Coachella Valley
Multiple Species Habitat Conservation Plan/
Natural Community Conservation Plan

2013 Annual Report




Submitted by
Coachella Valley Conservation Commission

June 2014

Table of Contents

Appendices

I. Rules for Land Acquisition and Management Credit

II. (A). Biological Monitoring Report

(B). Coachella Valley Wildlife Corridor Analysis

III. Table of Acquisitions for Conservation in 2013

IV. Status of Conservation Objectives by Conservation Area

V. Covered Activity Impact Outside Conservation Areas

I. Introduction

The Coachella Valley Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan (CVMSHCP) is a regional multi-agency conservation plan that provides for the long-term conservation of ecological diversity in the Coachella Valley region of Riverside County. The California Department of Fish and Wildlife (CDFW) issued the Natural Community Conservation Plan (NCCP) Permit for the CVMSHCP on September 9, 2008. The U.S. Fish and Wildlife Service (USFWS) issued the federal permit on October 1, 2008, completing a planning process that was initiated in 1996. The term of the permits is 75 years, which is the length of time required to fully fund implementation of the CVMSHCP.

The CVMSHCP includes an area of approximately 1.1 million acres in the Coachella Valley region within Riverside County. The plan area boundaries were established to incorporate the watersheds of the Coachella Valley within the jurisdictional boundaries of CVAG and within Riverside County. Indian Reservation Lands are not included in the CVMSHCP although coordination and collaboration with tribal governments has been ongoing.

The Coachella Valley Conservation Commission (CVCC) is the agency responsible for CVMSHCP implementation. The CVCC is comprised of elected representatives of the Local Permittees including Riverside County, the cities of Cathedral City, Coachella, Desert Hot Springs, Indian Wells, Indio, La Quinta, Palm Desert, Palm Springs, and Rancho Mirage, the Coachella Valley Water District, and the Imperial Irrigation District. The Riverside County Flood Control and Water Conservation District (County Flood Control), Riverside County Regional Park and Open Space District (County Parks), and Riverside County Waste Resources Management District (County Waste) are also Local Permittees. Other Permittees include three state agencies, the California Department of Parks and Recreation (State Parks), the Coachella Valley Mountains Conservancy (CVMC), and the California Department of Transportation (CalTrans). The major amendment process to include all of the City of Desert Hot Springs and Mission Springs Water District as Permittees is expected to conclude in 2014.

The CVMSHCP involves the establishment of an MSHCP Reserve System to ensure the conservation of the covered species and conserved natural communities in perpetuity. The existing conservation lands managed by local, state, or federal agencies, or non-profit conservation organizations form the backbone of the MSHCP Reserve System. To complete the assembly of the MSHCP Reserve System, lands are acquired or otherwise conserved by the CVCC on behalf of the Permittees, or by Permittee contributions in three major categories:

- Lands acquired or otherwise conserved by the CVCC on behalf of the Permittees, or through Permittee contributions
- Lands acquired by state and federal agencies to meet their obligations under the CVMSHCP
- Complementary Conservation lands including lands acquired to consolidate public ownership in areas such as Joshua Tree National Park and the Santa Rosa and San Jacinto Mountains National Monument. These acquisitions are not a Permittee obligation but are complementary to the Plan.

In addition to acquisition, land in the MSHCP Reserve System may be conserved through dedication, deed restriction, granting a conservation easement, or other means of permanent conservation. To meet the goals of the CVMSHCP, the Permittees are obligated to acquire or otherwise conserve 100,600 acres in the Reserve System. State and federal agencies are expected to acquire 39,850 acres of conservation land. Complementary conservation is anticipated to add an additional 69,290 acres to the MSHCP Reserve System. Figure 1 shows the progress as of December 31, 2013 toward the land acquisition goals identified in Table 4-1 of the CVMSHCP. Table 1 shows the breakdown of Conservation Credit since the issuance of the federal permit in October 2008. Significant progress has been made with over 83,000 acres of conservation lands acquired since 1996.

CVCC has recently completed a major update of the Acquisition Database in cooperation with CVMC, CDFW and USFWS. Most of the land conserved since 1996 has been accomplished by entities other than CVCC and the records associated with acquisitions have not always been complete or consistent. All acquisition records and the acreage figures used thoughout the 2013 Annual Report.have now been updated and made consistent with the rules shown in Appendix 1.

Figure 1: CVMSHCP Conservation Progress Toward Goals

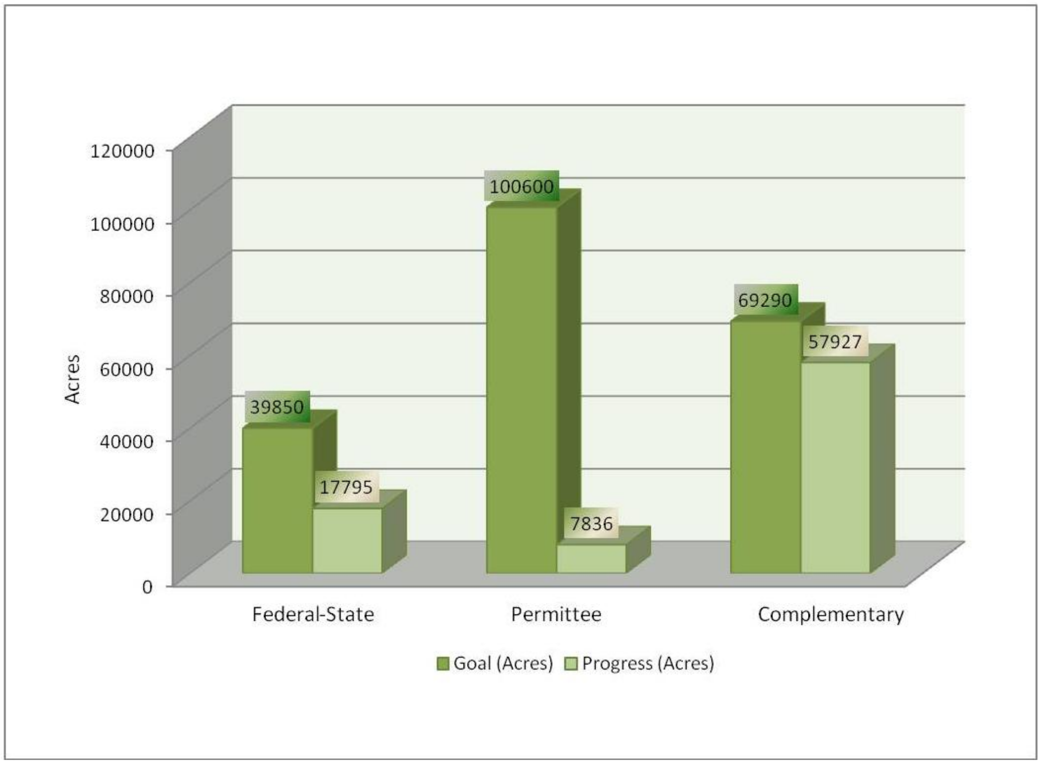


Table 1: Acres of Conservation Credit

Conservation Credit	Goal	Total Progress	1996 - 2009	2010	2011	2012	2013
Federal - State	39,850	17,795	14,362	511	164	1,597	1,161
Permittee	100,600	7,836	6,056	377	410	509	485
Complementary	69,290	57,927	48,368	2,210	4,707	1,916	726
Total	**209,740**	**83,558**	**68,785**	**3,098**	**5,280**	**4,022**	**2,372**

Table 2: Acres of Management Credit

Management Credit	Progress
Federal - State	50,625
Permittee	9,999
Complementary	22,934
Total	**83,558**

Reporting Requirements:

This Annual Report describes the activities for the period from January 1, 2013 to the end of the calendar year on December 31, 2013. As required by Section 6.4 of the CVMSHCP, this Annual Report will be presented at the CVCC meeting of June 12, 2014, where the report will be made available to the public. The report is also posted on the CVMSHCP website, www.cvmshcp.org.

II. Status of Conservation Areas: Conservation and Authorized Disturbance

The CVMSHCP identifies both qualitiative and quantitative conservation goals and objectives that must be met to ensure the persistence of the Covered Species and natural communities. The CVMSHCP is based on a very quantitative approach that is designed to be as objective as possible. The CVMSHCP includes specific acreage requirements for both the amount of authorized disturbance that can occur and the acres that must be conserved within each Conservation Area. These acreage requirements are identified in conservation objectives for each Covered Species and natural community as well as for essential ecological processes and biological corridors and linkages. The conservation objectives provide one measure of the progress toward meeting the requirements of the CVMSHCP under the state and federal permits. This report provides a detailed accounting of the status of the conservation objectives for each of the Conservation Areas up to December 31, 2013.

The planning process for the CVMSHCP was initiated on November 11, 1996, which is the baseline date for the acreages listed in the tables in Sections 4, 9, 10 and throughout the CVMSHCP document. This Annual Report provides an update of these baseline tables to account for all the Conservation and Authorized Disturbance that has occurred between January 1, 2013 and December 31, 2013.

Table 3 provides a summary of the amount of conservation and the acres of disturbance authorized within Conservation Areas in 2013. Authorized disturbance results from development projects in the Conservation Areas. In 2013, there was no Authorized Disturbance reported. The Total Authorized Disturbance in Table 3 includes Authorized Disturbance in years since 1996 that had not been reported to CVCC in the year in which the Disturbance occurred.

Table 3: Conservation and Authorized Disturbance Within Conservation Areas

Conservation Area	Conserva-tion Goal	Conserved in 2013	Conserved Since 1996	Allowed Authorized Disturbance	Authorized Disturbance in 2013	Total Authorized Disturbance since 1996
Cabazon	2,340	0	0	260	0	0
CV Stormwater Channel and Delta	3,870	0	0	430	0	5
Desert Tortoise and Linkage	46,350	270	3,534	5,150	0	0
Dos Palmas	12,870	42	2,206	1,430	0	0
East Indio Hills	2,790	0	0	310	0	0
Edom Hill	3,060	0	2,039	340	0	1
Highway 111/I-10	350	1	52	40	0	0
Indio Hills Palms	2,290	0	1,039	250	0	0
Indio Hills/Joshua Tree National Park Linkage	10,530	94	8,921	1,170	0	5
Joshua Tree National Park	35,600	4	12,398	1,600	0	0
Long Canyon	0	0	0	0	0	0
Mecca Hills/Orocopia Mountains	23,670	251	5,534	2,630	0	0
Santa Rosa and San Jacinto Mountains	55,890	576	30,118	5,110	0	9
Snow Creek/Windy Point	2,340	0	1,109	260	0	0
Stubbe and Cottonwood Canyons	2,430	26	862	270	0	29
Thousand Palms	8,040	5	3,629	920	0	54
Upper Mission Creek/Big Morongo Canyon	10,810	997	6,625	990	0	21
West Deception Canyon	1,063	0	1,713	100	0	0
Whitewater Canyon	1,440	0	956	160	0	1
Whitewater Floodplain	4140	0	569	460	0	32
Willow Hole	4920	106	2253	540	0	6
Total	234,793	2,372	83,558	22,420	0	163

III. Biological Monitoring Program

In 2013, the CVCC established a Biological Working Group as a mechanism to improve communication and collaboration with the Wildlife Agencies and other professional biologists, and capitalize on the expertise and resources of all our agency partners as well as the UC Riverside - Center for Conservation Biology. The Biological Working Group began meeting on a regular basis in November of 2013 and has developed a framework to improve monitoring protocols, the annual work plan, the three to five year strategic plan, and vetting of completed monitoring activities. The CVCC Habitat Conservation Management Analyst continued to manage contracts and logistics for monitoring and land management efforts, including coordinating meetings of the Reserve Management Unit Committees and the Biological Working Group. A contract with UC Riverside (UCR) - Center for Conservation Biology was approved for continued monitoring of species and science advisory for developing focused research questions and protocols through June, 2014. The Coachella Valley Wildlife Corridor Analysis was completed by UCR with support provided by the Friends of the Desert Mountains and Southern California Edison in 2013. A Western Yellow Bat study was also completed by a graduate student from Green Mountain College.

The CVMSHCP presents a unique, scientifically-based monitoring program for species, natural communities and landscapes listed under the Plan. To ensure long-term conservation goals are attained, monitoring activities are based on a three-phased approach and consist of 1) assessing baseline conditions and developing threat assessments, 2) performing focused monitoring when/if threats are determined, and, if deemed necessary, 3) conducting adaptive management efforts whereby the scientific method is employed to develop best management practices. CVCC has contracted with UCR to serve as the science advisor to provide support consistent with the scientific foundation underlying the monitoring program. In coordination with the Biological Working Group, UCR provides guidance and input on the development of the monitoring program tasks and performs the majority of monitoring efforts with their team of ecologists who have specialties in various aspects of the Coachella Valley desert ecology. The 2013 Annual Monitoring Report submitted by UCR can be found in Appendix 2A and the final report for the Coachella Valley Wildlife Corridor Analysis can be found in Appendix 2B.

Photos: 1 – A hatchling Flat-tailed horned lizard; 2 –Aeolian sand dunes below Mount San Jacinto; 3 - Little San Bernardino Mountains linanthus; 4 – Mecca Aster in full bloom

IV. Land Management Program

Management of lands acquired by CVCC and other local Permittees is coordinated with management of the existing conservation lands owned by state, federal and non-profit agencies. The Reserve Management Oversight Committee (RMOC) is the inter-agency group that provides a forum for coordination of management and monitoring lands within the Reserve System and makes recommendations to the CVCC. The Reserve Management Oversight Committee is supported by the Reserve Management Unit Committees.

The Reserve Management Oversight Committee held regular quarterly meetings on January 23, April 24, and July 24, 2013. The October 2013 meeting was not held due to lack of agenda items. Each RMOC meeting included a report regarding the Monitoring Program and the Land Management Program. At the April meeting, the RMOC reviewed the Reserve Management and Monitoring work plans and priority activities for the upcoming year. The recommendations from the RMOC were incorporated into the CVCC budget for FY 2013/14 and presented to the CVCC at their June 2013 meeting.

All but one of the Reserve Management Unit Plans (RMUPs) were finalized and adopted as of December 2012. CVCC staff will continue to work with Joshua Tree National Park to complete the RMUP for that Conservation Area. These management plans identify management activities for the CVMSHCP Reserve System. CVCC staff continues to coordinate with the RMOC and RMUCs to ensure that monitoring and research activities inform and support management of the Reserve Management Units.

Reserve Management Unit Committees

The six Reserve Management Units (RMUs) facilitate coordinated management by local, state and federal agencies to achieve the Conservation Objectives within the MSHCP Reserve System. The Reserve Management Unit Committee meetings were combined to reduce demands on staff time and provide for better coordination. The full RMUC met on March 6, April 16, September 23, and December 10, 2013. The March 6 RMUC meeting included a visit to some of the wildlife corridor study sites in the Stubbe, Cottonwood, Whitewater, and Dry Morongo Canyons. At the September 2013 meeting, the RMUC held a joint meeting with the Low Desert Weed Management Area to coordinate on invasive species. Because many of the same staff members are involved in both groups and staff resources are limited, these meetings will be coordinated in the future. The group discussed prioritizing invasive species control efforts,volunteer activities, and a weed assessment form.

Trails Management Subcommittee

The Trails Management Subcommittee meetings were held on April 17, June 19, and September 25, 2013. The Subcommittee continued working with jurisdictions on existing ordinances that relate to trail use. Revisions and updates to the Trails Plan which were initiated in spring of 2012 were the focus of the Subcommittee's efforts throughout 2013. A smaller working group of the Trails Management Subcommittee was established to review and discuss proposed changes. The Trails Management Subcommittee (TMS) identified a need to incorporate more flexibility in the Trails Plan. In the original Trails Plan, final approval of certain management actions is conditional on completion of the five year research program. In 2012, the CVCC decided to suspend the plans for a focused research program on trails and bighorn sheep and instead approach research needs on an ongoing, case-by-case basis. The proposed revision to the Trails Plan is inteneded to incorporate a more flexible approach to research to be conducted on an ongoing basis in response to specific questions or management needs. National Monument Manager Jim Foote took on the task of revising the Trails Plan which was then provided to the Trails Working Group for review. During 2013 the Trails Working Group and the subcommittee worked extensively on the Trails Plan revision. The revision is expected to be completed in 2014.

Land Improvement: Acquisition Cleanups

In 2013 the CVCC Acquisitions Manager performed pre-acquisition site inspections and job walks on 39 parcels and 10 projects in multiple Conservation Areas. During these inspections the Land Acquisitions Manager identified illegal dumping, hazardous conditions, OHV & equestrian activity, and the existence of listed species, as well as determined property fencing requirements. As per CVCC's standard Purchase & Sale Agreements, willing sellers are required to clean up illegal dumping and blight prior to closing. Contractors are met in the field by the Acquisitions Manager prior to a required cleanup to review the agency's standards and specifications for the particular site in question. After cleanup the job site is re-inspected to certify that cleanups meet the requirements, and if they are found lacking, the seller is notified if additional work will be necessary. This year, CVCC was directly responsible for removing an estimated 72.69 tons of refuse from the Coachella Valley, covering more than 570 acres and generating over $20,800.00 in contractor revenue from sellers' property sales.

Volunteer clean up efforts are a great opportunity for addressing some of the dumping problems on CVCC lands. The Friends of the Desert Mountains regularly provides volunteer assistance to the CVCC for clean-ups on an as needed basis. Corporate visitors to the region occasionally offer volunteer assistance, including an enthusiastic team from FedEx.

Volunteer Cleanup Projects

Photos: 1 –Fed-Ex volunteers pulling dumped carpet to rally point; 2– Fed-Ex volunteers posing at Indian Ave site cleanup

Whitewater Floodplain Fencing Project

Photos: 1 – Site of Whitewater fencing project looking northwest toward Garnet Hill; 2 – Biologists inspect dunefields for sensitive species; 3 – Pile of chicken wire to be removed from the site; 4 – Evidence of offroad vehicle trespass at the site; 5 – Southward view of ephemeral sand fields from the poleline road access point; 6- Northward view of site looking towards railroad tracks (within line of tamarisk)

Management & Monitoring

Monitoring the status of CVCC conservation lands is an essential and ongoing activity. Regular site visits and patrols are conducted on a weekly basis to various CVCC properties. Unfortunately, illegal dumping and vehicle access continue to be a problem on some of the Reserve lands. In 2013, a significant amount of trash, tires, and other illegal dumping were removed from our lands. A fencing and signage plan was developed and approved by CVCC to target lands in the Upper Mission Creek/Big Morongo Canyon Conservation Area. The plan identified locations for fences, gates, and barriers such as large boulders to be installed. Staff coordinated with city and county staff, utilities, and others to identify any concerns or access needs that needed to be addressed. Implementation of the fencing and signage program will be an ongoing effort. In addition, an experimental fencing project to try to capture windblown sand to improve sand dune habitat was installed on CVCC lands in the Whitewater Floodplain Conservation Area. This project will help to identify the most effective way to capture sand and retain it on the habitat lands.

In 2013, the CVCC approved a Memorandum of Understanding with the Coachella Valley Mountains Conservancy (CVMC) and the Friends of the Desert Mountains (FODM) to memorialize our continued cooperative partnership. The MOU provides for cooperative management of our lands and the potential for using shared equipment. This MOU will help to advance the ongoing coordination and cooperation among the signatories. Staff from the three agencies regularly cooperate on property inspections, installation of signage, and other land management tasks.

1 – Volunteers remove and spray to inhibit growth of invasive Tamarisk in Devil's Canyon; 2-Jennifer Prado poses with signage after a productiove day at Big Morongo Canyon.

V. Land Acquisition to Achieve the Conservation Goals and Objectives of the CVMSHCP

In 2013, CVCC completed 9 transactions acquiring 38 parcels totaling 485 acres at a cost of $1.1 million in CVCC funds. Friends of the Desert Mountains acquired 50 parcels totaling 1,888 acres with $7.1 million in funds from grants by the State of California Wildlife Conservation Board and the Coachella Valley Mountians Conservancy. All of these acquisitions are listed in Table 4. These parcels were acquired at an average cost per acre of $4,080. A table of CVCC acquisitions and/or otherwise conserved lands recorded during the period from January 1, 2013 to December 31, 2013 can be found in Appendix 3. Parcels acquired are listed by Assessor Parcel Number (APN**).** The acreage listed in Appendix 3 is the recorded acreage from the Riverside County Assessor.

Table 4: Lands Acquired by CVCC in 2013

Project	Acres	Conservation Area	Purchase Price
Castro	2.5	Willow Hole	$ 18,000
Chaffin	10	Willow Hole	$ 80,000
Diamico	1	Willow Hole	$ 8,000
Friedman	15.39	Willow Hole	$ 120,000
Hoffman	17.5	Willow Hole	$ 126,000
Ince	2.5	Willow Hole	$ 18,000
Keppler-Campobasso	2.5	Willow Hole	$ 18,000
Picininni	68	Upper Mission Creek/Big Morongo Canyon	$ 600,000
Tax Default Purchase	39.94	Desert Tortoise and Linkage	$ 3,955
Tax Default Purchase	39.12	Santa Rosa and San Jacinto Mountains	$ 12,388
Tax Default Purchase	20.02	Desert Tortoise and Linkage	$ 2,695
Tax Default Purchase	7.51	Desert Tortoise and Linkage	$ 3,576
Tax Default Purchase	38.65	Desert Tortoise and Linkage	$ 2,765
Tax Default Purchase	75.95	Desert Tortoise and Linkage	$ 8,769
Tax Default Purchase	20.12	Desert Tortoise and Linkage	$ 16,687
Tax Default Purchase	1.23	HWY 111/I10	$ 1,428
Tax Default Purchase	5.00	Indio Hills/Joshua Tree National Park Linkage	$ 3,269
Tax Default Purchase	0.43	MWSPA	$ 5,059
Tax Default Purchase	1.30	MWSPA	$ 3,618
Tax Default Purchase	39.00	Santa Rosa and San Jacinto Mountains	$ 2,553
Tax Default Purchase	1.09	Santa Rosa and San Jacinto Mountains	$ 2,010
Tax Default Purchase	1.21	Santa Rosa and San Jacinto Mountains	$ 2,161
Tax Default Purchase	1.02	Santa Rosa and San Jacinto Mountains	$ 1,632
Tax Default Purchase	29.89	Santa Rosa and San Jacinto Mountains	$ 8,622
Tax Default Purchase	33.20	Santa Rosa and San Jacinto Mountains	$ 11,711
Tax Default Purchase	4.98	Thousand Palms	$ 32,619
Tax Default Purchase	2.86	Upper Mission Creek/Big Morongo Canyon	$ 1,279
Tax Default Purchase	0.62	Willow Hole	$ 2,450
Tax Default Purchase	2.51	Willow Hole	$ 1,944
Total Purchases	485.02		$ 1,119,192

Figure 2: Total Acquisitions in 2013 by Conservation Area

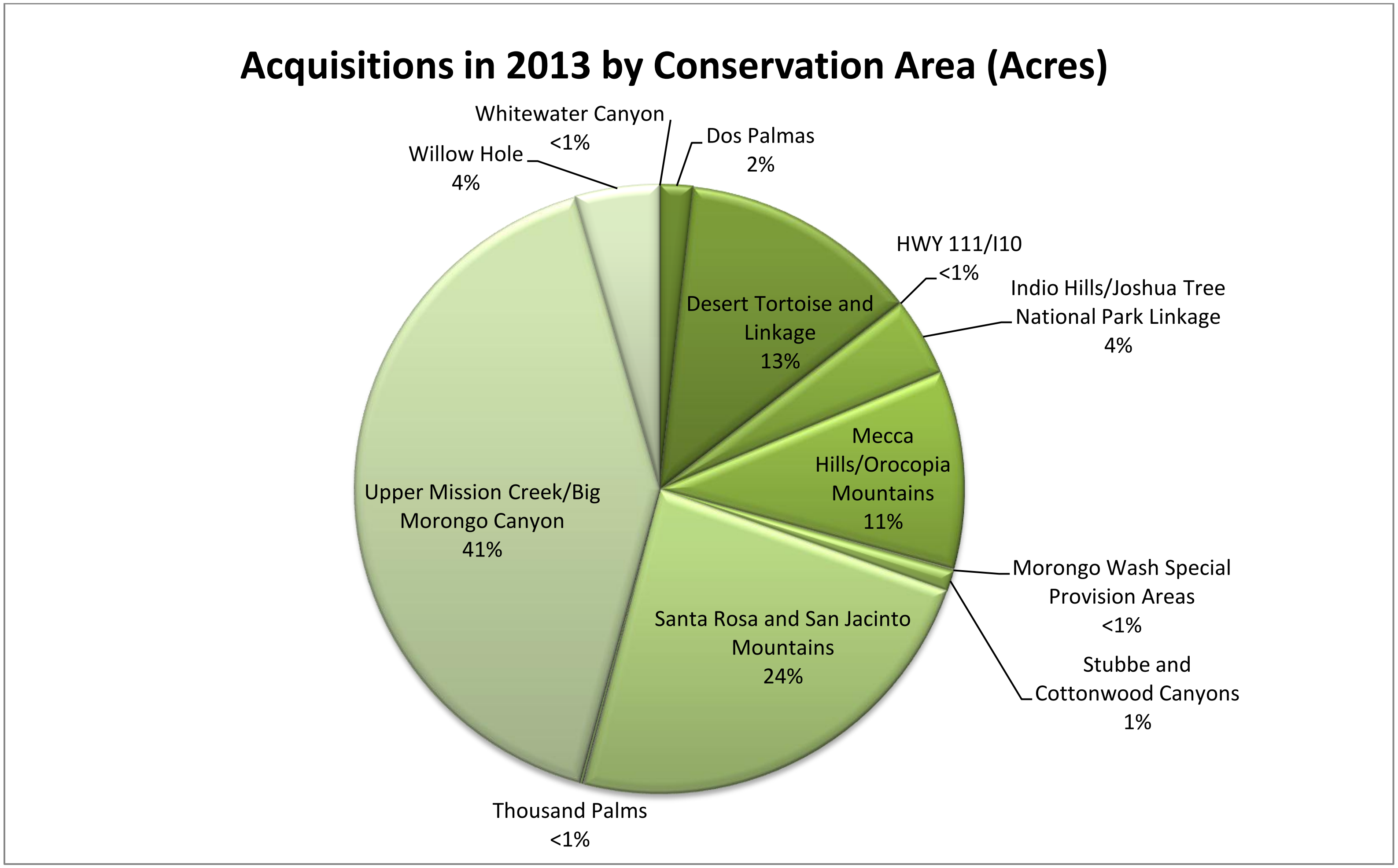


Figure 3: CVCC Acquisitions in 2013 by Conservation Area

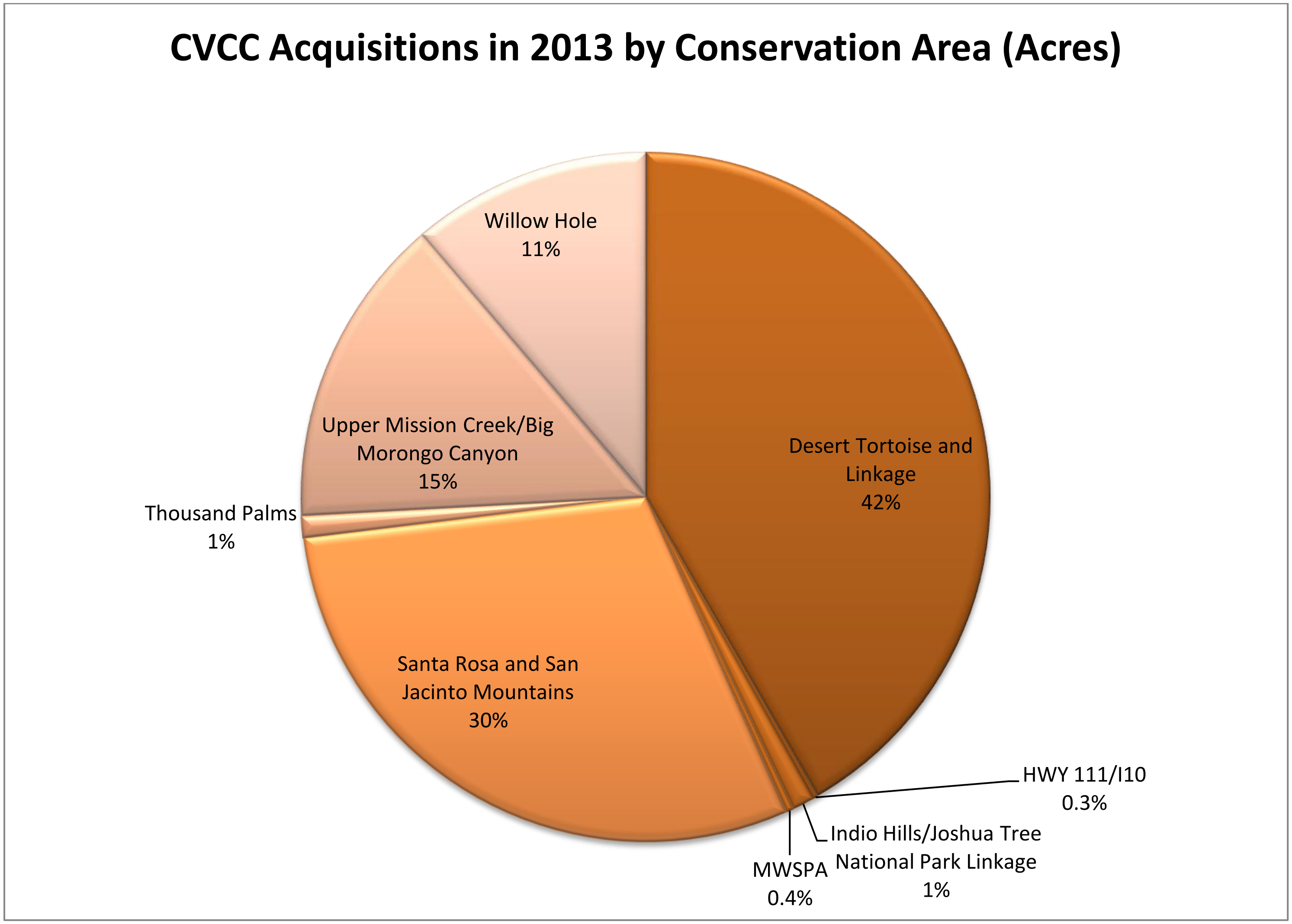
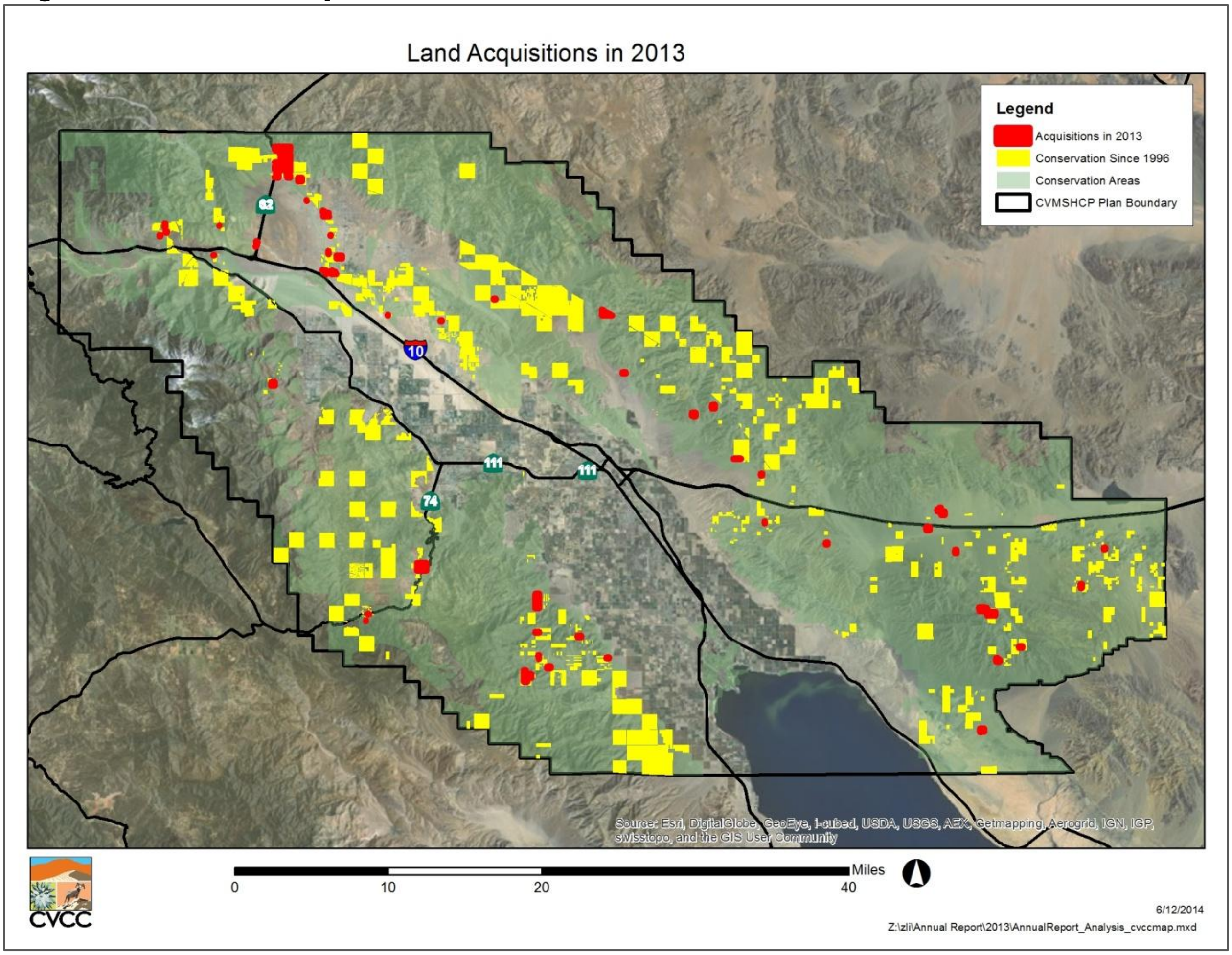


Figure 4: Land Acquisitions in 2013



VI. Conservation and Authorized Disturbance Within Conservation Areas

The progress toward achieving the Conservation Goals and Objectives for the CVMSHCP is reported here from two different perspectives, by Conservation Objective and by Covered Species or natural community. The CVMSHCP includes Conservation Objectives for conserving Core Habitat for Covered Species and conserved natural communities, Essential Ecological Processes necessary to maintain habitat viability, and Biological Corridors and Linkages within each of the 21 Conservation Areas. The amount of conservation and the amount of disturbance are reported in the same tables for comparative purposes. This Annual Report includes the conservation and authorized disturbance from January 1 to December 31, 2013.

The progress toward our goals in terms of the Conservation Objectives is presented in Appendix 4.

VII. Covered Activities Outside Conservation Areas

The CVMSHCP allows for development and other Covered Activities outside the Conservation Areas which does not have to meet specific conservation objectives A table that includes an accounting of the number of acres of Core Habitat and Other Conserved Habitat for the Covered Species and conserved natural communities that have been developed or impacted by Covered Activities outside the Conservation Areas can be found in Appendix 5. This information is listed for each of the Permittees with lands impacted by covered activities outside the Conservation Areas.

Development inside Conservation Areas has been carefully tracked and subject to review under the 1996 Memorandum of Understanding that began the planning process for the CVMSHCP. For development outside Conservation Areas, the acre figures in the table are estimates derived from the Developed area of the California Department of Conservation, Division of Land Resource Protection, Farmland Mapping and Monitoring Program GIS coverages from 1996 and 2008.

See http://www.conservation.ca.gov/dlrp/FMMP/Pages/Index.aspx for more detail on the Farmland Mapping and Monitoring Program.

VIII. Status of Covered Species

An overview of the status of each of the Covered Species for each Conservation Area can be found in Appendix 4.

IX. Significant Issues in Plan Implementation

CVCC has recently completed a major overhaul of the Acquisition Database in cooperation with CDFW, USFWS, Friends of the Desert Mountains (FODM) and the Coachella Valley Mountains Conservancy (CVMC). As part of this overhaul, a series of rules for credit was developed. These rules appear in Appendix 1.

Most of the land conservation since 1996 has been accomplished by entities other than CVCC and the records associated with acquisitions have not always been complete or consistent. All acquisition records and the acreage figures used thoughout the 2013 Annual Report.have now been made consistent with the rules in Appendix 1. This resulted in a recharacterization of acreage credit for the three categories of Federal/State, Permittee and Complementary. The greatest change was for acreage purchased with federal/state funding but located within areas where all federal/state acquisitions are considered Complementary. The Plan in Section 4.2.1 specifically requires that land purchased with Federal/State funds in Joshua Tree National Park, Mecca Hills Orocopia Mountains Wilderness and the Santa Rosa and San Jacinto Mountains National Monument be considered Complementary. In the past, some of these purchases were mistakenly classified as Federal/State. This error and several smaller errors have been corrected.

The basic information recorded for each purchase will now included all the funding information so that the funding source is explicit in each record. The revised Acquisition Database format will be used by CVCC, CVMC and FODM for acquisitions in the future so that the information on each transaction will be consistent.

Cooperation among CVCC, state and federal agencies and non-profits has always been high in the Coachella Valley. Often one organization will fund a purchase, another will take title to the land and then transfer title later to another organization for long term management. To better understand these relationships, beginning with this Annual Report, CVCC will include the acres under management in each of the three categories of Federal/State, Permittee and Complementary.

In 2013, CVCC completed the second Participating Special Entity (PSE) with Southern California Edison (SCE) for coverage of Path 42 transmission line. This PSE provided SCE with a quick turnaround for project approval of only several months as opposed to years for consultations in the past. CVCC received a fee payment of 5% of the project cost, $1,867,923.

Photos: SCE project

CVCC also took responsibility for the land acquisition for mitigation required through the USFWS Biological Opinion for SCE's Devers-Mirage transmission line. CVCC will sell the mitigation value of a number of CVCC owned parcels to SCE and purchase additional acreage to meet the specific mitigation requirements. As of December 31, 2013, SCE had placed into escrow approximately $2.2 million to cover the cost of the land, an endowment for perpetual management and monitoring, and all staff and transaction costs related to this project.

X. Expenditures for CVMSHCP: 2013/2014 Budget

	MANAGEMENT AND MONITORING	GENERAL ADMINISTRATION	LAND ACQUISITION	ENDOWMENT	LIZARD ENDOWMENT	TOTAL
BEGINNING FUND BALANCE	**$ 237,601**	**$ 116,183**	**$ 1,761,075**	**$ 5,330,105**	**$ 308,507**	**$ 7,753,471**
REVENUES:						
Development Mitigation Fees	$ 119,000	$ -	$ 581,000	$ -	$ -	$ 700,000
Agencies Mitigation Fees	-	-	1,558,453	725,590	-	2,284,043
Tipping Fees	-	363,000	-	-	-	363,000
Contributions	-	-	150,000	-	-	150,000
Grants	25,000	-	557,000	-	-	582,000
Other Revenue	-	-	-	-	-	-
Investment Income	1,200	250	6,000	20,000	1,300	28,750
Total Revenues	$ 145,200	$ 363,250	$ 2,852,453	$ 745,590	$ 1,300	$ 4,107,793
EXPENDITURES:						
Administrative Fees	$ 1,190	$ -	$ 5,810	$ -	$ -	$ 7,000
Accounting / Bank Service Charges	-	1,500	-	-	-	1,500
Comprehensive Insurance	-	8,442	-	-	-	8,442
Per Diem Payments	-	8,775	-	-	-	8,775
Office Supplies	-	3,000	-	-	-	3,000
Printing	-	15,000	-	-	-	15,000
Land Improvements	10,000	-	240,000	-	-	250,000
Legal Services	-	72,000	3,000	-	-	75,000
Professional Services	-	8,373	20,000	-	-	28,373
Consultants (Regular funds)	420,820	275,842	294,107	-	-	990,769
Consultants (Grant funds)	100,000	-	-	-	-	100,000
Land Acquisitions	-	-	3,247,000	-	-	3,247,000
Furniture and Equipment	500	-	-	-	-	500
Sub-Total Expenditures	$ 532,510	$ 392,932	$ 3,809,917	$ -	$ -	$ 4,735,359
OTHER						
Operating Transfers Out	$ -	$ -	$ -	$ 316,394	$ -	$ 316,394
Operating Transfers In	(316,394)	-	-	-	-	(316,394)
Sub-Total Other	$ (316,394)	$ -	$ -	$ 316,394	$ -	$ -
Total Expenditures and Other	$ 216,116	$ 392,932	$ 3,809,917	$ 316,394	$ -	$ 4,735,359
Net Excess (Deficit)	$ (70,916)	$ (29,682)	$ (957,464)	$ 429,196	$ 1,300	$ (627,566)
ENDING FUND BALANCE	**$ 166,685**	**$ 86,501**	**$ 803,611**	**$ 5,759,301**	**$ 309,807**	**$ 7,125,905**

XI. Compliance Activities of Permittees

All Permittees are in compliance with requirements of the CVMSHCP. CVCC completed two Joint Project Reviews in 2013.

All the cities are complying with the fee exemption language in the new ordinances (there are no exempted projects under county jurisdiction). All jurisdictions report their Local Development Mitigation Fee (LDMF) activity and remit the revenue to CVCC monthly. CVCC reviews all LDMF reports and receipts monthly. In 2013, a total of $1,113,642 was collected under the LDMF program, a 3% increase over 2012 collections.

XII. Annual Audit

CVCC approved their Fiscal Year 2013/2014 budget at the June 13, 2013 meeting.

The audit of the expenditures for the period July 1, 2012 to June 30, 2013 was approved by CVCC on February 13, 2014. The financial report was designed to provide citizens, members, and resource providers with a general overview of the CVCC's finances, and to show accountability for the money it receives. Questions about this report or for additional financial information can be obtained by contacting the CVCC Auditor, at 73710 Fred Waring Drive, Suite 200, Palm Desert, CA 92260.

XIII. Unauthorized Activities and Enforcement

Off road vehicles and dumping continue to be issues. Currently CVCC forwards reports of ORVs and dumping to the appropriate law enforcement agency. CVCC is working to develop an agreement with the Bureau of Land Management (BLM) under which CVCC would contribute funds to hire additional BLM law enforcement rangers to focus on the Conservation Areas.

Appendix 1
Rules for Land Acquisition and Management Credit

Acquisition Credit

In general, the source of funds for acquisition gets the credit of acres with the following modifications:

1) Per Plan Section 4.2.1 (p. 4-10), purchases with state or federal funding will be considered Complementary in Joshua Tree National Park, the Santa Rosa and San Jacinto Mountains National Monument, and the Mecca Hills and Orocopia Mountains Wilderness areas. Purchases within these areas with CVCC funds will be considered Permittee.
    a. If land purchased with non-federal/state funding in these areas is transferred to CVCC ownership, it will be considered a donation and CVCC will receive Permittee credit if they take title. Examples include:
        i. Purchases by Friends of Desert Mountains (FODM) – only if funds are from private foundations (e.g. Resources Legacy Fund);
        ii. Donations from landowners.

2) Acquisitions in Fluvial Sand Transport Only Areas will be credited to the funding entity (Permittee, Complementary, and Federal/State). Any overlap between Fluvial Sand Transport Only Areas and Joshua Tree National Park, the Santa Rosa and San Jacinto Mountains National Monument, and the Mecca Hills and Orocopia Mountains Wilderness areas, would counted as Complementary otherwise it will be counted as Federal/State or Permittee as appropriate.
    a. If federal/state funds will be counted as federal/state acquisition
    b. If land purchased with non-federal/state funding in these areas is transferred to CVCC, it will be considered a donation and CVCC will receive Permittee credit.

3) For 2013 Annual Report parcels adjacent to Conservation Areas will not be counted but will be included in the overall database and flagged for consideration after the issue of a legal instrument for conservation is resolved.

4) If a grant requires a matching amount, that portion of the grant will be credited to the source of the match . This includes cash contributions and in-kind contributions from bargain sales (not addressed in the plan). This does not include non-federal/state matches of land for a Section 6 grants.
    a. For example, if CVCC has 30% match for a Section 6 grant in-kind from bargain sales then 30% credit of the purchase would be credited to the Permittee category.
        i. Case study: Strommen-Palmwood (the section that contains Big Morongo Canyon, about 1/3 of the entire Palmwood project). It was appraised at $5.155M and sold for $4M and the $1.115M donation was used as a 30% match on federal Section 6 grant. The Permittees get 30% of the acreage credit and Federal/State gets 70% acreage credit for everything purchased with that Section 6 grant.

5) Mitigation for projects outside Plan Area (Wildlands, Inc. is the only current example ~ 7,000 acres) or mitigation for project not Covered as part of the Plan (Southern California Edison purchase of the mitigation value of CVCC in 2014) are included in the database but are zero for all credit and noted “conserved but it does not count for the Annual Report or Plan acreage numbers.”

6) No Acres within any Tribal Land are counted for the CVMSHCP under any circumstances as Tribal Land is “Not A Part” of the CVMSHCP Plan Area.

Management Credit

The land owner will be considered the managing entity except in the case of written agreement, including conservation easements, which transfer management responsibility to another entity. Fluvial Sand Transport Only Areas and conserved parcels adjacent to Conservations Areas will be included in Management Credit.

All acreage amounts are determined by calculating the acreage of a parcel using the most recent GIS layer from the Riverside County Assessors Office projected in the Universal Transverse Mercator (UTM) projection, Zone 11 North, North American Datum of 1984.

Some Relevant Sections of the Plan:

4.2.1 Complementary Conservation

Several acquisition efforts for Conservation purposes are ongoing. These acquisition programs have broader rationales than the MSHCP program and are independent of the MSHCP effort, though they may be coordinated with it. They complement implementation of the MSHCP, but the acquisition is not a Permittee obligation for purposes of the authorization of Take. In the case of public agencies, the goal of these acquisition programs is to consolidate public ownership of lands within Joshua Tree National Park, the Santa Rosa and San Jacinto Mountains National Monument, and the Mecca Hills and Orocopia Mountains Wilderness areas. Other Complementary Conservation includes acquisitions by non-profit organizations and possibly Tribal acquisition of land for Conservation purposes outside reservation boundaries. Between 1996 and November 2006, Complementary Conservation has accounted for the conservation of approximately 36,900 acres in the Conservation Areas. Table 4-5 shows where this Complementary Conservation has occurred, as well as where future Complementary Conservation is projected to occur.

During the term of the Permits, approximately 29,990 acres of additional Complementary Conservation is projected to occur in the Conservation Areas after November 2006. Based on past performance, this is a reasonable estimate of the acquisitions that might be accomplished through these programs over the life of the Permits. For purposes of projecting acquisition costs for the Plan, it has been assumed that future Complementary Conservation will occur in Joshua Tree National Park, the Santa Rosa and San Jacinto Mountains National Monument, and the Mecca Hills and Orocopia Mountains Wilderness areas. Figure 4-3 shows the location of these projected future Complementary Conservation areas. Acquisitions by non-profit organizations or Tribes may also occur in the Conservation Areas. Any such acquisitions will be considered as part of the Complementary Conservation acres projected under the Plan, as long as the Conservation is not for mitigation for projects or other HCPs. CVCC shall note in its Annual Report to the Wildlife Agencies how much land, if any, non-profit organizations and the Tribes have acquired in the Conservation Areas. If, during the course of Plan implementation, Complementary Conservation is not occurring as anticipated, the Parties will meet and confer regarding impacts to meeting Conservation Objectives.

4.2.1.1 Tribal Land outside the Reservation

Between 1996 and 2003, the Agua Caliente Band of Cahuilla Indians purchased approximately 3,800 acres of land outside the Indian Reservation and within the Santa Rosa and San Jacinto Mountains Conservation Area. This land is the subject of a proposed land exchange between the Agua Caliente Band and the Bureau of Land Management. It is not known at this time how much of the 3,800 acres may ultimately be included in the exchange. The purpose of the proposed land exchange is to consolidate tribal land inside the external boundaries of the reservation, and for BLM to consolidate its land within the Santa Rosa and San Jacinto Mountains National Monument. BLM would obtain some or all of the 3,800 acres of tribal lands outside the reservation. Upon completion of the land exchange, the CVCC will coordinate with the Agua Caliente Band of Cahuilla Indians regarding the preparation of a Minor Amendment without Wildlife Agency concurrence to adjust land ownership and conservation acreages in this Conservation Area.

4.2.2 Additional Conservation Lands

A minimum of 129,690 acres in the Conservation Areas will be conserved as Additional Conservation Lands after November 2006, to be acquired or otherwise conserved through state and federal acquisitions, Permittee contributions, and the Conservation of public and quasi-public lands.

