions of that community.

- **(1)** Create a baseline GIS map of the current extent of exotic, invasive animal species within the MSHCP/NCCP conserved areas. Those invasive species include crayfish, *Procambarus clarkii*, bullfrogs *Rana catesbeiana*, leopard frogs, *R. berlandieri*, various exotic fish species, exotic snails, and other snail species, including, but not limited to, quilted melania (*Tarebia granifera*) and channeled applesnail (*Pomacea canaliculata).*Red rim melania (*Melanoides tuberculatus*) and the quilted melania are particularly abundant in the drains and in some pupfish habitats. Mud snails, ramshorn snails and possibly others may also be present in some habitats. There is also the Asian clam (*Corbicula fluminea)* abundant in the drains and in some refuges. Also spiny softshell turtles (*Apalone spinifera*). Surveys to create this map shall be repeated initially every three years; the time between repeated mapping should be adjusted based on the rates of change measured (high rates of change would call for more frequent mapping).

- **(2&3)** Groundwater levels and salinity are likely to change within the plan area due to many stressors, ranging from groundwater over drafting, tectonic activity, eliminating leakage along the Coachella canal, changing irrigation practices due to reduced water availability and higher costs, climate change, fire, and the effect of invasive species such as salt cedar (Fig 2). Even though the effects may be similar, the management response, if any, will differ based on the source stressor. Within each community, on randomly located plots, or centrally located within a cluster of permanent plots, depth to groundwater, groundwater salinity, and soil salinity and water stable isotope signatures will be quantified the same month every year; the time between repeated surveys will be adjusted based on the rates of change measured (high rates of change would call for more frequent surveys, low variance would call for less frequent surveys).

- **(2, 3&4)** On permanent, randomly located plots located in each of the wetland communities, woody-perennial plant species richness and cover will be quantified every five years. For restoration/management plots, surveys will occur annually until species richness and cover values are within the variances measured on the undisturbed communities.

- For pupfish refugia populations, periodic translocations (approx. every 5-10 yrs) will be conducted to ensure genetic heterogeneity and reproductive fitness.

## SOIL/WATER SALINITY - WATER CHEMISTRY - GROUNDWATER DEPTH

A hand-held Hanna Instruments Soil/Liquid Conductivity meter (or similar device) will be used to determine salinity levels in both open water and in soils, and stable isotope analysis will be used for determining ground water sources or ages. Pieziometers will be installed on permanent plots or within clusters of permanent plots within community polygons.

Pertinent research/monitoring questions and objectives (numbers correspond to Fig. 2):

*Questions:*

- **(2&3)** Salinity and availability of water determine which of the desert wetland communities occur at a given location and thus what species will be able to find suitable habitat there (Fig. 1). What is the spatial extent of each of the desert wetland communities? What is the trajectory of those communities?

- **(2&3)** What is the range of salinity and groundwater depths characterizing each community?

- **(2&3)** What are the thresholds or tipping points of salinity and groundwater depth when communities begin to shift in character from one wetland community to another?

- **(2&3)** What is the source of change in salinity or groundwater that could bring a community to the tipping point of shifting from on community to another? To what extent does the lining of the Coachella canal, changing agricultural practices, tectonic shifts in fault zones, salt cedar densities, and/or climate change (precipitation inputs) impact salinity and groundwater levels?

- **(2&3)** How does salinity and groundwater depth impact the success of restoration efforts of native plant community composition? – Do they affect patterns of native vegetation recruitment?

    - **(2, 3&4)** How does salinity and groundwater depth impact invisibility?

    - **(2, 3&4)** Do invasive plant species impact salinity and groundwater depths?

*Objectives:*

- **(2&3)** Groundwater levels and salinity are likely to change within the plan area due to many stressors, ranging from groundwater over drafting, tectonic activity, eliminating leakage along the Coachella canal, changing irrigation practices due to reduced water availability and higher costs, climate change, fire, and the effect of invasive species such as salt cedar (Fig 2). Even though the effects may be similar, the management response, if any, will differ based on the source stressor. Within each community, on randomly located plots, or centrally located within a cluster of permanent plots, depth to groundwater, groundwater salinity, and soil salinity and water stable isotope signatures will be quantified the same month every year; the time between repeated surveys will be adjusted based on the rates of change measured (high rates of change would call for more frequent surveys, low variance would call for less frequent surveys). .

**PERENNIAL-WOODY PLANTS**

Permanent, randomly located plots will be 10m x 20m rectangles, following plot size and shape used by Stromberg et al. (2007). Plot centers will be random with respect to the community polygon, or in the case of restoration/management activities, random within the bounds of those activities. Where streams or moving water is present, the long axis of the plot will be parallel to that stream; otherwise the long axis will be oriented north-south. Plot corners will be marked with stakes to facilitate relocation in subsequent years. Plot centers will serve as the center for circular plot bird, arroyo toad and southern yellow bat surveys. Using a line intercept down middle of the long length of a permanent plot (see Fig. 5), quantify the percentage cover of live woody vegetation, by species. Where vegetation structure data are desired stratify line intercept levels at 0-1 m, 1-2 m, 2-4 m, and > 4 m.

Pertinent research/monitoring questions and objectives (nos. correspond to Fig. 3):

*Questions:*

- **(4)** Where do non-native invasive plant species occur within the wetland communities and what is their spatial extent? Those invasive species include but are not limited to, salt cedar, *Tamarisk ramossisima*, giant reed, *Arundo donax*, fountain grass, *Pennisetum setaceum*, Bermuda grass, *Cynodon dactylon,*

- **(4)** What are the trajectories in the occurrence and abundance of invasive species in each of the wetland communities?

- **(4)** To what extent do invasive plant species impact the occurrence of species within the wetland communities?

- **(4)** How does disturbance frequency and intensity (ie: from flooding, fires, or ORV trespass) impact the ability of invasive plant species to become established in wetland communities?

- **(4&5)** To what extent do invasive species impact the occurrence of fire in these wetland communities and how does fire impact the invisibility of those exotics?

- **(5)** What is the recolonization rate by native species into wetland communities after fire?

*Objectives:*

- **(2&3)** Create a baseline map of the current condition and extent of the wetland communities. This can be accomplished using current high resolution satellite imagery coupled with ground-truthing. Accurate polygons depicting the location and extent of each of the communities will be defined as GIS layers. This shall be repeated with new/current satellite imagery initially every three years; the time between repeated adjusted in the future based on levels of change between sampling periods.

- **(2, 3&4)** On permanent, randomly located plots located in each of the wetland communities, woody-perennial plant species richness and cover will be quantified every three years. For restoration/management plots, surveys will occur annually until species richness and cover values are within the variances measured on the undisturbed communities.

- **(4)** Create a baseline GIS map of the current extent of exotic, invasive animal species within the MSHCP/NCCP conserved areas. Those invasive species include but are not limited to, salt cedar, *Tamarisk ramossisima*, giant reed, *Arundo donax*, fountain grass, *Pennisetum setaceum*, Bermuda grass, *Cynodon dactylon,* Surveys to create this map shall be repeated initially every three years; the time between repeated mapping should be adjusted based on the rates of change measured (high rates of change would call for more frequent mapping). These data will also feed into the objectives of the low desert weed management area (NRCS).

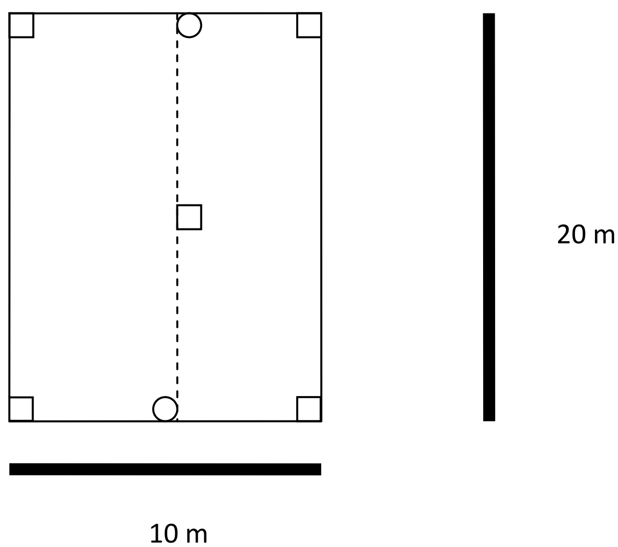



**Figure 5.** This is a permanent plot schematic. Small squares represent stakes marking the plot location; circles indicate recommended arthropod pitfall locations; dotted line shows the location a line-intercept vegetation transect.