4.2.2.1 The Role of Federal and State Governments in Assembly of the Reserve System

Sensitive species and their Habitats are public resources; the benefits of protecting these resources accrue broadly to the citizens of the state and the nation. The federal and state governments have acknowledged their role in Habitat Conservation and agree to assist in creating an MSHCP Reserve System that reduces or avoids the need to list additional species and contributes to the recovery of Covered Species. Between 1996 and November 2006, the state and federal governments have acquired or funded the acquisition of 37,700 acres in the Conservation Areas (in addition to Complementary Conservation). Through the MSHCP and its IA, the federal and state governments have agreed to partner with the Permittees in assembling, managing, and monitoring the MSHCP Reserve System. The federal and state governments will undertake the following actions:

• Acquire 21,390 acres of privately owned lands in the Conservation Areas after November 2006, as a contribution to Plan implementation.

• Manage certain federal and state lands in the MSHCP Reserve System.

• Participate in the Monitoring and Adaptive Management Program for the MSHCP Reserve System.

Biological value, cost, vulnerability to Development, and proximity to existing state and federal lands will be considered in determining which lands are acquired. State and federal potential funding sources and programs for land acquisition are described in Section 5 of the Plan.

4.2.2.2 Permittees’ Obligation in Assembly of the MSHCP Reserve System

As of 2006, the Permittees have an obligation to conserve approximately 115,140 acres in the Conservation Areas through:

• Conservation of 7,500 acres of currently non-conserved Local Permittee-owned lands. [See Section 4.2.2.2.1.]

• Conservation of 88,900 acres of Additional Conservation Lands by the Local Permittees and Caltrans through acquisition or other means, such as planning tools and land use regulation and the acquisition of 640 acres by State Parks, of which 100 acres can be developed for State Park facilities. [See Section 4.2.2.2.2.]

• Management of 18,200 acres of Local and State Permittee Existing Conservation Lands consistent with the MSHCP. [See Section 4.2.2.2.3.]

In addition, the Permittees will maintain the fluvial sand transport Essential Ecological Process in the Cabazon, Long Canyon, and West Deception Canyon Conservation Areas as described in Section 4.2.2.2.4.

Appendix 2A
Biological Monitoring Report

Coachella Valley Conservation Commission

June 30, 2013

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

Biological Monitoring Program

2012-2013 Year-End Report

Prepared by the University of California Riverside's Center for Conservation Biology

for the Coachella Valley Conservation Commission

Permittees and Partners to the
Coachella Valley Multiple Species Habitat Conservation Plan and
Natural Communities Conservation Plan

Permittees

Coachella Valley Association of Governments
Coachella Valley Conservation Commission
California Department of Parks and Recreation
Coachella Valley Mountains Conservancy
California Department of Transportation

Riverside County Flood Control
Riverside County Waste Resources Management District
Riverside County Regional Park & Open-Space District

City of Palm Springs
City of Cathedral City
City of Rancho Mirage
City of Palm Desert
City of Indian Wells
City of La Quinta
City of Indio
City of Coachella

Coachella Valley Water District
Imperial Irrigation District

Partners

United States Department of Fish and Wildlife
California Department of Fish and Wildlife
United States Bureau of Land Management
United States Forest Service
Joshua Tree National Park
Friends of the Desert Mountains
Center for Natural Lands Management

Table of Contents

List of Figures

I. Biological Monitoring Program Overview

The CVMSHCP provides for the long-term sustainability of covered species, communities and landscapes in reserve areas located throughout the Coachella Valley. To ensure that ecological conditions are maintained and species populations are vigorous, a biological monitoring framework was designed to inform the CVCC, wildlife agencies, and resource managers of the status of the plan's covered species and communities, and also to provide clear analyses as to the mechanisms behind any spatial and temporal fluctuations observed. The purpose of the biological monitoring program is to assess the success the CVMSHCP has in meeting its biological conservation goals, and to quantify the risk and urgency for any management actions that may be needed to support the continued sustainability of covered species and communities. The structure of the CVMSHCP monitoring framework is prescribed in CVMSHCP Chapter 8, "MSHCP Reserve System Management & Monitoring Program." That chapter describes goals and objectives of the monitoring and management programs, describes how the CVMSHCP reserve system will be managed, describes the monitoring program and how the monitoring and management programs will be integrated, describes research programs that will be performed under the CVMSHCP, and describes the archiving and reporting of information.

Scientific Principles

Section 8.3.2 of the CVMSHCP defines eight scientific principles "that will establish the standard for collection, analysis, and interpretation of data generated in this program. These principles will ensure a program that is scientifically rigorous, question-based, and with the strongest inference possible. These principles will also ensure that monitoring efforts efficiently provide data that are relevant and enable valid comparisons between populations separated by distance and time." The principles are:

1. Define the question. Monitoring strategies will be designed to address specific hypotheses. Conceptual, statistical, and spatially explicit models will define those hypotheses.
2. Define the area, also known as the target population, and create a sampling frame to which the statistical inference will be made.
3. Develop and state the assumptions in the hypotheses and models *a priori* to collecting monitoring data or conducting manipulations such as experiments and adaptive management.
4. When designing an experiment or using adaptive management, randomly select the units, randomize the allocation of treatments to the units, and use controls.
5. Use probability-based sampling to allocate sampling effort and incorporate spatial variation in the data. Using probability-based sampling allows unbiased inferences to the larger area (Morrison et al. 2001).
6. Replicate in space and time the number of sites surveyed during monitoring (e.g. survey sampling) and those receiving a treatment/management action.
7. Adjust the sensitivity of the data to reflect true changes in the resource being sampled. Adjust counts, measures of species richness, and patch occupancy (i.e., presence/absence) with an estimate of detection probability, such as those described by Lancia et al. (1994), Yoccoz et al. (2001), and Pollock et al. (2002).
8. Describe the methods and the assumptions of the methods used to collect and analyze data.

The CVMSHCP's biological monitoring framework is a departure from most monitoring programs being implemented elsewhere. As it represents a novel, innovative approach compared to previous biological monitoring standards it is important to both describe its philosophical basis and to have the framework receive rigorous peer review to ensure that it provides a scientific structure for meeting the information need or wildlife agencies and resource managers. The following publications demonstrate that peer review of the monitoring framework has occurred and continues.

Barrows, C.W. 1996. An ecological model for the protection of a dune ecosystem. Conservation Biology 10(3): 888-891.

Barrows, C.W., M.B. Swartz, W.L. Hodges, M.F. Allen, J.T. Rotenberry, B. Li, T. A. Scott and X. Chen. 2005. A framework for monitoring multiple species conservation plans. Journal of Wildlife Management 69:1333-1345.

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. 2013. An Ecosystem Approach to Defining Conservation Boundaries: Concepts and a Case Study. Natural Areas Journal 33

The biological monitoring program involves several fundamentally different types of monitoring. These types collectively represent a variety of different spatial, temporal, and functional scales. They have been chosen to present an accurate understanding of both the status of the species and ecosystems being monitored, and the effectiveness of management activities intended to influence those species and ecosystems. Species monitoring provides an assessment of covered species' abundances and/or occurrences as well as a determination of whether changes in those metrics constitute a need for new management actions. Community monitoring creates a context for understanding observed species dynamics as well as provides a measure of the condition of the covered communities. While community monitoring addresses the condition of habitat patches, landscape monitoring considers size, location, and distribution of these patches along with connecting corridors, and their dynamics over time in response to variation in natural and anthropogenic stressors. Further explanation of each type of monitoring follows.

Species Monitoring

There are 27 covered species under the CVMSHCP. Monitoring of individual covered species focuses on an understanding of patterns of occupancy, habitat use, measures of abundance and in particular species responses to natural and anthropogenic stressors. To efficiently acquire data on individual species, the CVMSHCP monitoring protocols group together individual species surveys within a "community context". That context means that in addition to species-specific occurrence data, information on resource abundance, substrate, disturbances, invasive species, predators, and potential competitors – the context that may explain the occurrence or abundance of a species – are also collected. This community context requires little additional survey time and generates a wealth of critical data for developing and evaluating hypotheses regarding individual species. Thus species monitoring not only provides scientifically defensible estimates of occurrence and/or measures of abundance but also provides critical ecological information, enabling better management, thus increasing the probability of successful conservation. Regular species monitoring tracks responses to resource fluctuations and, when methods are appropriately sensitive, identifies the level of impacts stressors have on individual species.

The conceptual, and later statistical, relationships between species abundance and/or occurrence with potential stressors can be modeled, and models can be used to focus future monitoring and identify thresholds for management actions. This represents the fundamental difference between the CVMSHCP's biological monitoring framework and monitoring elsewhere. Other monitoring programs focus on documenting species abundances or occurrences but often fail to identify the driver/stressors that influence that abundance or occupancy. This leaves a gap between documenting population change over time and understanding what is driving that change, whether that change warrants management action, and importantly identifying thresholds for initiating a change in management. In addition to tracking performance relative to goals and objectives for covered species, species monitoring should facilitate adaptive management, providing information on local-scale or short-term responses to adaptive management experiments.

For each covered species, a sampling design and monitoring methods are specified in the monitoring protocol for each community in which that species is primarily associated. Each protocol also evaluates alternative sampling methodologies, defines conceptual ecological models for each community, and selects and tests habitat metrics based on those ecological models. The details are different for each protocol but each uses quantitative methods that produce data robust enough for statistical analysis, in a manner consistent with the Plan's scientific principles.

A science-based monitoring framework is a process that follows steps that serve to ensure that the findings meet sufficient rigor. Those steps begin with questions and hypotheses and culminate with external peer review and reporting of results. This final step of peer review and then reporting is an essential means of establishing that the methods, analyses, and interpretations meet currently accepted levels of science. The following are publications based on monitoring-based species scale research conducted through the development and now implementation of the CVMSHCP that serve as a resource to the CVCC, habitat managers, and regulatory agencies to evaluate both the progress of the CVMSHCP at meeting conservation goals, to set habitat management priorities, and guide actions.

Barrows, C.W. 1997. Habitat relationships of the Coachella Valley fringe-toed lizard, *Uma inornata*. Southwestern Naturalist 42(2): 218-223.

Barrows, C.W. 2006. Population dynamics of a threatened dune lizard. Southwestern Naturalist 51:514-523.

Barrows C.W., K.L. Preston, J.T. Rotenberry, M.F. Allen. 2008. Using occurrence records to model historic distributions and estimate habitat losses for two psammophilic lizards. Biological Conservation 141:1885-1893.

Barrows, C.W. and M.F. Allen. 2009. Conserving Species in Fragmented Habitats: Population Dynamics of the Flat-tailed Horned Lizard, *Phrynosoma mcallii.* Southwestern Naturalist 54: 307-316.

Barrows, C.W., J. T. Rotenberry, and M. F. Allen. 2010. Assessing sensitivity to climate change and drought variability of a sand dune endemic lizard. Biological Conservation 143:731-743.

Chen, X., C. W. Barrows and B. Li. 2006. Is the Coachella Valley Fringe-toed Lizard (*Uma inornata*) on the Edge of Extinction at Thousand Palms Preserve? Southwestern Naturalist 51: 28-34.

Chen, X., C. W. Barrows and B. Li. 2006. Phase coupling and spatial synchrony of subpopulations of an endangered dune lizard. Landscape Ecology 21:1185-1193.

Latif, Q.S., K.D. Fleming, C. Barrows, and J.T. Rotenberry. 2012. Modeling seasonal detection patterns for burrowing owl surveys. Wildlife Society Bulletin 36-1: 155-160.

Prentice, T.R.., R.A. Redak, and C.W. Barrows. 2011. Survey methodology and distribution of a cryptic Jerusalem cricket species, *Stenopelmatus cahuilaensis* Tinkham (Orthoptera, Stenopelmatidae). Pan Pacific Entomologist 87:1-14.
Robinson, M.D., and C.W. Barrows. 2013. Namibian and North American sand-diving lizards. Journal of Arid Environments 93:116-125.

Community Monitoring

Monitoring of individual communities is necessary in order to understand the effectiveness of the design and to focus management of the CVMSHCP relative to the goals of maintaining and supporting the recovery of communities. Community monitoring focuses on species associations within a particular set of abiotic conditions and measures the aerial extent, functional attributes, species composition, trophic relationships, key ecosystem processes, and responses to variation in natural and anthropogenic stressors within that community context. Examples of how community monitoring has been applied to the Coachella Valley include Barrows and Allen (2007a, 2010) and Barrows et al. (2009). The components of each community within the CVMSHCP are laid out in conceptual ecosystem models providing data addressing the extent to which conservation goals and objectives for communities are being met. These goals and objectives are described in CVMSHCP Section 4.3 and Table 4-111. Community monitoring involves two primary elements. The first is geographically explicit tracking of the extent and composition of communities. This entails refinement and periodic updates of the natural communities (vegetation) map prepared for the CVMSHCP. The second element for community monitoring is the evaluation of natural community-level condition and trends as defined within the context of the conceptual ecological model for the community. The following sections describe the framework for these elements of the overall program.

Community Mapping

Section 8.3.4.3.1 of the CVMSHCP requires that "the natural community (vegetation) map created for the Plan will be used as the initial baseline for a revised and updated map. The natural communities map will be updated to bring it into conformance with the classification system of the Manual of California Vegetation (MCV) (Sawyer and Keeler-Wolf 1995) and unpublished updates." Mapping will be performed using recent satellite imagery and ground truthing will be performed using the plot sampling methodology detailed in each protocol.

Community Conditions and Trends

Community monitoring entails development, testing, and refinement of conceptual ecological models of the relationship between species composition, habitat condition, and stressors affecting communities. Such models identify metrics for both natural and anthropogenically-induced changes in community structure in time and space. Findings for community-scale monitoring based research to date include:

Barrows, C. 1998. The debate over tamarisk: a case for wholesale removal. Restoration and Management Notes 16(2): 135-139.
Barrows, C.W. 2000. Tenebrionid species richness and distribution in the Coachella Valley sand dunes (Coleoptera: Tenebrionidae). Southwestern Naturalist 45(3): 306-312.

Barrows, C. 2004. Indicator species and time series images reveal progress of dune habitat restoration. Ecological Restoration 22(1): 56.
Barrows, C.W., M.F. Allen and J.T. Rotenberry. 2006. Boundary processes between a desert sand dune community and an encroaching suburban landscape. Biological Conservation 131:486-494.
Barrows, C.W. and M.F. Allen. 2007. Community complexity: stratifying monitoring schemes within a desert sand dune landscape. Journal of Arid Environments 69:315-330.
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. 2012 Temporal abundance of arthropods on desert sand dunes. Southwestern Naturalist 57:263-266.

Landscape Monitoring

Monitoring at the landscape scale is necessary under the Plan and focuses on evaluating CVMSHCP goals relative to maintain habitat connectivity. Landscape scale relationships are identified in copceptual ecosystem models for each community, which incorporates spatial factors such as patch size and connectivity. Landscape monitoring provides data for understanding the extent to which conservation goals and objectives for communities (CVMSHCP Section 4.3 and Table 4-111) are being met at the spatial scale of the entire plan area. Those goals and objectives are evaluated in part by compliance monitoring that demonstrates compliance with land acquisition and recovery goals, in part by community monitoring that defines and measures individual community patches, in part by research that fills gaps in our knowledge of how covered species and communities are distributed at a landscape scale, and finally by monitoring activities specifically aimed at evaluating community patch size, shape,distribution, connectivity and the dynamics of those spatial patterns. This final component is the purview of landscape monitoring. Findings for community-scale monitoring based research to date include:

Barrows, C.W. and M. F. Allen. 2007. Persistence and local extinctions of an endangered lizard on isolated habitat patches. Endangered Species Research 3:61-68.
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.
Barrows, C.W., K.D. Fleming, and M.F. Allen. 2011. Identifying Habitat Linkages to Maintain Connectivity for Corridor Dwellers in a Fragmented Landscape. Journal of Wildlife Management 75:682-691.
Barrows, C.W., H. Gadsden, M. Fisher, C. García-De la Peña, G. Castañeda, and H. López-Corrujedo. 2013. Patterns of Lizard Species Richness within National Parks and Biosphere Reserves across North America's Deserts. Journal or Arid Environments 95:41-48.

Conceptual Ecological Models

Conceptual ecological models are planning tools used to identify and outline the various factors influencing community dynamics. They identify various drivers and stressors of natural systems, as well as the ecological effects of these influences, and ecological responses to them. Conceptual ecological models also represent a hypothesis or set of hypotheses that, with peer review, presents a consensus in the scientific understanding of the components, structure and processes affecting species, communities and landscapes (Barrows et al. 2005). Models are subject to revision and refinement in response to the collection and interpretation of data. Thus they are not static, and it is expected that all conceptual models developed under the CVMSHCP will periodically be restated and reformulated in response to received information. Even without refinement, models provide a basis for discussion and critique by other ecologists familiar with a system (Kendall 2001). Conceptual models provide a basis to refine hypotheses about the relative importance of various processes, and/or threats which may affect Covered Species and their conservation. The initial conceptual models developed for the CVMSHCP are presented in the discussions of community level monitoring and management in CVMSHCP Section 8.4; current conceptual models are presented in each community monitoring protocol in the Appendices to this document.

Monitoring Objectives, Metrics, Targets and Triggers

The dual goals of monitoring are to evaluate the effectiveness of conservation designs and to provide a decision tool to aide management decisions. An effective monitoring program collects information relevant to ecological management, indicates when management intervention is necessary, and determines when management has been effective (Barrows and Allen 2007b). One of the challenges in highly variable systems is identifying triggers or thresholds that call for a change in management practices. Ecological systems are not static, so what constitutes a healthy and sustainable community dynamic is not comprised of fixed, single points but rather a broad multivariate range of conditions.

The answer to this challenge is to identify and model the effects of stressors that can destabilize dynamic systems and cause those systems to lose their capability of sustaining the species and natural communities that are the focus of conservation efforts. Models help rank the risks, enabling managers to practice an informed triage, marshalling their efforts to the greatest need (Barrows and Allen 2007b). The models also identify ecological responses to stressors that would indicate a path to non-sustainability. Examples of such indicators could include climate change (Barrows et al. 2010), reduced reproduction in the presence of invasive species (Barrows et al. 2009), shifts in the temporal abundance of preferred prey species (Barrows and Allen 2009), or lack of occupancy along ecological reserve-suburban interfaces (Barrows et al. 2006).

II. 2012-2013 Monitoring Program Activities & Results

This year significant effort was put forth to monitor covered species and communities as well as develop the capacity and enhance the effectiveness of the biological monitoring program. In this section we summarize the year's accomplishments, identify specific tasks from the annual work plan, review current knowledge about various species and natural communities, provide protocols (as appropriate) and explain findings. Most of the data presented in this section consist of analyzed results; plot data including means & standard deviations may be found in Appendix 1.

All monitoring tasks planned for this year are listed below and those for which final reports were produced are denoted with an asterisk (*). Final reports can be found in Appendices 2 – 5. It is important to note that the appendices present two additional reports beyond what was promised in the CVMSHCP's annual work plan. These additional reports focus on the Western Yellow Bat and the usage of Wildlife Habitat Corridors and were shared with the monitoring program by UCR's Center for Conservation Biology as a result of their partnership to perform monitoring activities for the CVCC.

Monitoring Tasks

- Maintain and update monitoring protocols where needed.
- Pursue grant opportunities.
- Report monitoring results and assist with development of Plan Database.
- *Aeolian Sand Ecosystem Monitoring.
- Identify and Implement Baseline Monitoring of Other Covered Species as directed by CVCC Staff and RMOC.
- *Implement Burrowing Owl Feather Isotope Monitoring Program.
- Feasibility Study of Mesquite Restoration.
- Invasive Species Monitoring.
- Update the Natural Community Map/GIS Layer.

This year no changes were made to the content of any of the three approved biological monitoring protocols. However, CVMSHCP monitoring protocols for the Aeolian Sand, Desert Wetland and Alluvial Fan communities were approved by the Wildlife Agencies and vetted through the RMUCs and RMOC, but their formats were never finalized. new staff CVAG brought a new staff member on board to assist with the administration of the biological monitoring program. One of their first tasks was to finalize the biological monitoring protocols. During this fiscal year, these three protocols were finalized and reposted online, leaving the montane communities as the only monitoring protocol remaining to be developed. This protocol has not yet been drafted but will provide survey methods for the three covered species that reside in montane communities within the Plan area; these species include one plant, the Triple-Ribbed milkvetch (*Austragalus tricarinatus*), one mammal, the Peninsular Bighorn Sheep (*Ovis canadensis*), and one bird, the Gray Vireo (*Vireo vicinior*).

During the year two funding opportunities were pursued to assist with both ongoing and future monitoring projects. One opportunity was for a $25,000 grant from the BLM's National Landscape Conservation System program. A cooperative partnership between BLM and UCR was developed to apply for funds to assess climate-related changes in water resources within the Santa Rosa San Jacinto Mountains National Monument. This competitive application received funding in late May of 2013 and project activities will contribute to Trails Research Program as well as fulfill part of the montane natural communities monitoring requirement, to perform habitat assessments in the various natural communities as a component of overall species and natural community monitoring. Part of the assessment methodology will be included in the habitat assessment section of the monitoring protocol for montane natural communities. The other funding source pursed this year was a Desert LCC Interagency Agreement for $100,000 to support vegetative mapping for the Dos Palmas area, the largest portion of the "desert wetlands" natural community within the Plan area. See the subsection for the Vegetation Mapping Project for more information about the overall project. To assist with mapping the Dos Palmas Reserve Management Unit, a partnership was established between BLM (largest area landowner), UCR (as the research lead) and CVCC (as the coordinating/administrative entity). A Statement of Interest was submitted and the application process will continue into the next fiscal year, with a final decision not expected until late fall or early winter of 2013.

During monitoring activities an unusually large number of high-wind days were experienced which significantly reduced the time in which track-based data for aeolian species could be collected. Even so, surveys for all aeolian sand species were completed except the CV Giant Sand Treader cricket. After careful review of the monitoring program status midway through the year, the monitoring team made the decision not to collect data on this species this year. See the CVGSTC subsection for the rationale behind this decision. Instead, the monitoring team reprioritized work activities and conducted surveys for the Little San Bernardino Mountains linanthus during the springtime. The decision to survey for LSBML was made in light of the fact that this species is one of the remaining covered under the plan for which baseline data has yet to be collected and winter rainfall was higher than the previous year so it was hoped it may have been enough to support germination. See the LSBML subsection for survey details and results.

Another accomplishment this year includes the continued development of the CVMSHCP's biological database. During a meeting of the RMUCs in October, the CVCC and UCR presented a draft concept for expanding the biological database with the added capacity of taking in data from various agencies as well as the public, and for generating reports with current biological data within the plan area. Comments and suggestions received at this meeting ranged from genuine interest and desired features for the uploading process to concerns about making sensitive information easily accessible for animal poachers and other detrimental user groups. After this meeting, UCR monitoring staff performed a review of various forums used for similar purposes, including but limited to groups such as CalFlora and eBird. Findings from this review were presented at the following RMUC meeting, in March of 2013. Unfortunately the CVAG GIS staff tasked with this project departed for other work in late spring, and the data project has been placed on hold until a replacement is secured in the upcoming fiscal year.

Aeolian Sand Community Monitoring 2012-2013

Since the inception of the CVMSHCP, the biological monitoring program has focused heavily on sand dune communities and associated covered species and habitat characteristics. This year, ongoing monitoring continued for the Aeolian Sand ecosystem and associated Covered Species.

Weather

In arid environments the seasonality and intensity of precipitation stimulate varying levels of primary productivity. Levels of annual precipitation are therefore often a direct or indirect driver of population change in desert species. Responses to precipitation can be apparent the same year of the rainfall, or can be seen one or more years following depending on the species' natural history traits and the timing of surveys relative to the reproductive output of the species. Modeling the relationship between rainfall and population dynamics can provide a basis for distinguishing typical or expected changes in populations from those that might be catalyzed by stressors that require active management to control.

Because of the often dominant effect of rainfall, modeled relationships can require narrow confidence limits in order to detect the sometimes subtle initial effect of anthropogenic stressors. On some dune systems in the Coachella Valley, most notably the active dune and stabilized sand field communities, primary productivity creates a detritus base that nourishes detritivores for years following a rain event. In arid climates those detritivores are often the dominant arthropods and comprise the majority of insectivores' diets. One concern regarding the recent spread of the non-native Saharan mustard is that it has altered the character of that detritus resource, making it less suitable for native detritivores (Barrows 2012).

The Coachella Valley experiences a precipitation gradient from the more arid eastern valley (including the Thousand Palms Core Preserve) with a mean annual precipitation of 81 mm, to the wetter and cooler western valley (including the Windy Point – Snow Creek Core Preserve) with a mean annual rainfall of 311 mm. Between these two ends of the gradient, the more west-central valley north of Palm Springs has a mean annual rainfall of 139 mm. There are long-term rainfall records going back to the 1920s from the Indio Fire Station, the Palm Springs Airport, and Snow Creek Village. We also have more recent rain gauges on the Thousand Palms Preserve dunes, the UCR Palm Desert campus, and on survey plots the Snow Creek alluvial fan. Droughts (periods of annual rainfall ≤ 40 mm) and drought effects are more severe and longer lasting in the eastern valley, resulting in much closer correlations between rainfall and covered species abundances. The most severe drought in recent history occurred from 2000-2004. During that five year period the mean rainfall on the Thousand Palms Preserve was 38 mm, with three of the five years being below 40 mm; at the Palm Springs Airport the mean was 71 mm with just one of those years falling below 40 mm, and at Snow Creek the mean was 237 mm with no years below 40 mm. In addition to milder, shorter-lived droughts, the western and central valley regions include denser and more diverse perennial shrubs, many of which have palatable flowers and leaves. The result includes not only a shift to a more vegetarian diet for the otherwise largely insectivorous fringe-toed lizards (Barrows 2006), but since the shrubs often survive droughts, a somewhat decoupled relationship between rainfall and the population dynamics of covered species.

The precipitation in both 2012 and 2013 was at drought levels. For Thousand Palms rainfall levels were 12.5 and 19 mm; for Palm Springs they were 58 and 35 mm, and for Snow Creek they were 138 and 53 mm. In 2013 annual plants only germinated in the central and western regions. No Sahara mustard germinated in the eastern regions either year. The severity of the drought resulted in little or no leaf or flower production among the "palatable shrubs" on the central preserve sites. Based on these rainfall levels we should expect declines in species abundance across much of the valley floor, except for within the Snow Creek-Windy Point core Preserve.

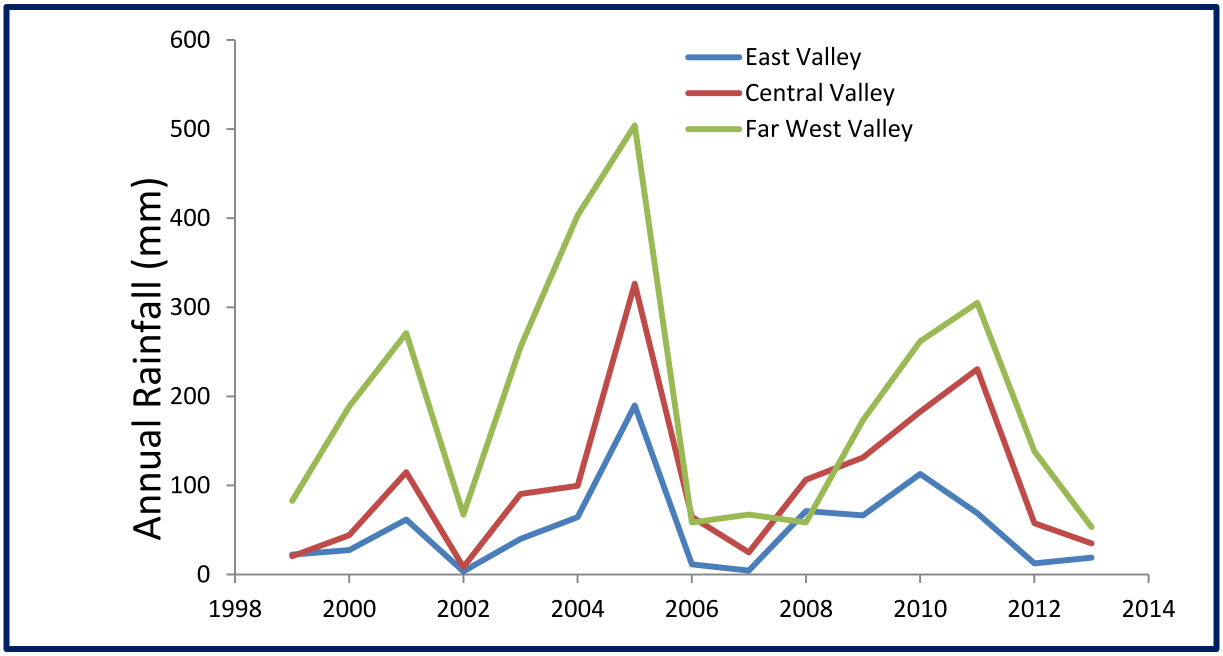


Figure 1. Rainfall data from three locations in the Coachella Valley shows the precipitation gradient from east to west and the drought conditions in 2012-2013. East Valley was measured on the dunes of the Thousand Palms core Preserve, Central Valley was measured at the Palm Springs Airport, and the Far West Valley was measured within the Snow Creek-Windy Point Core Preserve.

Aeolian Sand Communities

The naturally occurring aeolian sand communities of the Coachella Valley floor include active dunes, stabilized dunes (also referred to as mesquite hummocks), ephemeral sand fields, and stabilized sand fields. Ephemeral sand fields can be also divided into western and central regions reflecting the very different rainfall regimes they experience. These communities were initially defined based on distinct geomorphologies (see below), but also have distinct species associations and abundances (Barrows and Allen 2007a, Barrows and Allen 2010). Those communities that have undergone the greatest amount of loss due to human development include the active sand dunes and stabilized sand fields which would have occupied much of the central portion of the valley floor. As much as 83%-95% of these communities have been lost (Barrows et al. 2008). Another community which has lost much of its original extent is the stabilized dune, or mesquite hummock community type. Most of that loss occurred in the eastern portions of the valley in what are now the cities of La Quinta, Indio and Coachella. Ephemeral sand fields have been least impacted by human development, likely due to the high intensity wind and sand movement characterizing this community, making it less hospitable to human uses. The general locations where these communities still occur are shown in Figure 3 below.

Conceptual models can provide valuable tools in clarifying hypotheses as to how natural systems are formed, function, and how stressors may impact those systems (Barrows et al. 2005). A conceptual model for the development of the Coachella Valley aeolian sand communities is depicted in Figure 2. This model is unique to this valley due to the unidirectional (northwest) nature of winds strong enough to catalyze aeolian sand transport and the strong west to east gradient in precipitation. Identified stressors include barriers limiting fluvial inputs of sand (up-stream damming and/or channelization), barriers to aeolian sand transport (wind breaks), and stabilization due to the spread of invasive vegetation.

Metric	Active Dunes	Stabilized Sand Fields	Ephemeral Sand Fields	Stabilized Dunes
Aeolian sand depth	> 3 m	0-2 m	0-2 m	> 3 m
Base substrate	aeolian sand	silt, cemented sands	gravel, rocks	aeolian sand
Shrub Density	Mean < 0.005/ m^2	Mean > 0.01/ m^2	Mean > 0.049/ m^2	Mean > 0.048/ m^2
Wind velocity	moderate	moderate	high	moderate
Sand movement	high	moderate	very high	low
Precipitation gradient	extreme (low)	extreme (low)	moderate	moderate
Covered species primarily associated with this community	• **fringe-toed lizard** • **sand-treader cricket** • milkvetch • round-tailed ground squirrel • flat-tailed horned lizard	• fringe-toed lizard • round-tailed ground squirrel • **flat-tailed horned lizard**	• **fringe-toed lizard** • **sand-treader cricket** • **milkvetch** • **Jerusalem cricket**	• fringe-toed lizard • **round-tailed ground squirrel**

Figure 2. Conceptual model for the Coachella Valley aeolian sand communities

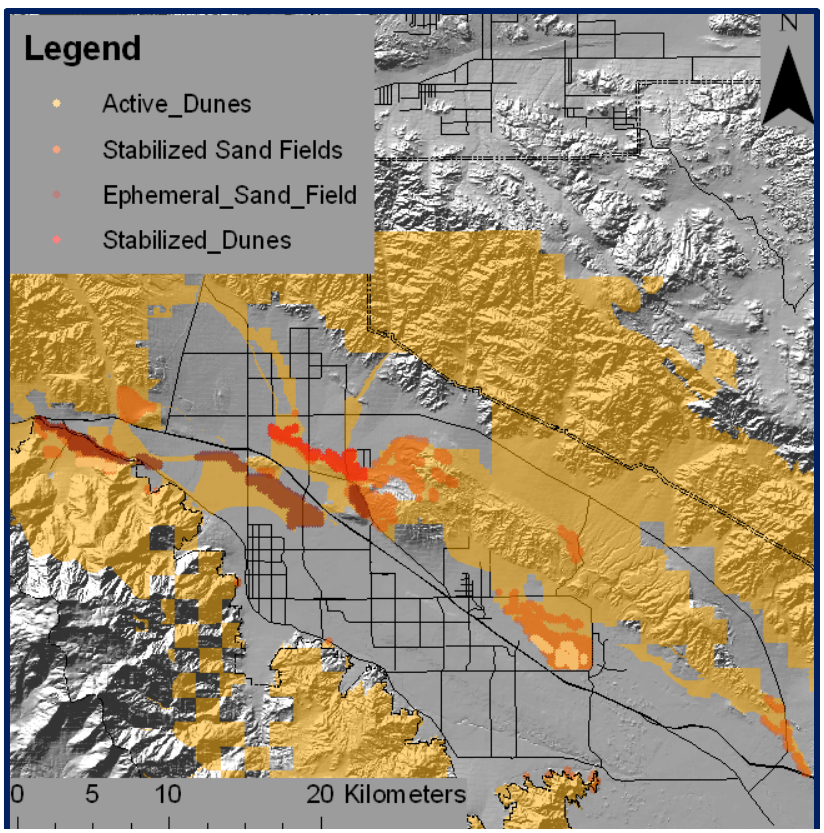


Figure 3. Map showing the extent and distribution of the remaining wind-blown (aeolian) sand communities within CVMSHCP Conservation Area boundaries.

The map in Figure 3 depicts the relative extent and distribution of the remaining aeolian sand communities within the boundaries of the CVMSHCP. The natural communities map will be more accurate and will be updated to bring it into conformance with the classification system of the Manual of California Vegetation (MCV) (Sawyer and Keeler-Wolf 1995). This classification system uses vegetation alliance /association hierarchies, but for desert sand dunes only one sand dune category currently exists: the *Dicoria canescens* (alliance) and *Abronia villosa* (association). In order to continue to reflect the community level differences among the sand dune associations we will create provisional alliances-association designations. To maintain continuity these will attempt to maintain a direct connection to the natural community designations currently in the CVMSHCP:

Current Community	Provisional Alliance/Association
Active Dune:	*Dicoria canescens/Oenothera deltoides*
Stabilized Sand Field:	*Dicoria canescens/Abronia villosa*
Ephemeral Sand Field:	*Dicoria canescens/Psorothamnus arborescens*
Stabilized Dune:	*Dicoria canescens/Prosopis glandulosa*

Plot Locations

Monitoring plots for the aeolian sand covered species and community are distributed among the community types and across the climate gradients of the Coachella Valley floor (see map in Figure 4 below). The plots on small habitat fragments largely in the Indio Hills are presence/absence plots, plots where the primary metric is occupancy by covered species. Presence-absence plots are surveyed once annually unless the covered species have been absent for up to three consecutive years. Those plots with consecutive years of absence are re-surveyed every 3-5 years. While clustered for survey efficiency, core aeolian sand community plots are randomly located and include annual assessments of vegetation, arthropods, sand compaction, and measures of relative abundance for vertebrates.

Due to priorities shifting among other, non-aeolian sand community covered species, and previous questions being adequately addressed, not all these core plots are currently surveyed. Of 141 original core plots, 86 are still surveyed annually. The following table indicates the number and distribution of plots among the natural community types by year. Variation in plot numbers and distribution within the natural communities occurred due to specific questions asked and answered, such as 2003-2004 (edge effects), the greater number of plots in the stabilized sand fields and active dunes (impact of Sahara mustard – ongoing).

Community	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Active Sand Dune	23	30	30	26	26	26	26	26	26	26	26	25
Stabilized Sand Field	58	70	70	39	39	39	39	39	39	39	39	26
Central Ephemeral Sand Field		12	12	12	12	12	12	12	12	12	12	12
Western Ephemeral Sand Field		6	24	12	12	12	12	12	12	12	12	6
Stabilized Mesquite Dune		5	5	17	17	17	17	17	17	17	17	17
Total	81	123	141	106	106	106	106	106	106	106	106	86

Figure 4. The number and distribution of plots among the natural community types by year.

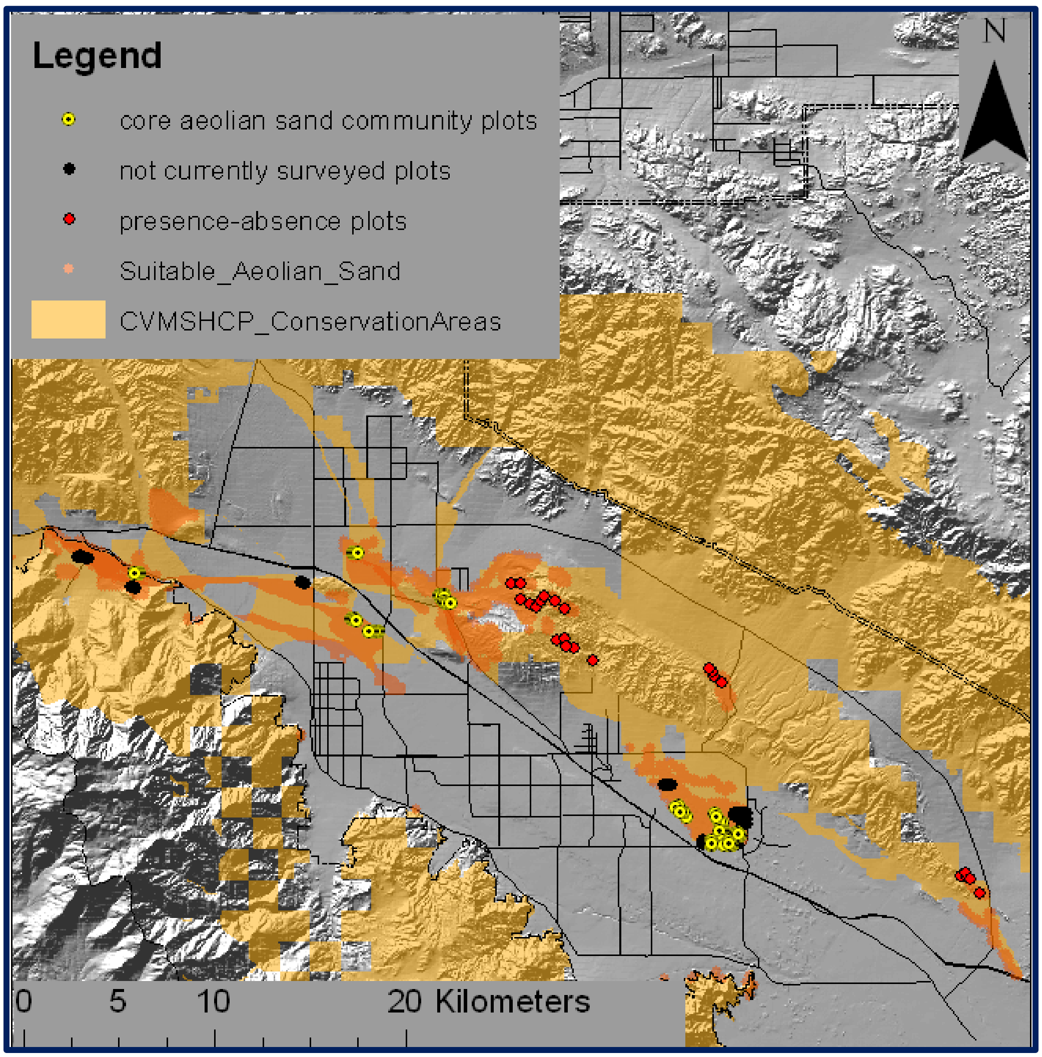


Figure 5. Map showing the distribution of the monitoring plots for aeolian sand covered species and community.

Aeolian Community Stressors-Drivers Conceptual Model

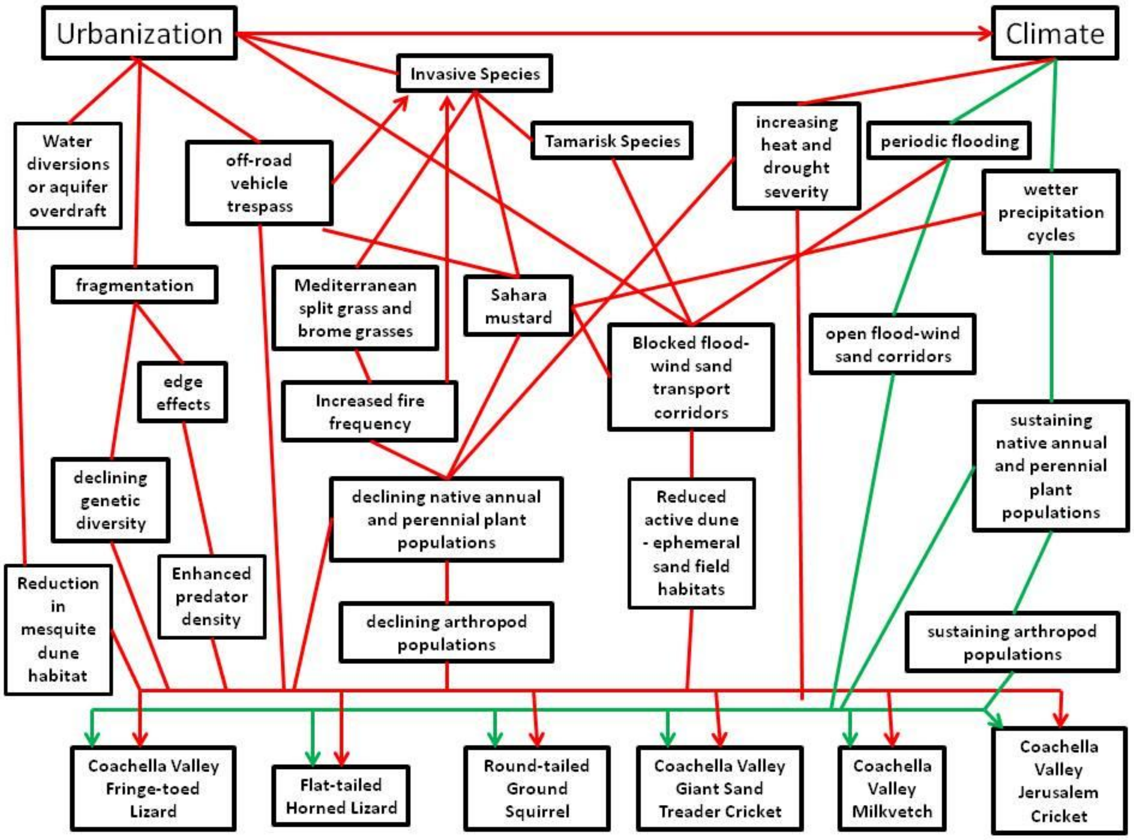


Figure 6. A conceptual model diagramming the relationships between stressors and drivers in aeolian sand-dependent communities.

This conceptual model is designed to illustrate the interaction of independent variables with each other and their outcomes with respect to the response, or dependent variables (covered species). Variable actions viewed as positive or increasing the population levels of the covered species are depicted with green lines/arrows; those viewed as negative, or stressors, are shown with red connectors. Ultimate driver/stressors are situated at the top of the model with more proximate diver/stressors at the lower levels of the model. One immediate value of this model is that it provides a glimpse of the complexity inherent in this system; simply measuring increases or decreases in covered species' population levels provides little insight as to the causes for change. In response to this understanding the monitoring protocols for the aeolian sand species and communities include collecting data climate/weather, sand compaction (relative to sand transport processes), invasive species, perennial and annual vegetation, arthropods, and the covered species themselves. With these data we can begin to dissect the relative influences of each of the driver/stressor variables on the covered species.

To date we have identified strong edge effects on flat-tailed horned lizards due to urbanization-fragmentation-enhanced predator effects (Barrows et al. 2006), on native annual plants and the Coachella Valley milkvetch from urbanization-invasive species-Sahara mustard (Barrows et al. 2009) work in progress extending that relationship to the covered species, and from climate change on both fringe-toed lizards and Coachella Valley Jerusalem crickets (Barrows et al. 2010; Prentice et al 2011). We have a near complete report detailing the urbanization-aquifer overdraft-reduction in mesquite dune linkage.

Aeolian Communities and Species Protocols

The information provided in this section was excerpted from the approved protocol for the aeolian sand community and is provided as a reference and preface to the review of 2012/2013 activities.

Reptiles (also applies to small mammals, burrowing owls – all surveyed simultaneously) - The fine aeolian sands of the Coachella Valley's dune fields provide an opportunity to quantify the occurrence and abundance of terrestrial species by tracks they leave as they moved across or within each plot. Nearly every species occurring on the aeolian sands can be identified to species and age class by their diagnostic tracks, and so variability in detection plaguing many other survey methods, caused by differences in activity times, cryptic coloration, or stealthy behavior, are largely nullified. We have found this survey method to be robust in the sense that we are able to detect species occurrences even when they are rare in the area being surveyed. Extensive training is required before biologists conducting tracking surveys can be proficient at species identification and enumeration, training levels similar to what would be required for conducting avian surveys where both sightings and vocalizations are used for identification.

As our recommended plot size (0.1 ha) is less than the home range for many of the species we survey, our tracking data were not equivalent to density data, although for at least Phrynosoma mcallii when we compared tracking data to mark and recapture derived densities there was a close proportional relationship (R2 = 0.9599 and P = 0.0006; Barrows and Allen, 2009). We also placed a set of plots near a long-term mark recapture study (Muth and Fisher, unpublished); the comparisons between their abundance data and the data collected on our plots are consistent in trajectory and scale. Our tracking data are best characterized as the number individuals of each species that occurred on each plot each survey day, averaged over six independent surveys per season; for reporting purposes we refer to this statistic as the mean relative abundance of each species / 0.01 ha (the plot area). In 2002 we conducted a power analysis and determined that 6 repetitions per plot were sufficient to detect between plot and year differences when the mean plot difference was ≥ 1.7 lizards at $\alpha = 0.05$, $\beta = 0.80$ for a two sample z-test. Because they are essentially ratios and so do not require precise population estimates, a mean relative abundance of the lizards can readily be incorporated to measures of reproductive success (mean relative abundance of hatchlings surveyed in the fall / mean relative abundance of adults surveyed in the late spring, or mean relative abundance of juveniles surveyed in the late spring / mean relative abundance of adults surveyed in the late spring), and population growth (natural log of the product of the mean relative abundance of all lizards surveyed in the late spring in year 2 / mean relative abundance of all lizards surveyed in the late spring in year 1). Data for each plot is considered independent, although in rare instances an individual could move from one plot to another and be recorded as occurring on both plots (between plot distance was ≥ 50 m).

Reptile surveys occur between May and July. Due to the timing of our surveys reproductive responses had an apparent one year lag to temporally variable environmental conditions. The reproductive responses (hatchling lizards and snakes) emerged from late summer through early winter, depending on the number and timing of clutches the adult reptiles produced. There is no single period in the fall when the total hatchling cohorts are present and active on the sand surface. The total reproductive effort is thus measured during the following year's survey period. Nevertheless a selected number of plots (62) have been surveyed in the fall (September-October). These plots provide a snapshot of the lizards' reproductive effort and provide a basis for estimates of reproductive success. All surveys would begin each morning after the sand surface temperature had risen sufficiently (35o C) so that diurnal reptiles were active. Consistent time of day and temperature reduces those variables' contributions to between survey variability. Surveys continue until late morning when the high angle of the sun reduces the observer's ability to distinguish and identify the tracks across the sand, and coincides with the cessation of activity for the diurnal reptiles due to high surface temperatures. One observer can complete a survey on a given plot in 10-15 minutes, recording all fresh tracks observed within the plot; depending on the travel time between plots that observer could survey 10-15 plots/day. We used track characteristics to identify individuals as well in order to quantify species' abundance. Track size, unique features, and following tracks off of the plots helped insure that each counted track represented a unique individual for each survey. Because late afternoon and evening breezes usually "wipe the sand clean" the next day's accumulation of tracks should not be confused with those from the previous day.