## ARTHROPODS

Arthropods can be sampled with dry, un-baited pitfall traps. Previous sampling has shown April to be a peak activity period for the harvester ants, arthropod abundance and species richness, thus pitfall surveys will be confined to this month alone. The pitfall traps measure 11 cm wide at the mouth, 14 cm deep, 1.0 L in volume (Fabri-Kal Corp., model no. PK32T 21), and include a tight fitting funnel that inhibited the ability of the ants to escape once they had fallen into the trap. A board measuring 20 cm x 20 cm x 0.5 cm is placed over the pitfall trap and elevated 1-2 cm with three wooden blocks, providing shade and cover for the arthropods captured by the trap. Place two pitfall traps within each plot, one at each end and the third at the plot middle. Collect the contents within 24 hrs of opening the traps. Arthropod data are summarized as the mean number counted per species per pitfall per plot. All arthropods will be identified to the species level whenever possible, and voucher collections will be made for each species. Pertinent research/monitoring objectives (numbers correspond to Fig. 2.

*Questions:*

- **(7)** What effect do exotic ants have on the occupancy and reproductive success of nesting riparian birds or arroyo toads? If there is an effect, is it through the depletion of native arthropod prey, or through ant predation on nestlings?

*Objectives:*

- **(1&6)** For sites being managed for desert wetland community birds, conduct surveys of arthropod community composition. For sites where exotic species control (including cowbirds) is undertaken, surveys should be annual and an assessment of reproductive success should occur. After three years, if there is small between-year variance, then surveys could be conducted every three years.

## DATA ANALYSES

When developing analytic methods, one must keep in mind one's research objectives. Analysis objectives of biological monitoring should be to 1) identify whether subject population dynamics are headed towards extinction, and 2) what factors (e.g., environmental change, anthropogenic disturbance) are driving observed dynamics. The typical analyses applied to data from monitoring focuses on the first of these objectives, i.e., addressing whether $N_{t^1} \neq N_{t^2}$ or $N_{t^1} = N_{t^2}$. However, quantification of extinction risk requires data that are difficult to acquire and therefore often unavailable (i.e., population viability analysis requires precise estimates of survivorship and fecundity). Furthermore, such an analysis would not identify population drivers (objective 2), which would lead to management actions (Barrows and Allen 2007). We instead focus our analyses, at least initially, on identification of variables that affect variation in abundance or at least are correlated with abundance over time and space. This approach allows analysis of spatial and temporal variation in relative abundance, which is easier to acquire than precise estimates of actual abundance and other demographic parameters. Once the driving factors underlying population change are identified, we will be in a position to evaluate the extent to which these factors reflect natural processes, to which species are more likely adapted, versus anthropogenic-induced processes, which may require management activities. If anthropogenic stressors are identified as population drivers, more detailed demographic studies of stressed species in conjunction with adaptive management may be conducted.

We envision exploring the factors driving population heterogeneity and dynamics in a regression context. For example, we might examine how spatial or temporal heterogeneity in relative abundance (Y) is related to independent variables representing hypothesized population drivers using a linear regression model, $Y = \alpha + \beta_1 * X_1 + \beta_2 * X_2 + \beta_3 * X_3 \ldots$, where $\alpha$ is a constant and $\beta_i$ are coefficients describing the magnitude of effects of population drivers on population size. Examples of where this approach has been successfully applied include analysis of population dynamics of fringe-toed lizards and flat-tailed horned lizards in aeolian sand communities (Barrows 2006, Barrows and Allen 2009, Barrows and Allen 2010). Alternatively, for relatively rare or sparsely distributed species, we may instead examine the distribution of the species among plots (i.e., presence/absence) using logistic regression. Where repeated sampling and distance-sampling are conducted (e.g., avian point counts), we will develop occupancy and abundance models explicitly describing the sampling process (Royle and Dorazio 2008). Some models require specific assumptions, such as homogeneity of variance across levels of explanatory variables and normality of the deviations between observed and model-predicted values for linear regression. Ecological data notoriously violate such assumptions, but recent advances have yielded a variety of alternative analytic methods for a wide range of data structures (Clark 2007, Bolker 2008). Although we have some idea of the types of statistical models that may be useful for addressing certain questions, we do not have complete *a priori* knowledge of how data will be structured until it has been collected. Therefore, we will select regression models best suited to analyzing particular datasets following initial exploratory examination of data structure once the data have been collected. Often multiple models are suited to a given dataset. We will explore the relative importance of various model structures, as well as combinations of independent variables representing various hypotheses, within an information theoretic framework (Burnham and Anderson 2002).