Sand-treader Crickets – Sand treader crickets are nocturnal, moisture sensitive insects. The crickets' first instars emerge coincident with winter rains and appear to be at maximum densities in January-February. After apparently incurring incremental mortality (inferred by their lower densities), the crickets reach adult size by April and by June usually disappear altogether.

Between 2003 and 2008 we compared two methods, pitfall trapping and detections via the cricket's characteristic "Δ" or delta-shaped burrow excavations. The species-specific burrow excavation shape was confirmed by excavating over 100 burrows. The burrows enter the sand at a shallow angle and generally extend 20-50 cm until the cricket reaches water-saturated sand, usually 5-20 cm below the sand surface during the winter months. Not all are occupied; the crickets appear to dig a new burrow each evening, leaving previous burrows vacant and visible until winds remove the excavations. Excavating the burrows to locate live crickets results in relatively high cricket mortality; once exposed to sunlight, daytime temperatures and low humidity the crickets expire quickly. The same is true for pitfall trapping. For burrow surveys we count all fresh burrows within the entire 10 m x 100 m plot (one survey/plot) in January-February, when their abundance is at its peak. Using this method, for determining fresh versus older burrows, the surveyor requires training and experience. Freshly excavated burrow sand is usually darker (still has residual moisture) than older burrow sand. Pitfall trapping occurs when total arthropod species richness and abundance is assessed in April.

Burrow counts were superior to pitfalls in detecting sand-treader crickets. As an example in 2008, a typical year from the perspective of sand-treader crickets, on all plots 724 crickets were detected using burrow counts, whereas 19 were trapped in pitfalls; burrow counts recorded the crickets on 75% of all plots surveyed whereas pitfalls recorded them on just 8%.

Coachella Valley Milkvetch – Coachella Valley milkvetch are annual or sometimes biennial plants. The biennial habit is generally restricted to the western, cooler-wetter portion of the Coachella Valley and years when high levels of sand moisture stay close to the surface through the summer. These plants usually occur at low densities so we have employed a total count / 10 m x 100 m plot survey protocol. The counts occur coincident to the general vegetation surveys in February-March, but are re-surveyed coincident with the arthropod surveys in April and sand compaction data collection in May to ensure all plants are counted. Data are reported as densities (plants/m2).

Round-tailed ground squirrels – There are two detection methods that work within the proposed monitoring design, tracking and recording the squirrels warning calls. In 2008 when the squirrel population was relatively low, out of 171 total detections, 91% were by tracking and 20% were by vocalizations (at many sites squirrels were both heard and detected by tracks). In 2006 when the squirrels were at a population high, again 91% of over 700 detections were by tracks, and 33% were by their calls. Using just calls alone (locations where no tracks were seen) only 9% of the squirrels were detected in both years. Nevertheless we use both methods in tandem to achieve the maximum detection rate.

2012-2013 Monitoring Results for Covered Aeolian Species

Coachella Valley milkvetch

The Coachella Valley milkvetch was surveyed for on all the aeolian sand plots (86) included in the monitoring for 2013. It reaches by far its highest abundances on the western ephemeral sand field community, periodically reaching numbers of 100s of plants / 0.1 ha plot. Keys to its abundance are sufficient rainfall to germinate seeds active sand movement to scarify those seeds. Regardless of rainfall it occurs only sporadically in the stabilized sand field and stabilized mesquite dune communities. On the more active sand movement communities, its abundance is directly related to rainfall and subsequent soil moisture. Primary threats appear to be factors that retard sand movement such as dense perennial shrubs, persistent annual vegetation such as Sahara mustard, and barriers that block sand movement corridors. In 2013, this species did not germinate on the eastern Thousand Palms Preserve (due to insufficient rainfall), germinated but had high seedling mortality on the central Whitewater Floodplain Preserve, and was abundant on the western Windy Point Preserve (reaching in excess of 400 plants / 0.1 ha plot at some sites). Summarized data for all years are available in Appendix 1.

Experiments in 2005 on the Thousand Palms Preserve, hand removing Sahara mustard from randomized plots with dense milkvetch germination demonstrated a strong inhibition on milkvetch reproduction from the mustard over-topping the milkvetch and usurping soil moisture (Barrows et al. 2009). Since 2005 the milkvetch has been increasingly scarce on the Thousand Palms Preserve where the mustard dominates, but still common further west on the ephemeral sand field communities.

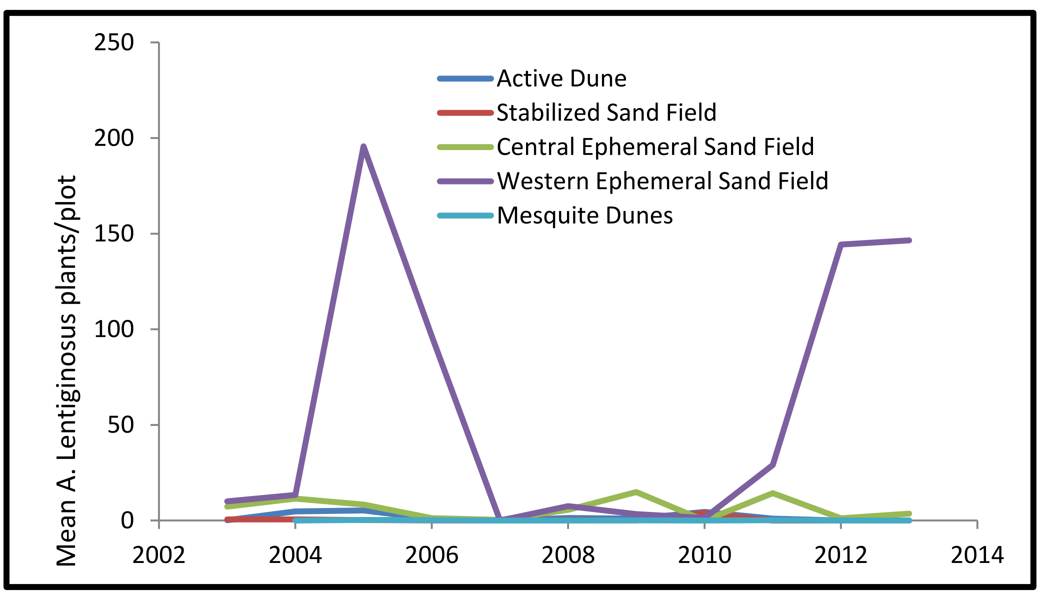


Figure 7. Abundance of Coachella Valley milkvetch plants found on monitoring plots

Coachella Valley Giant Sand Treader Cricket

Coachella Valley giant sand treader crickets occur in all of the aeolian sand communities, but are more abundant on those with more active sand transport. Their temporal abundance is closely correlated with annual rainfall. The spatial and temporal patterns of abundance for this species indicate rainfall is the primary driver and that Sahara mustard is not a significant stressor (Barrows 2012). For this reason the sand treader crickets were not surveyed in 2013 in order to provide time to survey other covered species (*Linanthus maculatus*). Surveys for this species no longer need to be conducted on an annual basis; every 3-5 years, focusing on wet winter conditions should be sufficient unless declines inconsistent with precipitation levels are noted. Summarized data for all years are available in Appendix 1.

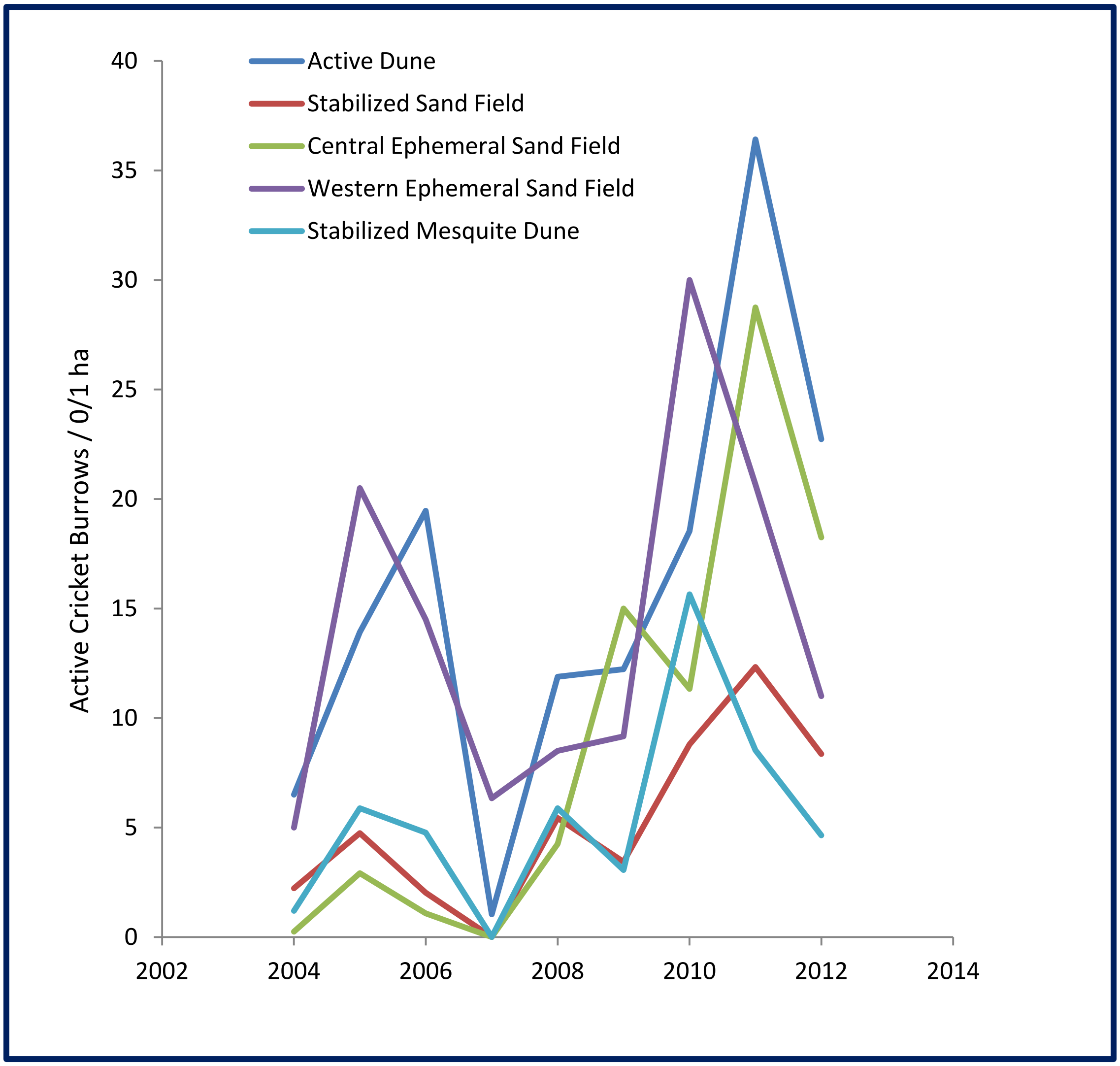


Figure 8. Abundance of Coachella Valley giant sand-treader cricket burrows found on monitoring plots in aeolian sand communities.

Palm Springs Pocket Mouse

Palm Springs pocket mice were surveyed for on all the aeolian sand plots (86) included in the monitoring for 2013. This species is not restricted to aeolian sand habitat; rather they occur in additional communities across the Coachella Valley floor, the common denominator being fine sands. In a more detailed analysis of the distribution of their suitable habitat, in addition to fine sandy soils, this species was found to prefer the cooler wetter conditions at the western portion of the Coachella Valley (Barrows et. al 2011). This spatial pattern is mirrored in the data we have collected across the aeolian sand habitats; the westernmost, cooler-wetter ephemeral sand fields consistently include the highest abundances of Palm Springs pocket mice. In addition to a higher abundance on western habitats, this species shows pronounced temporal dynamics that are correlated with rainfall patterns. Low abundances are associated with droughts and abundance peaks are associated with high rainfall years. Summarized data for all years are available in Appendix 1.

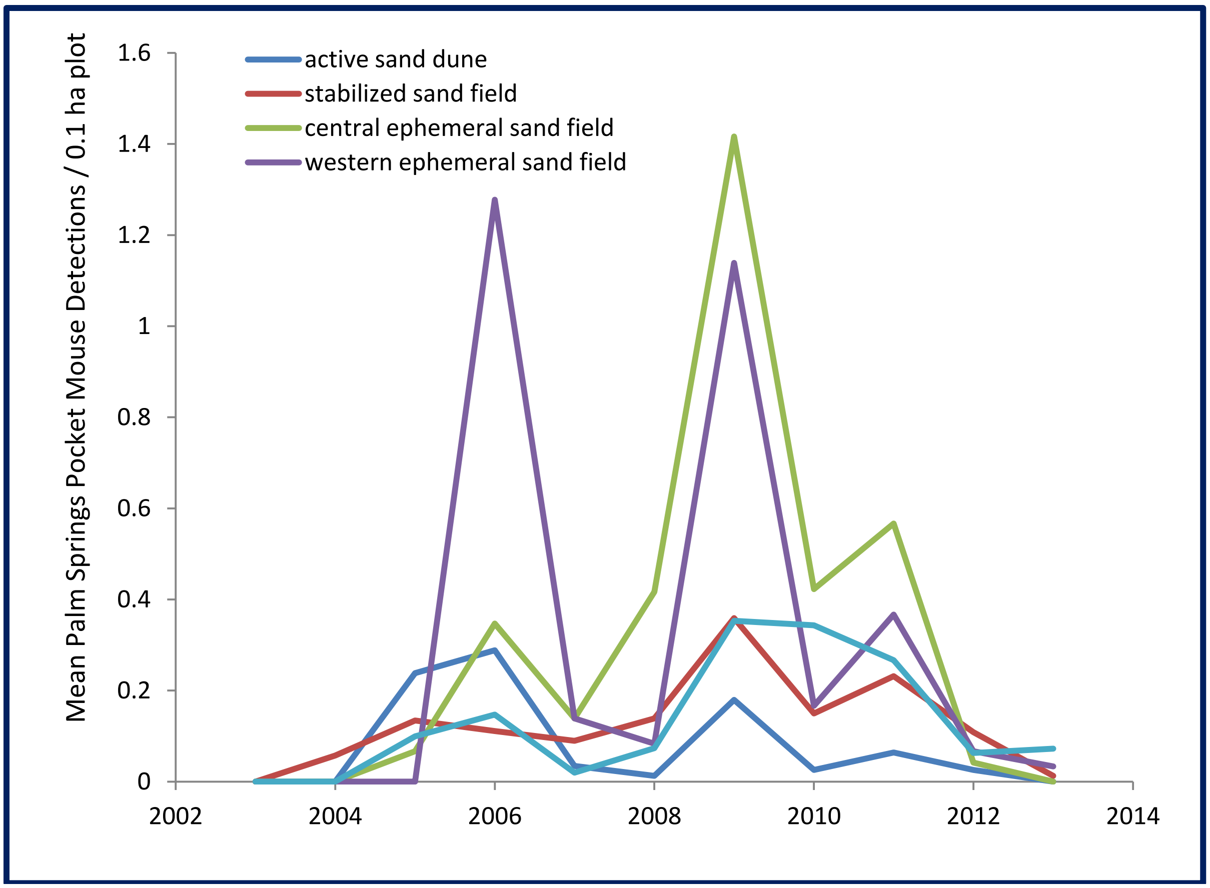


Figure 9. Detection of Palm Springs pocket mouse found on monitoring plots in aeolian sand communities.

Coachella Valley Round-tailed Ground Squirrel

Round-tailed ground squirrels were surveyed for on all the aeolian sand plots (86) included in the monitoring for 2013. Like Palm Springs pocket mice, round-tailed ground squirrels are not necessarily restricted to active aeolian sand habitats; they do prefer habitats with finer sandy soils, and are replaced by antelope ground squirrels as soils grade into coarse gravel and rocky substrates. Ball et al. (2005) concluded that honey mesquite was a key habitat feature necessary for sustaining populations of this species. Our data certainly supports that round-tailed ground squirrels reach higher abundances on habitats with mesquite, although we consistently find them, at lower densities, on sites far from any stands of mesquite. In 2013 no round-tailed ground squirrels were detected on any of the drier eastern plots on the Thousand Palms Preserve; however an off-plot reconnaissance found a dense population within roughly 1 km of our existing plots in a creosote bush dominated habitat, with no mesquite. A problem with the Ball et al. study was that they depended entirely upon the squirrels' warning calls for detections; at lower densities they call much less frequently and easily avoid detection using only that method. Our combined use of both calls and distinctive tracks enables us to detect this species even at low densities.

The moderate abundances of round-tailed ground squirrels on both the active dune and western ephemeral sand field communities in 2005-2006 indicates higher rainfall as a driver for population growth, however the lack of a response to the 2010-2011 rains suggests more complex driver-stressor relationships for this species. The negative impact of Sahara mustard on annual plants on the eastern sites (active dunes and stabilized sand fields) is correlated with the decline of round-tailed ground squirrels there. Summarized data for all years are available in Appendix 1.

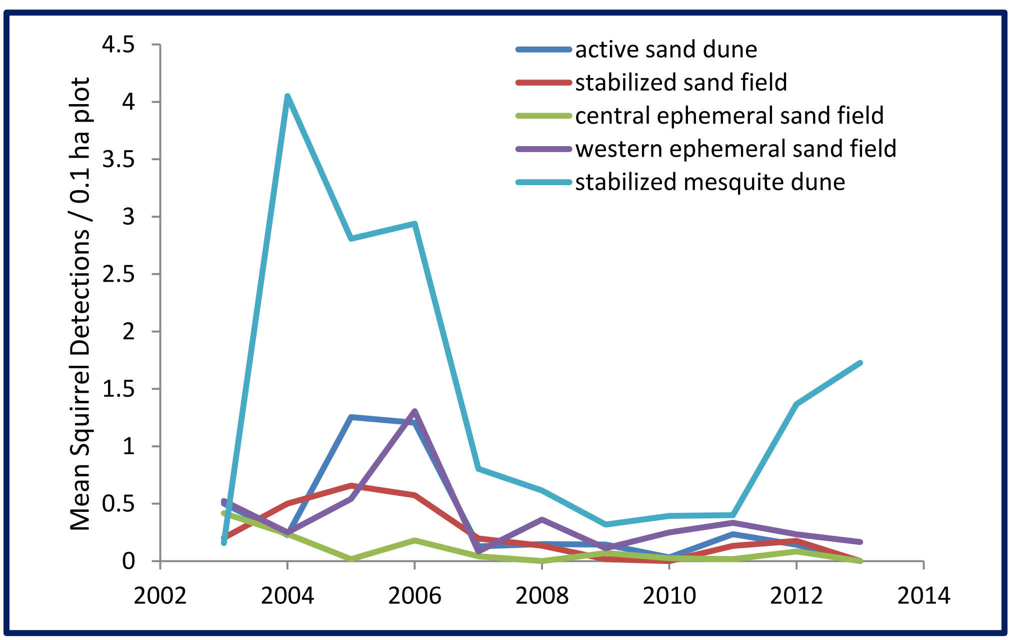


Figure 10. Abundance of Coachella Valley round-tailed ground squirrel found on monitoring plots in various aeolian sand communities.

Burrowing Owl

Burrowing owls were surveyed on all the aeolian sand plots (86) during 2013. Like the Palm Springs pocket mouse and round-tailed ground squirrel, burrow owls occur on the aeolian sand communities as well as across a broader range of habitats. Burrowing owls have been surveyed in both 2009 and 2011 using the approved road survey protocols across suitable habitat throughout the Coachella Valley (Latif et al., 2012). The aeolian sand surveys represent a subset of the valley's burrowing owl population that is not detected using road survey and represents foraging habitat rather than the burrow locations generally detected with the road surveys.

The burrowing owls are clearly more abundant on the stabilized mesquite dunes, although they can be common on both active dunes and stabilized sand fields on the Thousand Palms Preserve, and their temporal distribution coincides with rainfall peaks and valleys. Burrowing owl prey upon two other covered species, sand-treader crickets and Palm Springs pocket mice – both of which show similar temporal associations with rainfall levels. Summarized data for all years are available in Appendix 1. See Appendix 3 for analyses of feather isotope signatures for burrowing owls in the Coachella Valley and the potential uses of such data.

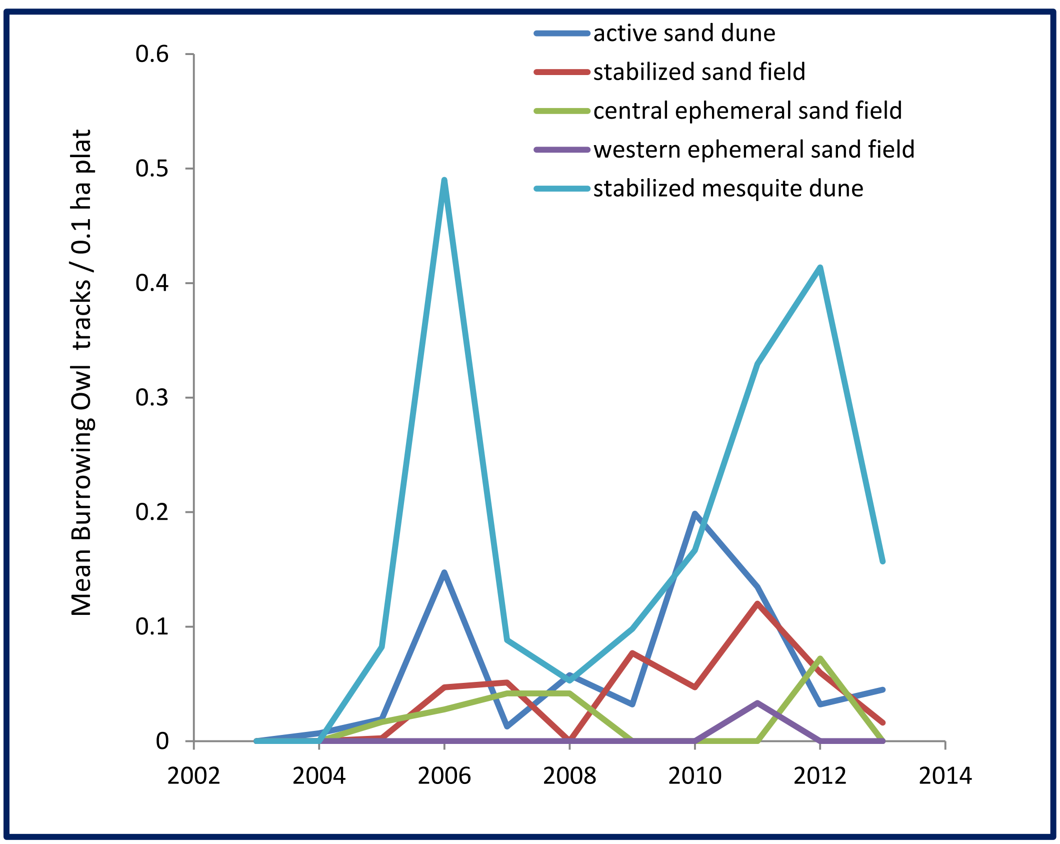


Figure 11. Presence of burrowing owls found on monitoring plots in various aeolian sand communities.

In addition to the 2013 aeolian sand investigation, an additional and separate monitoring task for burrowing owls was continued from the previous year's work. Burrowing owl feathers sampled from across the valley were analyzed for isotopic composition to identify where birds grew feathers during periods of their life cycle, to improve our understanding of burrowing owl movements within and between conserved lands across Riverside County. The full report on the burrowing owl feather isotope study is provided in Appendix 3.

Coachella Valley Fringe-toed Lizard

Coachella valley fringe-toed lizards were surveyed on all the aeolian sand plots (86) included in the monitoring for 2013. This species is restricted to the aeolian sand habitats of the Coachella Valley, and has been the focus of conservation efforts on the valley floor since 1980. It is still widespread on most of the remaining protected habitat, however there have been local extinctions due to a drought from 2000-2004 (Barrows et al. 2010), habitat fragmentation (Barrows and Allen 2007c), and altered sand transport processes (up-stream blockage in the San Gorgonio wash of new sand inputs by a large gravel operation and residential development impacting the Snow Creek area). Locations where lizards have not been observed for the last several years are shown in Figure 10. Current concerns regarding the impacts of Sahara mustard at the Thousand Palms Preserve underlines the need for on-going monitoring and active, adaptive management (see Appendix 2 for additional details). Summarized data for all years are available in Appendix 1.

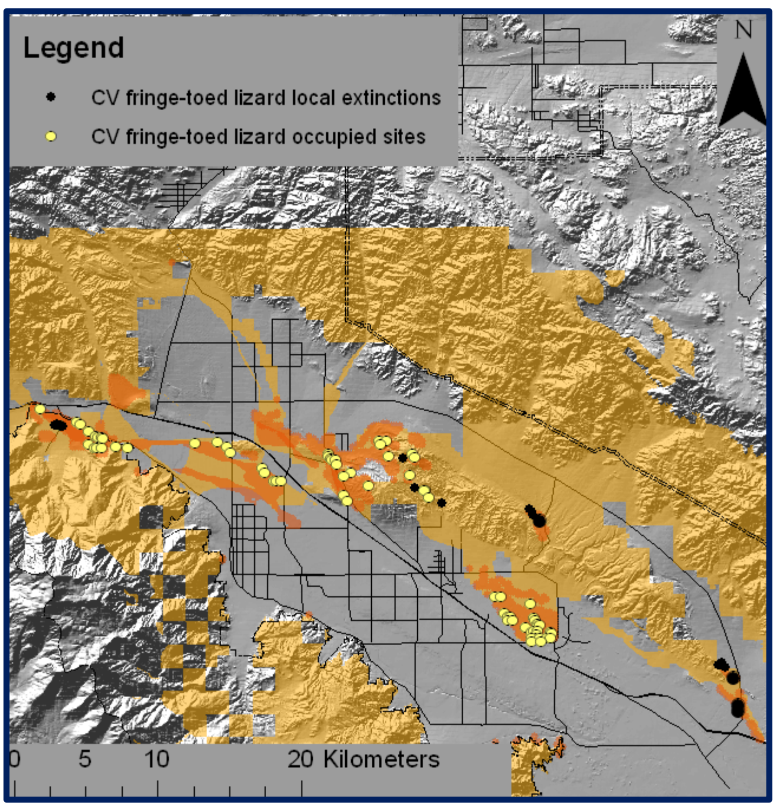


Figure 12. Location of monitoring plots for Coachella Valley fringe-toed lizards on occupied sites. Locations where local extinctions of this species have occurred are also shown

Population dynamics at each of the core preserves, and within different community types within the preserves show different responses to the dominant environmental driver – annual rainfall. Only at the Thousand Palms Preserve on active dunes is the rainfall-population dynamics relationship strong, but even there it appears to be decoupling (See Appendix 2 for a more detailed discussion). The apparent decoupling of the lizards population dynamics from precipitation levels (population growth has been below expectations for the past four years based on modeled relationships) represents the type of warning this monitoring framework was designed to identify. Two stressors, climate change and Sahara mustard, appear to be the primary factors responsible for this decoupling. The Thousand Palms Preserve is situated at the hottest-driest end of the valley's climate gradient and is at the highest density end of the Sahara mustard gradient. Whether this represents a new lower abundance – reduced response to rainfall reality for this population or is an isolated departure from previous patterns is an important question that will be answered with additional monitoring. An additional critical question is whether the control of the mustard, and a return to a native annual based food-web base, can reduce the impact of climate change here. Maintaining a robust population at this site is an important conservation objective for the CVMSHCP. Because of the Thousand Palms Preserve population is at the hottest-driest end of the currently occupied aeolian sand habitat gradient, it is the most vulnerable to the effects of climate change. If the decoupled population abundance-rainfall relationship continues, and if extended droughts become the new reality, then this population could be at risk of local extinction. For the first time since monitoring began, in 2013 the active dunes on the Thousand Palms Preserve did not have the highest abundance of fringe-toed lizards; even during the severe 2000-2004 the fringe-toed lizard numbers were higher. Summarized data for all years are available in Appendix 1.

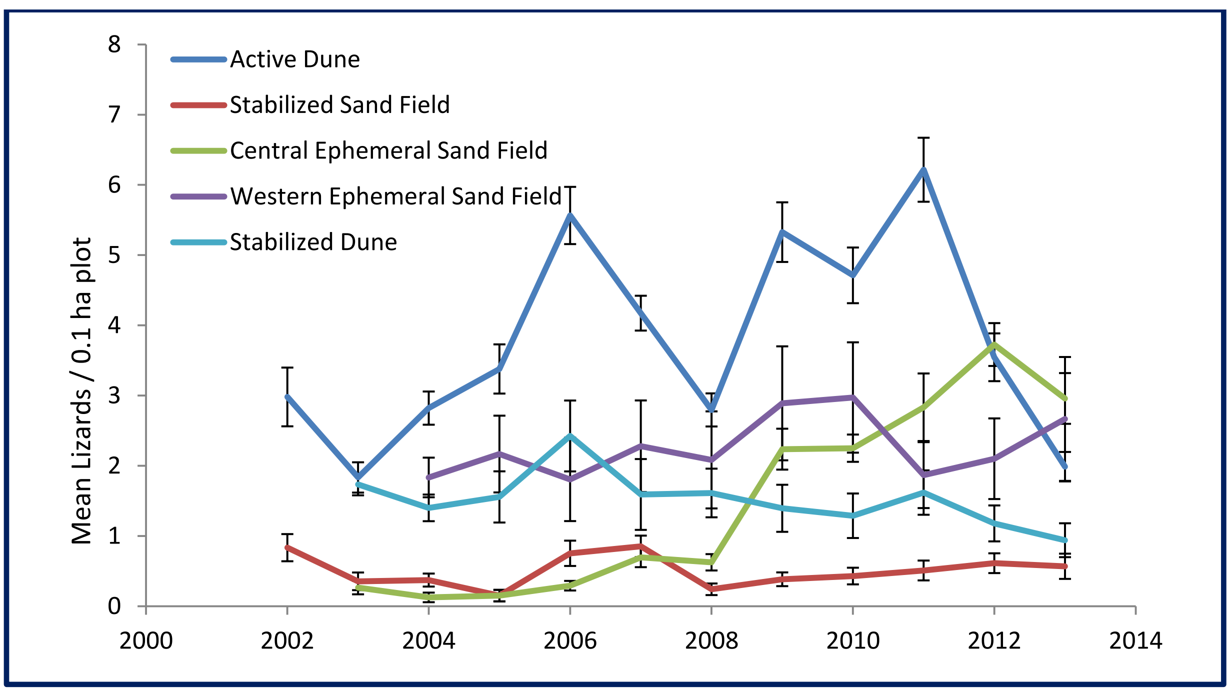


Figure 13. Abundance of Coachella Valley fringe-toed lizards found on monitoring plots in various aeolian sand communities.

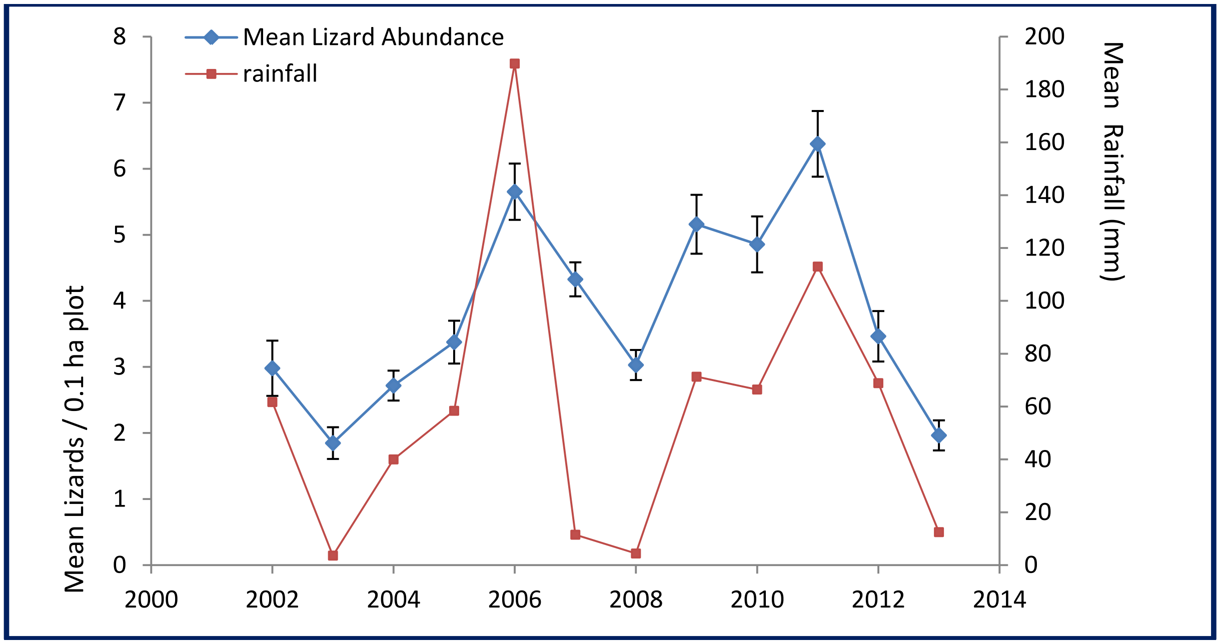


Figure 14. Correlation of abundance of Coachella Valley fringe-toed lizards with annual rainfall from 2002 to 2013.

Flat-tailed Horned Lizard

Flat-tailed horned lizards were surveyed on all the aeolian sand plots (86) included in the monitoring for 2013.As recently as the early1980s flat-tailed horned lizards had a much broader distribution in the Coachella Valley, occurring on what is now the Whitewater Floodplain Preserve, on the southern flanks of Edom Hill, and at the eastern end of the Indio Hills. Today the only remaining populations are on the Thousand Palms Preserve and much further south within the Dos Palmas Preserve (Barrows et al. 2008). At the Whitewater Floodplain Preserve flat-tails have been replaced by desert horned lizards, indicating that food resources are still largely intact, but that changes in either substrate and/or climate have favored the desert horned lizard. At the east end of the Indio Hills flat-tails are either extirpated or rare and below detection levels. The reason for this decline is likely fragmentation and/or climate (fringe-toed lizards were extirpated

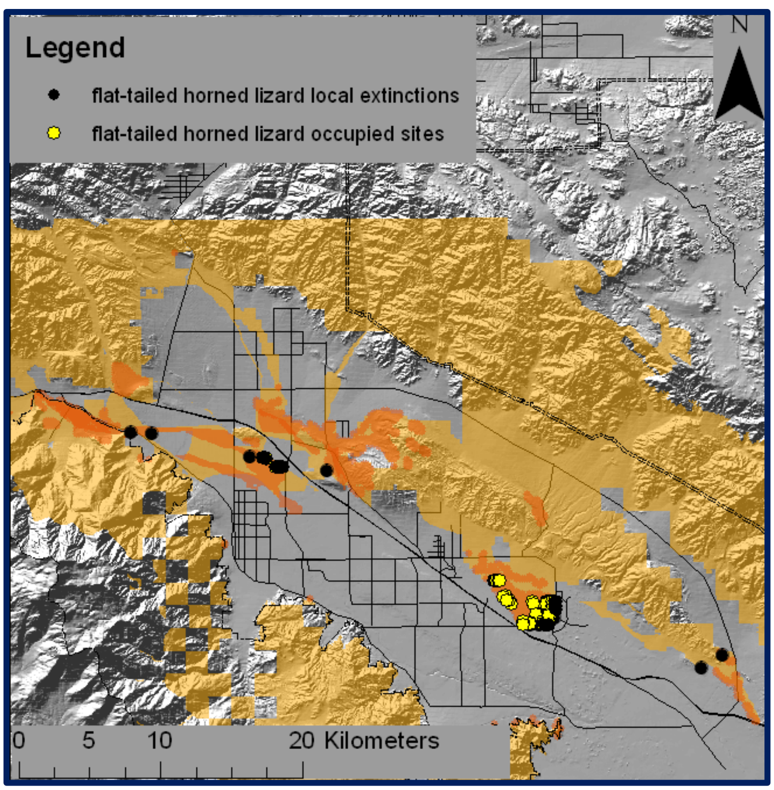
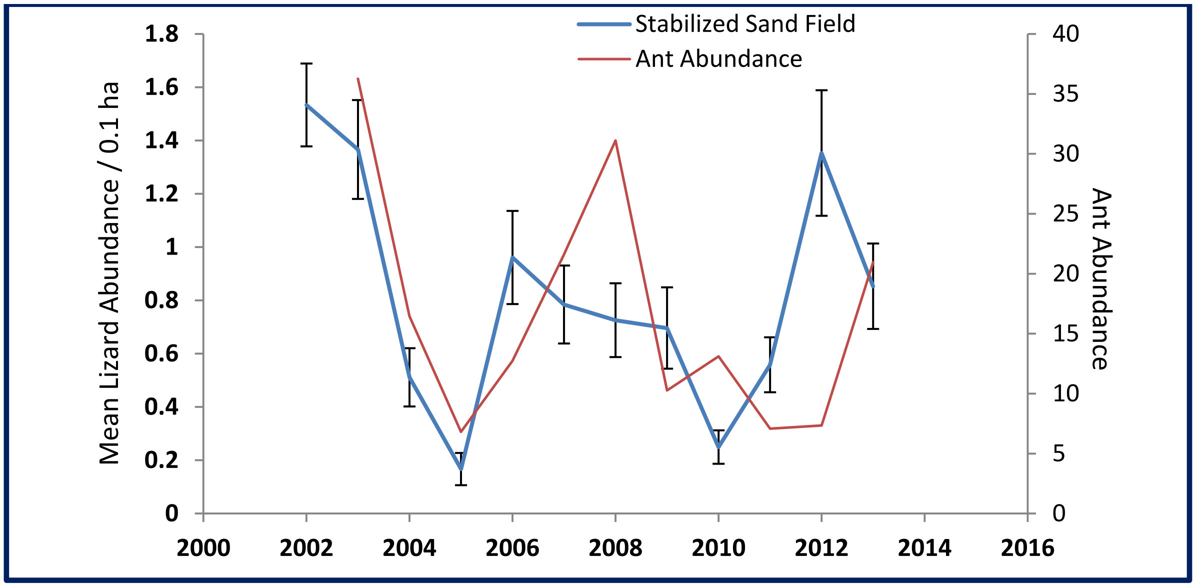


Figure 15. Location of monitoring plots for flat-tailed horned lizards on occupied sites within the Conservation Areas. Locations where local extinctions of this species have occurred are also shown.

there during the 2000-2004 drought al. 2010]). The east Indo Hills locations are resurveyed every other year since 2004 to determine whether recolonization has occurred by either fringe-toed lizards or flat-tailed horned lizards.

Flat-tailed horned lizard diets are almost exclusively harvester ants, and there is a close relationship between the ant population dynamics and that of the horned lizards.



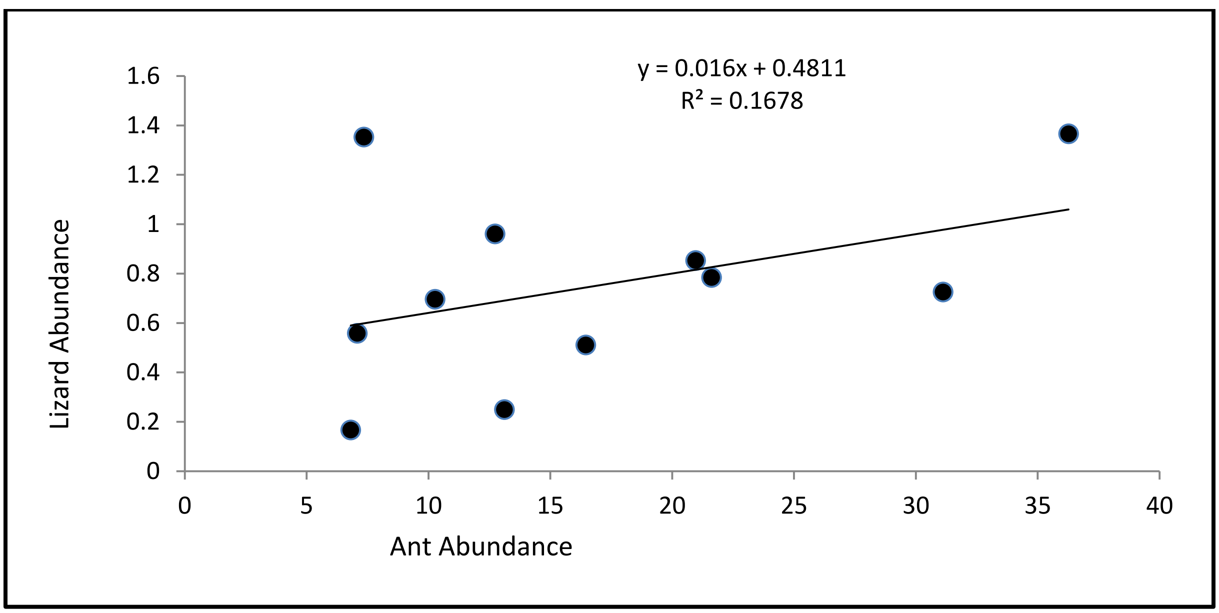


Figure 16-17. Correlation of abundance of flat-tailed horned lizards with ant abundance from 2002 to 2013.

However there is a negative relationship between the ants and the cover of Sahara mustard in any year. As long as the mustard continues to dominate the aeolian habitats on the Thousand Palms Preserve, and as long as the harvester ants are inhibited by the mustard, flat-tail populations will not be able to sustain the same population levels as they have prior to the dominance of the mustard. As with the fringe-toed lizard the flat-tailed horned lizard could be at risk of local extinction due to the interaction of both Sahara mustard and climate change. Measuring the ant-lizard responses as climate change progresses and if the mustard can be controlled is a critical task for on-going monitoring efforts. See Appendix 2 for a more detailed discussion and Appendix 1 for data summary.

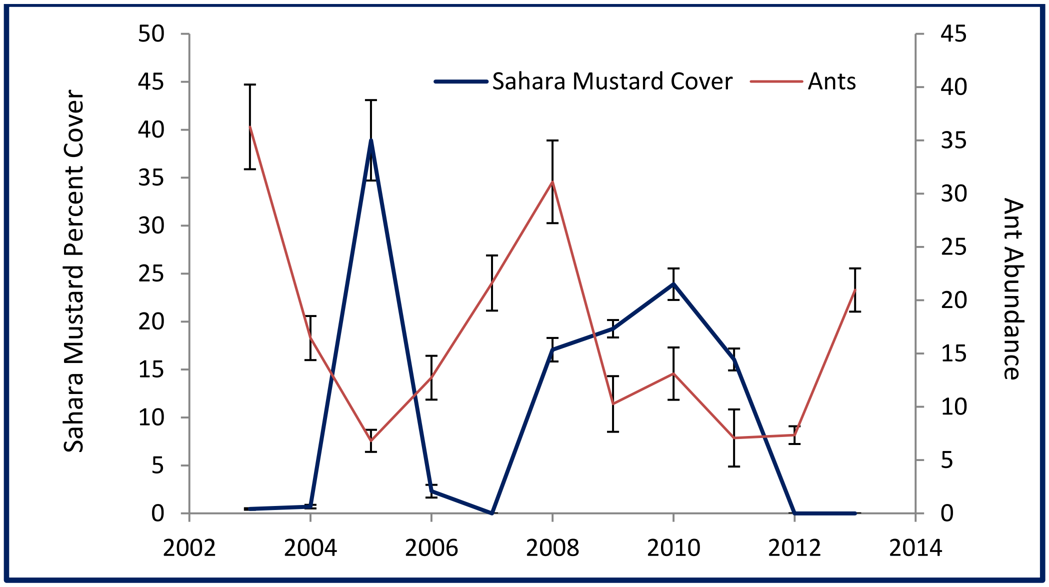


Figure 18. Correlation of the abundance of ants, a primary food source for flat-tailed horned lizards, with Sahara mustard percent cover from 2002 to 2013.

Other Covered Species – Community - Landscape Monitoring Efforts

Little San Bernardino Mountains Linanthus

Twelve 0.1 ha plots were established in January-February 2013 to monitor *Linanthus maculatus,* a minute annual plant species rarely larger than a nickel in size. The most recent monitoring for this species prior to 2013 was in 2003-2004. Each plot was surveyed in its entirety three times, once in February, March and April. No *Linanthus* were located. The habitat appeared largely intact, and so we assume that it was simply not the right precipitation pattern/amount to stimulate germination in this species. It will require multiple years and surveys before we develop a predictive model that will allow us to focus survey efforts on conditions that will provide a better assessment of this species population status.

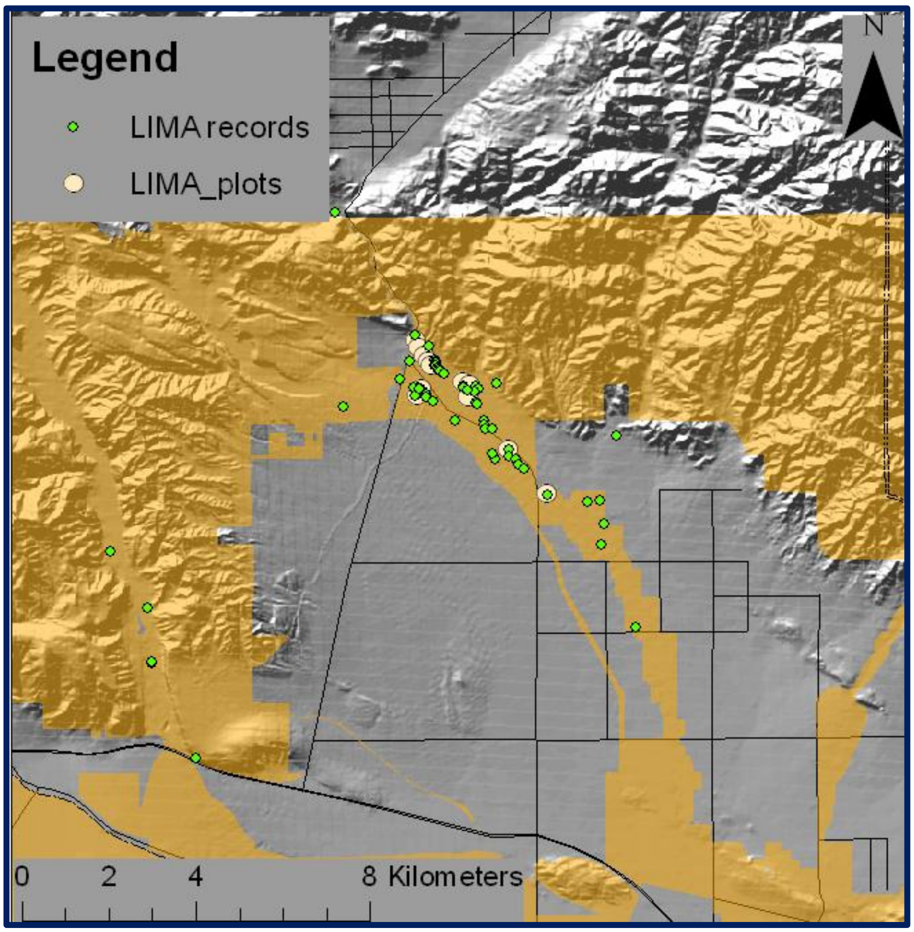


Figure 19. Location of monitoring plots established for Little San Bernardino Mountainslinanthus associated with known occurrences of this species within the Conservation Areas.

Western Yellow Bat

The first comprehensive survey of the distribution of the western yellow bat (*Lasiurus xanthinius*) within the CVMSHCP area was completed in 2013. The conceptual model and monitoring protocol for western bats in the Desert Wetland Monitoring Protocols (then called southern yellow bat, *Lasiurus ega*, however a taxonomic revision occurred since the protocol was approved) were preliminary pending actual survey data; they should now be revised based on the 2013 survey results.

.

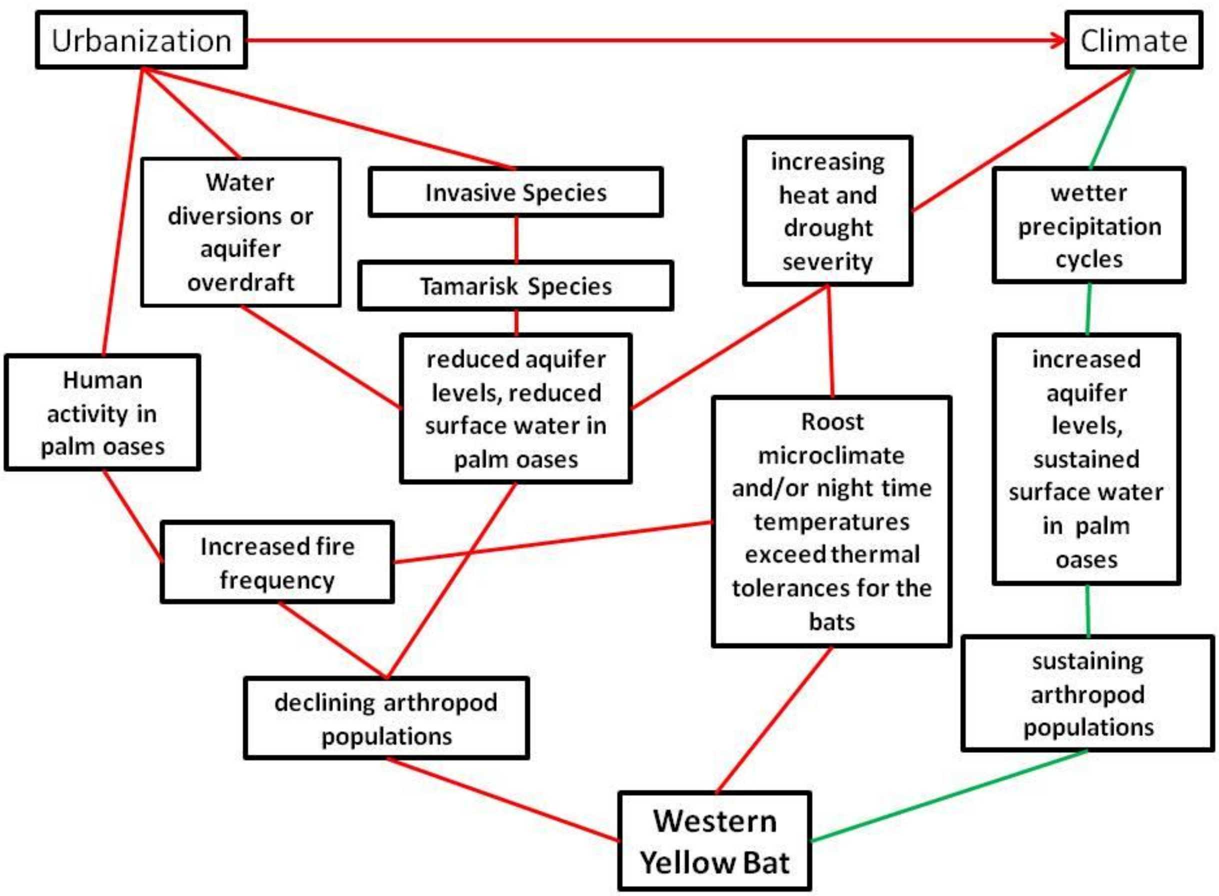


Figure 20. A conceptual model diagramming the relationships between stressors and drivers for western yellow bat populations within the Plan area.

The yellow bat conceptual model above reflects those findings. Red connectors indicate stressors, green indicate drivers. Yellow bat were located at 33 of the 31 palm oases surveyed and were confirmed roosting at 19 oases. Fire (its effect of palm skirt roost habitat), water at or near the surface promoting new palm growth, and climate change were identified as key factors influencing whether or not the bats roosted at a given oasis. See Appendix 3 for a complete description and analysis of yellow bat monitoring for 2013

Feasibility Study of Mesquite Restoration

During the fall of 2011, development of a restoration plan for the mesquite resources of the Coachella Valley was initiated. The Mesquite Restoration Plan should include a constraints analysis detailing site conditions where stands of mesquite (defined by leaf area and fruit production) are currently doing well or are declining or absent. This constraints analysis will form the basis of a draft restoration plan which will be submitted to the CVCC and other agencies for comments. As described in the CVMSHCP, the potential for creation or enhancement of mesquite hummock habitat should be considered in the context of Conservation Objectives for all covered species and natural communities. The restoration plan should include an evaluation of results from other areas where mesquite restoration has been attempted in terms of the potential for success. Water requirements, the source of water to support mesquite restoration or enhancement, and the relationship with groundwater levels should be addressed in this evaluation. Adding supplemental water at the surface would create the potential for invasive weeds and non-native ants to become established. These invasive plants and non-native ants are threats to the sand communities so the need fo rand impacts of subsurface supplemental water should be evaluated. The impacts to other natural communities and species should also be evaluated. The task should include a specific scope for completion of the mesquite restoration plan including an estimate of the hours needed and other costs necessary to complete this plan on an time and materials basis.

Findings to date: This report is currently in progress. Isotope analyses were delayed as was the digitizing of mesquite dynamics. We expect a final report by September 30, 2013. Figures 17 through 22 show preliminary comparisons between mesquite community extent determined by manual digitizing aerial imagery and nearest well depth records provided by CVWD:

Fault Line Dunes (1 km west of Palm Drive, north of 20th Ave.

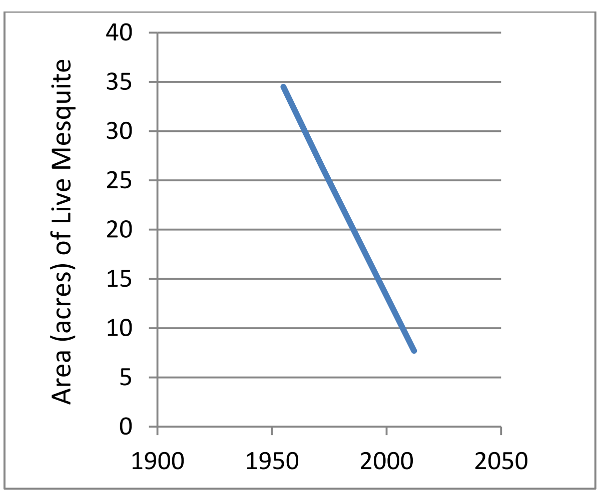


Figure 21. Area of live mesquite based on aerial photo analysis at the Fault Line Dunes

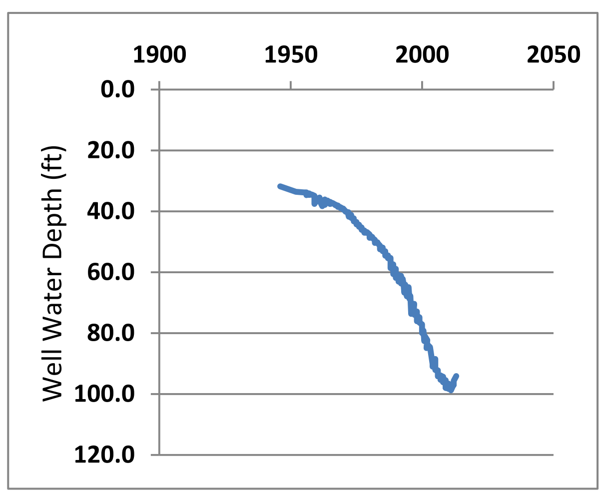
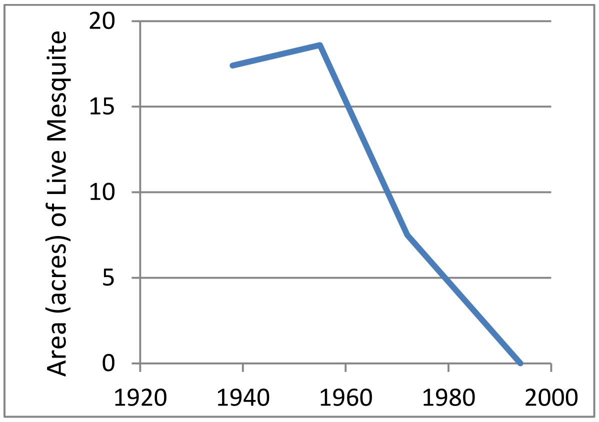


Figure 22. Well water depth at the Fault Line Dunes

38th Ave and Washington Street



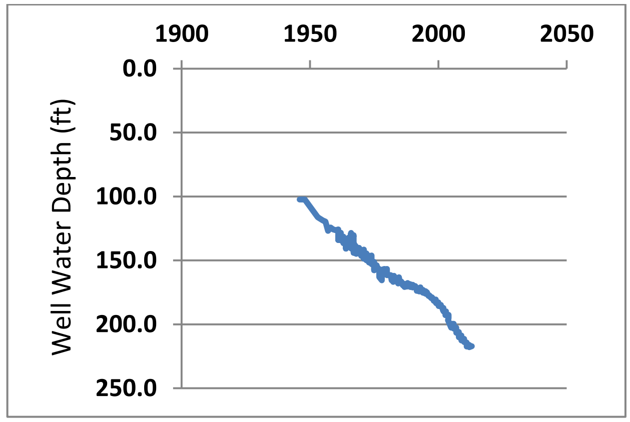
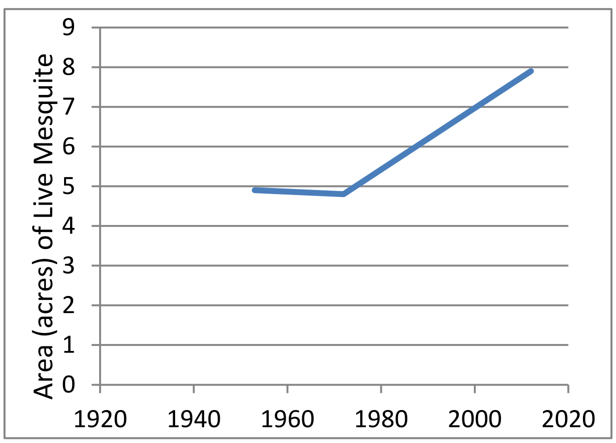


Figure 23. Area of live mesquite based on aerial photo analysis at 38th Ave/Washington St.

Figure 24. Well water depth at 38th Ave/Washington St.

Thousand Palms Canyon



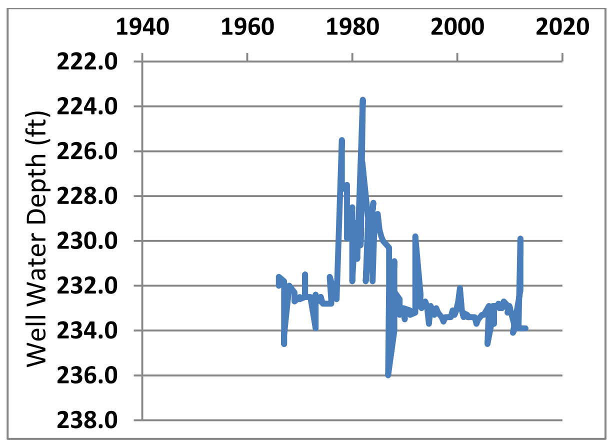


Figure 25. Area of live mesquite based on aerial photo analysis at Thousand Palm Canyon.

Figure 26. Well water depth at Thousand Palms Canyon

Vegetation/Natural Community Mapping

This task was delayed. We surveyed 98 vegetation assessment plots (see red dots on Figure 23 below) which we will use to identify vegetation alliance/association polygons once mapping commences. We anticipate completion of the valley floor vegetation mapping within the CVMSHCP boundary by September 30, 2013.

We anticipate the vegetation mapping project for the CVMSHCP occurring in multiple phases, each phase taking a discrete portion of the CVMSHCP. Phase1 will be the valley floor, inarguably the portion of the CVMSHCP that has received the greatest amount of anthropogenic change compared to any other sub-region of the CVMSHCP.

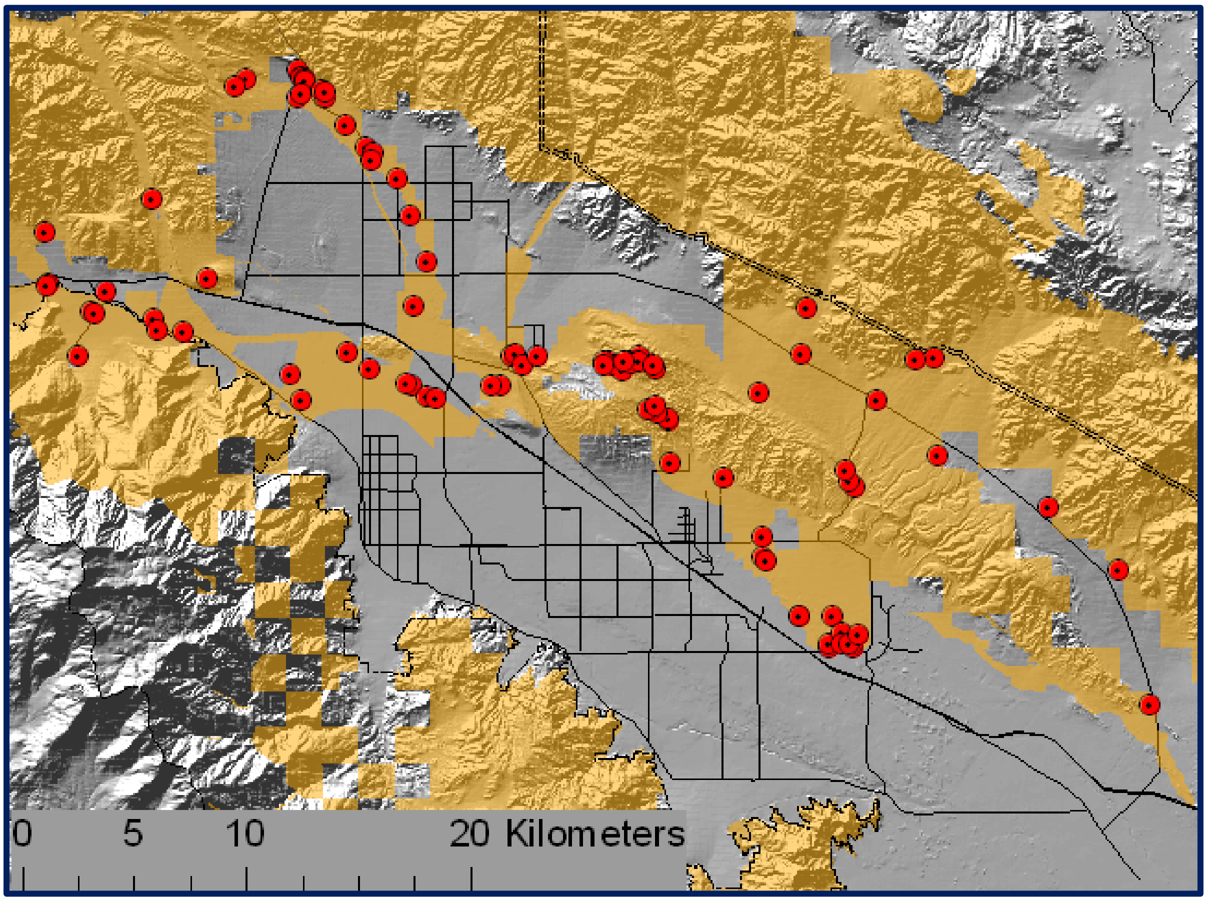


Figure 27. Location of vegetation/natural community assessment plots for the valley floor natural communities within the Conservation Areas.

III. Monitoring-Based Science Questions Moving Forward

The loss and fragmentation habitat are widely acknowledged to be primary reasons for reduced biodiversity; second to these pressures are invasive species (Wilcove et al.1998; Ludsin and Wolfe 2001; Simberloff 2004). The desert ecosystems of the southwestern U.S. and northwestern Mexico have been negatively impacted by invasive plants despite a harsh environment that would seem to otherwise inhibit the establishment of species that haven't evolved to those specific conditions (Van Devender et al. 1997). For the Coachella Valley, Sahara mustard (*Brassica tournefortii)* has severely degraded native annual plant communities (Barrows et al. 2009), with growing evidence of negative impacts cascading across tropic levels, amplifying effects to groups such as arthropods (Barrows 2012) and vertebrates (Barrows et al. in prep). In addition to these known stressors, one of the factors generating the greatest level of uncertainty in predicting the sustainability of natural systems is climate change (i.e. Barrows et al. 2010, Barrows and Murphy-Mariscal 2012). Climate change may usurp habitat loss by the mid to later part of this century as a leading cause of declines in biodiversity. The fossil record has documented that periods of climate shifts are associated with increased extinction rates. Climate is a primary predictor of many species' distributions; those species with narrow climate preferences and limited mobility or access to climate refugia will be most at risk. Climate change for this region will include warming temperatures, and is predicted to reduce precipitation (including snow packs which supply aquifers and then support riparian habitats) impacting both human communities and natural systems (Ali et al. 2012, Gao et al. 2012). Together these stressors will influence species or communities synergistically resulting in greater negative impacts than could be predicted from research focusing on individual stressors. The relative influence from most community stressors and drivers are spatially and temporally dynamic, causing selective pressures to change.. This complexity presents an enormous challenge to the success of conservation programs. Identifying key questions and then designing monitoring programs to provide critical information will prepare habitat managers to focus on priority tasks aimed at facilitating species sustainability here in the Coachella Valley as well as creating a framework for such efforts elsewhere.

Aeolian Sand Dune System

From the standpoint of natural biodiversity, within the CVMSHCP, no other landscape has been as altered as much as has the valley floor aeolian sand system. Prior to the 1950s there was a nearly 100 mi^2 largely unfragmented aeolian sand dune system; today as little as 5% remains and those remnants are fragmented into just four patches where the ecosystem processes are still intact to sustain this habitat (Barrows 1996, Barrows et al. 2008). Within this dune landscape the invasive Sahara mustard has degraded native annual plant communities in the eastern portions of the remaining aeolian sand systems and an drought event from 2000-2004 resulted in the local extinctions of fringe-toed lizards on the eastern most dune fragments (Barrows et al. 2010). Due to the reduced available habitat, species limited to sand dunes cannot simply move up the mountain slopes to suitable climatic conditions, nor can they move westward within the system to the cooler-wetter conditions found there due to habitat fragmentation. Previous research has identified relationships between rainfall, food resources and population growth for many of the dune species covered under the CVMSHCP, however the synergistic elements of climate change, invasive species and habitat fragmentation appear to have caused those relationships to weaken or degrade altogether, and the entire system to become more unpredictable. That previous research has created a foundation from which to identify the relative influences of stressors as they develop and so to then prioritize management actions. Key questions for aeolian sand dune systems include:

- Given the current severe drought, will the covered species within this system respond to a continued drought as they did in 2000-2004, or will the impacts be more severe, perhaps due to the lack of detritus reserves resulting from the prolonged dominance of the mustard?
- When wet winter-spring conditions return, will covered species rebound as they have before, or will the dominance of the mustard dampen recovery?
- How has fragmentation of this system impacted genetic heterogeneity within fragments (USGS analysis is in progress)
- What are the most effective controls for Sahara mustard, and what are their impacts on the natural system and which may be best suited for use with adaptive management?
- Assuming the invasive mustard can be controlled, will the native annual plant assemblage recover to composition/abundance levels prior to the mustard's dominance? How will that impact the larger food web?
- Will controlling mustard increase the resiliency of the entire aeolian system to the effects of climate change?
- What will be the impact on covered species if the stabilized honey mesquite dune habitats continue to lose honey mesquite as a stabilizing element?
- How is the absolute and relative extent of the aeolian sand communities changing within habitat fragments? Is that change oscillating over time or is it on a unidirectional trajectory?

Desert Wetland Systems

In desert regions, riparian and wetland systems present unique habitat with a relative abundance of water. However the supply and quality (salinity level) of water to these systems are issues, as are invasive species. Direct habitat loss due to anthropogenic habitat conversion and/or fragmentation has not been a factor in the conservation of desert wetlands within the CVMSHCP. Climate change may represent an additional stress for desert wetlands. A limiting resource for wetlands is surface water or near surface groundwater; predicted reduced precipitation in arid regions will likely deplete already stressed groundwater aquifers (Ali et al., 2012). Predicted increased drought frequency and intensity in the region including the Colorado Desert (Gao et al., 2012) may reduce the vigor of wetlands that are already water stressed.

Within the CVMSHCP area most desert wetland systems are tied to earthquake faults that allow deep groundwater to reach the surface. The size and extent of the aquifer supplying the water flow determines the degree to which groundwater extraction can occur before impacting the native habitats. The Dos Palmas wetlands stand out as examples of how dynamic desert wetlands can be. Dos Palmas is a seemingly incongruous wetland in the midst of the hottest and direst portion of the Colorado Desert, where vital desert riparian habitat is supported by an active and ever-changing hydrological regime. As a water conservation measure, the Coachella Canal was lined after 2001 and inputs from canal seepage ceased, thus the area's water availability and dependant habitat are changing again. While some change from the canal lining was anticipated and mitigation measures were established, the initial amount of change may be exceeding those expectations.

- Many desert wetland systems have been heavily altered due to invasions by non-native plants (especially salt cedar, *Tamarix ramosissima*), fish, frogs, crayfish, and snails. Although not documented non-native Argentine and red fire ants may also spread to these areas. What are the impacts of these invasives on CVMSHCP covered species, the natural community and ecosystem processes? What potential control measures should be examined to potentially return the system to a more native assemblage?
- Can desert pupfish eggs survive desiccation, and if so would temporary drying of desert ponds and wetlands provide an effective management tool for controlling invasive aquatic species?
- Although brown-headed cowbirds are known to occur in all the desert wetlands within the CVMSHCP, the level of their effects on covered bird species is unknown. Do cowbirds represent a threat to the sustainability of the covered wetland bird species of the CVMSHCP?
- How is the absolute and relative extent of the wetland communities changing? Is that change oscillating or is it on a unidirectional trajectory?

Alluvial Fan Systems

Habitat loss and fragmentation has eliminated alluvial fan systems along the much of the southern boundary of the Coachella Valley, but are largely intact along the northern and eastern boundary. Monitoring efforts on alluvial fan species to date have included burrowing owls (in 2009 & 2011), LeConte’s thrasher(in 2005), desert tortoise (ongoing work, performed by USGS), and the Palm Springs pocket mouse (in 2007), and have identified important system stressors including anthropogenic fire (only in the western most regions) and invasive species such as invasive grasses and mustard. Given the skewed distribution of several of the covered alluvial fan associated species toward the cooler-moister northwestern - Desert Hot Springs region (Palm Springs pocket mouse, LeConte’s thrasher, burrowing owl, Little San Bernardino Mountains *Linanthus*) it can be surmised that climate change will likely have a negative impact on at least those species.

- What is the current distribution of the alluvial fan communities and species?
- What are the species associations within the alluvial fan communities and how are they changing over time with respect to fire frequency, invasive species and climate change? How sensitive are the alluvial fan species to that change?

Montane Systems

Habitat loss and fragmentation has not been a substantial issue for this system, although loss of connectivity to alluvial fans along the base of the Santa Rosa and San Jacinto Mountains National Monument has occurred and may have importance to the bighorn sheep populations there. Invasive plant species include salt cedar, *Tamarisk ramosissima*, and fountain grass, *Pennisetum setaceum*. Covered species under the CVMSHCP include Peninsular bighorn sheep, triple ribbed milkvetch and the gray vireo. The milkvetch has been surveyed within the past two years by Joshua Tree National Park and the Ranch Santa Ana Botanic Gardens. All recent occurrences for this species are on US Forest Service, BLM ACEC, or National Park Service lands where the bulk of the populations appear restricted to particular soils (occasional waifs are found on the river bed habitats below the soil types), but no obvious stressors have been identified.

The gray vireo has been surveyed by the Grinnell re-survey efforts of the San Diego Museum of Natural History. They have detected a dramatic decline in this species throughout southern California, with perhaps no more than two recent occurrences within the CVMSHCP, all on US Forest Service lands. Possible explanations include an altered fire frequency, or shifts in the distributions and enhanced abundances of nest predators (scrub jays, cowbirds), but there are no data to evaluate those hypotheses. Given the small numbers within the CVMSHCP, and the more range-wide declines that have been identified, any science questions regarding this species will only be answered by looking range-wide and will require an initiative promoted by the US Forest Service or the federal or state wildlife regulatory agencies.

Bighorn sheep within the CVMSHCP, and throughout the Peninsular Mountain Ranges, have been stable or increasing in numbers throughout much of the past decade. Identified stressors have included disease transmitted by domestic sheep and goats, and enhanced mountain lion predation at least in part due to the cover provided by salt cedar cover at critical water sources. Climate change will likely impact the sheep, although there is sufficient elevation and topography in the local mountains to allow the sheep to move upslope to continue to experience preferred climate conditions. That up slope movement is currently inhibited by dense vegetation, but that will likely open up due to the impacts associated with climate change. The availability of water sources for the sheep and how those sources will change in a future of reduced rainfall and snow should be a concern. There is also a perceived conflict between trail recreation and the recovery of Peninsular bighorn sheep within the CVMSHCP. Unfortunately the bighorn sheep monitoring that has occurred within the CVMSHCP for decades was not designed to identify key habitat features nor provide meaningful data to conclude whether hikers and horseback riders have an effect on the sheep. This conflict consumes an enormous amount of human resources and will continue to do so until data are collected and analyzed (with external peer review) that answer this question.

Priority science questions include:

- What are the key habitat variables associated with successful reproductive recruitment in bighorn sheep?
- Is there a level of trail use that impacts that recruitment?
- Where are current water sources within the National Monument and how have they changed over the past decades? (this will be addressed under a separate BLM-CVCC contract in 2013-2014)
- How is the absolute and relative extent of the montane communities changing? Is that change oscillating over time or is it on a unidirectional trajectory?

IV. Literature Cited

Ali, R., D.McFarlane, S. Varma, W. Dawes, I. Emelyanova, G. Hodgson, and S. Charles. 2012. Potential climate change impacts on groundwater resources of south-western Australia. Journal of Hydrology 475:456–472.

Ball, L.C., P.F. Doherty, Jr., and M.W. McDonald. 2005. An occupancy modeling approach to evaluating a Palm Springs ground squirrel habitat model. Journal of Wildlife Management 69:894–904.

Barrows, C.W., M.B. Swartz, W.L. Hodges, M.F. Allen, J.T. Rotenberry, B. Li, T. A. Scott and X. Chen. 2005. A framework for monitoring multiple species conservation plans. Journal of Wildlife Management 69:1333-1345.

Barrows, C.W., M.F. Allen and J.T. Rotenberry. 2006. Boundary processes between a desert sand dune community and an encroaching suburban landscape. Biological Conservation 131:486-494.

Barrows, C.W. and M.F. Allen. 2007. Community complexity: stratifying monitoring schemes within a desert sand dune landscape. Journal of Arid Environments 69:315-330.

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. and M. F. Allen. 2007. Persistence and local extinctions of an endangered lizard on isolated habitat patches. Endangered Species Research 3:61-68.

Barrows C.W., K.L. Preston, J.T. Rotenberry, M.F. Allen. 2008. Using occurrence records to model historic distributions and estimate habitat losses for two psammophilic lizards. Biological Conservation 141:1885-1893.

Barrows, C.W. and M.F. Allen. 2009. Conserving Species in Fragmented Habitats: Population Dynamics of the Flat-tailed Horned Lizard, *Phrynosoma mcallii.* Southwestern Naturalist 54: 307-316.

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.

Barrows, C.W., J. T. Rotenberry, and M. F. Allen. 2010. Assessing sensitivity to climate change and drought variability of a sand dune endemic lizard. Biological Conservation 143:731-743.

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., K.D. Fleming, and M.F. Allen. 2011. Identifying Habitat Linkages to Maintain Connectivity for Corridor Dwellers in a Fragmented Landscape. Journal of Wildlife Management 75:682-691.

Barrows, C.W. 2012. Temporal abundance of arthropods on desert sand dunes. Southwestern Naturalist 57:263-266.

Barrows, C.W., and M.L. Murphy-Mariscal. 2012. Modeling impacts of climate change on Joshua trees at their southern boundary: how scale impacts predictions. Biological Conservation. 152:29–36

Gao, Y., L.R. Leung, E.P. Salathé Jr., F. Dominguez, B. Nijssen, and D.P. Lettenmaier. 2012. Moisture flux convergence in regional and global climate models: Implications for droughts in the southwestern United States under climate change. Geophysical Research Letters 39:1-5.

Latif, Q.S., K.D. Fleming, C. Barrows, and J.T. Rotenberry. 2012. Modeling seasonal detection patterns for burrowing owl surveys. Wildlife Society Bulletin 36-1: 155-160.

Ludsin, S.A. and A.D Wolfe. 2001. Biological invasion theory: Darwin's contributions from the Origin of the Species. Biosci 51:780–789

Simberloff, D. 2004. Community ecology: is it time to move on? Am. Sci. 163:787–799.

Van Devender, T.R., R.S. Felger, and A. Burquez-Montijo. 1997. Exotic plants in the Sonoran Desert region, Arizona and Sonora. California. Exotic Pest Plant Council, 1997 Symposium Proceedings.

Yoccoz, N.G., J.D. Nichols, and T. Boulinier. 2001. Monitoring of biological diversity in space and time. *Trends in Ecology and Evolution* 16(8):446-453.

Appendix 1: Data Summaries for Covered Species – 2012-2013 Monitoring

Covered Species	Natural Community	Metric	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
CV Milkvetch														
	active sand dune	mean/plot		0.2	4.7	5.2	0.9	0.0	1.3	1.0	4.5	1.0	0.0	0.0
		std. error		0.1	1.5	1.7	0.4	0.0	0.3	0.4	1.2	0.4	0.0	0.0
	stabilized sand field	mean/plot		0.5	0.6	0.3	0.0	0.0	0.3	0.0	4.0	0.0	0.0	0.0
		std. error		0.3	0.3	0.1	0.0	0.0	0.1	0.0	1.4	0.0	0.0	0.0
	central ephemeral sand field	mean/plot		7.3	11.4	8.3	1.3	0.3	5.6	14.8	0.0	14.3	1.2	3.6
		std. error		3.9	7.0	4.6	0.6	0.1	2.5	3.9	0.0	3.6	0.7	2.0
	western ephemeral sand field	mean/plot		10.0	13.3	195.7	96.5	0.0	7.5	3.3	1.3	29.0	144.3	146.5
		std. error		3.9	5.2	37.6	20.2	0.0	3.7	1.6	1.3	11.7	61.3	81.4
	stabilized mesquite dune	mean/plot			0.0	0.3	0.1	0.0	0.0	0.1	0.0	0.2	0.0	0.0
		std. error			0.0	0.2	0.1	0.0	0.0	0.1	0.0	0.1	0.0	0.0
CV Giant sand-treader cricket														
	active sand dune	mean/plot			6.5	13.9	19.5	1.0	11.9	12.2	18.5	36.4	22.7	
		std. error			1.0	1.4	1.9	0.5	0.9	1.0	2.6	3.1	3.0	
	stabilized sand field	mean/plot			2.2	4.7	2.0	0.0	5.4	3.4	8.8	12.3	8.4	
		std. error			0.7	1.3	0.5	0.0	1.0	0.8	1.6	2.1	1.4	
	central ephemeral sand field	mean/plot			0.3	2.9	1.1	0.0	4.3	15.0	11.3	28.8	18.3	
		std. error			0.1	0.9	0.3	0.0	1.7	1.4	2.8	2.5	2.2	
	western ephemeral sand field	mean/plot			5.0	20.5	14.5	6.3	8.5	9.2	30.0	20.7	11.0	
		std. error			0.4	3.4	1.5	1.7	0.9	1.5	5.6	2.2	7.0	
	stabilized mesquite dune	mean/plot			1.2	5.9	4.8	0.0	5.9	3.1	15.6	8.5	4.6	
		std. error			0.6	1.2	1.1	0.0	1.3	0.7	2.8	0.9	1.0	
CV Fringe-toed lizard														
	active sand dune	mean/plot	3.0	1.8	2.8	3.4	5.6	4.2	2.8	5.3	4.7	6.2	3.5	2.0
		std. error	0.4	0.2	0.2	0.4	0.4	0.2	0.2	0.4	0.4	0.5	0.3	0.2
	stabilized sand field	mean/plot	0.8	0.4	0.4	0.2	0.8	0.9	0.2	0.4	0.4	0.5	0.6	0.6
		std. error	0.2	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.2
	central ephemeral sand field	mean/plot		0.3	0.1	0.2	0.3	0.7	0.6	2.2	2.3	2.8	3.7	3.0
		std. error		0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.2	0.5	0.3	0.4
	western ephemeral sand field	mean/plot			1.8	2.2	1.8	2.3	2.1	2.9	3.0	1.9	2.1	2.7
		std. error			0.3	0.5	0.6	0.7	0.7	0.8	0.8	0.5	0.6	0.9
	stabilized mesquite dune	mean/plot		1.7	1.4	1.6	2.4	1.6	1.6	1.4	1.3	1.6	1.2	0.9
		std. error		0.2	0.2	0.4	0.5	0.5	0.3	0.3	0.3	0.3	0.3	0.2
Flat-tailed horned lizard														
	active sand dune	mean/plot	0.0	0.0	0.0	0.1	0.2	0.2	0.0	0.2	0.2	0.2	0.7	0.3
		std. error	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.2	0.1
	stabilized sand field	mean/plot	1.5	1.4	0.5	0.2	1.0	0.8	0.7	0.7	0.2	0.6	1.4	0.9
		std. error	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.2	0.2
CV Round-tailed ground squirrel														
	active sand dune	mean/plot		0.5	0.2	1.3	1.2	0.1	0.1	0.1	0.0	0.2	0.1	0.0
		std. error		0.1	0.1	0.2	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.0
	stabilized sand field	mean/plot		0.2	0.5	0.7	0.6	0.2	0.1	0.0	0.0	0.1	0.2	0.0
		std. error		0.0	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
	central ephemeral sand field	mean/plot		0.4	0.2	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.1	0.0
		std. error		0.2	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0
	western ephemeral sand field	mean/plot		0.5	0.3	0.5	1.3	0.1	0.4	0.1	0.3	0.3	0.2	0.2
		std. error		0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2
	stabilized mesquite dune	mean/plot		0.2	4.1	2.8	2.9	0.8	0.6	0.3	0.4	0.4	1.4	1.7

Covered Species	Natural Community	Metric	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Palm Springs pocket mouse														
	active sand dune	mean/plot		0.00	0.00	0.24	0.29	0.03	0.01	0.18	0.03	0.06	0.03	0.00
		std. error		0.00	0.00	0.06	0.06	0.01	0.01	0.06	0.01	0.03	0.02	0.00
	stabilized sand field	mean/plot		0.00	0.06	0.13	0.11	0.09	0.14	0.36	0.15	0.23	0.11	0.01
		std. error		0.00	0.04	0.03	0.02	0.02	0.03	0.07	0.04	0.04	0.02	0.01
	central ephemeral sand field	mean/plot		0.00	0.00	0.07	0.35	0.14	0.42	1.42	0.42	0.57	0.04	0.00
		std. error		0.00	0.00	0.04	0.08	0.03	0.06	0.28	0.11	0.17	0.03	0.00
	western ephemeral sand field	mean/plot			0.00	0.00	1.28	0.14	0.08	1.14	0.17	0.37	0.07	0.03
		std. error			0.00	0.00	0.40	0.03	0.04	0.15	0.14	0.10	0.04	0.03
	stabilized mesquite dune	mean/plot		0.00	0.00	0.10	0.15	0.02	0.07	0.35	0.34	0.27	0.06	0.07
		std. error		0.00	0.00	0.04	0.06	0.01	0.04	0.08	0.08	0.05	0.03	0.05
Burrowing owl														
	active sand dune	mean/plot		0.00	0.01	0.02	0.15	0.01	0.06	0.03	0.20	0.13	0.03	0.04
		std. error		0.00	0.01	0.01	0.04	0.01	0.03	0.02	0.05	0.04	0.01	0.02
	stabilized sand field	mean/plot		0.00	0.00	0.00	0.05	0.05	0.00	0.08	0.05	0.12	0.06	0.02
		std. error		0.00	0.00	0.00	0.02	0.01	0.00	0.02	0.03	0.03	0.02	0.01
	central ephemeral sand field	mean/plot		0.00	0.00	0.02	0.03	0.04	0.04	0.00	0.00	0.00	0.07	0.00
		std. error		0.00	0.00	0.02	0.02	0.03	0.02	0.00	0.00	0.00	0.04	0.00
	western ephemeral sand field	mean/plot		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
		std. error		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
	stabilized mesquite dune	mean/plot		0.00	0.00	0.08	0.49	0.09	0.05	0.10	0.17	0.33	0.41	0.16
		std. error		0.00	0.00	0.03	0.11	0.03	0.02	0.04	0.05	0.06	0.12	0.12
	valley-wide road surveys	total owls detected								86		88		
Little San Bernardino Mountains linanthus														
	Sonoran creosote bush scrub	mean/plot												0.00
		std. error												0.00
Yuma clapper rail (data from CVWD)														
	cismontane alkali marsh	# rails detected using 3 surveys at ca 21 plots					8	17		10		10		*
California black rail (data from CVWD)														
	cismontane alkali marsh	# rails detected using 3 surveys at ca 21 plots					0	1		1		0		*
Desert pupfish														
			*	*	*	*	*	*	*	*	*	*	*	*
Western yellow bat														
	desert fan palm oases	confirmed sites with roosting												19/41
	desert fan palm oases	detected at sites												33/41
*	Indicates data were collected but have not yet been made available to the CVCC biological monitoring program													

Appendix 2: Population drivers of Coachella Valley fringe-toed lizard and flat-tailed horned lizard

PREPARED BY: CAMERON W. BARROWS
University of California Riverside, Center for Conservation Biology, Palm Desert, CA

Abstract
Here I examine the contribution of annual rainfall and other independent variables affecting population dynamics for two aeolian sand community vertebrates, the Coachella Valley fringe-toed lizard, *Uma inornata*, and the flat-tailed horned lizard, *Phrynosoma mcallii*. For the fringe-toed lizard, rainfall's importance as a proxy for food resources in predicting rates of population growth was clearly demonstrated; however in the most recent four years (2009-2012) that relationship has decoupled and become statistically non-significant. For the flat-tailed horned lizard in the Coachella Valley annual rainfall surprisingly provides no prediction of population growth. Their diet consists entirely of harvester ants, and the ants were negatively correlated with Sahara mustard cover (Sahara mustard is positively correlated with rainfall). For both lizards mustard cover emerged as an environmental variable inhibiting population growth.

In arid environments annual or seasonal rainfall accumulations are often dominant drivers in plant and animal population dynamics (Noy-Meir1973, Barrows 2006). The challenge is identifying the often more subtle influence of additional environmental variables, especially potential threats, affecting population trajectories and ultimately the persistence of conservation targets. Long-term data sets collected across environmental gradients are required to partition dominant rainfall effects from stressors and to assess whether their influence is growing (Barrows et al. 2005). While the negative impacts of Sahara mustard, *Brassica tournefortii*, on native annual plants occurring on the aeolian sand community of the Coachella Valley have been documented (Barrows et al. 2009), the impacts of this invasive species on vertebrates has not received a rigorous analysis. Hulton et al. (in review) have examined patterns of arthropod abundance, diversity and species richness on the Coachella Valley's aeolian sand communities and have documented a temporal decline in all their arthropod metrics over the past decade; however that decline was statistically significant only on those sites with dense Sahara mustard cover and those with increasing mustard levels. Evidence of negative impacts from the mustard on both annual plants and arthropods as mustard cover increases could be harbingers of broader biodiversity declines including higher trophic levels.

This report provides an analysis of the population dynamics for two aeolian sand community vertebrates, the Coachella Valley fringe-toed lizard, *Uma inornata*, and the flat-tailed horned lizard, *Phrynosoma mcallii*. Both species are a focus for conservation efforts in the Coachella Valley and for the horned lizard also elsewhere within its limited range. Previous research has identified important environmental variables that describe both suitable habitat as well as population changes in these species, including annual rainfall, sand compaction, harvester ant abundance, and vegetation characteristics, including Sahara mustard (Barrows 2006, Barrows and Allen 2009, Barrows and Allen 2010). The ten years of species abundance and community condition data we have collected have included areas of dense mustard cover as well as areas where the mustard has made only limited inroads. Temporally these data spanned extreme record-setting droughts as well as near-record wet years. That time span has also included years when the mustard was an uncommon component of the community to the current condition where in wet years it dominates to the near exclusion of indigenous annual plant species. These spatial patterns and temporal changes provide an *in situ* natural experiment from which to understand the importance of a suite of environmental variables in driving the population dynamics, and ultimately the long-term persistence, for these two lizard species.

Methods

Study Sites – The primary study sites were located within the Coachella Valley, near Thousand Palms, Riverside County, California, USA, on the Coachella Valley National Wildlife Refuge and California State Ecological Reserve (latitude 33.78, longitude -116.32). This area is part of an extremely arid shrub desert with a mean annual rainfall of 79 mm (most recent 60 year means, Western Regional Climate Center, Indio reporting station). The lowest rainfall years on record occurred in 2002 and 2007, with <10 mm of rainfall recorded. In contrast, in 2005, 210 mm of rainfall was measured, the largest annual rainfall total recorded in the past 50 years. Temperatures show similar extremes ranging from a low approaching 0° C in the winter to high exceeding 45°C commonly recorded during July and August. Although we collect data on the condition of the aeolian sand community on over 100 plots throughout the Coachella Valley, these analyses are limited to just the eastern-most plots, sites where the mustard dominates annual plant growth. The plots were also limited to only those sites where these two lizard species are detected with regularity; calculating population growth requires consecutive years of detections (see below). Thirty-four study plots were surveyed within active to partially stabilized dunes for assessing the population dynamics of the fringe-toed lizard, and 19 plots were surveyed within stabilized sand fields and partially stabilized dunes to examine the horned lizard dynamics. Study sites were located in a random manner; horned lizard plots located within 50 m of roadways were excluded to avoid confounding edge effects (Barrows et al 2006). Each plot was 1m × 100 m (0.1 ha).

Species and habitat data collection – We followed the monitoring protocols developed for the Coachella Valley Multiple Species Habitat Conservation Plan (CVMSHCP) throughout. The fine aeolian sand of the Coachella Valley's dune fields provided an opportunity unique to sand dunes to quantify the occurrence and relative abundance of lizards occurring within plots by counting individuals of each species by tracks they left as they moved across or within each plot. Each reptile species occurring on the aeolian sands could be identified to species and age class by their diagnostic tracks. Our tracking method was also non-intrusive, which is particularly important when surveying threatened or endangered species such as Coachella Valley fringe-toed lizards. Identifying differences in track size and features, and following tracks off the plots ensured that each counted track represented a unique individual. Because late afternoon and evening breezes would usually remove all evidence of tracks, those from any sampling could not confused with those from the previous day. At least for flat-tailed horned lizards when we compared tracking data to mark and recapture derived densities there was a close proportional relationship ($R^2 = 0.9599$ and $P = 0.0006$; Barrows and Allen, 2009). Each plot was surveyed six times from late May through early July each year; lizard abundance metrics represented a mean of those six repetitions for each year.

Annual plants were counted and cover estimated in a 1 m^2 frame placed at 12 locations along the midline of each plot. Four samples were taken on alternating sides of the centre line at each end point, and two samples were taken on each side of the centre point. In each frame all individual plants were counted by species to determine species densities, and for each species we made a visual estimate of its percent cover within each frame. These values were then averaged for each species for the 12 frames of each plot. Annual plant data presented in our analyses were all measures of percent cover. Sand compaction has been described as a key habitat variable for *U. inornata* (Barrows, 1997, 2006). In order to capture the variation within each plot, sand compaction was measured at 25 points, approximately 4 m apart, along the plot midline, each year, using a hand-held pocket penetrometer with an adapter foot for loose soils (Ben Meadows Company, Janesville, WI, USA). Data were recorded as the force (kg/cm^2) required to penetrate the sand surface. Annual precipitation was measured from a rain gauge located within the study area. In all but one year the data represent total rainfall for the rain year from July1 through June 30. The exception was in the 2006 rain year when the majority of rain fell in September and had no discernible impact on the following spring's annual plant germination and associated food resources. In that year only December 1 through June 30 rainfall was used.

Arthropods were sampled using dry pitfall traps in April. Pitfall traps were placed at both ends and at the middle of each plot for a total of three pitfalls per plot. The traps were collected within 24 h of being set out to avoid any mortality of vertebrates captured in the traps. All arthropods were identified to the species level. Arthropod data are presented here as the total individuals/taxa/plot (combined counts for the three pitfall traps).

Analyses – Our dependent variable metric for describing population dynamic in the two lizard species was the observed mean annual rate of lizard population increase (r) was calculated using $r = \ln(N_{i+1}/N_i)$ where N_i is the mean count of lizards observed during spring surveys in year i.

Results

Fringe-toed Lizards – Annual rainfall is a dominant driver of population growth (λ) in Coachella Valley fringe-toed lizards (Figure 2-1). Mean population growth relative to the log (ln) of annual rainfall follows a linear relationship, becoming positive as annual rainfall levels rise approximately above 25 mm; however, there is substantial variability between individual plots, with negative and positive population growth occurring under the full range of rainfall levels experienced here from 2003-2008. The mean population growth-log annual rainfall regression model for 2002 through 2008 is statistically significant ($t = 6.48$, $p = 0.0031$). The 2009-2012 data resulted in a substantial decline in the data fit to the model (R^2); the mean population growth-log annual rainfall regression model for these years fell short of reaching traditional levels of statistical significance ($t = 1.21$, $p = 0.287$). For 2009-2012 there was an average decline in expected mean population growth of 0.5 (0.2-1.075) compared to the 2002-2008 regression model predictions.

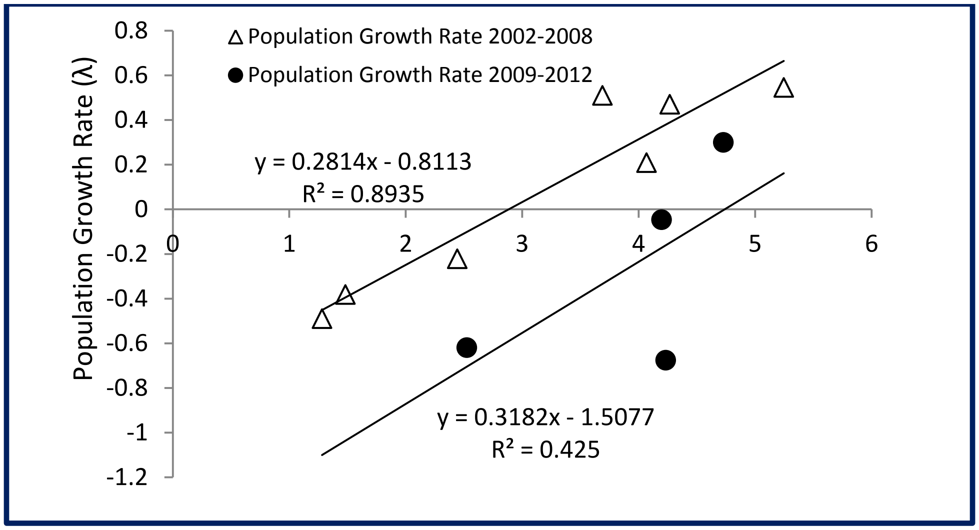


Figure 2-1. Mean population growth rate (λ) (Y axis) compared to the log (ln) of annual rainfall (X axis) for fringe-toed lizards on active dunes within the Thousand Palms Core Preserve. Comparison includes two time series, 2002-2008, and 2009-2012.

Flat-tailed Horned Lizards – A comparison between the mean population growth rate and the log (ln) of annual rainfall for flat-tailed horned lizards (FTHL) revealed no relationship between the two variables (Figure 2-2) ($t = 1.35$, $p = 0.324$). The lack of significant relationship was consistent for all year combinations.

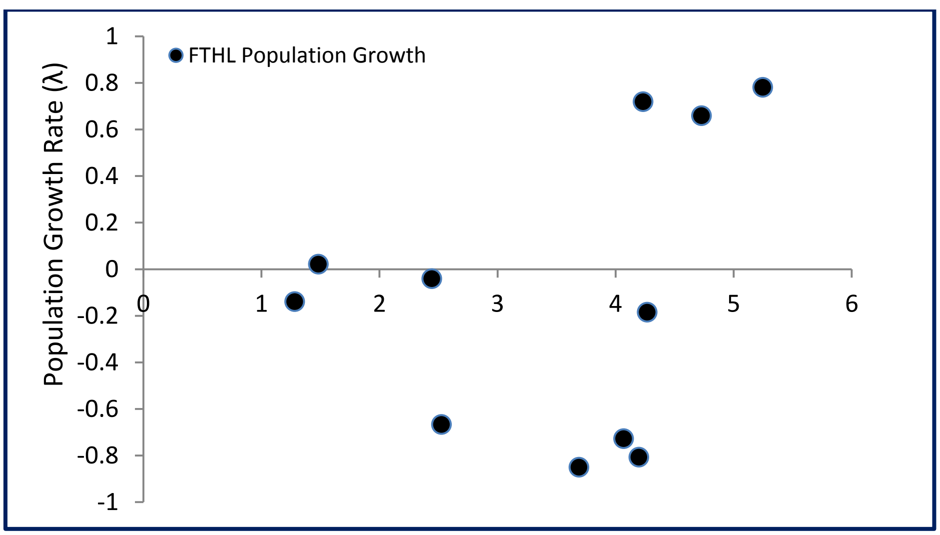


Figure 2-2. Mean population growth rate (λ) (Y axis) compared to the log (ln) of annual rainfall (X axis) for flat-tailed horned lizards on stabilized sand fields within the Thousand Palms Core Preserve.