When designing a study and analyzing data, researchers should be concerned with whether there will be or are enough data to address the research questions at hand. This concern is ideally addressed during study design, at which point power analyses may be applied to calculate the necessary sample sizes to address questions of interest (Hayek and Buzas 1997). To conduct a power analysis, a researcher must have in mind a particular effect size that he/she is interested in documenting. However, as is often the case in ecological studies, the precise hypotheses and predictions necessary to conduct power analyses are not available for most of the questions guiding this study. Therefore we use the general rule-of-thumb for multivariate analyses of keeping the ratio between the number of independent variables and the number of observations ≤ 1:10. This rule-of-thumb mainly addresses the potential risk of over-fitting a model to the data (i.e., yielding a non-general model; Osborne and Costello 2004), rather than issues of statistical power. Nevertheless, this rule does provide a useful lower bound for sample size. We anticipate, at least initially, using measurements for individual plots as our unit of observation. Thus, a given model could contain a maximum of one independent variable for every 10 plots. Portions of this protocol involve taking multiple measurements per plot. Since we do not expect measurements to be independent of each other within a plot, an average value for each measurement will be calculated for each plot, resulting in a final measurement that should be reasonably representative of the plot. Since we have not conducted an *a priori* analysis of statistical power, we will consider a lack of power to be a potential explanation for any results from these initial analyses. If statistically marginal but potentially biologically meaningful relationships are apparent, subsequent investigation can incorporate additional plots or alternative sampling protocols to address questions of interest in an adaptive fashion. *Post hoc* power analyses based on preliminary data could be used to inform the design of follow-up studies.

Population responses to environmental heterogeneity are often scale-dependent (Wiens et al. 1986), and we have no *a priori* basis upon which to expect species-environmental sensitivities to arise at any particular scale. The use of a stratified random array of permanent plots would allow analysis of population sensitivities to environmental change at multiple spatial scales. In addition, individual movement or dispersal between adjacent localities could drown out local-scale environmental effects on population size. Such spatial autocorrelation in local abundance could be accounted for by including model parameters associated with the identity of plot clusters and the spatial coordinates of plots in regression models. Spatial autocorrelation would significantly reduce our statistical power to detect local-scale environmental effects, so the presence of spatial autocorrelation could necessitate follow-up studies. Identification of scale-dependencies and elucidation of the spatial scales at which population drivers operate would be critical to effectively inform management decisions.

Unlike the aeolian sand communities where data have been collected for multiple years, for the most part there are not existing data sets to assess the accuracy of proposed methodologies, how landscape heterogeneity effects occupancy levels, or how species are distributed across these landscapes. The initial 2-5 years of surveys within the desert wetland communities will need to assess these questions so that the distribution and number of survey plots needed to model variables that correlate with population dynamics can be developed.

**LITERATURE CITED**

Barrows, C. W. 2006. Population Dynamics of a Threatened Dune Lizard. Southwestern Naturalist 51:514-523.

Barrows, C. W. and M. F. Allen. 2007. Biological Monitoring and Bridging the Gap between Land Management and Science. Natural Areas Journal 27:194-197.

Barrows, C. W., E. B. Allen, M. L. Brooks, and M. F. Allen. 2009. Effects of an Invasive Plant on a Desert Sand Dune Landscape. Biological Invasions 11:673-686.

Barrows, C. W. and M. F. Allen. 2010. Patterns of Occurrence of Reptiles Across a Sand Dune Landscape. Journal of Arid Environments 74:186-192.

Bolker, B. M. 2008. Ecological Models and Data in R. Princeton University Press, New Jersey.

Burnham, K. P. and D. R. Anderson. 2002. Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach. 2nd Edition. Springer-Verlag, New York.

Clark, J. S. 2007. Models for Ecological Data. Princeton University Press, New Jersey.