Unlike fringe-toed lizards which are omnivorous, eating plants, arthropods of multiple orders, and occasionally vertebrates (hatchling lizards), flat-tailed horned lizards are diet specialists, eating almost exclusively harvester ants. Although the regression coefficient (R^2) indicated a poor fit to the regression model, harvester ant abundance was nevertheless significantly negatively associated with annual rainfall

(Figure 2-3) (t = 4.38, p = 0.002). Consistent with their specialized diet, flat-tailed horned lizard abundance is positively associated with harvester ant abundance, with the regression nearly reaching traditional levels of statistical significance (Figure 2-4) (t = 2.12, p = 0.063).

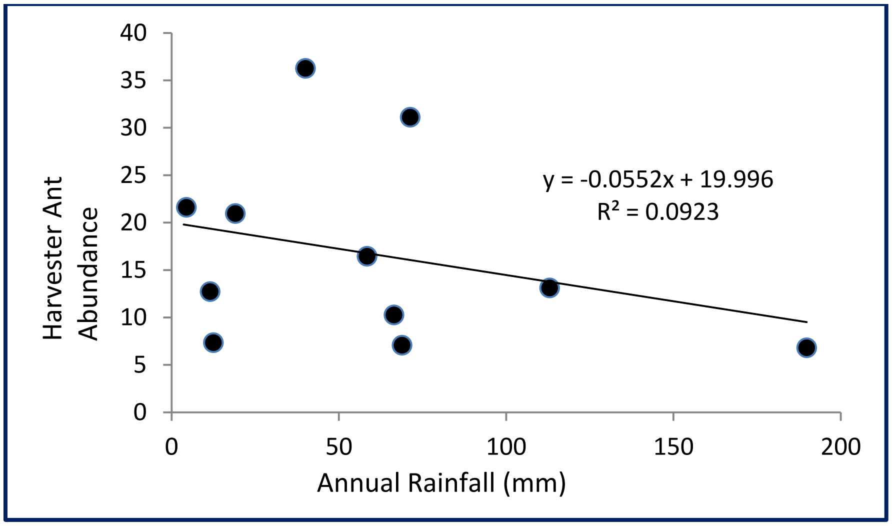


Figure 2-3. The relationship between harvester ant abundance and annual rainfall on the stabilized sand fields within the Thousand Palms Core Preserve.

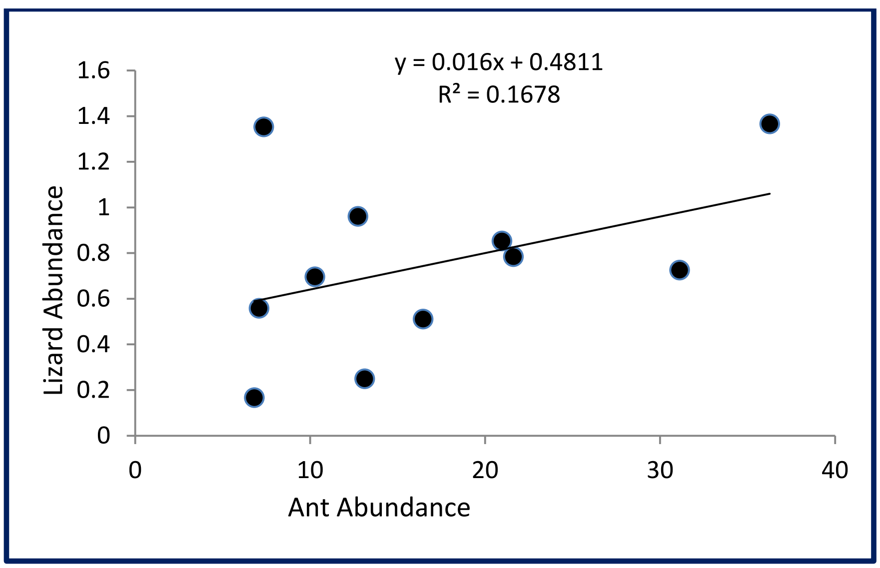


Figure 2-4. The relationship between harvester ant abundance and flat-tailed horned lizards on the stabilized sand fields within the Thousand Palms Core Preserve.

Discussion

For the fringe-toed lizard, rainfall's dominance was clear in determining population growth rates. This finding provides an important tool for identifying departures from that rainfall-population dynamics connection. Just such a decoupling of that relationship has occurred from 2009-2012. It is now critical to determine the cause of that separation. Leading the list of possibilities is the dominance of Sahara mustard, however additional analyses are required before that cause-effect can be more certain.

Nevertheless there is growing evidence for a negative trophic cascade, beginning with the degradation of the native annual plant assemblage, to arthropods, and now vertebrates.

For flat-tailed horned lizards a very different pattern emerged. Rainfall did not correlate with mean population rates, in fact the horned lizards' primary food, harvester ants, showed a negative relationship with annual rainfall. This pattern goes against expectations; the ants should respond positively to the seed resources catalyzed by higher rainfall. Two hypotheses may explain these phenomena. Possibly the ants are actually less active during years of plenty – they may be able to gather sufficient food stores with minimal effort and then stay below ground to avoid predation. Alternatively, the ants may either not be able to consume mustard seeds (even though they readily collect them and bring them to their colonies), or they may require the diverse seed resources available before the mustards' dominance in order to meet limiting nutritional needs. Additional data will be required in order to test these hypotheses.

The more stabilized aeolian sand habitat seemingly preferred by the horned lizards has much higher mustard cover than the more active sand preferred by fringe-toed lizards (Barrows 2006, Barrows and Allen 2009). The horned lizards earlier (post-2005) than the fringe-toed lizard (post-2008) response to the mustard may be related to the much denser mustard cover on their habitat. Prior to 2005 few horned lizards were detected in the more active dune areas; since 2005 horned lizards have increasingly been found in the more open active dunes. In 2012 we measured growth rates in juvenile flat-tailed horned lizards occurring on both active dunes and stabilized sand habitats. During the June juvenile horned lizards on the stabilized sand fields were 10% smaller than those on active dunes. While a seemingly small, such size differences are enough to determine whether or not these juvenile lizards will reach adult size and breed within their first year; due to relatively high annual mortality positive population growth occurs only when a high proportion of first year lizards are successful breeding (Barrows and Allen 2009). While other potential mechanisms, such as reduced mobility and increased sand compaction were not examined, our size difference observation points to reduced food resources as a causal factor, and is consistent with the findings of reduced arthropods due to the increasing dominance of mustard by Hulton et al. (in review). The apparently stronger negative response by the horned lizards to the mustard invasion may be due to their more exclusive diet of harvester ants, while fringe-toed lizards have a much broader plant diet of plants and other arthropods (Barrows 2006, Barrows and Allen 2009).

The active dune areas do not have a level of primary productivity that could support the abundant lizard populations and diverse arthropod community that occurs there. This seeming enigma can be explained realizing the food web is based on detritus blowing onto the active dunes from surrounding communities providing for a diverse and abundant arthropod detritivore guild (Seely 1978, 1991, Barrows 2012). Whether Sahara mustard can replace the more species diverse detritus generated by native annual plants is unknown, however the mustard does not disarticulate as readily as the nave plants, due staying rooted in the ground or blowing across the dune intact. It may not result in the fine particulate detritus generated by native species. If this is the case, then the mustard not only reduces plant species diversity but disrupts ecosystem processes that provide the active dunes resources for a multi-trophic functioning food web. The detritus does take many years to either be consumed or be blown off of the dunes and so could account for the delayed and subtle response from the fringe-toed lizards. At least for the fringe-toed lizards there are areas within the Coachella Valley that are occupied by the lizards and that appear to be resistant to the mustard invasion.

Although flat-tailed horned lizards have a limited range outside the Coachella Valley, within this northwestern-most corner of their distribution there is just one otherwise sustainable population left, and it is heavily infested by the mustard. With climate change dominating concerns about our ability to sustain natural communities, populations and species, one of the important proactive actions conservation programs can take is to reduce other stressors. Whether those additional stressors are additive or have multiplying effects, with climate change these threats have a greater probability of leading to local population losses. Our results support other findings that Sahara mustard is eroding biodiversity across trophic levels within those aeolian sand habitats where it is becoming, or has become the dominant annual plant species.

Literature Cited

Barrows, C. W. 1996. An ecological model for the protection of a dune ecosystem. Conservation Biology 10:888–891.

Barrows, C. W. 1997. Habitat relationships of the Coachella Valley fringe-toed lizard, *Uma inornata*. Southwestern Naturalist 42(2): 218-223.

Barrows, C. W., M.B. Swartz, W.L. Hodges, M.F. Allen, J.T. Rotenberry, B. Li, T. A. Scott and X. Chen. 2005. A framework for monitoring multiple species conservation plans. Journal of Wildlife Management 69:1333-1345.

Barrows, C. W. 2006. Population dynamics of a threatened dune lizard. Southwestern Naturalist 51:514-523.

Barrows, C. W., M. F. Allen, and J. T. Rotenberry. 2006. Boundary processes between a desert sand dune community and an encroaching suburban landscape. Biological Conservation 131:486–494.

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. 2009. Conserving Species in Fragmented Habitats: Population Dynamics of the Flat-tailed Horned Lizard, *Phrynosoma mcallii.* Southwestern Naturalist 54: 307-316.

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.

Barrows, C. W. 2012 Temporal abundance of arthropods on desert sand dunes. Southwestern Naturalist 57:263-266.

Hulton, H.L, A.M. Hansen, C.W. Barrows, Q. Latif, M.W. Simon, and K.E. Anderson. Relationships between changes in arthropod community structure and Sahara mustard (*Brassica tournefortii*) across environmental gradients and levels of invasion. Submitted to Biological Invasions

Noy-Meir, I. 1973. Desert ecosystems: environment and producers. Annual Review of Ecology and Systematics 4:25–51.

Seely, M.K. 1978. The Namib dune desert: an unusual ecosystem. Journal of Arid Environments 1:117-128.

Seely, M.K. 1991. Sand dune communities. *In* Polis, G.A. (ed) The Ecology of Desert Communities. The University of Arizona Press, Tucson, Arizona. Pg. 348-382.

Appendix 3: Isotopic analyses and spatial ecology of Riverside County burrowing owls (*Athene cunicularia*)

KATHLEEN D. FLEMING, CAMERON W. BARROWS, QURESH LATIF, JOHN D. ROTENBERRY
University of California Riverside, Center for Conservation Biology, Palm Desert, CA

The use of stable isotopes to track wildlife migration patterns is a widely used technique in the avian biology field. It has proven especially effective for determining migratory routes of birds and arthropods across large regions (Bowen et. al, 2005). For western burrowing owls, *Athene cunicularia hypugae*, which are assumed to be non-migratory in the arid deserts and open grasslands of North America (Korfanta et. al, 2005), isotope analyses may offer a technique to reveal movements within and between conserved lands within Riverside County. Such movements could indicate sources or sinks where the owl populations are reproducing and emigrating from versus where little or no successful recruitment occurs. It could indicate levels of connectivity between populations, and so important corridors and conservation targets across and between conservation areas. To help us better understand the spatial ecology of the burrowing owls in our region and movement within Riverside County and between the Western Riverside County and Coachella Valley populations, we used markers of spatial origin to determine local isotopic compositions of burrowing owl feathers. We analyzed δ2H, δ13C, and δ15N isotope ratios of adult and nestling feathers to develop isotopic signatures of nestlings native born to localities across Riverside. We then compared these isotopic signatures to developed environmental isoscapes to determine if the techniques could be used on a local scale to understand the spatial boundaries of populations and to determine philopatric (native born) and immigrant owls.

Within the Coachella Valley, burrowing owls are habitat generalists, often found anywhere opportunistic burrows exist, adjacent to suburban and urban development, within washes, fallow fields, sand dunes, and agricultural drains (CVAG BUOW report, 2010). There are no specific vegetation types which are exclusively used to classify suitable habitat, and distributional models favor other variables such as topography, soil types, and the presence of occupiable burrows created by California ground squirrels and other burrowing mammals (USFWS, 2003; Latif et.al, 2012; CVAG BUOW report, 2010). Although previous DNA analyses have found that southern California burrowing owls do not migrate the significant distances of the burrowing owls found farther north, large dispersal distances are not out of the question within a region (Korfanta et.al, 2005). This raises questions about whether our local populations are migrating from outside other areas within Riverside and San Bernardino Counties, or from other sites within the Coachella Valley.

Feather isotope analysis provides a method of analyzing where birds grew feathers during periods of their life cycle which helps us learn the area of origination for birds and their migration patterns (Lott and Smith, 2006). To best determine a feather's isotopic composition, we had to determine the environmental isotopic composition of where the feather was grown, and compare them to established isoscapes to infer spatial relationships. Due to differing environmental variables, Salton Sea birds vs. Coachella Valley birds vs. Western Riverside County birds should all possess different isotopic ratios within feathers grown at a certain time. Precipitation patterns and regional differences in watersheds, along with owl diet should have the greatest effect on feathers grown in a particular area, inferring that they will acquire a local isotopic signature which would match the regional isoscapes yet be different enough between populations to infer spatial relationships. Since, the primary factors determining a feather's isotopic composition are the environmental isotopic composition of where the feather was grown, water is the primary source of hydrogen (H) and oxygen (O) and food is the primary source of carbon (C) and nitrogen (N) (Bowen et al, 2005). Consequently, isotopic concentrations for H and O should depend upon the precipitation within a watershed, with prey animals that makeup diet determining C and N concentrations, which in turn, should reveal differences in wildland, agricultural, and suburban populations due to their foraging environment.

Methods

The Center for Conservation Biology conducted a population study in 2009 within the Coachella Valley, and identified several colonies of burrows, with the majority of owls found between April and August indicating a preferable time during breeding and post-breeding seasons where detectability is highest (Latif et.al, 2012; CVAG BUOW report, 2010 and 2012). Building on that knowledge, known nest sites within colonies were monitored regularly for nestlings during the beginning of the breeding season. With the assistance of California State permitted burrowing owl trappers, Jared Bond with the Riverside County Environmental Programs Department, and Ginny Short, manager of the Thousand Palms Preserve, we were able to monitor additional nests and capture emerging nestlings at their burrows using standard raptor trapping techniques (UCR AUP #20110003). No burrowing owl was harmed in the trapping efforts, and all birds were weighed, sexed, aged, and banded before release.

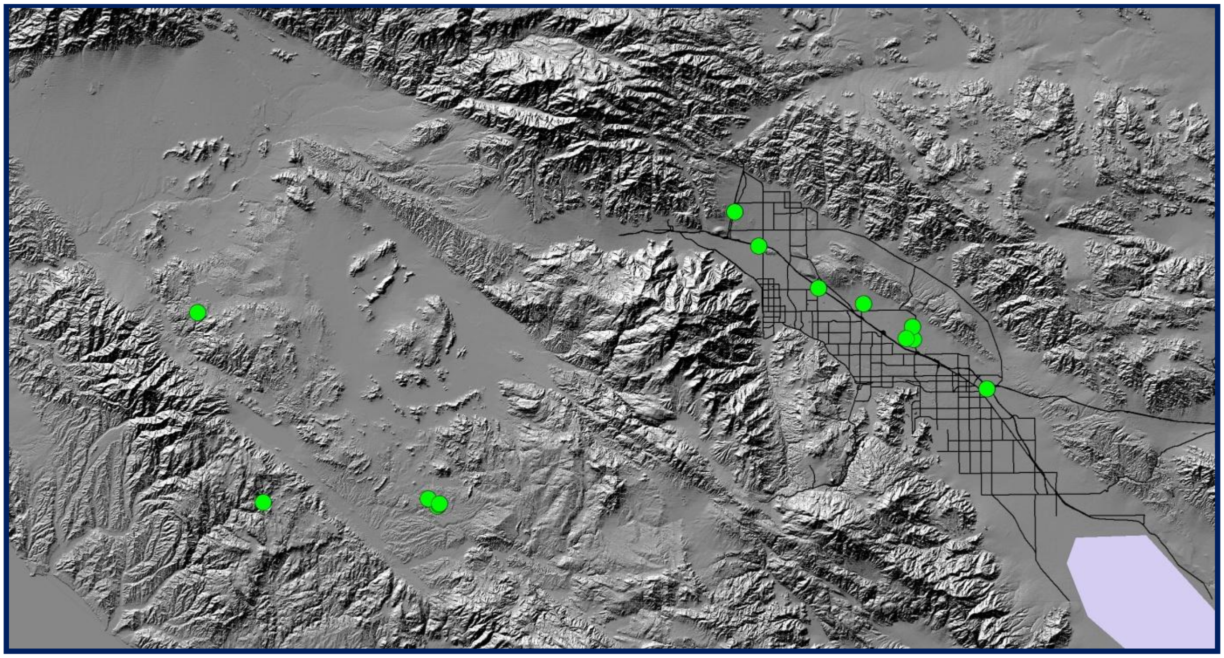


Figure 3-1: Locations of nest sites where feathers were collected in 2011

To be accurate in assigning spatial origin, feathers were collected primarily from nestlings, with the exception of and three adults found in the Whitewater Stormwater Channel. Feathers were pulled from the backs of 31 individuals at 14 spatially independent locations in Western Riverside County and the Coachella Valley between mid-April and late June in 2011. Gloves were worn to minimize transference of skin cells or oils to the feathers. Feathers were then wrapped in aluminum foil, marked, and stored in Zip-lock bags until analysis. To achieve our target sample size, we trapped nestlings at 6 nest sites in western Riverside County and 8 nest sites in the Coachella Valley. Each nest had a brood size of 1-5 nestlings. In the Coachella Valley, we collected feathers from at least 7 individuals in each habitat types (wildland, suburban, and agricultural). In western Riverside County, feathers were collected exclusively from nestlings within wildland-habitat nest burrows. In addition to collection of feathers, burrowing owl pellets were also opportunistically collected and analyzed to determine food sources for Coachella Valley owls. Information on local diet helps to facilitate interpretation of any observed spatial variation in C and N feather concentrations (CVAG BUOW report, 2012). Collecting feathers directly from wild owls, particularly owls of known spatial origin, allows maximum control over the spatial and temporal origin of feathers. In addition, plucking feathers from owls is preferable to cutting feathers since plucking provides the necessary stimulus for feather re-growth. Feathers were transferred in the autumn of 2012 to the Facility for Isotope Ratio Mass Spectrometry in the Department of Environmental Sciences at UC Riverside and were processed by February 2013. We then compared feather hydrogen isotope data to precipitation measurements and isoscapes from Hobsen and Wasenaar, 1997 and Hobsen et al 2004. Carbon and Nitrogen isotopes were compared to regional vegetation isoscapes derived from Suit el al, 2005 and Macias-Duarte, 2011.

Results

Deuterium (δ2H) from feathers collected in Western Riverside County had three major groupings, and was found to range from -16 to – 63 ‰ with a mean δ2H of -43 ‰; the groupings were -16 to -18 ‰, -40 to -63 ‰, with one outlier at -84 ‰. Agricultural owls within the Coachella Valley had δ2H isotopic results from -24 to -48 ‰ with a mean of -37 ‰, and only two major groupings from the -24 to -29 ‰ and -38 to -48 ‰ range. The urban and wildlands of Western Coachella Valley had δ2H readings of -15 to -86 ‰ with a mean of -56 ‰, and three major groupings of -15 to -19 ‰, -42 to -66 ‰, and -78 ‰ to -86 ‰ (Figure 3-2). δ15N concentrations were found to be from 7 to 13 ‰ with a mean of 9 ‰ in feathers collected from the Western Coachella Valley, and closely resembles the Western Riverside County's concentrations of 5 to 14 ‰ with a mean of 8 ‰ . The agricultural areas of Coachella Valley ranged from 9- 21 ‰ with a mean of 15‰ (Figure 3-3). δ13C concentrations ranged from -19 to -22 ‰ with a mean of -21 ‰ in feathers collected from the Western Coachella Valley, -16 to -20 ‰ with a mean of -18 ‰ in agricultural regions of the Coachella Valley, and -21 to -24 ‰ with a mean of -23 ‰ in Western Riverside County (Figure 3-4). δ15N ‰ and δ13C ‰ were then compared to analyze spatial differentiations between isoscapes and food sources (Figure 3-5).

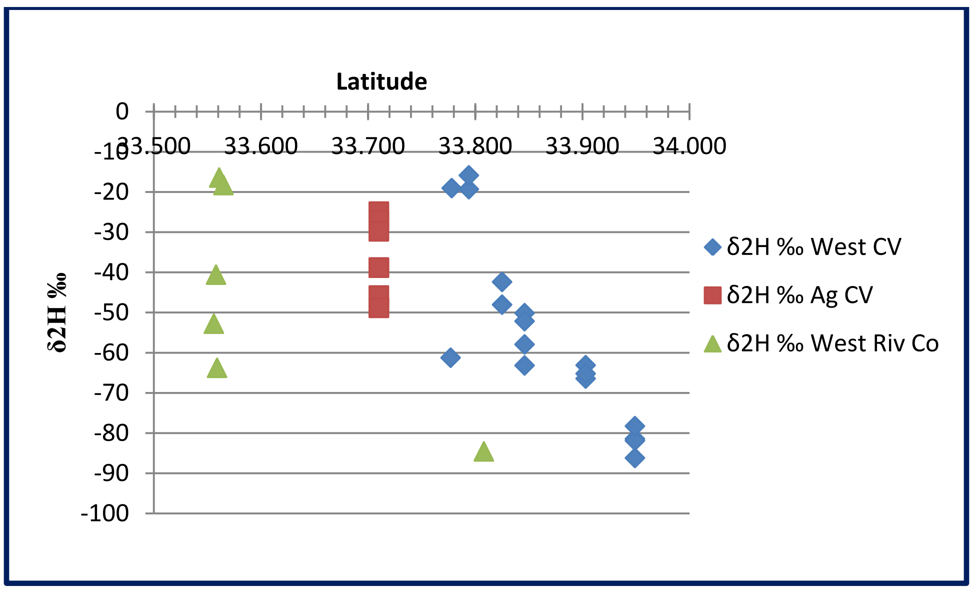


Figure 3-2: δ2H concentrations structured along a latitudinal gradient for feathers collected in Western Coachella Valley (West CV), Agricultural Areas of the Coachella Valley (Ag- CV), and Western Riverside County (West Riv Co).

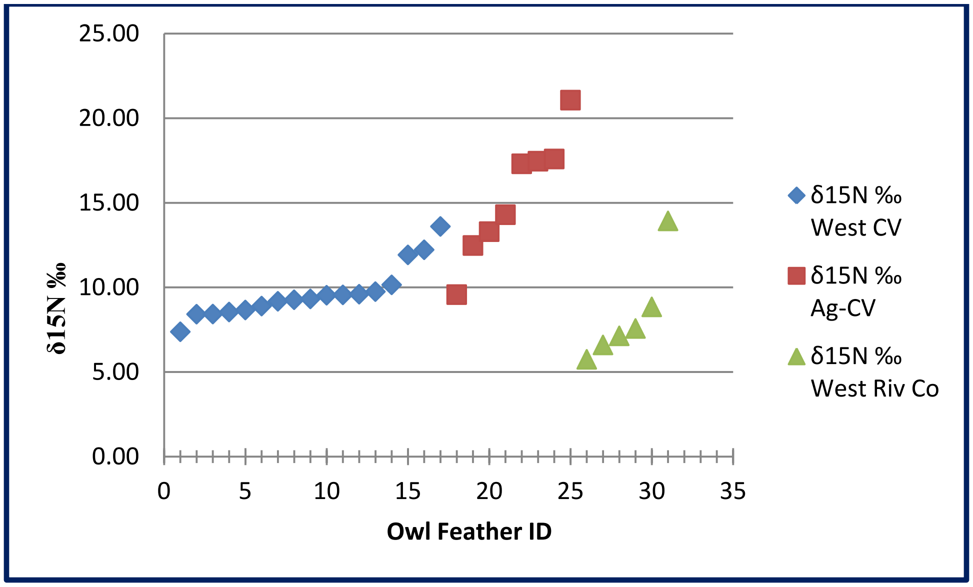


Figure 3-3: δ15N concentrations from feathers collected in Western Coachella Valley (West CV), Agricultural Areas of the Coachella Valley (Ag- CV), and Western Riverside County (West Riv Co).

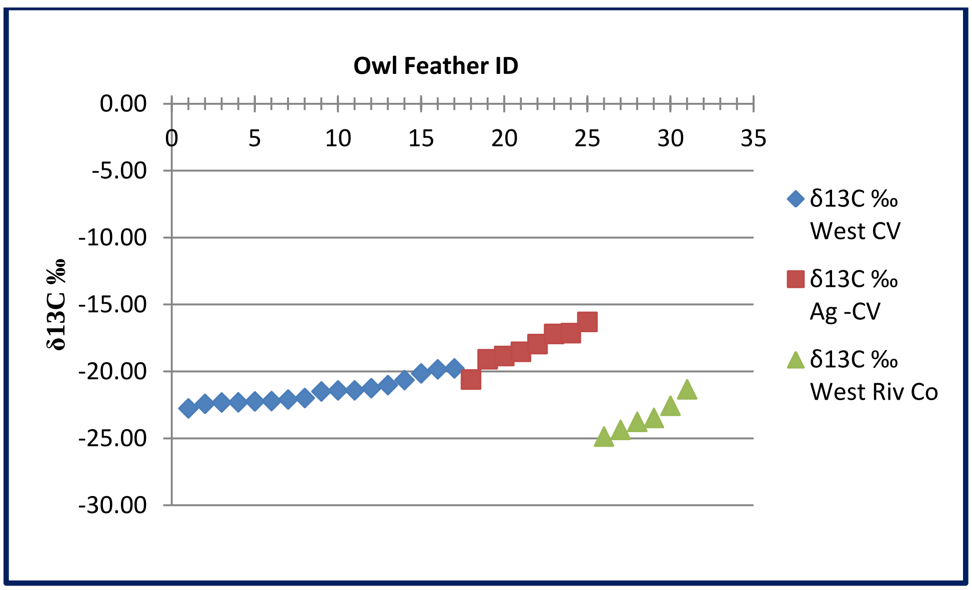


Figure 3-4: δ13C concentrations from feathers collected in Western Coachella Valley (West CV), Agricultural Areas of the Coachella Valley (Ag- CV), and Western Riverside County (West Riv Co).

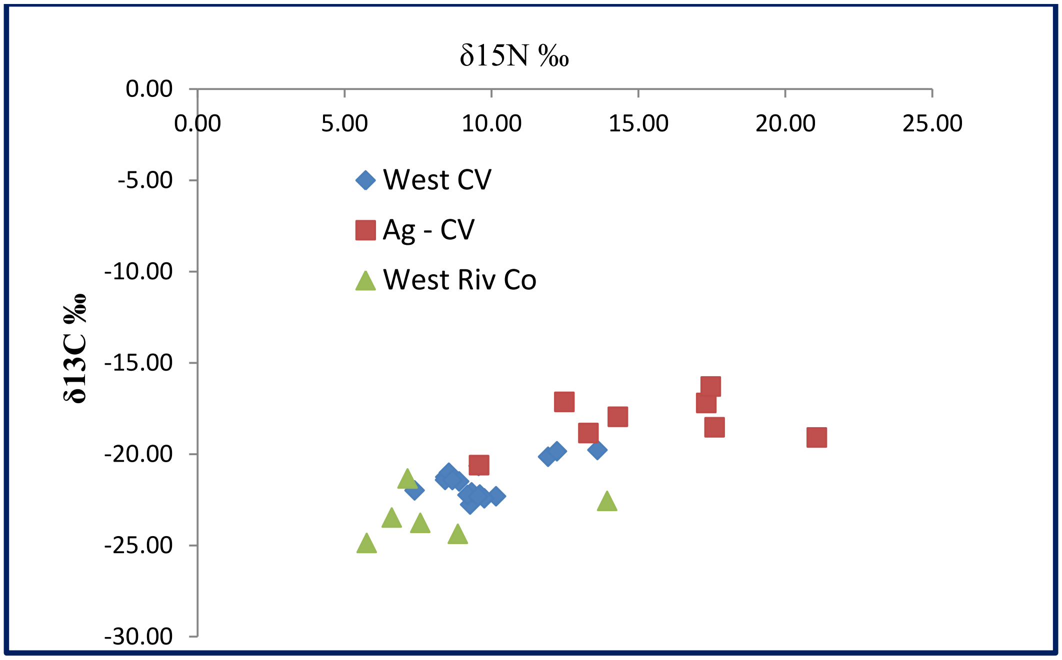


Figure 3-5: Comparisons of δ13C and δ15N from feathers collected in the western Coachella Valley (West CV), agricultural areas of the Coachella Valley (Ag-CV) and Western Riverside County.

Discussion

Identifying spatial groupings for analysis of δ2H, δ13C and δ15N concentrations is imperative when analyzing these results against isoscapes and determining whether they are independent enough to use for spatial inferences in populations. For our δ2H analysis, the groupings were -16 to -19 ‰ (n=5) in wildland/urban areas of western Coachella Valley and Western Riverside, -24 to -66 ‰ for the largest portion of our owls (n=21), and a grouping from -81 to -86 ‰ (n = 5). When comparing these results to previous studies (Hobson, 2004; Suit et al 2005; Macias-Duarte, 2011; Ehrlinger et al 2010, water isotopes.org) which have described δ2H isoscapes for precipitation to be within the range of -40 to -79 ‰ for areas within southern California, -80 to -100 for areas along the Colorado River watershed, and a gradient of -10 to -40 for northern to central Mexico. The majority of our nestling owls exhibited isotopic signatures within the precipitation range for deuterium in southern California. We had 3 adults from which feathers were collected along the Coachella Valley Stormwater Channel which exhibited deuterium readings closer to those we would expect from Mexico. We also have 5 samples collected from individuals in the Lake Matthews and Whitewater Hill locations which match the deuterium concentrations expected from the Colorado River watershed, therefore we can infer that those individuals have access to Colorado River water on a regular basis. Our remaining five samples from western Coachella Valley and western Riverside County returned deuterium readings off of local scales and closest to deuterium gradients in the Yucatan and southeastern United States. Although immigration from these areas has been documented through other studies, it is unclear why nestlings would carry a deuterium signature that resembles precipitation patterns from such a long distance (Macias-Duarte and Conway, In Press). Furthermore, deuterium helps determine spatial relationships across latitudinal gradients, but is less helpful in determining fine scale and longitudinal gradients. Our current understanding of how deuterium from precipitation is transformed into deuterium extracted from keratin in feathers is weak in the scientific community, but deuterium analyses have been known to vary widely both within watersheds and between habitats (Macias-Duarte 2011; Hobson et al 2009, Bowen et al 2004). Therefore deuterium analyses are usually coupled with another technique to accurately tease out spatial relationships within a landscape.

δ13C and δ15N comparisons to local isotopic ratios derived by Macias-Duarte (2011) for the Salton Sea Wildlife Refuge reveals that an average δ13C of -20 to -25‰, and δ15N concentrations of 8-15‰. Unlike the δ2H and the δ15N gradients, δ13C provides longitudinal gradients which when coupled with the δ15N, details how populations can group themselves spatially along latitudinal and longitudinal gradients from Western Riverside County to the agricultural areas of the Coachella Valley. Since δ13C and δ15N concentrations are derived from food sources, it can be inferred that the wildland/urban populations of burrowing owls in Riverside County have similar diets of rodents and arthropods, whereas the diet of the agricultural owls is almost specifically arthropods (Latif et al 2012, CVAG BUOW report 2012). Analysis of pellets from the Coachella Valley sites confirms that burrowing owls in these areas consume rodents such as *Perognathus longimembris bangsi*, *Chaetodipus pencillatus*, and *Dipodomys merriami*, along with several species of arthropods. Within Western Riverside County species of equivalent size could be included in burrowing owl diets regularly, including *Perognathus longimembris brevinasus*, *Chaetodipus californicus*, and *Dipodomys stephensi*) (CVAG BUOW report 2010 and 2012).

The difference in selection of prey needs to be factored in when using isotope analysis to determining spatial heterogeneity in local populations of burrowing owls. When coupled with genetic information, isotope analyses can be used to reveal the origin of breeding adults in a population as well as immigration and emigration patterns (Macias-Duarte, 2011). By themselves these isotopic studies only allow us to infer origin of breeding adults across vast landscape gradients, eg southern California vs. northern Mexico. Further refining maps for δ15N will allow for more precise indicators of origins as well, and although previous studies have called for more refined vegetation maps (Chamberlain et al 2000, Macias-Duarte 2011), refined δ15N scales are not currently available. More data is needed on these populations as well as surrounding populations before isotope analyses can be used reliably to determine population dynamics at the county level, however once variability within sites and regions is taken into account, it could be useful in future conservation efforts to reveal immigration and emigration patterns of a larger scale.

Literature cited

Bowen, G. J., L. I. Wassenaar, and K. A. Hobson. 2005. Global application of stable hydrogen and oxygen isotopes to wildlife forensics. Oecologia 143:337-348.

Chamberlain, C. P., J. D. Blum, R. T. Holmes, X. H. Feng, T. W. Sherry, and G. R. Graves. 1997. The use of isotope tracers for identifying populations of migratory birds. Oecologia 109:132-141.

Chamberlain, C. P., S. Bensch, X. Feng, S. Akesson, and T. Andersson. 2000. Stable isotopes examined across a migratory divide in Scandinavian willow warblers (*Phylloscopus trochilus trochilus* and *Phylloscopus trochilus acredula*) reflect their African winter quarters. Proceedings of the Royal Society of London Series B-Biological Sciences 267:43-48.

Ehleringer, J. R., T. E. Cerling, J. B. West, D. W. Podlesak, L. A. Chesson, G. J. Bowen. 2008; "Spatial considerations of stable isotope analyses in environmental forensics", in book: Issues in

Environmental Science and Technology, vol. 26: Environmental Forensics, Publisher: RCS Publishing.

Hobson, K. A., L. I. Wassenaar, and E. Bayne. 2004b. Using isotopic variance to detect long-distance dispersal and philopatry in birds: An example with Ovenbirds and American Redstarts. Condor 106:732-743

Hobson, K. A., S. L. Van Wilgenburg, K. Larson, and L. I. Wassenaar. 2009. A feather hydrogen isoscape for Mexico. Journal of Geochemical Exploration 102:167-174.

Holroyd, G. L., R. Rodriguez-Estrella, and S. R. Sheffield. 2001. Conservation of the Burrowing Owl in western North America: Issues, challenges, and recommendations. *Journal of Raptor Research* 35:399-407.

Korfanta, N. M., D. B. McDonald, and T. C. Glenn. 2005. Burrowing owl (*Athene cunicularia*) population genetics: A comparison of north american forms and migratory habits. Auk 122:464-478.

Lott, C.A. and J.P. Smith. 2006. A Geographic-Information-System approach to estimating the origin of migratory raptors in North America using stable hydrogen isotope rations in feathers. *The Auk*, 123:822-835.

Macias-Duarte, A. 2011. Change in Migratory Behavior as a Possible Explanation for Burrowing Owl Population Declines in Northern Latitudes. Ph.D. Dissertation, University of Arizona, Tucson, Arizona.

Suits, N. S., A. S. Denning, J. A. Berry, C. J. Still, J. Kaduk, J. B. Miller, and I. T. Baker. 2005. Simulation of carbon isotope discrimination of the terrestrial biosphere. Global Biogeochemical Cycles 19.

Appendix 4: Western yellow bat (*Lasiurus xanthinus*) occupancy patterns in palm oases in the Lower Colorado Desert


PREPARED BY: DANIELLE D. ORTIZ AND CAMERON W. BARROWS
Green Mountain College, Poultney, VT 05764; Present address: U.S. Forest Service, Big Bear Ranger Station, Fawnskin, CA (DDO)
University of California Riverside, Center for Conservation Biology, Palm Desert, CA (CWB)

ABSTRACT --Where their ranges overlap, western yellow bats, *Lasiurus xanthinus*, often select roost sites in the attached fronds of native desert fan palms, *Washingtonia filifera,* as well as in other palm species. While associated with palm trees, western yellow bat occupancy patterns across the Colorado Desert and what characteristics of palm trees or palm oases are important for roost selection has previously been unknown. We surveyed 41 palm oasis sites throughout the Colorado Desert, with 33 of those locations having western yellow bat activity, and 19 of which were confirmed day roosts. Variables that distinguished palm oases where the bats were found roosting versus those where they were absent included higher elevations, evidence of new palm growth, and sites where palms had a full range of skirt lengths within a given palm oasis. Our findings have implications for managing palm oases and the potential impacts of climate change.

Western yellow bats, *Lasiurus xanthinus*, inhabit southeastern California, southern Arizona, extreme southwestern New Mexico, and parts of Baja California (Bowers, et al., 2004). Where their range overlaps with that of native desert fan palms, *Washingtonia filifera*, western yellow bats appear to select those palms (as well as occasionally other palm species) for roosting (Higginbotham et al., 2000), roosting individually or in small groups in palm tree skirts (O'Farrell et al., 2004). This species has been a focus for conservation efforts; they are listed as a Species of Special Concern by the State of California, and, as an example, are protected under the Coachella Valley's Multiple Species Habitat Conservation

Plan (http://www.cvmshcp.org/). However, neither the distribution nor the roosting habitat preferences of western yellow bats are understood well enough to guide effective conservation efforts.

Our study focused on identifying spatial patterns western yellow bat occupancy and characteristics of palm oases used for their roosts within the northwestern Colorado Desert. Native palm oases in this region are popular for picnicking, camping, and destinations for recreational hiking. This use has sometimes resulted in wildfires. Although palm trees aren't necessarily killed as a result of fires, the attached dead leaf fronds (skirts) are removed. While the lack of a palm skirt (immediately after fires) would clearly eliminate roosting habitat for bats, no studies have determined whether the bats use the shorter palm skirts that may be the only structure for roosting available for years following fire until young, unburned trees mature, or how long after a fire before a palm oasis provides adequate roosting habitat for western yellow bats. Human activity in palm oases is another factor that may impact bat use of a site. Studies have shown some bat species to be sensitive to human activity, such as the gray bat, *Myotis grisescens,* which will abandon its roost when disturbed (Gore et al., 2012). While most tree roosting bats select roosting sites high off the ground where humans are not able to directly disturb them, indirect disturbances may still have an effect in areas with heavy human disturbances, such as trails and campsites. Disturbances, such as light and sound, can incite arousals in hibernating bat populations (Thomas, 1995), but have unknown effects on non-hibernating populations such as western yellow bats.

Native palm oases are often invaded by non-native invasive plant species, primarily tamarisk or salt cedar, *Tamarix ramosissima*, and fountain grass, *Pennisetum setaceum,* which were originally introduced for landscaping or wind breaks (Barrows, 1993). The impact of these invasive species in isolated oases with finite water inflow can be the reduction or elimination of surface water, drying the soil surface, and in the case of salt cedar exuding salt from their leaves (Barrows 1993). While a negative association between *Lasiurus xanthinus* and *Tamarix spp*. in desert riparian habitat was identified by Vizcarra et al. (2012), the impacts of invasive plant species on western yellow bats occurring in isolated oases have not been previously studied.

Climate change may represent an additional stress for palm oases, and therefore for western yellow bats. A limiting resource for native palms is surface water or near surface groundwater; predicted reduced precipitation in arid regions will likely deplete already stressed groundwater aquifers (Ali et al., 2012). Predicted increased drought frequency and intensity in the region including the Colorado Desert (Gao et al., 2012) may result in reducing the vigor of palm oases that are already water stressed. Our research creates an important baseline to assess how climate, as well as other habitat changes, may impact the patterns of occurrence of this species throughout much of the Colorado Desert.

MATERIAL AND METHODS – Our study area was within the Colorado Desert subdivision of the Sonoran Desert in southern California (Figure 4-1). Of the approximately 168 *Washingtonia filifera* palm oases occurring in the wild (Cornett, 2010) 41 (24%) were included in our surveys. Additional palm oases within this region were not surveyed due to difficulties gaining permitted access or steep inaccessible topography. Yellow bat surveys included palm oases within the Santa Rosa and San Jacinto Mountains National Monument, Joshua Tree National Park, the Coachella Valley Multiple Species Habitat Conservation Plan, Anza Borrego Desert State Park and on Bureau of Land Management lands. Palm oasis names and ownerships are shown in Table 1. Oasis names were derived from nomenclature used on maps or in instances in which a name was not evident, we named the palm oasis after the canyon where the palms were located or a designated trail nearest to the palms. In some instances the palm oases were partitioned into multiple sites if they were distinctly separated from the other palm sites spatially and/or structurally (i.e. burned versus unburned, tamarisk versus no tamarisk).

Our survey protocol required surveying each of the 41 palm oases at least once from May through October of 2012. If *L. xanthinus* occurrence and roosting could not be confirmed through acoustic and visual affirmation on the first round of surveys, then oases were resurveyed up to two more times (for a maximum of up to three surveys at each site). Surveys were limited to nights when rain and lightening were not in the forecast, and when winds did not exceed 15km/hr. Where possible, surveys were conducted at or near level to the crown of palms in order to get a better visual on the emergence of the bat from its roost by accessing hillsides near palms. Talking was minimized as there were numerous instances where we were able to hear rustling noises from the skirt of the palm which was a helpful indictor of the yellow bat getting ready to take flight from its day roost in the palm skirt. Occupancy by western yellow bats in a palm oasis was determined through a combination of acoustical monitoring and visual identification at emergence from its roost. *L. xanthinus* was only considered to be "confirmed" roosting in the oases if the bat was seen dropping out of a palm tree skirt with the aid of a spotlight and acoustics were recorded of the species on the Anabat SD2 bat detector (Titley Scientific USA 601 Business Loop 70, Suite 110, Columbia, Missouri, 65203-2546, usa@titley-scientific.com).

We employed the Anabat SD2 to actively monitor bat occurrences, moving around the palm oases to maximize bat detections; monitoring began at the twilight-dark interface and continued for one hour after sunset to confirm day roost location. Active monitoring was selected over passive monitoring; the quality of a call being recorded was higher as a direct result of being able to maintain contact with individual bats by adjusting the orientation of the microphone in relation to the movement of the bat in flight (Brigham et al, 2004). The western yellow bat shares the characteristic backward J-shaped call signature shared among tree roosting bats in the genus *Lasiurus*. Call sequences typically begin in the 60 kHz range and end at 32 kHz with a steep sweep, although there can be some variation within call sequences depending on the echolocation activity of the bat (Adams, 2003). While watching calls being displayed on the PDA screen in real time, we also listened for movement in the palm skirt and then spotlighted bats for visual identification. There can be acoustic overlap with *Lasiurus borealis* and *Eptesicus fuscus* (Western Bat Working Group, http://www.wbwg.org/speciesinfo/survey_matrix/recommended_survey_methods.pdf), however the eastern United States range of *L. borealis* does not overlap with *L. xanthinus*. As a result of identifying western yellow bat real-time in the field, any acoustic overlap was eliminated by observing the species in flight with its medium sized body, bright yellow coloration of fur, and its tendency to fly high off the ground, compared to other bat species that may also occur in a palm oasis. The only bat species that somewhat resembled the western yellow bat in physical appearance was the pallid bat, *Antrozous pallidus*, which was differentiated by its call, pale yellow fur, and behavior of flying low to the ground with an unusual behavior of flying very close up to us as we monitored the palms, something western yellow bats never did.

Table 4-1. List of oasis names and land ownerships for those oases surveyed in this study. Bat occurrences were categorized as not detected (ND), detected (D), and roosting confirmed (R).

Name of Palm Oasis	Land Manager of Site Surveyed	Western Yellow Bat Occurrence
Oswit Canyon Palms	Agua Caliente Band of Cahuilla Indians	ND
Borrego Canyon Palms	Anza-Borrego Desert State Park	D/R
Mountain Palm Springs Palms	Anza-Borrego Desert State Park	D/R
Seventeen Palms	Anza-Borrego Desert State Park	ND
Art Smith Trail Palms #1	Bureau of Land Management	D
Art Smith Trail Palms #2	Bureau of Land Management	D
Bogert Trail Palms	Bureau of Land Management	D
Corn Springs Palms	Bureau of Land Management	D
Cox Palms	Bureau of Land Management	D
Dead Indian Canyon Palms	Bureau of Land Management	D/R
Devil Canyon Palms	Bureau of Land Management	D/R
Folgers Palms	Bureau of Land Management	D/R
Green Hill Palms	Bureau of Land Management	D/R
Hidden Palms	Bureau of Land Management	D/R
Hunter Palms	Bureau of Land Management	D
Indian Palms	Bureau of Land Management	ND
Ranch House Palms	Bureau of Land Management	D
San Andreas Fault Palms	Bureau of Land Management	D
Sheep Hole Palms	Bureau of Land Management	ND
Vargas Palms	Bureau of Land Management	ND
Willis Palms	Bureau of Land Management	D
Willow Hole Palms	Bureau of Land Management	ND
Carrizo Canyon Palms	California Department of Fish and Wildlife	D/R
Grapevine Canyon Palms	California Department of Fish and Wildlife	D/R
Hidden Palms Eco. Rreserve	California Department of Fish and Wildlife	D/R
Magnesia Canyon Palms #1	California Department of Fish and Wildlife	ND
Magnesia Canyon Palms #2	California Department of Fish and Wildlife	D/R
Magnesia Canyon Palms #3	California Department of Fish and Wildlife	ND
McCallum Palms	Center for Natural Lands Management	D/R
Thousand Palms	Center for Natural Lands Management	D
Applegarth/Lakeshore Palms	Friends of the Desert Mountains	D
Biskra Palms	Indio Hills State Park	D
Hidden Palms	Indio Hills State Park	D/R
Macomber Palms	Indio Hills State Park	D
Pushwalla Palms	Indio Hills State Park	D/R
Cottonwood Springs Palms	Joshua Tree National Park	D/R
Forty-nine Palms	Joshua Tree National Park	D/R
Lost Palms	Joshua Tree National Park	D/R
Dos Palms	United States Forest Service	D
Bear Creek Palms	University of California Riverside	D/R
Deep Canyon Palms	University of California Riverside	D/R

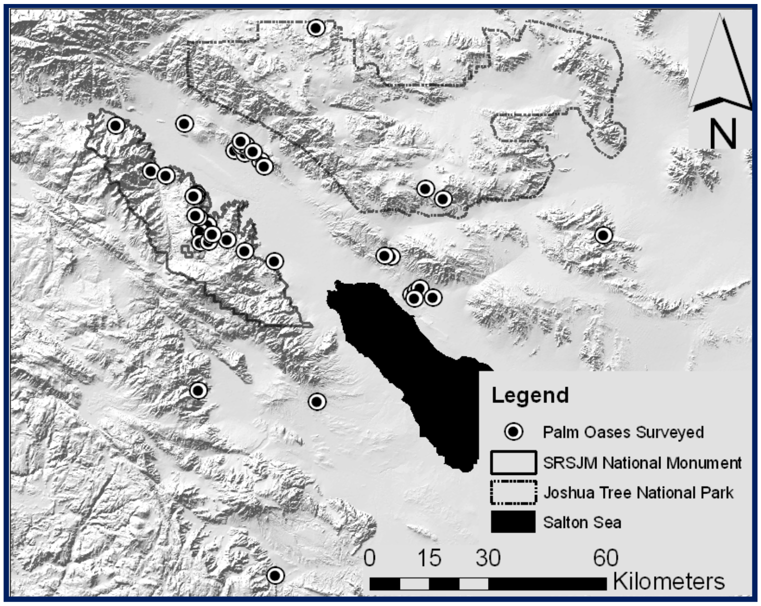


Figure 4-1. Map of the palm oases where western yellow bats were surveyed.

Table 4-2. Habitat parameters used in constructing logistic regression models explaining the presence and absence of western yellow bats in palm oases.