Coachella Valley Mountains Conservancy 2000. Administrative review draft Coachella Valley Multiple Species Conservation Plan/Natural Communities Conservation Plan. Coachella Valley Association of Governments, Palm Desert, California

DeSante, D. F. 1981. A Field Test of the Variable Circular-Plot Censusing Technique in a California Coastal Scrub Breeding Bird Community. In, C.J. Ralph and M. Scott eds., Estimating Numbers of Terrestrial Birds. Studies in Avian Biology No. 6, Cooper Ornithological Society.

Hayek, L., and M.A. Buzas. 1997. Surveying Natural Populations. Columbia University Press, New York, New York. 563 pp.

Holland, R. F. 1986. Preliminary Descriptions of the Natural Communities of California. State of California, the resources Agency, Department of Fish and Game, Natural Heritage Division, Sacramento, California.

Osborne, J. W., and A. B. Costello. 2004. Sample Size and Subject to Item Ratio in Principal Components Analysis. Practical Assessment, Research and Evaluation 9 (11).

Ralph, C. J., G. R. Geupel, P. R. Pyle, T. E. Martin, D. F. DeSante. 1993. Handbook of Field Methods for Monitoring Landbirds. General Technical Report. PSW-GTR-144. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture. 41pp.

Reynolds, R. T., J. M. Scott, and R. A. Nussbaum. 1980. A Variable Circular-Plot Method for Estimating Bird Numbers. Condor 82:309-313.

Royle, J. A. and R. M. Dorazio. 2008. Hierarchical Modeling and Inference in Ecology. Elsevier Academic Press, Oxford, UK.

Stromberg, J. C., T. J. Rychener, and M. D. Dixon. 2007. Return of Fire to a Free-Flowing Desert River: Effects on Vegetation. Restoration Ecology 15:1-12.

Weller, T. J. 2008. Using Occupancy Estimation to Assess the Effectiveness of a Regional Multiple-Species Conservation Plan: Bats in the Pacific Northwest. Biological Conservation 141:2279-2289.

Wiens, J. A., J. F. Addicott, T. J. Case, and J. Diamond. 1986. Overview: The Importance of Spatial Scale and Temporal Scale in Ecological Investigations. Pages 145-153 *in* J. Diamond and T. J. Case, editors. Community Ecology. Harper and Row, New York.

## APPENDIX 1.

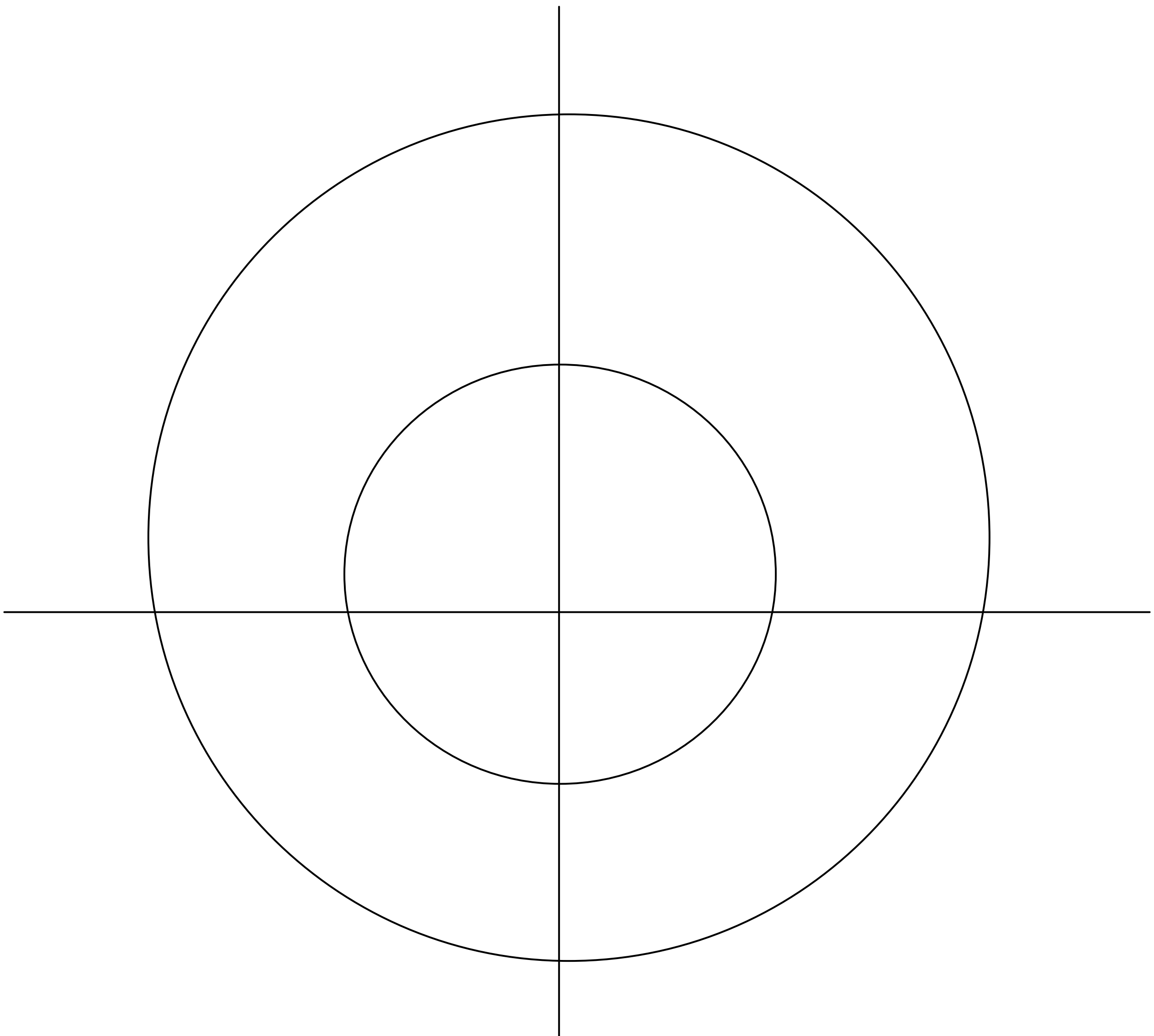
### POINT COUNT DATA FORM: RIPARIAN BIRDS

Location ______________________ Date ____________ Observer ____________________

Time Start________ Time End_______ Point ____ of _____ Visit # _______

Temp (C) ______ Wind ________________ Sky_______________________

UTM (easting, northing)____________________________________________________



Fly-Overs: ________________________________________

__________________________________________________

V=visual, C=call, S=song
Count for 15 min.
1=obs'd in 0-3 minute count period
2="" 3-5 min.
3="" 5-10 min.
4=""10-15 min.
Ring 1=25m, Ring 2=50m,
Outside Ring 2 is any detection >50m

RIPARIAN HABITAT ASSESSMENT FORM

Point location:___________________________ Date:___________ Observer: __________

| | grade (0-3) | Description (distance from point; amount; quality) |
|---|---|---|
| SURFACE WATER | | |

| | Apx. total width | Apx. total length | % of 50m circle | % cov by veg |
|---|---|---|---|---|
| RIPARIAN HABITAT | | | | |
| Description of riparian habitat (community type; quality) | | | | |

| DOMINANT VEG SPECIES | % rel cov | Avg. height | Notes/other species: |
|---|---|---|---|
| 1) | | | |
| 2) | | | |
| 3) | | | |
| 4) | | | |

| | N | S | E | W |
|---|---|---|---|---|
| DENSIOMETER/PHOTOS | | | | |

| HUMAN ACTIVITY | grade (0-3) | Description (recent/old activity; extent; in/near habitat) |
|---|---|---|
| trash/litter | | |
| damaged/removed vegetation | | |
| vehicle tracks/presence | | |
| paved roads/structures | | |
| human footprints/presence | | |
| other (describe) | | |

| OTHER DISTURBANCES | grade (0-3) | Description (recent/old damage; extent; in/near habitat) |
|---|---|---|
| cattle tracks/presence | | |
| flood damage | | |
| fire damage | | |
| other (describe) | | |

| INVASIVE NON-NATIVES | grade (0-3) | Description (species; extent; in/near habitat) |
|---|---|---|
| tamarisk | | |
| arundo | | |
| fountain grass | | |
| other shrubs and trees | | |
| other grasses and herbs | | |

| LANDSCAPE (other habitat types <50m; known habitat types and disturbances 50m-1km; description): |
|---|
| |

| OTHER NOTES: |
|---|
| |

(grades: 0=absent, 1=small amount, 2=moderate amount, 3=large amount or substantial)