Variable Name	Description
Elevation	Derived from Google Earth; measurements recorded in meters.
New palm growth	Identification of new palm tree growth by which plants were 1 foot in height or less and no "woody" tissue evident. New growth was found in areas of the oasis where a spring, seepage, or body of water was present.
Next oasis distance	Derived from Goggle Earth; linear distance to the nearest palm oases
Water distance	Derived from Google Earth: distance to open water for drinking - watering holes that were at least 1 foot by 1 foot , open and unobstructed, including swimming pools.
Owl roost	Evidence of owl roosting in palm oasis (whitewash and or pellets) and/or visual of owl
Urbanization	Derived from Google Earth: distance to urbanization was measured in meters
Total palms	Total number of individual palms in an oasis were counted
Palm skirts 0-49	Number of palm trees in the oasis with 0 to 49% of palm skirt and not dead; only palms over 10 feet tall were included.
Palm skirts 50-100	Number of palm trees in the oasis with 50 to 100% of palm skirt; only palms over 10 feet tall were included.
Tamarisk	The presence of *Tamarisk spp*. was denoted as present (1) or not present (0).
Density	Derived from Google Earth: a polygon around each oasis obtained the area in hectares of the palm oasis. Using the total number of palms we divided the number of palms by the area to obtain a density.
Human Activity	A rating of (0) = rarely visited, (1) = regular daytime but no nighttime human use, (2) = daytime and nighttime use (i.e. campground)
Fire	A rating of (0) = no evidence of a recent fire with skirts nearly reaching the ground. (1) = Palms in which a fire occurred within ≥10 years and skirts not exceeding half of the height of the palm tree. (2) = fire occurred < 10 years palm trunks were heavily charred and there was little to no palm skirt development.

Habitat variables associated with palm oases were measured prior to active monitoring of bats at each palm oasis. The specific independent environmental metrics measured are described in Table 2. We constructed logistic regressions to determine which combination of these variables best explained the bat's occupancy and roost patterns. A logistic regression was used as it allowed inclusion of both the categorical and continuous predictor variables we measured at each oasis. Statistical analyses were conducted using SAS (Statistical Analysis System - Copyright © SAS Institute Inc.). All possible combinations of measured variables were analyzed to construct the model that best explained the yellow bat occurrences. The best-fit model was determined by the variable combination that yielded a statistically significant model ($p < 0.05$, determined using a chi-square analysis) and which had the lowest AIC value (Akaiki Information Criterion); models with ΔAIC scores within < 2 points of the model with the lowest AIC value have strong support for also being best choice models (Burnham and Anderson, 2002). The two dependent variables were yellow bat occupancy (1 = detected, 0 = undetected) and confirmed roosting (1 = confirmed, unconfirmed = 0). Independent continuous variables included number of palm trees, area of palm oasis, palm density, distance to other palm clusters/oases (i.e. isolation), distance to closest water source, and the number of palms with palm skirt ratings of 0-49% or 50-100%. Independent categorical variables included human disturbance, invasion of *Tamarix spp*., surface water availability, the occurrence of recent or current palm germination, and fire history.

Results

Forty-one palm oases were surveyed for the occurrence of *L. xanthinus* for a total of 106 nights of active monitoring. Roosting yellow bats were confirmed at 19 of the palm sites, representing nearly half of all the palm oases surveyed. Western yellow bats were found using, though not always roosting at 33 oases; no western yellow bats were detected at eight palm oases (Table 1). The majority of the sites with no yellow bat detections occurred in the northwestern end of the Colorado Desert, near the San Gorgonio Pass (Figure 4-2). These oases sites also exhibited much less activity by other bat species compared to the rest of the locations we surveyed; Willow Hole Palms had no bat activity on all three occasions in which surveys were conducted. Even though 22 sites were identified as having western yellow bats present but "unconfirmed" for roosting, it did not mean that they were not roosting in those oases, only that after three separate visits no yellow bats emerging from palm skirts were observed. Both Borrego Palm Canyon and Lost Palms were the sites in which the greatest amount of western yellow bat calls were recorded on the Anabat within a one hour period on a single night of surveys.

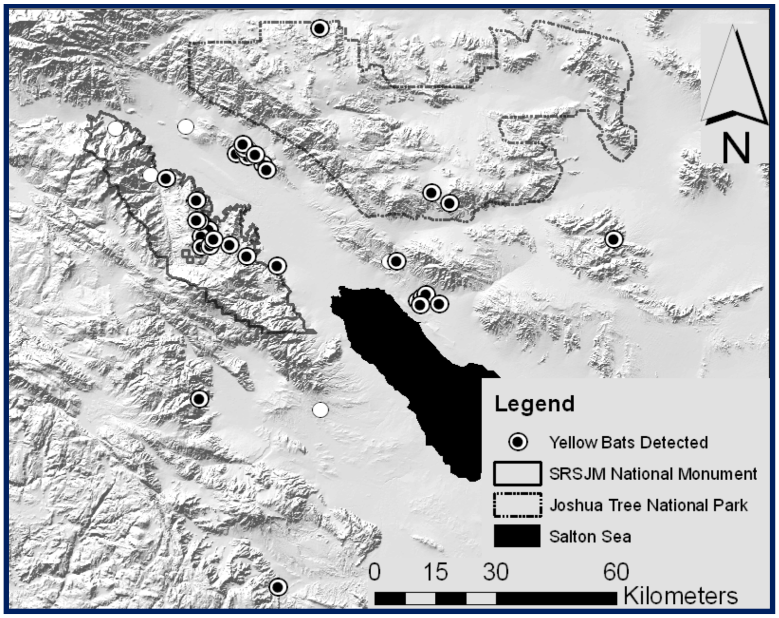


Figure 4-2 - Map depicting the 33 palm oasis sites in the Colorado Desert in which western yellow bats (*Lasiurus xanthinus*) were detected in the spring, summer and fall of 2012. Empty circles indicate sites where western yellow bats were not detected.

Logistic regression models were constructed for sites with confirmed roosting and presence (but unconfirmed roosting) of yellow bats. The combinations of variables which best distinguished western yellow bat roosting habitat are shown in Table 3. The first four models all include new palm growth, elevation, and palms with skirt length ratings of 0-49% as important variables. In comparison, Table 4 shows the best models for palm oases in which yellow bats were detected only as present during the survey. Consistent variables comprising these models overlapped with those in the best models for confirmed roosting sites (elevation, and palms with skirt length ratings of 0-49%) however additional variables emerged as important for describing the bats' occurrence. Those additional variables included (the absence of) owls roosting in the palms, distance to the next palm oasis and palm skirt ratings of 50-100%.

While the logistic models identified which variables were important for discerning sites where the bats roosted or were present, it is important to identify characteristics of those variables the bats may be selecting. We identified those variables that were consistent components of the highest ranking models and then contrasted those values for those sites with confirmed yellow bat roosting with sites where the bats were never detected (Table 5). Western yellow bats roosted at oases with significantly higher elevation and with more palms with partial to full skirts. Of the 19 palm oases in which confirmation of a yellow bat roost was recorded: one had a mean skirt rating of 0-24%, nine had a 25-49% rating, three had a skirt rating of 50-74% and six had skirt rating of 75-100%. Additionally, for palm oases with confirmed roosts, 74% showed evidence of new palm growth in the area whereas all locations in which the species was absent lacked any evidence of new growth.

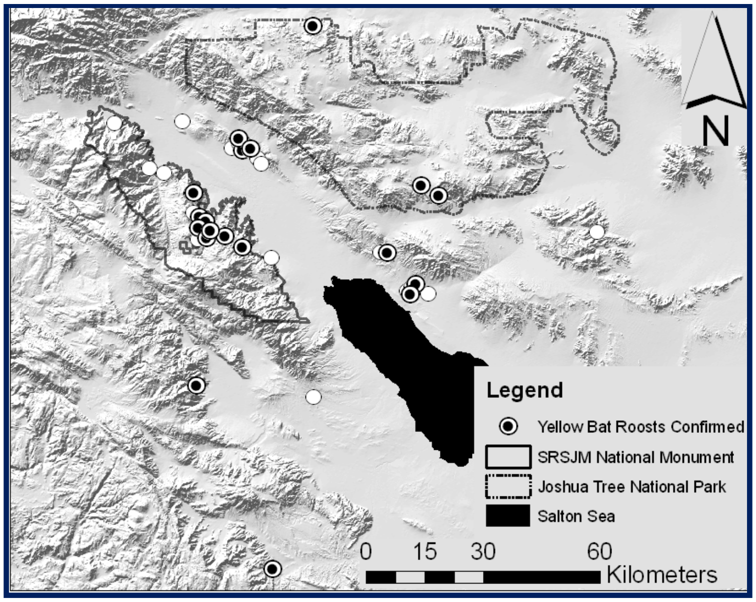


Figure 4-3 - Map depicting the 19 palm oasis sites in the Colorado Desert where western yellow bats (*Lasiurus xanthinus*) were confirmed roosting in the spring, summer and fall of 2012. Empty circles indicate sites where western yellow bats were not confirmed roosting.

Table 4-3 - Akaike's Information Criterion scores (AIC), difference values (ΔAIC) and the p-value (p) for confirmed day roosts of western yellow bats in desert fan palm oases in the California portion of the Colorado Desert.

Model Variables	AIC	Δ AIC	p
New growth + elevation + next oasis + water + 0-49	41.290	_______	0.0031
Elevation + 0-49 + water + new growth	42.013	0.723	0.0045
New growth + elevation + next oasis + water + owl roost + 0-49 + 50-100	42.833	1.543	0.0086
New growth + urbanization + elevation + 0-49 + next oasis + water	43.253	1.963	0.0065
New growth + urbanization + elevation + 0-49 + 50-100 + next oasis + water	44.915	3.625	0.0187
Elevation + next oasis + owl roost + 0-49 + 50-100	45.100	3.81	0.0272
New growth + urbanization + elevation + 0-49 + 50-100 + next oasis + water + total palms	46.915	5.625	0.0322
Elevation + next oasis + water + owl roost + 0-49 + 50-100	47.054	5.764	0.0487
Elevation + owl roost + 50-100 + new growth	49.906	8.616	0.0039
New growth + elevation + next oasis + water	51.344	10.054	0.0042

Table 4-4 - Akaike's Information Criterion scores (AIC), difference values (ΔAIC) and the p-value (p) for detection of western yellow bats in desert fan palm oases in the California portion of the Colorado Desert.

Model Variables	AIC	Δ AIC	p
Elevation + 0-49 + 50-100 +owl roost	43.830	________	0.0182
Elevation + 0-49 + 50-100 + next oasis + owl roost	45.100	1.27	0.0272

Table 4-5. Variables identified in the logistic regression analyses compared between confirmed roosting habitats versus oases where yellow bats were absent. Variables denoted with an asterisk (*) were found to be statistically different ($p < 0.05$) using a t-test for samples with unequal variances.

	Yellow Bat Roosting Confirmed		Yellow Bat Absence	
	Mean	Standard Error	Mean	Standard Error
Elevation (m)*	439.4	72.5	263.3	39.3
Proximity to water (m)	1886.4	647.6	1273.4	450.8
Distance to next oasis (m)	2312.2	629.2	2494.9	1124.2
Palm trees over 10 FT 0-49%*	65.6	22.2	14.2	8.7
Palm trees over 10 FT 50-100% *	160.6	67.7	24.5	8.1
Evidence of new palm growth	74%		0%	

Discussion

We found western yellow bats widespread at palm oases within the Colorado Desert of southeastern California, detecting them at 80% of the oases we surveyed. Confirmed roosting was observed at 46% of the oases surveyed; although it is likely with a more intensive survey effort some additional roost sites would be confirmed. Sites with confirmed yellow bat roosting were significantly higher in elevation, with more palm skirts of variable lengths, and had more young palm growth than sites where the bats were undetected. Additionally there appeared to be an avoidance of palm oases at the northwestern edge of the palms' distribution in Colorado Desert.

Our original concern regarding the negative impact of increased fires in palm oases on the occurrence and roosting of yellow bats was supported indirectly. Of the five oases surveyed that had the most severe fire damage (charred trunks, only short skirts), 80% lacked detections of yellow bat roosting. Although fire history did not emerge as an important habitat variable, the existence of palm skirts of variable lengths was important. Many of the palm oases included trees of mixed skirt lengths due to fire history or winds blowing off fronds. A benefit of having a grove of palm trees with assorted skirt lengths may be that the microclimate within different skirt lengths could provide the yellow bat with various levels of warmth, cool air and protection, allowing the bats opportunities for seasonal as well as daily roost switching without having to do much traveling. More than half of confirmed roosting sites were in the 0-49% skirt length rating. While fires may be advantageous to diversifying palm habitat within a given oasis over long periods of time, oases with more recent fire histories lacked diverse skirt lengths and appeared to have a negative effect on the species. Sites in which the majority of the palm oases were recently burned lacked activity by the yellow bat, as well as reduced activity in general from any bat species.

Human disturbance within the oases did not emerge as an important habitat variable. Only two of the oases we surveyed had regular nighttime human visitation (camping), and those sites also lacked detections of roosting yellow bats. However no patterns emerged with moderate and infrequent human use to warrant any conclusions based on just two sites with regular camping activity, and so we believe additional research is need to answer the question of direct human disturbance.

The occurrence of tamarisk or salt cedar also did not emerge as an important habitat variable. This may indicate that tamarisk is unimportant as an either positive or negative influence on western yellow bats, or that the tamarisk abundance at the sites we surveyed had not yet reached a threshold of having a negative impact. The occurrence of new, young palm growth was an important variable, and was indicative of sites with high or at the surface water tables. These same conditions support tamarisk germination and expansion; two of the five oases with the densest tamarisk growth also had new young palm growth. However as tamarisk stands mature at sites where water is limiting they can reduce or eliminate surface or near surface water, and then reduce new palm growth (Barrows, 1993).

We did not measure the impact of climate change directly, nevertheless two of the habitat variables that emerged as important for determining sites where the yellow bats roosted, elevation and new palm growth, could be impacted by the predicted levels of warming and drying for this region (Seager et al., 2007; Gao et al., 2012). Elevation was a significant component of every highly significant model assembled; sites with confirmed yellow bat roosts ranged from 25 to 948 m, but averaged more than 170 m higher than those where the bats were never detected. The two lowest elevation sites (25 and 89 m) had abundant open water nearby which may have facilitated occupancy of such otherwise "hot" sites. Assuming the bats' selection of middle elevation sites for roosting reflected a thermal preference for themselves and/or their insect prey, a warming climate could shift their roost sites to higher elevations. In a separate study, McCain (2007) found highest bat species richness at mid-slope, and inferred a relationship with temperature and water.

The area with the greatest altitude that we surveyed was at Dos Palms in the Pinyon Crest community within the Santa Rosa and San Jacinto National Monument (1097 m), which was a transition area between desert and pinyon-juniper forest. Although yellow bats were not confirmed roosting at this location, they were detected at the oasis on two of the three nights surveyed. Additionally, there were five other palm sites which were over 800 meters in altitude – all of which yellow bats were confirmed roosting. Surveys conducted by the San Diego Natural History Museum also confirmed this species in nearby Taquitz Valley (in the San Jacinto State Park) (San Diego Natural History Museum, http://www.sdnhm.org/science/birds-and-mammals/projects/san-jacinto-resurvey/results-and-products/) which is over 2400 m in elevation. This finding demonstrates the yellow bat is not entirely a desert dwelling species. During the more hot-arid summer season, these higher elevation sites could be a refuge when temperatures are extremely hot, providing some relief in a cooler environment. Western yellow bats appear to occur in a greater range of suitable habitats than was previously known, and that plasticity may enable them to move foraging and perhaps roosting sites up slope as climate gets warmer and drier. While the bats appear to be able to move upslope to avoid hotter-drier conditions, increased drought could reduce groundwater levels (Gao et al. 2012), reducing the vigor of palm oases, and potentially reducing roost habitat suitability, especially at lower elevations.

Many tree roosting bat species tend to be solitary and so their population levels and dynamics are difficult to study; there were no quantitative comparisons of long-term population trends of these foliage roosting bats (Carter et al, 2003). In lieu of demographic or population-level data, identifying patterns of occupancy provides the best indication of distributional and particular site occurrence changes with respect to shifting environmental conditions. This study provides land managers and biologists with important baseline data from which to evaluate the impacts of habitat and landscape changes due to land use, invasive species and climate change.

We are very thankful for the help of our field assistants who spent many nights studying bats during the hottest time of the year: A. Nuckels, C. Barrows, G. Raymond, R. Jarvinen, S. Jarvinen, B. Rooney, L. Rooney, S. Robles, C. Robles, G. Decker, J. Purcell, J. Danos, T. Martin, K. Doran, B. Pope, V. James, J. Grossman, R. Vincent, S. Greely, G. Short, D. Scriven, D. Scriven, J. Futterman, I. Hawkins, and . A. Ortiz. We would also like to thank agencies and organizations for allowing us the to conduct surveys on their land: Santa Rosa & San Jacinto Mountains National Monument, Bureau of Land Management, U.S. Forest Service, Friends of the Desert Mountains, Center for Natural Lands Management, Indio Hills State Park, Ana-Borrego Desert State Park, California Department of Fish and Wildlife, Joshua Tree National Park, and University of California Riverside, Boyd Deep Canyon. Bat Conservation International provided a scholarship to attend their Acoustic Monitoring Workshop in 2011 and gain experience and knowledge using the Anabat SD2 bat detector with C. Corben.

LITERATURE CITED

ADAMS, R. A.2003. Bats of the Rocky Mountain West: natural history, ecology, and conservation. University Press of Colorado, Boulder, Colorado. 328 p.

ALI, R., D.MCFARLANE, S. VARMA, W. DAWES, I. EMELYANOVA, G. HODGSON, AND S. CHARLES. 2012. Potential climate change impacts on groundwater resources of south-western Australia. Journal of Hydrology 475:456–472.

BARROWS, C.W. 1993. A Success Story. Restoration & Management Notes. 11 (1): 35-38.

BOWERS, N, R, BOWERS, AND K. KAUFMAN. 2004. Kaufman Focus Guides: Mammals of North America. Houghton Mifflin Company, New York, NY. 352 p.

BRIGHAM, R.M, KALKO, E.K.V. JONES, G. PARSONS, S. AND LIMPENS, H.G.A. 2004. Bat echolocation research: tools, techniques and analysis. Bat Conservation International. Austin, TX. 81 p.

BURNHAM, K.P. AND ANDERSON, D.R. 2002. Model selection and multi model inference: a practical information-theoretic approach. (2nd ed). New York, NY: Springer.

CARTER, T.C., MENZEL, M.A. AND D.A. SAUGEY. 2003. Population trends of solitary foliage-roosting bats. Pages 41-47 in O'Shea, T.J. and Bogan, M.A., editors. Monitoring trends in bat populations of the United States and territories: problems and prospects. U.S. Geological Survey, Biological Resource Discipline, Information and Technology Report, USGS/BRD/ITR –2003-0003, 274p.

CORNETT, J.W. 2010. Desert palm oasis. Nature Trails Press, Palm Springs, CA. 80 p.

GAO, Y., L.R. LEUNG, E.P. SALATHÉ JR., F. DOMINGUEZ, B. NIJSSEN, AND D.P. LETTENMAIER. 2012. Moisture flux convergence in regional and global climate models: Implications for droughts in the southwestern United States under climate change. Geophysical Research Letters 39:1-5.

GORE, J.A., L. LAZURE, AND M.E. LUDLOW. 2012. Decline in the Winter Population of Gray Bats (*Myotis grisescens*) in Florida. Southeastern Naturalist, 11:89–98

HIGGINBOTHAM, J.L., DIXON, M.T., AND L.K. AMMERMAN. 2000. Yucca provides roost for *Lasiurus xanthinus* (Chiroptera: Vespertilionidae) in Texas. The Southwestern Naturalist, 45, 338-340.

MCCAIN, C.M. 2007. Could temperature and water availability drive elevational species richness patterns? A global case study for bats. Global Ecology and Biogeography, 16, 1-13.

O' FARRELL, M.J., J.A. WILLIAMS, AND B. LUND. 2004. Western Yellow Bat (*Lasiurus xanthinus*) in Southern Nevada. The Southwestern Naturalist, 49(4), 514-518.

SEAGER, R., M. TING, I. HELD, Y. KUSHNIR, J. LU, G. VECCHI, H.HUANG, N. HARNIK, A. LEETMAA, N. LAU, C. LI, J. VELEZ, AND N. NAIK. 2007. Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America. *Science* 316, 1181-1184.

THOMAS, D.W. 1995. Hibernating bats are sensitive to nontactile human disturbance. Journal of Mammalogy, 76:940-946.

VICARRA, B., L. PIEST, V. FRARY, AND ARIZONA GAME AND FISH DEPARTMENT. 2012. Lower Colorado River Multi-Species Conservation Program: Monitoring of covered and evaluation bat species for the Lower Colorado River Multi-Species Conservation Program – 2010 Final Report. Retrieved on March 22, 2012, from http://www.lcrmscp.gov/steer_committee/technical_reports_species.html

Appendix 5: Assessing wildlife connectivity at key landscape linkages via highway underpasses in a desert environment

Prepared BY: MICHELLE L. MURPHY-MARISCAL[1], MICHAEL F. ALLEN[1] AND CAMERON W. BARROWS[1]
University of California Riverside, Center for Conservation Biology, Palm Desert, CA 92211. e-mail: michelle.murphy@ucr.edu

Abstract

Habitat connectivity is a key component of conservation planning for the persistence of wildlife populations. In desert environments extreme swings in precipitation and temperature can result in temporal and spatial shifts in habitat suitability; population persistence can depend on species ability to track those shifts and so connectivity becomes a critical conservation strategy. The predicted extent of our current climate change and its effects with respect to shifts in habitat suitability makes landscape-level connectivity all the more critical. Expansion of urbanization and energy resource development, as well as the transportation and energy infrastructure required to support those changes, are fragmenting desert environments at an increasing rate. While highway underpasses and culverts are often identified in conservation planning as wildlife corridors, their success at facilitating connectivity in deserts has, prior to our study, rarely been tested. We assessed wildlife use of seven pre-existing highway underpass structures to determine whether they were utilized as corridors for wildlife movement. The underpasses occur in a key landscape linkage between southern California's Peninsular and Transverse Mountain Ranges, connecting Baja California's biotic province and that of the Sierra Nevada. We utilized camera traps, track-plates, and track beds over 13 months to determine rates of underpass use, identify spatial and temporal wildlife use patterns, and to assess factors that may constrain wildlife use. While we found extensive use of highway underpasses by wildlife, we found a negative association between native carnivore presence and human activity within and near the underpass structures. Bobcats exhibited a strong negative relationship with motorized vehicles while coyotes displayed a weak negative relationship with humans on foot. Future strategies for maintaining or enhancing landscape connectivity in desert systems should provide a range of underpass structures to support use by multiple species, and develop underpasses that discourage or minimize human use, particularly motorized vehicles.

Introduction

Landscape connectivity is a key component for the persistence of populations, for maintaining genetic diversity, and for weathering environmental extremes and climate shifts (Noss 1987). Habitat loss and fragmentation are currently recognized as the leading threats to biological diversity (Wilcox and Murphy 1985, Wilcove et al. 1998, Brooks et al. 2002, Fahrig 2003). A consequence of human development is often the loss of this original connectivity; maintenance of wildlife corridors among suitable habitat patches has therefore been emphasized as a conservation strategy to decrease isolation and mitigate detrimental effects of fragmentation (Diamond 1975, Wilson and Willis 1975). In desert environments extreme swings in precipitation and temperature can result in temporal and spatial shifts in habitat suitability; population persistence can depend on species ability to track those shifts, and so maintaining connectivity becomes critical to conservation planning. Knowledge of the environmental tolerances and movement patterns of wildlife in these areas becomes especially important to land managers responsible for ensuring population persistence.

The California Floristic Province is among 25 hotspot areas that have been identified globally as having both the greatest concentration of biodiversity and threats to that biodiversity; it is therefore a high priority area for focused conservation efforts (Mittermeier et al. 1998, Myers et al. 2000). As urban expansion begins to reach its limits in the coastal areas of California, and as opportunities for alternative energy resource development are realized, California's desert regions are experiencing increased development and fragmentation (Chen et al. 2010). Highways exacerbate fragmentation by creating linear barriers to wildlife movement, which then interrupts gene flow, alters wildlife behavior and isolates populations (Bennett 1991, Jackson 1999). Underpass structures beneath highway systems may serve as critical linkages in environments that have been bisected by roadways. A wide range of wildlife species utilize underpasses as linkages; however, differential use of underpass structures has been observed (Clevenger and Waltho 2000, Clevenger and Waltho 2005). Understanding species preference for underpass characteristics, such a location and levels of human use, has become especially significant to wildlife managers charged with the task of maximizing connectivity for endangered or special concern species that may be particularly impacted by fragmentation (Foster and Humphrey 1995, Gloyne and Clevenger 2001). Corridor studies focusing on underpasses located in arid or desert environments are rare; only within the last decade have such studies begun to emerge (see Dodd et al. 2007, Gagnon et al. 2011).

The focus of our study was to evaluate the use of highway underpasses as wildlife corridor linkages between the Peninsular and Transverse mountain ranges in southern California's desert region. Our objectives were, first, to determine what wildlife species utilize existing underpass structures and the rate of that use; second, to identify spatial and temporal wildlife use patterns; and third, to assess how human activity near the structures may constrain wildlife use. Southern California's extreme human population growth coupled with high levels of biodiversity has catalyzed extensive conservation planning and the development of multiple regional habitat conservation plans. A human population increase of 200% between 1980 and 2002 made Riverside County the fastest growing county in California, with more residents than in 13 other entire U.S. states (Chen et al. 2010, http://www.countyofriverside.us/visiting/aboutriverside/riversidecounty.html). This increased growth accelerated fragmentation and decreased landscape permeability for dispersing wildlife. Assessing the utility of designated wildlife corridors and identifying management strategies that may enhance connectivity are critical components of the effective implementation of those plans.

Materials and Methods

Study Area

The landscape linkage between the Peninsular and Transverse mountain ranges is located in the western portion of the Coachella Valley, Riverside County, California, USA (Fig. 1). This area is situated in a zone where three ecoregions, the South Coast, Mojave Desert, and Sonoran Desert, converge. It is also where flora and fauna with affinities to Baja California (in the San Jacinto and Santa Rosa Mountains of the Peninsular Range) meet those with affinities to the Sierra Nevada and further north (in the San Bernardino Mountains of the Transverse Range). This geographic and ecological juxtaposition results in a region rich in biodiversity and is the closest point of connection for facilitating wildlife movements between these two mountain ranges (Penrod et al. 2005b).

The eight lane Interstate-10 highway (hereafter referred to as I-10) and four lane Highway 111 run west to east through the Coachella Valley and are bordered on the north by the San Bernardino Mountains and to the south by the San Jacinto Mountains (Fig. 2). State Route 62 (hereafter SR-62) is a four lane highway which branches off of the I-10 north of Palm Springs, California, and bisects the San Bernardino mountains where they converge with the Little San Bernardino mountains (Fig. 2). In the absence of effective corridor structures these roadway systems present a significant barrier to wildlife movement between these mountain ranges. Several underpasses are located along these highway systems allowing water runoff and sand to flow unimpeded beneath the roadway. Although not specifically designed for wildlife crossings these underpass structures may be functioning as important linkages by facilitating the movement of wildlife utilizing the corridor.

Characteristics of the Underpass Structures

Seven underpass structures were included for monitoring in this study (Fig. 3). Six of the seven underpasses contain atria, large openings in the roof of the underpass which allow water and sunlight to penetrate the underpass interior (Fig. 4), and most consist of several chambers that are formed by support beams running the length of the structure. Being that each underpass was constructed to allow natural washes to flow unimpeded beneath the highway, substrate within most of the underpasses is natural, comprised of dirt, gravel, or sand deposited from wind and water. Length (measured from opening to opening, including the span of atria when present), width (full span of the opening, including all chambers), height (from the ceiling of the structure to the substrate), and openness (height x width / length) were obtained by the authors and supplemented by Penrod et al. (2005a, 2005b) (Table 1).

Sampling Techniques

We utilized three techniques to document species use of the underpass structures: infrared motion detection trail cameras (Ford et al. 2009), track beds (Rodriguez et al. 1996), and sooted aluminum track-plate stations (Taylor and Raphael 1988). Cameras (DLC Covert II, 4338 Greenridge Spa Road, Lewisburg, KY 42256 and Bushnell Trophy Cam Model 119436c, Bushnell Corporation, 9200 Cody, Overland Park, KS 66214) were placed low to the ground to decrease detection by humans and increase detection of small wildlife species. Photographs taken by the cameras allowed the distinction between species with similar tracks, such as domestic dogs and coyotes. Species identification, date, time, direction of travel, and type of activity were recorded for each detection event. Rate of underpass usage was determined by dividing the number of detections of a species by the number of days the camera was active per site.

To complement the camera surveys, track beds (Rodriguez et al. 1996) and sooted aluminum track-plate stations (Taylor and Raphael 1988) were deployed at each underpass opening to record the tracks of animals utilizing the corridor. These methods enabled the detection of both small-bodied and fast-moving animals that may not have triggered the motion sensor cameras. Track beds consisted of 1-meter wide swaths of sandy substrate spread evenly across the entire width of each underpass opening. During each visit, tracks left in the sand were recorded and then the track bed was smoothed with a broom ensuring only new tracks would be recorded during subsequent surveys. The majority of the underpasses surveyed had naturally occurring sandy substrates; in underpasses where substrate was inadequate, supplements of sand were required to develop and maintain a track bed. On average, surveys were conducted three times per month per site. During winter months, when flooding and inclement weather prevented site access, surveys were conducted at least once per month per site. At sites where theft was frequent, surveys were conducted once per month, on average. Sooted aluminum track stations consisted of two 40.6-cm x 81.3-cm (16-in x 32-in) sheets of 24 gauge galvanized aluminum, to which a light layer of soot was applied by an acetylene gas torch. When an animal walked onto the plate soot was transferred from the plate to the animal's paw leaving behind an imprint of the track. After a few months of monitoring with both track methods we discontinued use of the track plates due to their sensitivity to weather conditions. Rates of occurrence at the underpass were recorded as the number of occurrences of a particular species at a track bed or plate divided by the number of days the track bed or plate was sampled.

Analyses

Due to non-normality, non-parametric tests were used to analyze the data. Spearman's rank correlation (MATLAB Version 7.7.0, R2008b) was used to quantify the relationship between use of the underpass structures by wildlife and the extent of human activity near each underpass. Human activity consisted of five categories: (1) rate of full-sized vehicles, (2) rate of off-highway vehicles, (3) rate of humans on foot, (4) total human use, calculated as the rates of the three previous categories combined, and (5) the rate of canids. Due to the difficulty of distinguishing between domestic canine and coyote by tracks, only camera data were used in the Spearman's rank correlation analysis when the relationships for those species were examined. For all other species camera and track data were combined.

The Mann-Whitney U test was used to detect differences in the rates of wildlife use and human activity between sites with adjacent habitat deemed "close to or approximating a natural condition and/or low human use" versus sites deemed "disturbed, where native cover was replaced with cement, rocks, or non-native vegetation and/or human use was extensive". Sites were first analyzed according to amount of human related activity, with sites having crossing rates of <0.5 for total human activity being placed in the "natural" category ($n = 9$) and all other sites being placed in the "disturbed" category ($n = 5$; Table 1). For the second analysis, sites were divided according to nearby vegetative cover and quality. Sites generally natural in vegetation composition and cover ($n = 9$) were compared to more disturbed habitat sites ($n = 5$, Table 1). These designations clearly have a subjective character, however understanding the additive impacts of surrounding vegetation management, habitat conditions, and human use patterns and the range of acceptable surrounding land use can provide important information for effective corridor designations. A traditional a level for statistical significance is most often $P \leq 0.05$; however due to small sample size and the use of non-parametric tests, we have opted to follow Ng et al. (2004) and use $P \leq 0.10$ as our significance threshold. We acknowledge while this level does increase the chance for a Type I error (assigning statistical significance to a relationship that would prove not significant with a larger sample size), it reduces the chance of a Type II error (dismissing relationships as not significant when in fact they are). We prefer to emphasize the potential statistical patterns uncovered by our limited data set and encourage additional research to establish their ultimate utility in corridor design and management.

Results

Diversity of Wildlife Use

In total 1,846 wildlife occurrences and 906 human-related activities were recorded as tracks and photos near the underpasses during the 13-month monitoring period (Table 2). Of wildlife detections, 74 (4.0%) were of reptiles, 192 (10.4%) were of birds (Figure 5-5a), 821 (44.5%) were of small mammals (Figure 5-5b; includes ground squirrel species, and small rodent species), 442 (23.9%) were of medium-sized mammals (Figure 5-5c; includes desert cottontails, black-tailed jackrabbits (*Lepus californicus*), striped skunks, raccoons, and domestic felines), and 317 (17.2%) were of large-bodied mammals (Figure 5-5d-f; includes bobcats, coyotes, gray fox (*Urocyon cinereoargenteus*), mountain lions, mule deer and domestic canines). Data collected from the cameras allowed for accurate distinction between coyote and domestic canine occurrences, therefore only those records were used when the relationships for those two species were analyzed. Combining track and camera data for canid species (coyote, gray fox, and domestic canine) resulted in almost three times as many detections (n = 256) than camera data alone (coyote n = 19, gray fox n = 3, domestic canine n = 67). Of the human related activities detected, 454 (50.1%) were of humans on foot, 351 (38.7%) were of full-sized vehicles, and 101 (11.2%) were of off-highway vehicles.

Relationships between Human Activity and Wildlife Use

Small rodent species (including, but not limited to, Pocket mice (*Perognathus* spp.), kangaroo rats (*Dipodomys* spp.), woodrats (*Neotoma* spp.), and deer mice (*Peromyscus* spp.)) had a weak positive, but not significant trend with humans on foot and total human activity (both $r_s = 0.643$, $P = 0.139$; Table 5-3). Ground squirrel species (including California ground squirrels (*Spermophilus beecheyi*), round-tailed ground squirrels (*Spermophilus tereticaudus*), and white-tailed antelope ground squirrels (*Ammospermophilus leucurus*)) and medium-bodied mammals were each positively correlated with off-highway vehicle use ($r_s = 0.739$, $P = 0.0706$ and $r_s = 0.793$, $P = 0.039$, respectively. Bobcat crossing rates were negatively correlated with full-sized vehicles ($r_s = -0.901$, $P = 0.0095$), off-highway vehicles ($r_s = -0.927$, $P = 0.0079$) and canids (coyotes and domestic canines; $r_s = -0.703$, $P = 0.0897$). Canid (coyotes, gray fox, and domestic canines) occurrence was positively correlated with off-highway vehicles ($r_s = 0.829$, $P = 0.0302$). Using only camera data to accurately distinguish between coyotes and domestic canines indicated that both coyotes and domestic dogs had weak positive but not statistically significant associations with off-highway vehicles ($r_s = 0.574$, $P = 0.244$, and $r_s = 0.544$, $P = 0.261$). Although weak trends exist, human activity was not significantly correlated with any of the passage attributes.

The Mann-Whitney U test was used to detect differences between sites categorized as "natural" versus "disturbed" on the basis of human activity (Table 5-4). The test revealed that the crossing rates of small-bodied mammals (U = 3.378, P = 0.0530), medium-bodied mammals (U = 9.00, P = 0.0027), canids (U = 9.00, P = 0.0027), and all wildlife analyzed together (excluding canids; U = 5.44, P = 0.02) were lower in sites categorized as "natural" versus sites categorized as "disturbed". The crossing rates of bobcats were not different between natural versus disturbed sites (U = 0.55, P = 0.458), which is likely due to their use of the underpasses occurring at different times.

Spatial and Temporal Wildlife Use Patterns

For sites categorized as "primarily natural habitat" versus "disturbed" on the basis of habitat quality and proximity to human developments, the Mann-Whitney U test detected differences between the crossing rates of medium-bodied mammals (U = 2.778, P = 0.096) which were lower at "primarily natural habitat" versus "disturbed" sites (Table 5-4). Differences were also detected for rates of full-sized vehicles (U = 3.247, P = 0.072) and total human activity (U = 2.778, P = 0.0960) which were higher at "disturbed" sites. When temporal partitioning of underpass use was examined, we found that bobcats generally used crossing structures during hours of the day when human activity was least likely (Fig. 6).

Discussion

We found a wide variety of wildlife utilizing the underpass structures, confirming their value in allowing wildlife movement. Habitat within the corridor can be important for sustaining small-bodied and less motile corridor-dwelling species (Barrows et al. 2011), and such species were found both near and within the underpasses. For species with small home ranges, such as ground squirrels, desert cottontails, and black-tailed jackrabbits, underpasses likely provide convenient access to foraging habitat on either side of the highway. Small rodent species and reptiles may be residing within or near the underpass structures. Large-bodied mammal species, such as coyotes and bobcats, are utilizing the underpasses as linkages between larger territories and home ranges.

Ground squirrel species and medium-bodied mammals were positively associated with off-highway vehicle use. This could be due to the weak trend of off-highway vehicle activity near underpasses with low openness ratios, a structural attribute which was found to be highly associated with both wildlife groups. Rates of occurrence of small-bodied mammals, medium-bodied mammals, canids, and all wildlife analyzed together (excluding canids) were higher in sites categorized as "disturbed" on the basis of human activity which may indicate a willingness for these wildlife groups to use areas near human activity, not necessarily an attraction to the human activity itself. This is likely true of ground squirrel species and domestic canines. Since the majority of human activity occurred during daylight hours (between dawn and dusk) another possible explanation is that crepuscular species (most small rodents, raccoons, and skunks) temporally avoid human activities, thus minimizing human influence. Although bobcats were negatively associated with vehicle usage at the underpasses, no difference was detected between the rates of bobcat usage for sites deemed "natural" versus "disturbed" on the basis of total human activity (Table 5-4). It has been suggested that bobcats residing near fragmented areas adjust their behavior to spatially and temporally avoid human activities (Tigas et al. 2002); our results paralleled those previous findings.

For sites categorized as “disturbed” on the basis of habitat quality and proximity to human developments, the rates of occurrence for medium-bodied mammals were found to be higher. This may be due to the availability of water and food resources near residential communities with “disturbed” habitat, which might attract several of the species included in the medium-bodied mammal category, namely domestic felines, skunks, and raccoons. Another possibility is that, being habitat generalists, these species do not have strict habitat requirements and were therefore less affected by the habitat quality near residential areas. No differences were detected for large bodied mammals. Large bodied mammals are likely to only be utilizing the areas surrounding the underpass structures as move-through habitat and are less likely to be affected by habitat quality if adequate cover is present. The rates of occurrence for vehicles and total human activity were found to be higher in the “disturbed” sites, as these are nearest to human habitation and therefore offer more convenient access.

Mule deer and mountain lions were only documented at the corridor with mountainous, relative natural habitat in close proximity to both sides of the underpass structure (G). Numerous studies have reported that ungulate species are particularly influenced by structural characteristics of underpasses (Reed et al. 1975, Foster and Humphrey 1995, Dodd et al. 2007). Although this underpass has high ratios of human use, preferred dimensions (short length and large chamber width which contribute to it high openness ratio (Dodd et al. 2007)) in addition to its close proximity to the mountain ranges on either side may combine to make this a suitable crossing structure for ungulates. Previous underpass studies have found that human activity has a negative impact on underpass use by wildlife (Clevenger and Waltho 2005). Mountain lions, however, show little aversion to human activities (Beier 1995), and previous studies found no correlation between human and cougar use of underpass structures (Gloyne and Clevenger 2001).

We recommend that monitoring of the underpass structures continue for as long as possible in order to capture the range of variation between years caused by the dynamic wildlife-human-land use interactions in this area, and to minimize the potential for spurious results (Clevenger and Waltho 2003). Additionally, these results only account for the frequency of occurrence near the underpass structures monitored, and do not provide the data necessary to address whether these structures are effective- that is, whether gene flow is enabled. Genetic analysis of populations on both sides of the barrier should be undertaken to determine whether there is genetic variability and whether heterozygosity among populations is being maintained (Riley et al. 2006). Additional sampling should be implemented within the matrix surrounding the underpass structures to determine if certain species are avoiding the road or whether wildlife species decrease in abundance as the highway is approached, a phenomenon known as a filter effect. Special attention should be extended to determine wildlife behavioral responses to alternative energy projects near the corridor and whether these projects are impacting or impeding movement through the landscape matrix, especially by wide ranging species.

Acknowledgements

Funding for this project was provided by Friends of the Desert Mountains, Southern California Edison, the Center for Conservation Biology’s Shipley-Skinner Reserve- Riverside County Endowment, and The California Desert Research Fund at The Community Foundation. Special thanks go to V. Rorive and C. Gonzalez for their administrative assistance, R. Johnson for his GIS expertise, K. Kitajima for his statistical knowledge, and K. O’Connor for assistance securing permits, M. Felix, C. Mariscal, T. Mok, and J. Hur, for their assistance in the field, and lastly J. Rotenberry and R. Redak for their thoughtful feedback on earlier versions of this manuscript.

References

Barrows, C.W., K.D. Fleming, and M.F. Allen. 2011. Identifying habitat linkages to maintain connectivity for corridor dwellers in a fragmented landscape. The Journal of Wildlife Management. 75(3):682-691.

Beier, P. 1995. Dispersal of juvenile cougars in fragmented habitat. The Journal of Wildlife Management. 59(2):228-237.

Bennett, A.F. 1991. Roads, roadsides, and wildlife conservation: a review. Pp. 99-118 *in* D.A. Saunders and R.J. Hobbs (eds.) Nature conservation 2: The role of corridors. Surrey Beatty & Sons, Chipping Norton. Australia.

Brooks, T.M., R.A. Mittermeier, C.G. Mittermeier, G.A.B. da Fonseca, A.B. Rylands, W.R. Konstant, P. Flick, J. Pilgrim, S. Oldfield, G. Magin, and C. Hilton-Taylor. 2002. Habitat loss and extinction in the hotspots of biodiversity. Conservation Biology. 16:909–923.

Chen, X., B. Li, and M.F. Allen. 2010. Characterizing urbanization, and agricultural and conservation land-use change in Riverside County, California, USA. Annals of the New York Academy of Sciences. 1195: E164-E176.
.

Clevenger, A.P., and N. Waltho. 2000. Factors influencing the effectiveness of wildlife underpasses in Banff National Park, Alberta, Canada. Conservation Biology. 14(1):47-56.

Clevenger, A., and N. Waltho. 2003. Long-term, year-round monitoring of wildlife crossing structures and the importance of temporal and spatial variability in performance studies. UC Davis: Road Ecology Center. Retrieved from: http://www.escholarship.org/uc/item/3g69z4mn

Clevenger, A.P., and N. Waltho. 2005. Performance indices to identify attributes of highway crossing structures facilitating movement of large mammals. Biological Conservation. 121:453-464.

Diamond, J.M. 1975. The island dilemma: lessons of modern biogeographic studies for the design of nature reserves. Biological Conservation. 7:129-146.

Dodd, N. L., J. W. Gagnon, A. L. Manzo, and R. E. Schweinsburg. 2007. Video surveillance to assess highway underpasses by elk in Arizona. Journal of Wildlife Management. 71:637–645.

Fahrig, L. 2003. Effects of habitat fragmentation on biodiversity. Annual Review of Ecology, Evolution, and Systematics. 34:487-515.

Ford, A.T., A.P. Clevenger, and A. Bennett. 2009. Comparison of methods of monitoring wildlife crossing-structures on highways. Journal of Wildlife Management. 73(7):1213-1222.

Foster, M.L., and S.R. Humphrey. 1995. Use of Highway underpasses by Florida panthers and other wildlife. Wildlife Society Bulletin. 23(1):95-100.

Gagnon, J.W., N.L. Dodd, K.S. Ogren, and R.E. Schweinsburg. 2011. Factors associated with use of wildlife underpasses and importance of long-term monitoring. Journal of Wildlife Management. 75(6):1477-1487.

Gloyne, C.C., and A.P. Clevenger. 2001. Cougar *Puma concolor* use of wildlife crossing structures on the Trans-Canada highway in Banff National Park, Alberta. Wildlife Biology. 7:117-124.

Jackson, S.D. 1999. Overview of transportation related wildlife problems. Pp. 1-4 *in* G.L. Evink, P. Garrett, and D. Zeigler (eds.) Proceedings of the Third International Conference on Wildlife Ecology and Transportation. FL-ER-73-99. Florida Department of Transportation, Tallahassee, Florida.

Mittermeier, R.A., N. Myers, J.B. Thomsen, G.A.B. da Fonseca, and S. Olivieri. 1998. Biodiversity hotspots and major tropical wilderness areas: Approaches to setting conservation priorities. Conservation Biology. 12(3):516-520.

Myers, N., R.A. Mittermeier, C.G. Mittermeier, G.A.B. da Fonseca, and J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature. 403:853-858.

Ng, S., J. Dole, R. Sauvajot, S. Riley, and T. Valone. 2004. Use of highway undercrossings by wildlife in Southern California. Biological Conservation. 115:499-507.

Noss, R. 1987. Corridors in real landscapes: a reply to Simberloff and Cox. Conservation Biology. 1(2):159-164.

Penrod, K., C. Cabanero, P. Beier, C. Luke, W. Spencer, and E. Rubin. 2005a. South coast missing linkages project: A linkage design for the San Bernardino-Little San Bernardino connection. South Coast Wildlands, Idyllwild, CA. www.scwildlands.org.

Penrod, K., C. Cabanero, P. Beier, C. Luke, W. Spencer, and E. Rubin. 2005b. South coast missing linkages project: A linkage design for the San Bernardino-San Jacinto connection. South Coast Wildlands, Idyllwild, CA. www.scwildlands.org.

Reed, D.F., T.N. Woodard, and T.M. Pojar. 1975. Behavioral response of mule deer to a highway underpass. Journal of Wildlife Management. 39(2):361-367.

Riley, S.P.D., J.P. Pollinger, R.M. Sauvajot, E.C. York, C. Bromley, T.K. Fuller, and R.K. Wayne. 2006. A southern California freeway is a physical and social barrier to gene flow in carnivores. Molecular Ecology. 15(7):1733:1741.

Rodriguez, A., G. Crema, and M. Delibes. 1996. Use of non-wildlife passages across a high speed railway by terrestrial vertebrates. Journal of Applied Ecology. 33(6):1527-1540.

Taylor, C.A., and M.G. Raphael. 1988. Identification of mammal tracks from sooted track stations in the pacific northwest. California Fish and Game. 74(1):4-15.

Tigas, L., D. Van Vuren, and R. Sauvajot. 2002. Behavioral responses of bobcats and coyotes to habitat fragmentation and corridors in an urban environment. Biological Conservation. 108:299-206.

Wilcove, D.S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. BioScience. 48(8):607-615.

Wilcox, B., and D. Murphy. 1985. Conservation strategy: the effects of fragmentation on extinction. The American Naturalist. 125(6):879-887.

Wilson, E.O., and E.O Willis. 1975. Applied biogeography. Pp. 522-534 *in* M.I. Cody and J.M. Diamond (eds.) Ecology and Evolution of Communities. Belnap Press, Cambridge, Massachusetts.

Table 5-1. Characteristics and classifications of the seven underpass structures monitored in this study.

Underpass Attributes		A	B	C	D	E	F	G
Width (m)		11.5	17	39	150	68	30.5	18.3
Length (m)		112	112	77	48.2	37	44.5	12.2
Height (m)		4.5	4.5	2.9	9	2.5	5.4	7.6
Openness		0.46	0.68	1.47	28.01	4.59	3.70	11.40
Highway location		I-10	I-10	I-10	I-10	Highway 111	SR-62	SR-62
Substrate		Natural	Natural	Concrete bottom with sand deposition	Natural	Natural	Natural	Natural
Atrium Present		Yes	Yes	Yes	Yes	Yes	Yes	No
Number of Chambers		1	1	3	8	7	4	1
Habitat on other side of structure clearly visible?		No	No	Yes	Yes	Yes	No	Yes
Classification based on rate of human activity	Opening: 1	Disturbed	Disturbed	Natural	Natural	Natural	Natural	Disturbed
	2	Natural	Disturbed	Natural	Natural	Natural	Natural	Disturbed
Classification based on vegetation quality & cover	Opening: 1	Disturbed	Disturbed	Disturbed	Natural	Disturbed	Natural	Natural
	2	Natural	Natural	Natural	Natural	Natural	Natural	Disturbed

Attributes measured by the author and supplemented by Penrod et al. (2005a, 2005b). Openness is calculated by (W*H)/L, with larger values indicating greater openness. The last two rows indicate the classification of each underpass opening based on rate of human activity and nearby vegetation quality and cover. “Opening 1” corresponds to northern or eastern openings and “Opening 2” corresponds to southern or western openings, based on underpass orientation.

Table 5-2. Crossing rates of wildlife at each underpass site. (Rate = No. of occurrences per species / No. of monitoring days)

	A		B		C		D		E		F		G	
No. of Days Monitored	299		17		354		381		351		229		333	
Species	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**
Reptile species	6	0.0201	3	0.1765	15	0.0424	14	0.0367	17	0.0484	6	0.0262	13	0.0390
Small rodent species	42	0.1405	15	0.8824	108	0.3051	227	0.5958	21	0.0598	90	0.3930	182	0.5465
Ground squirrel species	55	0.1839	5	0.2941	32	0.0904	9	0.0236	3	0.0085	17	0.0742	15	0.0450
Bird species	21	0.0702	8	0.4710	14	0.0395	17	0.0446	17	0.0484	29	0.1266	86	0.2583
Desert cottontail	164	0.5485	11	0.6471	85	0.2401	15	0.0394	10	0.0285	39	0.1703	47	0.1411
Black-tailed jackrabbit	2	0.0067	2	0.1176	7	0.0198	2	0.0052	13	0.0370	13	0.0568	3	0.0090
Striped skunk	0	0.0000	0	0.0000	1	0.0028	1	0.0026	0	0.0000	0	0.0000	2	0.0060
Raccoon	0	0.0000	1	0.0588	0	0.0000	6	0.0157	1	0.0028	1	0.0044	0	0.0000
Domestic cat	3	0.0100	0	0.0000	8	0.0226	1	0.0026	4	0.0114	0	0.0000	0	0.0000
Canid species	29	0.0970	13	0.7647	28	0.0791	28	0.0735	28	0.0798	17	0.0742	120	0.3604
Bobcat	3	0.0100	0	0.0000	0	0.0000	9	0.0236	5	0.0142	18	0.0786	3	0.0090
Mountain Lion	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	5	0.0150
Mule deer	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	2	0.0060
Horse and burro	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	9	0.0270
Human on Foot	40	0.1338	34	2.0000	35	0.0989	143	0.3753	69	0.1966	11	0.0480	122	0.3664
Off-highway Vehicle	16	0.0535	13	0.7647	28	0.0791	7	0.0184	9	0.0256	6	0.0262	22	0.0661
Full-sized Vehicle	10	0.0334	169	9.9412	44	0.1243	4	0.0105	40	0.1140	0	0.0000	84	0.2523

Table 5-3. Spearman rank correlation coefficient values for human activity variables and rates of wildlife crossings.

Species	Full-Sized Vehicle	Off-Highway Vehicle	Humans on Foot	Total Human	Canid
Small rodent species	0.286 (0.556)	0.234 (0.623)	0.643 (0.139)	0.643 (0.139)	0.500 (0.267)
Ground squirrel species	0.357 (0.444)	**0.739 (0.0706)**	0.000 (0.000)	0.000 (0.000)	**0.786 (0.048)**
Medium-bodied mammals	0.429 (0.354)	**0.793 (0.0397)**	-0.071 (0.906)	-0.036 (0.964)	**0.750 (0.066)**
Canid	0.679 (0.120)	**0.829 (0.0302)**	0.321 (0.498)	0.429 (0.354)	----
Coyote	0.261 (0.617)	0.574 (0.244)	-0.319 (0.556)	-0.029 (0.983)	----
Domestic Canine	0.232 (0.667)	0.544 (0.261)	0.058 (0.939)	0.203 (0.722)	----
Bobcat	**-0.901 (0.0095)**	**-0.927 (0.0079)**	-0.306 (0.501)	-0.505 (0.255)	**-0.703 (0.0897)**

Statistical relationships are indicated in parentheses. All categories were calculated from camera and track data combined, with the exception of coyote and domestic canine, which were calculated from camera data only.

Table 5-4. Mann-Whitney U values for wildlife and human relative frequencies at sites deemed “natural” versus “disturbed” on the basis of human activity and habitat quality.

	Small-bodied mammals	Medium-bodied mammals	Canids	Bobcats	All wildlife	Full sized vehicles	Off-highway vehicles	Humans on foot	Total Human
Habitat Quality									
Median: Natural	0.3588	0.2825	0.0802	0.0157	0.7375	0.0334	0.0489	0.1338	0.2825
Median: Disturb	0.5726	0.5560	0.4760	0.0057	0.6556	0.2320	0.1162	0.2600	0.5560
U	0.538	2.778	1.960	0.368	0.040	3.247	1.960	1.960	2.778
P-value	0.4630	0.0960	0.1620	0.5440	0.8410	0.0720	0.1620	0.1620	0.0960
Human Activity									
Median: Natural	0.2843	0.2825	0.0791	0.0157	0.6556				
Median: Disturb	0.5916	2.9375	0.6429	0.0030	1.2857				
U	3.738	9.000	9.000	0.550	5.440				
P-value	0.0530	0.0027	0.0027	0.4580	0.0200				

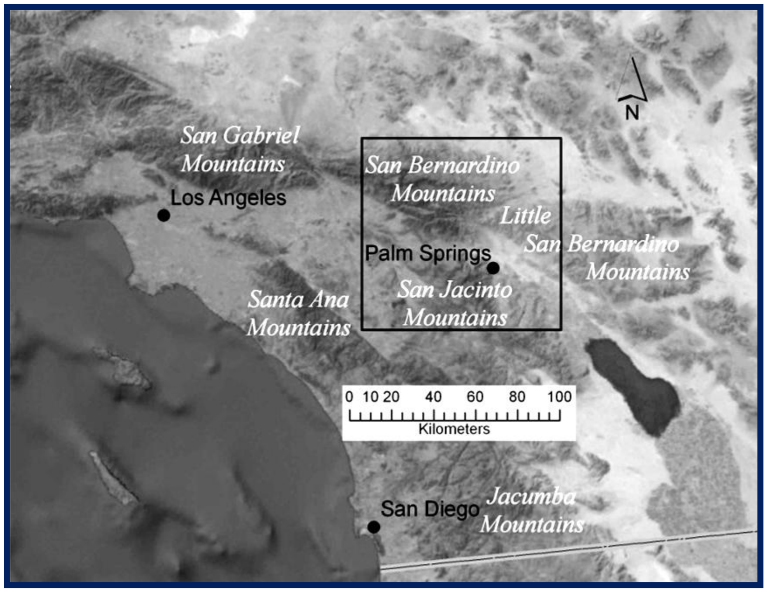


Figure 5-1. Southern California; a black box encloses the study region. The San Jacinto Mountains are part of the Peninsular Ranges and the San Bernardino and Little San Bernardino Mountains are both part of the Transverse Range.

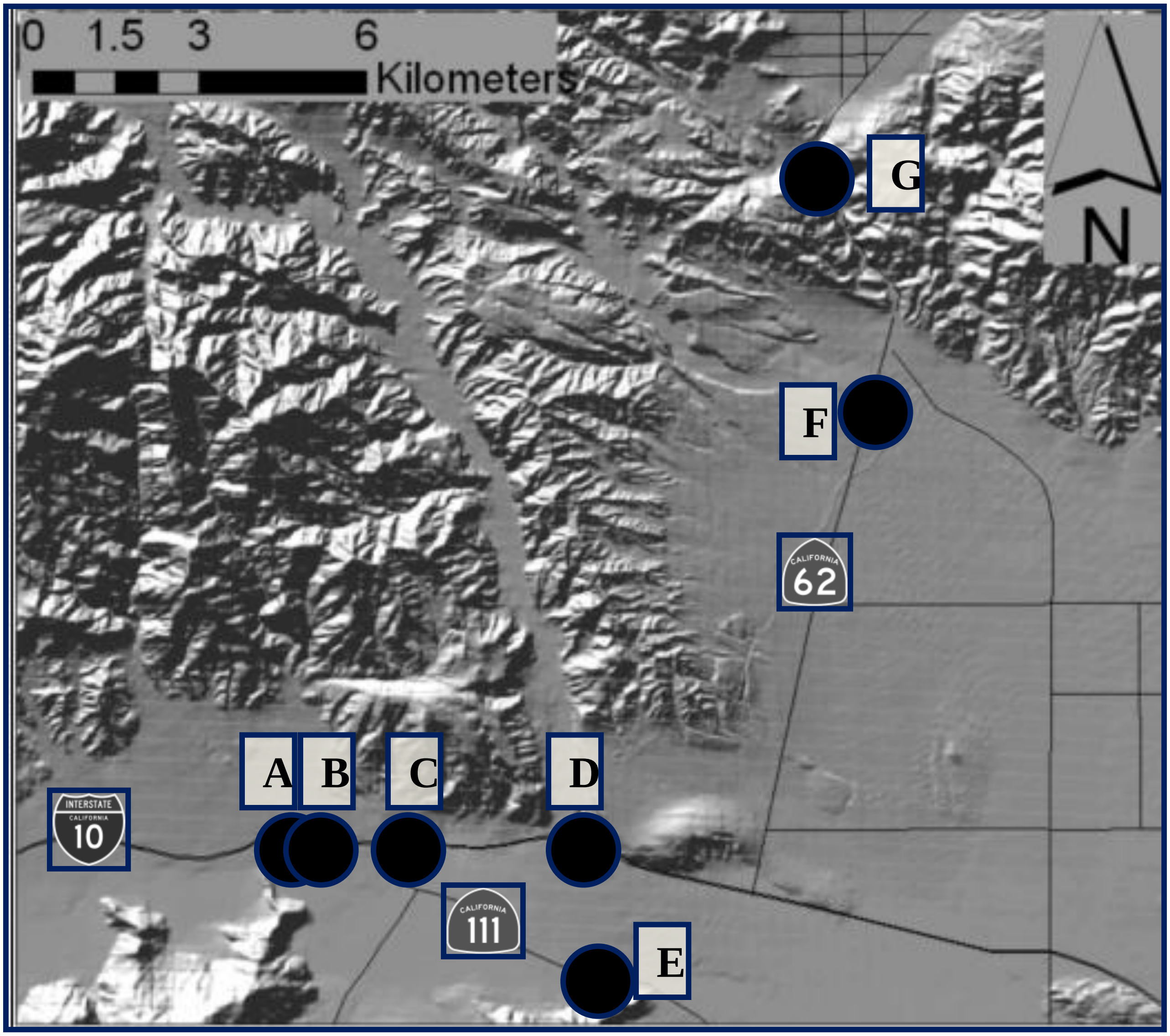


Figure 5-2. Locations of the underpasses monitored in this study. Interstate-10 and Highway-111 bisect the *San Bernardino Mountains to the north and the San Jacinto Mountains to the south*. U*nderpasses F and G are located between the San Bernardino mountains to the northwest and the Little San Bernardino mountains to the northeast along State Route 62*. Underpass locations are indicated by circles.

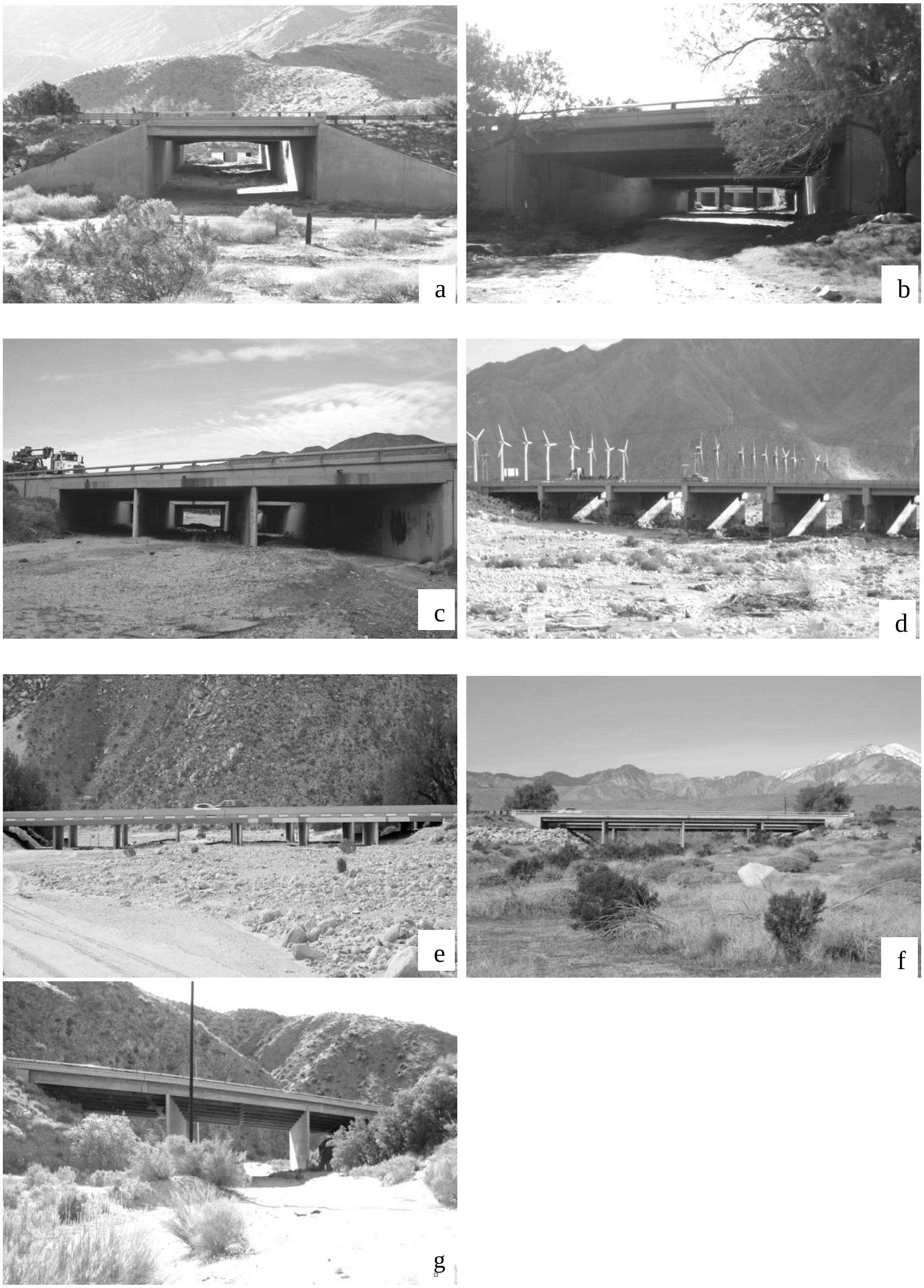


Figure 5-3. Photographs of the seven underpass sites. (a.) north side of underpass A, (b.) north side of underpass B, (c.) south side of underpass C, (d.) north side of underpass D, (e.) north side of underpass E, (f.) west side of underpass F, and (g.) east side of underpass G.

Figure 5-4. *Photograph of a characteristic atrium, a large opening in the roof of the underpass structure.*

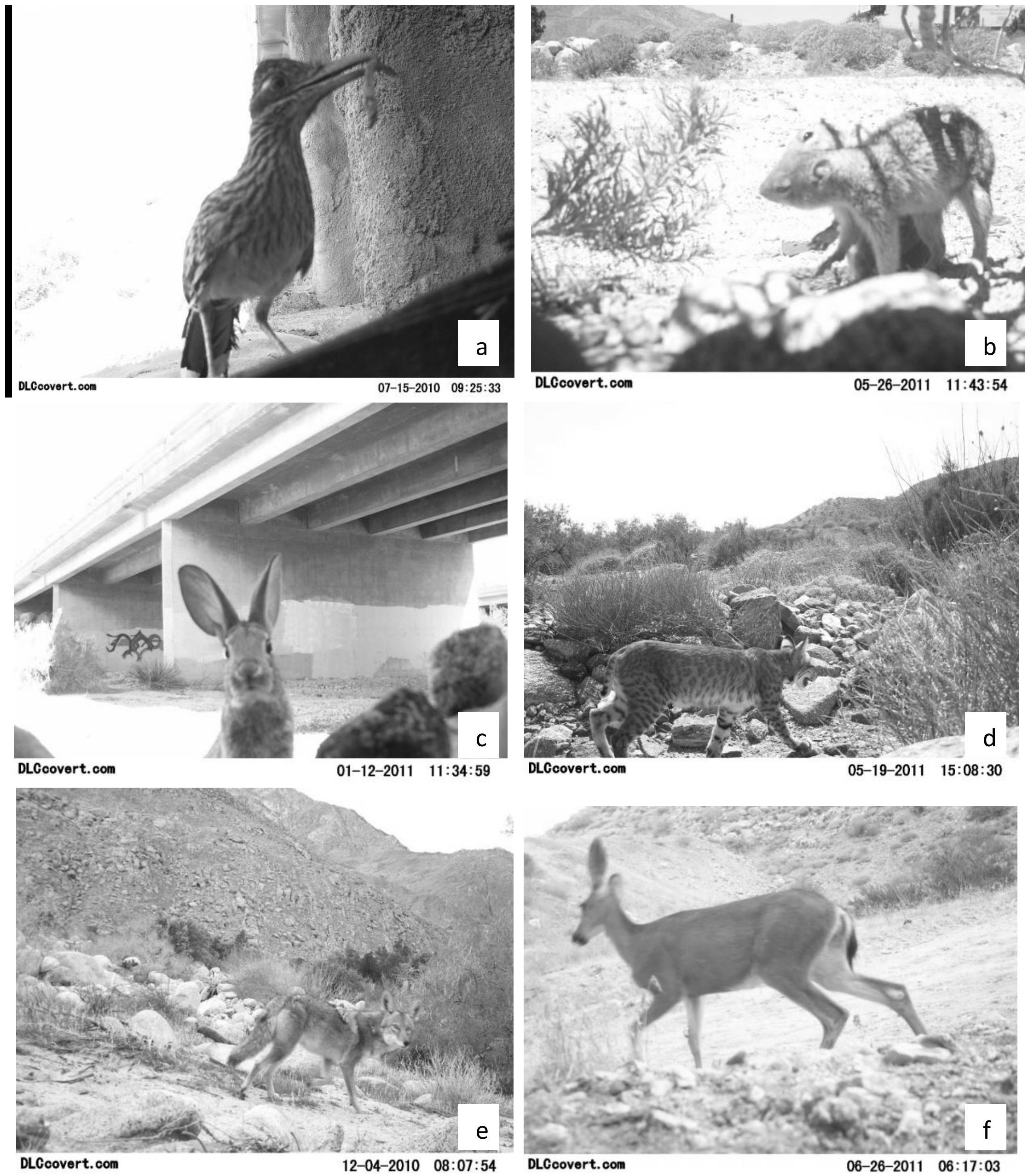


Figure 5-5. Photographs of wildlife taken by the infra red cameras: (a) Greater roadrunner (b) California ground squirrels, (c) desert cottontail, (d) Bobcat, (e) coyote, and (f) mule deer.

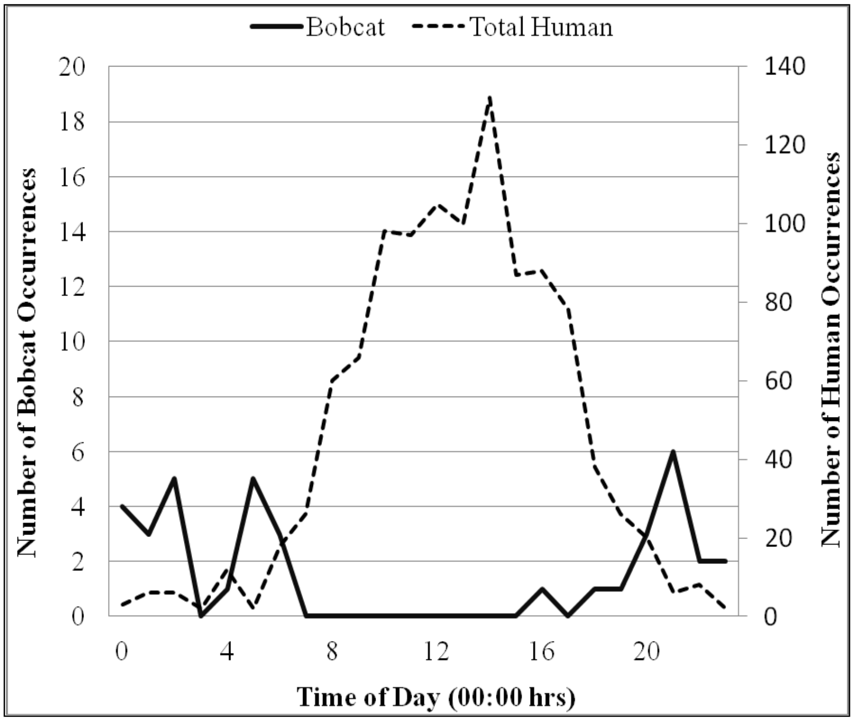


Figure 5-6. Number of bobcats utilizing the underpass structures by time of day compared to humans. Total human count includes full-sized vehicles, off-highway vehicles, and humans on foot.

Appendix 2B
Coachella Valley Wildlife Corridor Analysis

Friends of the Desert Mountains
Coachella Valley Conservation Commission

January 2013

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

Coachella Valley Wildlife Corridor Analysis

Final Report

Michelle L. Murphy-Mariscal &
Cameron W. Barrows

Prepared by the
University of Riverside Center for Conservation Biology
Funded by Southern California Edison

Abstract

Habitat connectivity is a key component for the persistence of populations, for maintaining genetic diversity, and for weathering environmental extremes and climate shifts. Desert environments are stressful largely because of extreme swings in precipitation and temperature, and thus maintaining connectivity becomes a critical conservation strategy to ensure mobile species can track temporal and spatial shifts in habitat suitability. Expansion of urbanization and energy resource development, as well as the transportation and energy infrastructure required to support those changes, are fragmenting desert environments at an increasing rate. Highway underpasses are often identified in conservation planning as wildlife corridors, providing connections between previously contiguous suitable habitats, but do they facilitate or constrain wildlife movement? Wildlife use of seven pre-existing interstate freeway and state highway underpass structures were evaluated to determine whether they are utilized as corridors for wildlife movement. The underpasses occur between southern California's Peninsular and Transverse Mountain Ranges, a key linkage between Baja California's biotic province and that of the Sierra Nevada. Non-invasive monitoring methods were utilized over 29 months to capture wildlife occurrence rates, identify spatial and temporal wildlife use patterns, and to assess factors that may constrain wildlife use. Our results indicate that a wide diversity of wildlife species utilize the underpass structures. Structural attributes of the underpasses were found to influence occurrence rates of small and medium-bodied mammals, whereas for bobcats structural characteristics and human activity both contribute to determining preference. Differences were found for both wildlife and human occurrence rates between the canyon and the underpass sites monitored. Activity patterns exhibited by bobcats and coyotes suggest that these species modify their behavior to avoid human activity at the underpass sites. Wildlife in this desert environment are adapted to evade peak daytime temperatures which also minimizes the influence of human activities on their behavior. Future strategies for maintaining or enhancing landscape connectivity in desert systems should provide a range of underpass structures to support use by many animals, and develop underpasses that minimize human disturbance.

Table of Contents

Introduction

A consequence of human development is often habitat fragmentation and the loss of habitat connectivity. Wildlife corridors, which function to connect habitat patches, can be critical conservation design components for sustaining biodiversity in increasingly fragmented landscapes. Such corridors provide a means for species to disperse, to track preferred habitat conditions in a dynamic environment, and enable genetic heterogeneity between populations (Noss 1987). Wide-ranging animals, such as large-bodied carnivores, require extensive ranges to sustain their needs and are especially impacted by habitat fragmentation (Haas 2000, Morrison and Boyce 2009). When forced to move through a human-dominated landscape, wildlife encounter increased contact with humans and urban development leading to mortality from poaching, vehicle collisions, and depredation by land and livestock owners (Beier 1995, Foster and Humphrey 1995, Tigas et al. 2002, Morrison and Boyce 2009).

With extensive recent and on-going urban and agricultural development within southern California’s arid lands, and with opportunities for alternative energy resource development on the horizon, California’s desert regions are becoming increasingly fragmented. A population increase of 200% between the years 1980 and 2002 made Riverside County the fastest growing region in California, now with more residents than live in 13 other states (Chen et al. 2010, http://www.countyofriverside.us/visiting/aboutriverside/riversidecounty.html). Additionally, this region is expected to experience some of the most pronounced departures from current climate conditions due to anthropogenic climate change (Kerr 2008), further emphasizing the need for available dispersal conduits. In order to enable the persistence of the rich biodiversity of southern California’s arid lands in the face of these stressors, evaluating the permeability of landscapes and maintaining corridors for wildlife movement will become especially important.

The Coachella Valley is a primary transportation artery between coastal areas and the rest of the continental U.S., in addition to being a major center of suburban development. Highway systems, which connect these population centers, exacerbate fragmentation by creating linear barriers to wildlife movement which may result in gene flow disruption, alteration of wildlife behavior and isolation of wildlife populations (Jackson 1999, Bennett 1991). Highway underpasses are a key feature which may ameliorate some of the restrictive barriers development places on natural systems. Underpasses may facilitate dispersal and animal movement beneath roadway barriers, decreasing faunal and human motorist mortality due to roadway collisions during crossing attempts, and allow genetic connectivity between otherwise severed habitats and populations.

Understanding species preference for underpass characteristics has become especially significant to wildlife managers charged with the task of maximizing connectivity. Several studies have focused on identifying factors which influence the efficacy of crossing structures, many of which found that structural attributes of the passages are important in determining usage (Reed et al. 1975, Clevenger and Waltho 2005, Dodd et al. 2007, Gagnon et al. 2011). For example, Clevenger and Waltho (2005) examined 13 wildlife crossing structures in Banff National Park, Canada, for 34 months post-construction and found that structural attributes were most influential for determining usage by both predator and prey species when human activity was absent. The presence of atria, cover, and natural substrate within underpass structures has also been determined to positively influence wildlife crossings (Jackson and Griffith 1998, van der Ree et al. 2007). Atria are openings in the roof of an underpass structure where highway traffic is separated. These openings allow natural light to illuminate the underpass during the day and may facilitate growth of vegetative cover within the underpass. Also, placement and surrounding habitat have been found to influence underpass use in other studies (Foster and Humphrey 1995, Yanes et al. 1995, Rodriguez et al. 1996, Ng et al. 2004).

The differences between the influence of habitat, placement, and structural attributes of the underpasses on determining use can most likely be explained by species- or habitat-specific factors (Clevenger and Waltho 2005) or by inter-specific species interactions. For example, carnivores have been shown to prefer underpasses with low human activity and high vegetative cover (Rodriguez et al 1996, Clevenger and Waltho 2000, Clevenger and Waltho 2005), and small mammals tend to prefer narrow passages where the potential for predation may be low (Rodriguez et al. 1996). Ungulates are inclined to utilize passages with high openness ratios (Dodd et al. 2007). In a study of 11 underpasses in Banff National Park, Canada, ungulate use of underpass structures was determined by structural and landscape characteristics whereas carnivore use of the same underpasses was negatively related to human activity (Clevenger and Waltho 2000). Still other studies have found that wildlife may become habituated to structures over time thus decreasing the influence of structural characteristics on wildlife preference (Gagnon et al. 2011).

Evaluations of underpass effectiveness have been rarely addressed in arid landscapes and research on the efficacy of corridor configuration in developing desert regions is needed to provide scientific input to conservation planning efforts. Understanding wildlife movement near and through pre-existing structures will provide a framework for decisions made regarding construction of wildlife specific structures, such as overpasses and underpasses, in the future as well as inform local conservation planning and habitat management efforts. To avoid further deterioration of the existing natural connectivity, UCR’s Center for Conservation Biology has been engaged to assess the effectiveness of existing highway underpasses as wildlife corridors at what is believed to be a critical point of connectivity between the Peninsular and Transverse Mountain ranges (Penrod et al. 2005a). This region of the western Coachella Valley potentially connects the flora and fauna of Baja California to the northern mountains of the Sierra Nevada and beyond, as well as desert mountain ranges in Joshua Tree National Park to much larger coastal mountains of the Transverse Range. Our objectives of this study were first, to evaluate whether wildlife utilize existing underpass structures at critical wildlife linkages between the Peninsular and Transverse mountain ranges; second, to identify spatial and temporal wildlife use patterns; third, to assess factors, such as structural attributes and human activity, that may constrain wildlife use; and fourth, to ascertain whether the same suite of species occurring in habitat adjacent to the underpasses, i.e. the canyons, are also utilizing the underpass structures.

Methods

Study Area

Southern California's Coachella Valley is situated at the junction of the Sonoran and Mojave Deserts with the costal and cismontane ecoregions to the west, as well as between the Peninsular and Transverse Mountain Ranges which connect Baja California to the Sierra Nevada (Fig. 1). The juxtaposition of geographic and bioregional features results in an area rich in biodiversity.

The eight lane Interstate-10 freeway (hereafter referred to as I-10) and four lane Highway 111 run west to east through the Coachella Valley and are bordered to the north by the San Bernardino Mountains and to the south by the San Jacinto Mountains (Fig. 2). The San Jacinto – San Bernardino corridor linkage, which is bisected by these two highways, has been identified as a critical connection between the Peninsular and Transverse Mountain ranges (Penrod et al. 2005a). State Route 62 (hereafter SR-62) is a four-lane highway that branches off of the I-10 north of Palm Springs, California, and bisects the San Bernardino Mountains where they converge with the Little San Bernardino Mountains (Fig. 2). SR-62 presents a potential barrier at another critical corridor connection between the South Coast and Mojave Desert ecoregions of the Transverse Mountain range (Penrod et al. 2005b). Several underpass structures are located along these highways allowing water runoff to flow unimpeded beneath the roadway. Although not specifically designed for wildlife crossings these underpass structures may be functioning as important linkages by enabling the movement of wildlife utilizing the corridors.

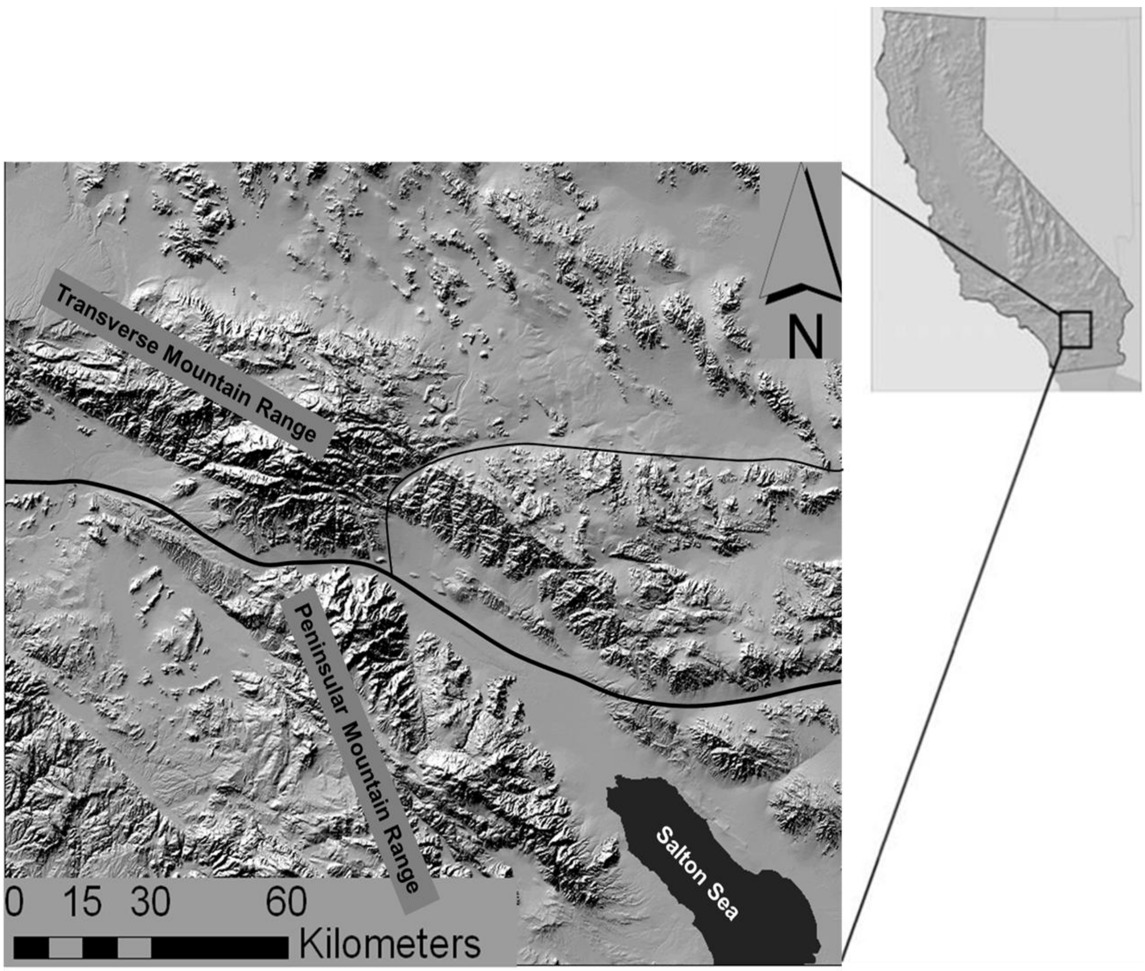


Figure 1. Location of the study region within the Coachella Valley in southern California The study area includes the San Jacinto Mountains, which are part of the Peninsular Range, and the San Bernardino and Little San Bernardino Mountains which are part of the Transverse Range. Interstate-10 and State Route 62 are depicted as black lines.

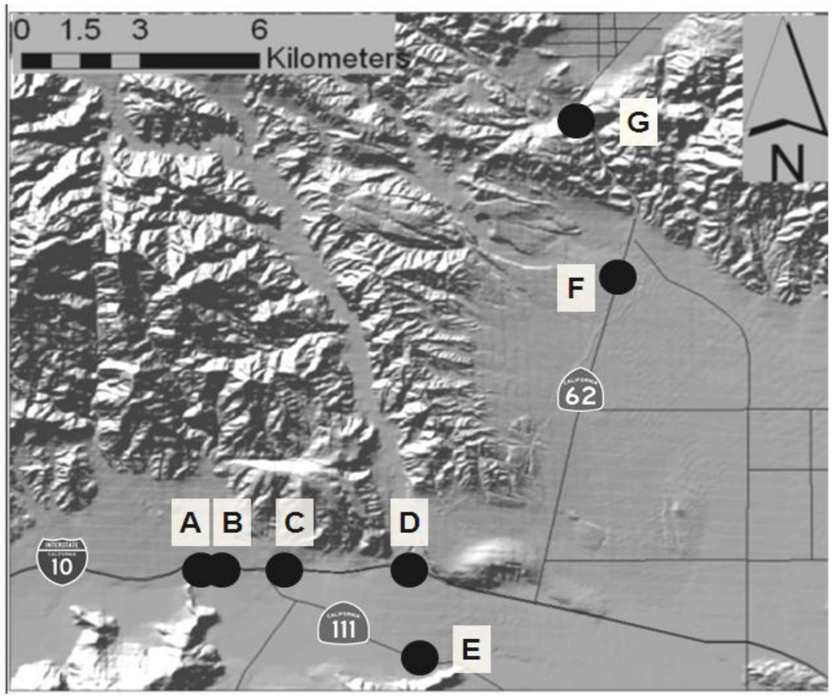


Figure 2. Locations of the underpasses monitored in this study, indicated by black circles: (A) Stubbe West, (B) Stubbe East, (C) Cottonwood, (D) Whitewater, (E) Highway 111, (F) Mission Creek, and (G) Dry Morongo.

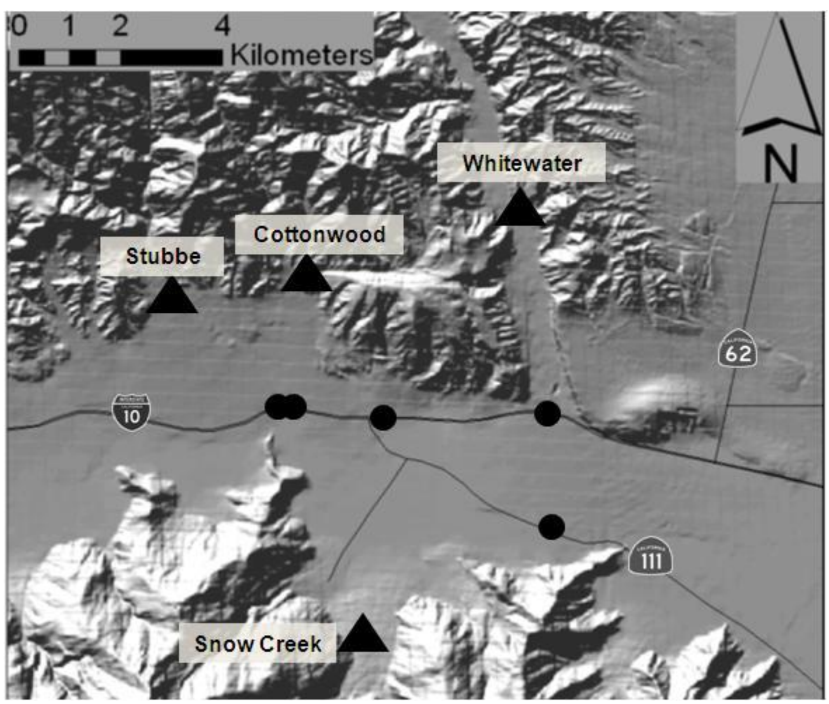


Figure 3. Locations of the canyon sites monitored in this study, indicated by black triangles. Underpass locations are indicated by black circles.

Study Sites

The canyon sites were included in this study to determine whether the same suite of species occurring within the habitat adjacent to the underpasses are also approaching and utilizing the underpass structures. This data was intended to help us to determine if certain species do not approach the freeway as well as whether wildlife species decrease in occurrence as the highway is approached, a phenomenon known as a filter effect. The canyon sites are also assumed to have a lower rate of human occurrence and thus offer an opportunity to examine the influence of human activity near the underpass structures via comparisons with the canyon sites.

Stubbe Canyon and its corresponding underpasses are the western-most of the linkages we studied, and located north of I-10 at the southern edge of the San Bernardino Mountains (Fig. 2). Stubbe Canyon was monitored during the second sampling period to determine wildlife diversity. Two underpass structures run beneath the I-10 highway and adjacent railway and are separated by a distance of 30-m.The western structured is aptly named Stubbe West (Fig. 4a) and the eastern structure is referred to as Stubbe East (Fig. 4b). Both structures contain three atria and the portion of underpass beneath the highway is comprised of a single chamber. The length of the underpass (Table 1, Fig. 5) was calculated as the distance needed to traverse the full length of the structure and includes the structures beneath the freeway, beneath an adjacent utility road and an adjacent railway, with an atrium separating each (Fig. 6). The substrate within the structures is natural and is comprised of hard packed soil, gravel and sand. Due to the railway at the southern end of both underpasses being offset, the visibility through the underpasses is obstructed. Although the structures are similar in dimensions they differ in rates of human and wildlife usage. Stubbe East is utilized by hikers on the Pacific Crest Trail (a long-distance hiking trail running between Canada and Mexico) and utility vehicles accessing properties located south of the underpass whereas Stubbe West is used only occasionally by off-road vehicles and humans on foot. Access by full-sized vehicles is limited due to substrate loss and the narrow underpass openings beneath the railway at the southern end which restrict access by full-sized vehicles.

Cottonwood Canyon is located east of Stubbe Canyon at the base of the San Bernardino Mountains (Fig. 3). The wash leading out of the canyon has been modified into a concrete channel as it approaches the I-10 from the north, and consists of natural habitat to the south. Concrete support walls run the length of the underpass dividing the structure into three separated chambers (Fig. 4c). The substrate within the underpass is concrete with patches of sand repeatedly deposited and washed away by wind and water. During January 2012, Riverside Flood Control District removed debris and sediment that had accumulated within the underpass structure. During this process, sparse shrubbery which had taken root in the debris was also removed, eliminating all cover within the underpass. Prior to this, during the first sampling period, the substrate consisted of blow sand and gravel, with patches of exposed concrete. Visibility through the underpass is unobstructed and the structure has one atrium.

Whitewater Canyon is the easternmost of the canyons and of the corresponding underpasses located along I-10 (Fig, 2-4d). This canyon was monitored during the first sampling period until the camera and suitable tracking medium were washed away during a flood event. Monitoring was subsequently moved to Stubbe Canyon. Whitewater River flows through the canyon and underpass year-round providing recreational opportunities as well as riparian habitat for a number of species. The underpass is comprised of eight chambers (Table 1) containing rocky outcroppings against all support walls, and a large atrium. The chambers are not separated from each other within the underpass; therefore movement between chambers is possible. Substrate consists of earthen material and the natural habitat on both sides of the freeway is clearly visible from the entrance of each opening.

One underpass structure was selected for monitoring along Highway 111, located almost directly south of the Whitewater underpass (Fig. 2, 4e). This bridge underpass contains one atrium and seven chambers which are not separated from each other within the structure (Table 1).The line of sight through the underpass is unobstructed and substrate consists of fine sand which contributes to the sand dune habitat located to the south. Although this habitat is closed to off-highway vehicle activity, vehicles are frequently observed accessing the habitat via this underpass structure. South of Highway 111, at the base of the San Jacinto Mountains, Snow Creek Canyon and Oasis de los Osos are the likely points of arrival and departure for a species traversing this corridor to and from the south. Snow Creek Canyon was monitored for the full duration of the study to determine species diversity.

Mission Creek underpass is located north of I-10, along SR-62, where the dry wash of Mission Creek intersects with the highway (Fig. 2, 4f). The structure is comprised of four chambers and a large atrium, with earthen substrate throughout (Table 1). Due to dense vegetative cover and uneven topography at the eastern opening of the structure, line of sight through the underpass is obstructed.

Dry Morongo underpass is located on the border of Riverside and San Bernardino Counties and is the northern-most site included in this study (Fig. 2, 4g). Relative to the other monitored structures, Dry Morongo underpass is closest to the mountain ranges on either side of the underpass openings, is the only underpass lacking an atrium, and has the second highest openness ratio (Table 1). Visibility through the underpass is high and the substrate consists of natural material. Several homes exist at the mouth of the canyon to the west of the underpass opening and the underpass is used frequently by humans on foot, and by off-highway and full-sized vehicles.

Table 1. Characteristics and classifications of the seven monitored underpass structures

Underpass Attributes		Stubbe West	Stubbe East	Cotton-wood	White-water	Highway 111	Mission Creek	Dry Morongo
Width (m)		11.5	17	39	150	68	30.5	18.3
Length (m)		112	112	77	48.2	37	44.5	12.2
Height (m)		4.5	4.5	2.9	9	2.5	5.4	7.6
Openness		0.46	0.68	1.47	28.01	4.59	3.70	11.40
Adjacent Highway		I-10	I-10	I-10	I-10	Highway 111	SR-62	SR-62
Substrate		Natural	Natural	Concrete	Natural	Natural	Natural	Natural
Atrium Present		Yes	Yes	Yes	Yes	Yes	Yes	No
Number of Chambers		1	1	3	8	7	4	1
Visibility through Underpass		No	No	Yes	Yes	Yes	No	Yes
Classification based on rate of human activity	Opening: 1	Natural	Disturbed	Natural	Disturbed	Natural	Natural	Disturbed
	2	Natural	Disturbed	Natural	Natural	Natural	Natural	Disturbed
Classification based on vegetation quality & cover	Opening: 1	Disturbed	Disturbed	Disturbed	Natural	Disturbed	Natural	Natural
	2	Natural	Natural	Natural	Natural	Natural	Natural	Disturbed

Attributes measured by the author and supplemented with measurements from Penrod et al. (2005a, 2005b). Openness is calculated by (W*H)/L, with larger values indicating greater openness. The last two rows indicate the classification of each underpass opening based on rate of human activity and vegetative quality.

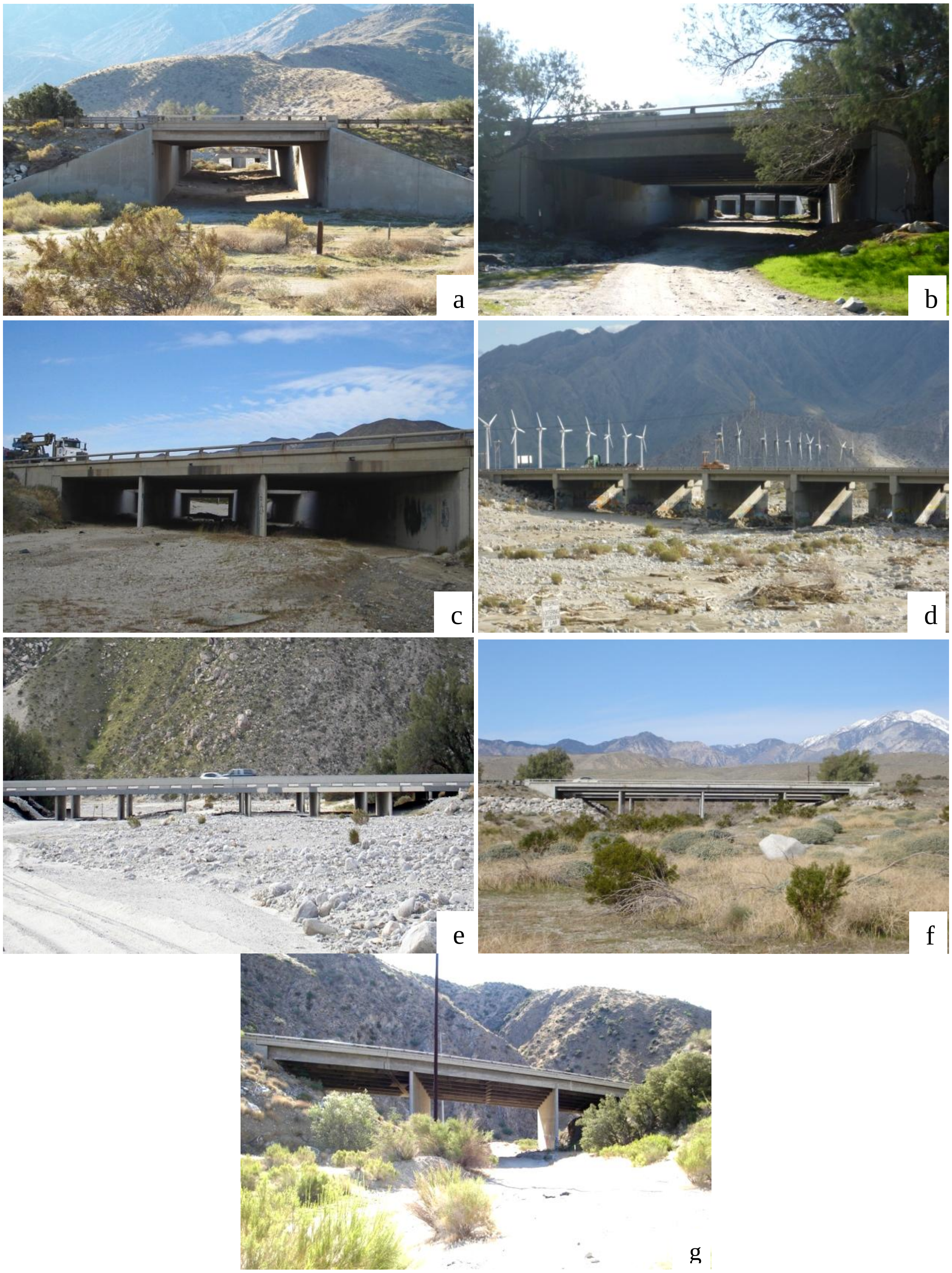


Figure 4. Photographs of the seven underpass sites: (a) north side of Stubbe West, (b) north side of Stubbe East, (c) south side of Cottonwood, (d) north side of Whitewater, (e) north side of Highway 111, (f) west side of Mission Creek, and (g) east side of Dry Morongo.

Figure 5. Photograph of a characteristic atrium, a large opening in the roof of the underpass structure. Stubbe West (pictured) has three atria.

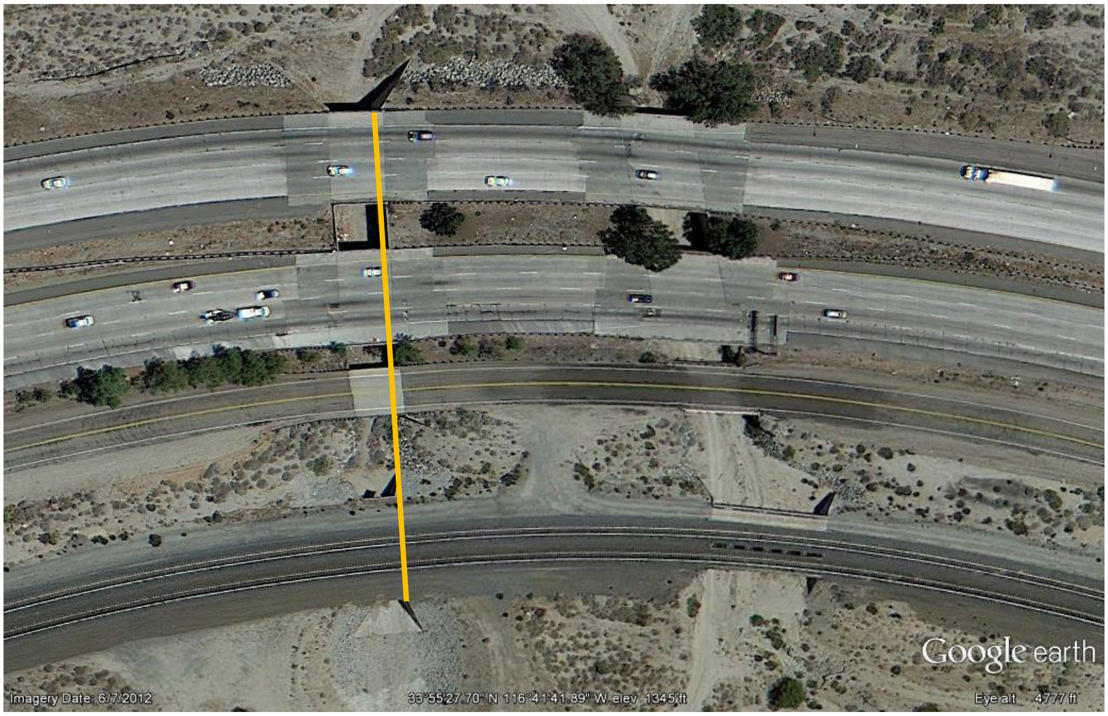


Figure 6. Photograph of Stubbe West and Stubbe East underpass structures. Stubbe West underpass is pictured on the left and Stubbe East on the right. The westbound and eastbound lanes of traffic on I-10 are separated by an atrium at the top of the figure, followed by an adjacent raised utility roadway and an adjacent railway at the bottom of the figure. The orange line illustrates the distance over which the length was measured. This photograph was obtained from Google Earth.

Data Collection

We monitored wildlife movement at each of the highway underpasses from July 2010 through November 2012, resulting in 29 months of data by the study's conclusion. There were two sampling periods, the first ranged from July 2010 through August 2011 and the second sampling period was from September 2011 through November 2012. To document use of the underpass structures two non-invasive monitoring methods were utilized: track beds and infrared motion detection trail cameras (DLC Covert II, 4338 Greenridge Spa Road, Lewisburg, KY 42256, and Bushnell Trophy Cam Model 119436c, Bushnell Corporation, 9200 Cody, Overland Park, KS 66214). At least one camera was maintained at each monitoring site and at some sites a second camera was maintained, depending upon instances of theft and availability of secure camera placement locations. Cameras were placed low to the ground to make them less detectible by humans and to increase the detection of small wildlife species. Camera placement was dependent upon locations deemed suitable to disguise or minimize camera detectability, and locations selected were generally within 45-cm (18 inches) from the ground. In the event of human or animal movement near the underpass opening, the camera would be triggered to take three photos at one second intervals. Cameras saved data onto 4GB memory cards and memory cards were replaced twice per month per site on average. Photos were then downloaded from the memory card onto a computer where they would be viewed, and species would be identified. The date, time, direction of travel and type of activity occurring in each of the photos would be recorded. Additionally, photographs allowed the distinction between species with similar tracks, such as domestic canines and coyotes. Rate of species occurrence was determined by dividing the number of detections of a species by the number of days the camera was active. In the event of multiple occurrences of the same species, only one occurrence was recorded per every half hour. If a distinction could be made between individuals of the same species (for example two canines with different coat colors) occurring multiple times then each individual would be recorded once per direction of travel. Because individuals could not be identified in most photographs these data represent occurrence rather than abundance of the species present at each study site.

To complement the camera surveys, track beds (Rodriguez et al. 1996) were employed at each underpass to record the tracks of animals utilizing the corridor. In this study, track beds, ranged from 1.5 to 2-m wide and consisted of swaths of sandy substrate spanning the entire width of the underpass opening, enabling the detection of small bodied mammals and reptiles that may not have triggered the motion sensor cameras. Supplements of sand were required at sites where naturally occurring sand was insufficient to develop a track bed. During each visit to an underpass, tracks left in the sand of the track bed were inspected and species identification and direction of travel were recorded. The track bed was then smoothed with a broom to eliminate all tracks, ensuring that only new tracks would be recorded during subsequent surveys. Earthen substrate in each underpass wash and at each canyon site was also opportunistically surveyed for tracks to determine species presence; that is, substrate was studied while accessing each site and tracks were recorded opportunistically rather than along developed transects. Rate of species occurrence was recorded as the number of detections of a particular species at a track bed divided by the number of days the track bed was sampled. In the event of multiple occurrences of the same species, only one occurrence was recorded in each direction of travel; multiples of the same species were recorded if distinct individuals could be determined by track size comparisons. As with cameras, these data represent occurrence rather than abundance of the species present at the study sites.

Analysis

Due to non-normality, non-parametric tests were used to analyze the data. As with similar studies (Yanes et al. 1995, Ng et al. 2004), Spearman's rank correlation was used to quantify the relationship between use of the underpass structures by wildlife and underpass characteristic variables, which include structural attributes (length, width, height, and openness) and extent of human activity near each underpass. Human activity consisted of six categories: (1) rate of humans on foot (2) rate of off-highway vehicles), (3) rate of full sized full-sized vehicles, (4) rate of all vehicles (full-sized and off-highway vehicles combined), (5) total human use (calculated as the rates of the previous categories combined), and (6) the rate of domestic canines. Due to the difficulty of distinguishing between domestic canines and coyotes by tracks, only camera data were used in the analyses when the relationships for those species were examined. For all other species, camera and track data for each site visit were combined. Data were then compared to identify duplicate records which were removed to prevent double-counting an occurrence. For the analyses, wildlife species were grouped according to body size classifications and whether they were carnivores or prey species, per previous underpass studies (Yanes et al. 1995, Rodriguez et al. 1996, Ng et al. 2004, Clevenger and Waltho 2005). The carnivore category included both canid and feline carnivore species due to their similar prey base and large range requirements.

The Mann Whitney U test was used to compare differences in occurrence rates of wildlife and human activity between underpass sites, and between canyon and underpass sites. Data was composed of camera and track records from the full sampling period. The Mann-Whitney U test was also used to detect differences in the rates of wildlife use between sites deemed "natural" versus sites deemed "disturbed" on the basis of human activity and adjacent habitat vegetative quality (Table 1). For these analyses underpass openings were considered as separate sites. Sites with crossing rates of <0.5 for total human activity were placed in the "natural" category (n = 9) and all other sites were placed in the "disturbed" category (n = 5). For the second analysis, sites were divided according to nearby vegetative cover and quality. Sites generally natural in vegetation composition and cover (n = 9) were compared to more disturbed habitat sites (n = 5, Table 1). These designations clearly have a subjective character, however understanding the additive impacts of surrounding vegetation management, habitat conditions, and human use patterns and the range of acceptable surrounding land use can provide important information for effective corridor designations. Camera data used for the last two Mann-Whitney U analyses were from the full sampling period.

A traditional a level for statistical significance is most often $P \leq 0.05$; however due to small sample size and the use of non-parametric tests, we have opted to follow Ng et al. (2004) and use $P \leq 0.10$ as our significance threshold. We acknowledge while this level does increase the chance for a Type I error (assigning statistical significance to a relationship that would prove not significant with a larger sample size), it reduces the chance of a Type II error (dismissing relationships as not significant when in fact they are).

Results

Diversity of Wildlife

In total, 3,676 wildlife occurrences and 5,541 human-related activities were recorded as tracks and photos at the underpass sites (Table 2, Fig. 7). At the canyon sites, 1,139 wildlife occurrences and 304 human-related activities were recorded. Of total wildlife detections (canyon and underpass sites combined), 242 were of reptiles, 822 were of birds (Fig. 8a), 1433 were of small-bodied mammals (Fig. 8b), 1130 were of medium-bodied mammals (Fig. 8c), and 1188 were of large-bodied mammals (Fig. 8d-f). Data collected from the cameras allowed for accurate distinction between coyote and domestic canine occurrences, therefore only those records were used when the relationships for those two species were analyzed. Combining track and camera data for canid species (coyote, gray fox, and domestic canine) resulted in almost twice as many detections (n = 786) than camera data alone (coyote n = 216, gray fox n = 4, domestic canine n = 209). Of the human related activities detected, 2227 were of humans on foot, 3272 were of full-sized vehicles, and 346 were of off-highway vehicles.

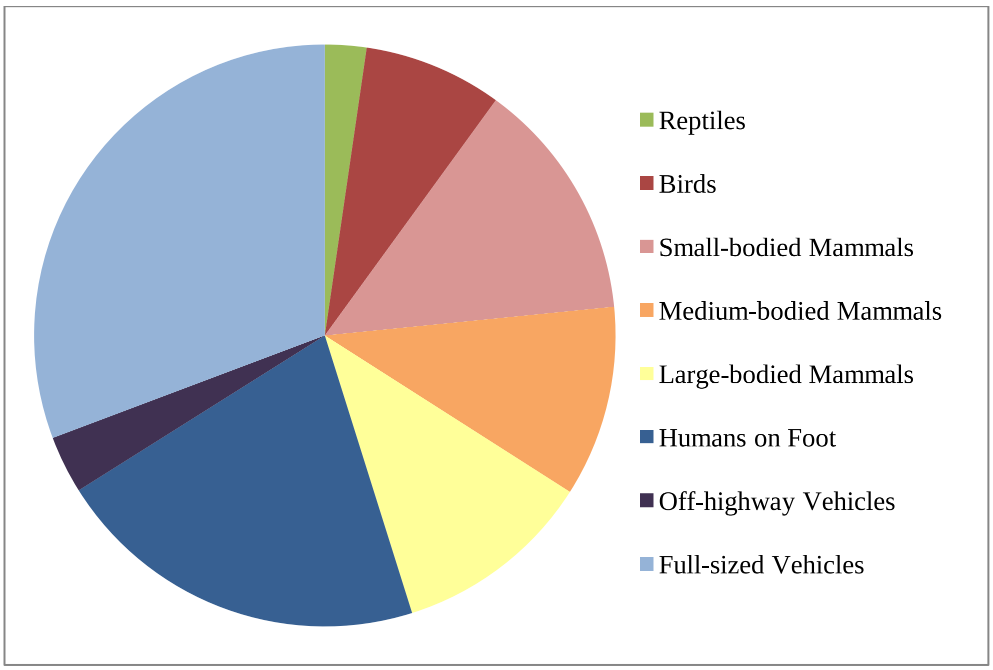


Figure 7. Proportions of wildlife and human activity, underpass and canyon sites combined.

Figure 8. Photographs of wildlife taken by the trail cameras: (a) Greater roadrunner at Mission Creek underpass, (b) California ground squirrel at Cottonwood underpass, (c) raccoon at Highway 111 underpass, (d) juvenile bobcat at Whitewater underpass, (e) coyote in Stubbe Canyon, and (f) cattle in Stubbe Canyon.

Table 2. Crossing rates of wildlife during each monitoring period, camera and track data combined

	Underpass Sites						Canyon Sites					
Sampling Period	1		2		Full		1		2		Full	
No. of Days Monitored	1964		2278		4242		644		898		1542	
Species	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**
Reptile	74	0.038	115	0.050	189	0.045	29	0.045	24	0.027	53	0.034
Small-bodied mammal	821	0.418	429	0.188	1250	0.295	120	0.186	63	0.070	183	0.119
Medium-bodied mammal	442	0.225	386	0.169	828	0.195	91	0.141	211	0.235	302	0.196
Bird	192	0.098	342	0.150	534	0.126	113	0.175	175	0.195	288	0.187
Large-bodied mammal	317	0.161	558	0.245	875	0.206	63	0.098	250	0.278	313	0.203
Total Animal	**1846**	**0.940**	**1830**	**0.803**	**3676**	**0.867**	**416**	**0.646**	**723**	**0.805**	**1139**	**0.739**
Human on Foot	454	0.231	1471	0.646	1925	0.454	281	0.436	21	0.023	302	0.196
Off-Highway Vehicle	101	0.051	243	0.107	344	0.081	1	0.002	1	0.001	2	0.001
Full-Sized Vehicle	351	0.179	2921	1.282	3272	0.771	0	0.000	0	0.000	0	0.000
Total Human Activities	**906**	**0.461**	**4635**	**2.035**	**5541**	**1.306**	**282**	**0.438**	**22**	**0.024**	**304**	**0.197**

(Rate = No. of occurrences / No. of monitoring days)

Relationships between Underpass Structural Attributes and Wildlife Use

When both monitoring periods were combined to explore the relationships between underpass structural attributes and wildlife occurrences medium-bodied mammals had a significant negative association with underpass width and openness ratios (P < 0.01; Table 3). Bobcat occurrences were significantly associated with underpass width and openness (P < 0.01 and P = 0.10, respectively). Reptiles, small-bodied mammals, birds, canid species, and large mammals did not display any significant trends. When analyzed together, carnivore species (including canid species, bobcats and mountain lions) had significant positive associations with underpass height and openness (P < 0.10 and P = 0.10, respectively), while prey species (including small and medium-bodied mammals) had a negative association with underpass openness (P = 0.10).

Table 3. Spearman rank correlation coefficient values for underpass structural variables and rates of wildlife occurrences

Species	Length	Width	Height	Openness
Reptile	-0.134	0.214	0.402	0.464
Small-bodied mammal	-0.170	0.071	0.509	0.357
Bird	0.116	-0.357	0.688	0.107
Medium-bodied mammal	0.670	**-0.893****	-0.295	**-0.893****
Canid	-0.402	0.036	0.598	0.536
Coyote	-0.188	0.027	0.491	0.080
Domestic Canine	-0.045	-0.134	0.580	0.366
Bobcat	-0.473	**0.857****	0.313	**0.714***
Large mammal	-0.402	0.036	0.598	0.536
Carnivore	-0.491	0.214	**0.723***	**0.714***
Prey	0.688	-0.679	-0.134	**-0.714***

Statistically significant associations are indicated with asterisks (**P* < 0.10, ***P* < 0.05, ****P* < 0.01).

Relationships between Human Activity and Wildlife Use

When both monitoring periods were combined to explore the relationships between human activity and wildlife use of the underpass structures, small-bodied mammals and birds both had a significant positive association with domestic canines, and medium-bodied mammals had a significant positive association with off-highway vehicle use (Table 4). Reptile species were found to have significant positive associations with humans on foot and total human activity. Bobcat occurrence rates were negatively associated with full-sized vehicles and all vehicles analyzed together. Prey species (small-bodied mammals and medium-bodied mammals) had a strong positive association with off-highway vehicle use. There was no significant relationship between the carnivore grouping and any of the human activity categories.

Using only camera data to accurately distinguish between coyotes and domestic canines, coyotes were positively associated with domestic canines and domestic canines were positively associated with total human activity (Table 4). When these relationships were explored temporally, domestic canines and total human activity follow the same pattern of peak activity occurring during daytime hours, whereas coyote activity was crepuscular (Fig. 9).

Off-highway vehicle use was the only human activity that was significantly associated with any of the passage attributes (Table 5), and their use was found to be associated with narrow structures and low openness ratios. This relationship is important to note because it may confound results; that is, wildlife found to be associated with OHV activity may display that relationship because of a mutual preference for the same structural attributes. A Mann-Whitney U test was used to detect differences between sites categorized as “natural” versus “disturbed “on the basis of human activity (Table 1). The test revealed that the occurrence rates of large-bodied mammals, coyotes and domestic canines were higher in sites categorized as “disturbed” (Table

6a). There were no significant relationships found when “natural” versus “disturbed” sites based on vegetative quality were analyzed (Table 6b).

Stubbe West and Stubbe East underpass structures are similar in dimensions, but differ in rates of human usage (see Appendix), although only being separated by roughly 30-m. This presents an opportunity to examine the influence that human activity may have on wildlife preference of these structures. When a Mann-Whitney U test was used to compare the occurrence rates of human activities at Stubbe West and Stubbe East a significant difference was found between sites (U=18.581, P < 0.001). When the rates of occurrences for total wildlife were compared between sites, no significant difference was found. When each wildlife group was analyzed separately, a significant difference was found between sites for the large mammal and carnivore groupings (both U= 3.89, P < 0.05).

Table 4. Spearman rank correlation coefficient values for human activity variables and rates of wildlife occurrences

Species	Full-Sized Vehicle	Off-Highway Vehicle	Total Vehicle	Humans on Foot	Total Human	Domestic Canine
Reptile	0.393	-0.143	0.286	**0.857****	**0.857****	0.705
Small-bodied mammal	0.393	0.071	0.321	0.214	0.429	**0.848****
Medium-bodied mammal	0.464	**0.964*****	0.536	-0.071	-0.036	-0.009
Canid	0.393	-0.107	0.357	0.643	**0.750***	------
Coyote	0.241	0.223	0.313	0.313	0.402	**0.714****
Domestic Canine	0.563	0.152	0.491	0.598	**0.759****	------
Bobcat	**-0.750***	-0.107	**-0.786****	-0.286	-0.357	-0.188
Bird	0.357	0.286	0.321	0.643	0.643	**0.830****
Large mammal	0.393	-0.107	0.357	0.643	**0.750***	------
Carnivore	0.214	-0.321	0.143	0.607	0.679	------
Prey	0.607	**0.929*****	0.643	0.107	0.214	0.366

Statistically significant associations are indicated with asterisks (*P < 0.10, **P < 0.05, ***P < 0.01).

Table 5. Spearman rank correlation coefficients for underpass structural variables and rates of human activities at the underpass sites

Human Activity	Length	Width	Height	Openness
Full-Sized Vehicle	0.116	-0.357	-0.277	-0.214
Off-Highway Vehicle	0.670	**-0.857****	-0.295	**-0.857****
Total Vehicle	0.080	-0.464	-0.348	-0.321
Humans on Foot	0.116	0.000	0.295	0.250
Total Human	-0.045	0.000	0.205	0.286

Statistically significant associations are indicated with asterisks (*$P < 0.10$, **$P < 0.05$).

Table 6. Mann-Whitney U values for wildlife occurrence rates at sites deemed "natural" versus "disturbed" based on (a) human activity and (b) habitat quality.

	Small-bodied Mammals	Medium-bodied Mammals	Large-bodied Mammals	Coyote	Bobcat	Dom. Canine	Full Sized Vehicles	Off Highway Vehicles	Humans on Foot
(a) Human Activity									
Median: Natural	0.1429	0.0536	0.0336	0.0101	0.0122	0.0169			
Median: Disturbed	0.1326	0.0750	0.1892	0.0240	0.0063	0.0938			
U	0.218	0.040	8.218	3.771	0.112	4.840			
P-value	0.641	0.841	**0.004*****	**0.052***	0.738	**0.028****			
(b) Habitat Quality									
Median: Natural	0.2538	0.0998	0.1032	0.071	0.0122	0.0201	0.0214	0.0661	0.1202
Median: Disturbed	0.0625	0.0226	0.0336	0.0063	0.0063	0.0235	0.1034	0.0621	0.1445
U	1.604	0.538	0.751	1.977	0.363	0.111	1.284	0.040	0.040
P-value	0.205	0.463	0.386	0.160	0.547	0.739	0.257	0.841	0.841

Statistically significant associations are indicated with asterisks (*$P < 0.10$, **$P < 0.05$, ***$P < 0.01$).

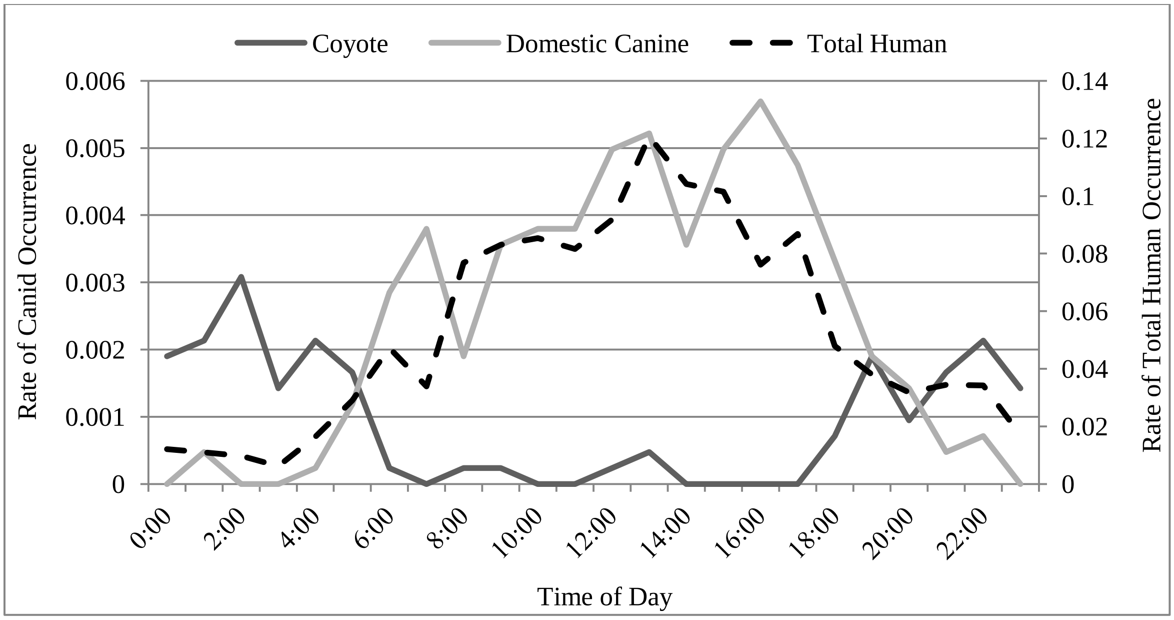


Figure 9. Temporal comparisons of coyote, domestic canine, and total human activity at the underpass sites over the full sampling period.

Patterns of Occurrence at Underpass Sites versus Canyon Sites

Wildlife occurrence rates between the canyon and underpass sites were significantly different (U = 3.007, P = 0.083; Figure 10), as were the occurrence rates of total human activity (U = 28.305, P < 0.0001). When wildlife groups were compared between canyons and underpass sites, differences in occurrence rates were identified. Small-bodied mammals made up the largest proportion of wildlife occurrences at the underpass sites (34.0%), whereas birds, medium-bodied mammals and large mammals made up relatively equal proportions at the canyon sites (25.3%, 26.5%, and 27.5%, respectively). All human activities had higher occurrences at the underpass sites. Statistically, bobcat occurrence rates were significantly difference between canyon and underpass sites (U= 3.687, P= 0.055), as were small-bodied mammals, large-bodied mammals, carnivores and prey species (Table 7).

Next, the temporal activity of wildlife species during the full monitoring period was examined. Peak activity for coyotes at the underpass sites occurred at approximately 02:00 military time whereas peak coyote activity at the canyon sites occurred at approximately 06:00 (Fig. 11a). Human activity at the underpass sites begins to increase between 04:00-06:00, the time period during which coyote activity begins to decrease (Fig. 11b). A similar pattern was found for bobcat, with activity near the underpasses peaking at approximately 04:00 (Fig. 12a), before the increase in human activity (Fig 12b), and activity at the canyon sites peaking at approximately 06:00.

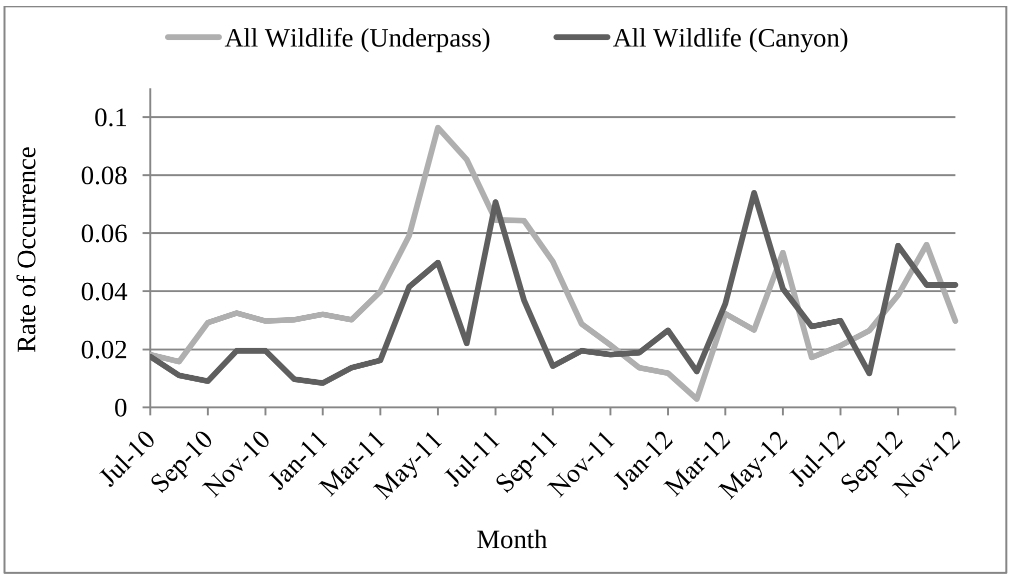


Figure 10. Occurrence rates of wildlife at the canyon and underpass sites over the full sampling period.

Table 7. Mann-Whitney U values for wildlife occurrence rates at canyon versus underpass sites

Grouping	Small-bodied Mammal	Medium-bodied Mammal	Large-bodied Mammal	Bobcat	Coyote	Carnivore	Prey	All Wildlife	Total Human
U	16.578	0.197	6.119	3.687	0.57	8.291	7.622	3.007	28.305
P-value	**0.00004*** **	0.657	**0.013** **	**0.055***	0.45	**0.004*** **	**0.005*** **	**0.083***	**0.0001*** **

Statistically significant associations are indicated with asterisks (*P < 0.10, **P < 0.05, ***P < 0.01).

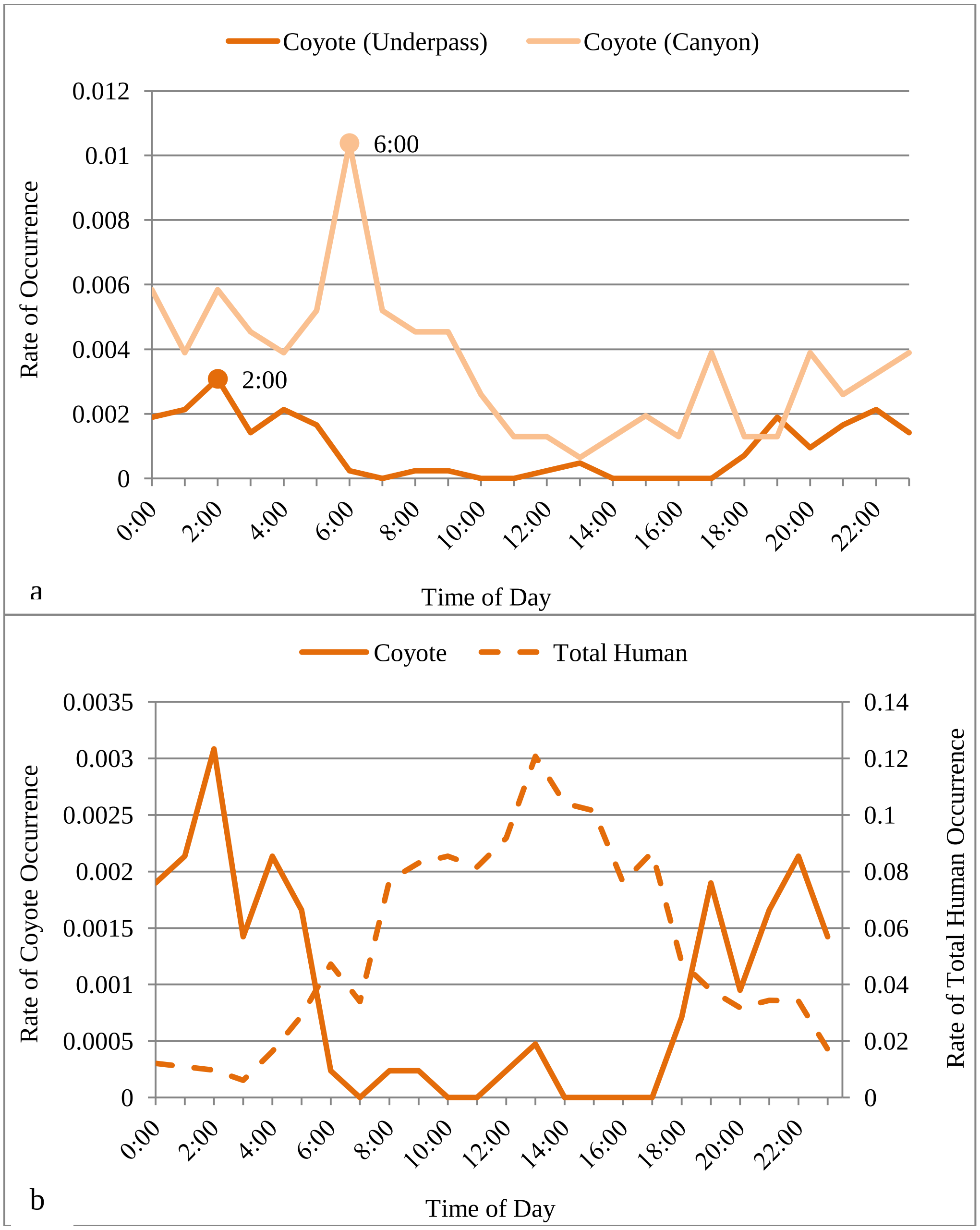


Figure 11. Temporal comparisons of coyote activity (a) at the underpass sites and the canyon sites, and (b) compared to total human activity at the underpass sites.

Figure 12. Temporal comparisons of bobcat activity (a) at the underpass sites and the canyon sites, and (b) compared to total human activity at the underpass sites.

Discussion

A wide variety of wildlife used each of the underpass structures included in this study, confirming their value in allowing wildlife movement. For species with small home ranges, such as ground squirrels, desert cottontails, and black-tailed jackrabbits, underpasses likely provide convenient access to foraging habitat on either side of the highway. Small rodent species and reptiles may reside within or near the underpass structures. Habitat within the corridor can be important for sustaining small-bodied and less motile corridor-dwelling species (Barrows et al. 2011), and such species were found both near and within the underpasses. Large-bodied mammal species, such as coyotes and bobcats, are utilizing the underpasses as linkages between larger territories and home ranges.

Relationships between Underpass Structural Attributes and Wildlife Use

Because there was only one underpass that lacked an atrium (Dry Morongo) and only one underpass that lacked natural substrate (Cottonwood) an analysis of the influence of these two factors on wildlife preference was not possible. Atria allow vegetation to grow within the underpass structures and also provide natural illumination making them appear less confining; this structural feature is generally preferred, however traffic noise within the underpass is higher when atria are present and may disturb more sensitive species (Jackson and Griffith 1998). Because this is an attribute common to the underpasses in our study area, wildlife may be accustomed to the noise levels within the structures and the benefits may outweigh the impact. Substrate can be another important feature influencing wildlife preference (van der Ree 2007, Jackson and Griffith 1998), thus the natural substrate occurring within most of the underpass structures is likely a feature that encourages rather than constrains use.

When the occurrence rates for medium-bodied mammals were analyzed there was a negative association with underpass width and openness ratios. Prey species also had a negative association with underpass openness. Similar relationships have been found elsewhere for this group (Ng et al. 2004, Rodriguez et al. 1996). Rodriguez et al. (1996) hypothesized that this preference exists because prey species are better secured from being ambushed by predatory species in structures with these attributes.

Data collected from the cameras allowed for accurate distinction between coyote and domestic canine occurrences. Therefore only those records were used when the relationships for those two species were analyzed. Data from the first monitoring period indicated that coyote occurrence rates were negatively correlated with underpass width. These data were at odds with expected results, such as those reported by Clevenger and Waltho (2005) during their 34 month study of 13 newly constructed underpasses who found that carnivore species, such as wolves (*Canis lupus*), tend to prefer structures that are wide and short. Because of these contrasting results additional monitoring was suggested to better understand these relationships. When data from the first and second monitoring periods were combined the relationships between coyote and carnivore species more closely resembled that reported by previous studies, that is, a negative trend with underpass length, and a positive trend with openness ratios.

Overall, the similarity in these trends between studies may indicate that animal behavior in desert environments resembles that of more mesic, vegetated habitats. The data available from underpass studies conducted in other environments may also be applicable to our desert study sites with regards to wildlife structural preferences.

Relationships between Human Activity and Wildlife Use

Medium-bodied mammals had a significant positive association with off-highway vehicle usage. Both of these groups were negatively correlated with width and openness structural characteristics which indirectly resulted in these groups being positively correlated with each other. Small bodied mammals and birds were both positively associated with domestic canines, however there is no direct evidence to explain these relationships. Reptile species were positively correlated with humans on foot, which could be due to both group's propensity to utilize open areas; reptiles to thermoregulate or sun themselves, and humans to travel unimpeded.

For sites categorized as "natural" versus "disturbed" on the basis of human activity, the rates of occurrence of large-bodied mammals, coyotes, and domestic canines were higher in sites categorized as "disturbed". This may indicate a willingness for these wildlife groups to use areas near human activity, not necessarily an attraction to the human activity itself. Indeed, when coyote and domestic canine temporal activity patterns were explored, domestic canines and total human activity followed a similar pattern of peak daytime activity, whereas coyotes, which were found to be positively associated with domestic canines, had a crepuscular activity pattern which evaded both domestic canine and total human activity peaks. The significant finding for the large mammal grouping is likely influenced by the inclusion of coyotes and domestic canines, as bobcats were not significantly different when analyzed separately and other large mammals species (cattle, mule deer) where rarely detected at the underpass sites.

When data from the first sampling period was analyzed for an earlier report, the same test revealed that the crossing rates of small-bodied mammals, medium-bodied mammals, canids, and all wildlife analyzed together (excluding canids) were higher in sites categorized as "disturbed". Occurrence rates for small and medium-bodied mammals decreased between the first and second sampling period, whereas occurrence rates for large-bodied mammals increased (Table 3). This may reflect why differences were detected during the first sampling period for small and medium-bodied species, a period of time when those groupings were more prevalent.

When sites were analyzed as “natural” versus “disturbed” on the basis of vegetative quality and proximity to human development during the first sampling period, a Mann-Whitney U test detected differences between the crossing rates of medium-bodied mammals ($U = 2.778$, $P = 0.096$) which were lower at “good” versus “compromised” sites, as well as for rates of full-sized vehicles ($U = 3.247$, $P = 0.072$) and total human activity ($U = 2.778$, $P = 0.0960$) which were both higher at “compromised” sites. When data from the second sampling period were added no significant difference was found for any of the groupings. The results for both of the “natural” versus disturbed” analyses based on either human activity or vegetative quality highlight the importance of extended monitoring to capture the range of variation common in dynamic natural environments.

Because the Stubbe West and Stubbe East underpasses are closely located and have similar dimensions, but differ in their rates of human activity, they provide an opportunity to examine the influence that human activity may have on wildlife preference of these structures. Human activity was significantly different between sites, with higher rates of occurrence at Stubbe East. The narrow southern opening of Stubbe West is only wide enough to allow the passage of off-highway vehicles; therefore, full-sized vehicle passage is concentrated at Stubbe East. Additionally, the Pacific Crest Trail passes beneath the I-10 freeway at Stubbe East. A peak in human foot traffic occurs during the spring through Stubbe East when hikers are utilizing the trail. Although human activity has been demonstrated as being much higher at Stubbe East, when total wildlife occurrence rates were compared between sites no significant difference was found.

When each wildlife group was analyzed, a significant difference was found for large mammals and carnivores. When domestic canines were excluded from the carnivore category to analyze native carnivore occurrence rates (which essentially included bobcats and coyotes because no mountain lions or gray foxes were detected at either site), no significant difference was found. Although domestic canine occurrence rates were not significantly different between sites when analyzed alone, these results indicate that they contributed considerably to influencing significance when the data were grouped. The Spearman Rank analysis determined that domestic canines were significantly associated with total human activity at the underpass sites, therefore their inclusion in both wildlife groupings is most likely the cause of the significant findings. Previous underpass studies have found that human activity has a negative impact on underpass use by wildlife (Clevenger and Waltho 2005). A possible explanation for the lack of a significant difference for total wildlife between sites, despite the difference in human activity, may be a product of adaptations by wildlife to this desert environment; crepuscular and nocturnal activity to evade peak daytime temperatures also minimizes the impact of human activities.

Patterns of Occurrence at Underpass Sites versus Canyon Sites

When the occurrence rates of wildlife at the canyon versus the underpass sites were compared a significant difference was detected. Bobcat occurrence rates were significantly different between the canyon and underpass sites, with more occurrences near the underpass structures. This is likely due to the "funneling" or concentrating nature of the underpasses; that is, bobcats attempting to cross the highway are funneled towards a limited number of underpass structures, and are more likely to be detected than bobcats in the canyons where they traverse a wider expanse of area. Indeed, most of the wildlife groups show this same concentration effect at the underpass sites (Table 2).Occurrence rates of total human activity were also significantly different between canyon and underpass sites. Overall wildlife occurrence rates as well as patterns for individual species were found to be influenced by human activity. Although no significant difference was found for coyote occurrence rates between canyon and underpass sites, coyotes displayed different activity patterns between these sites. At the canyon sites, coyotes remained active later in the morning with a peak in activity occurring 4 hours after peak coyote activity near the underpass structures. Bobcat occurrence patterns were significantly different between the canyon and underpass sites, and they displayed an activity pattern similar to coyotes, with activity in the canyons peaking two hours after the peak in activity near the underpass sites. Both of these species are crepuscular, with peaks in activity typically occurring during dusk and dawn. While the data support crepuscular activities, the decreases in bobcat and coyote activity at the underpass sites as human activity begins to increase also indicates an influence by human activity. It has been suggested that bobcats and coyotes residing near urbanized areas adjust their behavior to spatially and temporally avoid human activities (Tigas et al. 2002); thus these species are avoiding underpass structures during times when human activity is most likely.

Wildlife Diversity

While we recorded a wide range of species using the underpasses, there were apparent differences between underpasses with regards to species use. Mule deer were only documented at Whitewater underpass (n = 1) and Dry Morongo (n = 12). Of the underpasses included in this study, Dry Morongo has the shortest length (Table 1) and the largest single chamber width (Fig. 4g), which both contribute to its relatively high openness ratio of 11.40. Numerous studies have reported that ungulate species are particularly influenced by structural characteristics of underpasses (Reed et al. 1975, Foster and Humphrey 1995, Dodd et al. 2007). Preferred underpass dimensions combined with close proximity to the mountain ranges on either side of the structure may combine to make this a suitable crossing structure for ungulates. However, desert bighorn sheep (*Ovis canadensis nelsoni*), which are known to inhabit the mountain ranges on either side of State Route-62 (Penrod et al. 2005a) and which were documented near the underpass (I. Hawkins, *pers. comm*. and M.L. Murphy-Mariscal, *wildlife camera*), were never found approaching or utilizing the underpass. This may be due to the high relative frequency of human activity and domestic canines near and through this underpass structure, as well as use of this structure by other ungulates (Bristow and Crabb 2008).

Although Dry Morongo has a relatively high human activity occurrence rate, it was also the only underpass in our study where mountain lion crossings were verified. Mountain lions show little aversion to human activities (Beier 1995), and previous studies found no correlation between human and cougar use of underpass structures (Gloyne and Clevenger 2001). A positive correlation has been found between cougars, mule deer and white-tailed deer, the latter being the primary food source of the lions (Gloyne and Clevenger 2001). As Dry Morongo underpass had the highest mule deer occurrence rate, cougars may be utilizing this underpass to track this food source between mountain ranges.

Whitewater Canyon was delineated as a primary least cost corridor, or best potential route, for mountain lions by a landscape permeability analysis (Penrod et al. 2005b). Although mountain lions have been observed traversing the canyon (Frazier Haney, Whitewater Preserve, *pers. comm*.) no mountain lions were documented near the underpass opening. Bobcats were recorded on several occasions as having utilized the underpass, indicating no aversion to the underpass dimensions or surrounding landscape characteristics and therefore demonstrating the potential suitability of this structure for use by other large carnivore species.

Conclusions and Recommendations

Highways may present impenetrable barriers to wildlife movement; however, underpass structures can mitigate this problem by providing linkages which connect suitable habitats on both sides of the barrier. This study identified that underpass structures along Interstate-10, Highway 111 and State Route- 62 in the Coachella Valley are facilitating crossings by a broad range of wildlife beneath these potential barriers, and are serving to maintain connectivity between the Peninsular and Transverse Mountain ranges for many of the species occurring in this area. By utilizing non-invasive monitoring methods we were able to identify specific wildlife species which utilize the underpasses, temporal and spatial use patterns by both humans and wildlife, and potential factors which constrain or encourage underpass use by wildlife.

Existing literature suggests that wildlife preference of underpass structures is influenced by human activity. Data from our first sampling period was in agreement with the literature; that is, human activity had a greater influence than structural characteristics in determining underpass preference. However when we analyzed the data from the full sampling period we found that human activity had less of an impact than was originally determined. Our comparison of Stubbe West and Stubbe East underpass sites illustrates this point. However, those results were site-specific. The contribution of each variable, overall, should be evaluated when explaining wildlife preference. For example, bobcats were found to have a negative association with vehicle usage across all sites and a positive association with structural width and openness. If we consider the combined influence of each of these variables, the widest underpasses with the lowest vehicle occurrence rates (Whitewater, Highway 111 and Mission Creek underpasses) all consequently had the highest bobcat occurrence rates. When openness is factored in, Whitewater underpass, having the highest openness ratio, a high measure of width, and a relatively low vehicle occurrence rate, promoted the highest bobcat occurrence rate of all the structures monitored.

The results presented here only account for the frequency of occurrence near the underpass structures and canyons monitored, and do not provide the data necessary to address whether these structures are effective; that is, whether gene flow is enabled. Genetic analysis of populations on both sides of the barrier should be undertaken to determine whether there is genetic variability and whether heterozygosity among populations is being maintained (Riley et al. 2006). Special attention should be extended to determine wildlife behavioral responses to alternative energy and transmission projects near the corridor and whether these projects are impacting or impeding movement through the landscape matrix, especially by wide ranging species.

All but one of the structures included in this study (Dry Morongo) contain atria which allow natural sunlight and water to enter the passages and have been found to be beneficial to wildlife preference. However refuse has accumulated within the Stubbe West structure inhibiting growth of vegetation beneath the atria. Clearance of the refuse is recommended to allow growth of native vegetation within the structure and may improve the condition of this underpass and positively influence its use by native wildlife species.

The Bureau of Land Management has protected 3-km of land on both sides of Dry Morongo underpass, which secures connectivity between the mountain ranges for bighorn sheep movement (Penrod et al. 2005b). Although land south the Dry Morongo underpass was delineated as a best potential route for bighorn sheep movement by a landscape permeability analysis (Penrod et al 2005b), no bighorn sheep were found approaching or utilizing Dry Morongo underpass during the duration of monitoring. Human recreational activities may inhibit wildlife use and degrade habitat quality. Regulators may want to reduce vehicle access to Dry Morongo underpass to eliminate habitat disturbance and wildlife avoidance of these areas.

Appendix. Crossing rates of wildlife at each site for the full monitoring period, tracks and camera images combined

		Stubbe East		Stubbe West		Cottonwood		Whitewater		Highway 111		Dry Morongo	
	No. of Days Monitored	232		752		658		810		752		448	
Group	**Species**	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**
Reptile species		15	0.065	16	0.021	24	0.036	49	0.060	39	0.052	24	0.054
Small-bodied mammals	Pocket mouse (*Perognathus* spp.), kangaroo rat (*Dipodomys* spp.), woodrat (*Neotoma* spp.), deer mouse (*Peromyscus* spp.), California ground squirrel (*Spermophilus beecheyi*), round-tailed ground squirrel (*Spermophilus tereticaudus*), white-tailed antelope ground squirrel (*Ammospermophilus leucurus*)	71	0.306	145	0.193	278	0.422	303	0.374	77	0.102	204	0.455
Bird species		62	0.267	62	0.082	49	0.074	136	0.168	44	0.059	114	0.254
Medium-bodied mammals	Desert cottontail (*Sylvilagus audubonii*), black-tailed jackrabbit (*Lepus californicus*), striped skunk (*Mephitis mephitis*), raccoon (*Procyon lotor*), domestic cat	88	0.379	320	0.426	150	0.228	37	0.046	84	0.112	62	0.138
Large-bodied mammals	Domestic dog, coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), bobcat (*Felis rufus*), mountain lion (*Puma concolor*), mule deer (*Odocoileus hemionus*), horse, burrow, cattle	65	0.280	68	0.090	66	0.100	222	0.274	118	0.157	237	0.529
Humans on Foot		886	3.819	128	0.170	64	0.097	399	0.493	193	0.257	215	0.480
Off-highway Vehicle		57	0.246	77	0.102	66	0.100	7	0.009	44	0.059	43	0.096
Full-sized Vehicle		2807	12.099	39	0.052	131	0.199	4	0.005	117	0.156	172	0.384

Appendix. Continued

		Mission Creek		Cottonwood Canyon		Snow Creek Canyon		Whitewater Canyon		Stubbe Canyon	
	No. of Days Monitored	590		653		682		135		72	
Group	**Species**	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**	**N**	**Rate**
Reptile species		22	0.037	22	0.034	25	0.037	4	0.030	2	0.028
Small-bodied mammals	Pocket mouse (*Perognathus* spp.), kangaroo rat (*Dipodomys* spp.), woodrat (*Neotoma* spp.), deer mouse (*Peromyscus* spp.), California ground squirrel (*Spermophilus beecheyi*), round-tailed ground squirrel (*Spermophilus tereticaudus*), white-tailed antelope ground squirrel (*Ammospermophilus leucurus*)	172	0.292	83	0.127	72	0.106	28	0.207	0	0.000
Bird species		67	0.114	130	0.199	127	0.186	5	0.037	26	0.361
Medium-bodied mammals	Desert cottontail (*Sylvilagus audubonii*), black-tailed jackrabbit (*Lepus californicus*), striped skunk (*Mephitis mephitis*), raccoon (*Procyon lotor*), domestic cat	71	0.120	264	0.404	29	0.043	4	0.030	5	0.069
Large-bodied mammals	Domestic dog, coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), bobcat (*Felis rufus*), mountain lion (*Puma concolor*), mule deer (*Odocoileus hemionus*), horse, burrow, cattle	99	0.168	115	0.176	64	0.094	36	0.267	98	1.361
Human on Foot		40	0.068	25	0.038	11	0.016	266	1.970	0	0.000
Off-highway Vehicle		50	0.085	2	0.003	0	0.000	0	0.000	0	0.000
Full-sized Vehicle		2	0.003	0	0.000	0	0.000	0	0.000	0	0.000

Literature Cited

Barrows, C.W., K.D. Fleming, and M.F. Allen. 2011. Identifying habitat linkages to maintain connectivity for corridor dwellers in a fragmented landscape. The Journal of Wildlife Management. 75(3):682-691.

Beier, P. 1995. Dispersal of juvenile cougars in fragmented habitat. The Journal of Wildlife Management. 59(2):228-237.

Bennett, A.F. 1991. Roads, roadsides, and wildlife conservation: a review. Pp. 99-118 *in* D.A. Saunders and R.J. Hobbs (eds.) Nature conservation 2: The role of corridors. Surrey Beatty & Sons, Chipping Norton. Australia.

Bristow, K., and M. Crabb. 2008. Evaluation of distribution and trans-highway movement of desert bighorn sheep: Arizona Highway 68. Final Report 588. Arizona Department of Transportation, Phoenix, AZ. 42 p.

Chen, X., B. Li, and M.F. Allen. 2010. Characterizing urbanization, and agricultural and conservation land-use change in Riverside County, California, USA. Annals of the New York Academy of Sciences. 1195: E164-E176.

Clevenger, A.P., and N. Waltho. 2000. Factors influencing the effectiveness of wildlife underpasses in Banff National Park, Alberta, Canada. Conservation Biology. 14(1):47-56.

Clevenger, A.P., and N. Waltho. 2005. Performance indices to identify attributes of highway crossing structures facilitating movement of large mammals. Biological Conservation. 121:453-464.

Dodd, N. L., J. W. Gagnon, A. L. Manzo, and R. E. Schweinsburg. 2007. Video surveillance to assess highway underpasses by elk in Arizona. Journal of Wildlife Management. 71:637–645.

Foster, M.L., and S.R. Humphrey. 1995. Use of Highway underpasses by Florida panthers and other wildlife. Wildlife Society Bulletin. 23(1):95-100.

Gagnon, J.W., N.L. Dodd, K.S. Ogren, and R.E. Schweinsburg. 2011. Factors associated with use of wildlife underpasses and importance of long-term monitoring. Journal of Wildlife Management. 75(6):1477-1487.

Gloyne, C.C., and A.P. Clevenger. 2001. Cougar *Puma concolor* use of wildlife crossing structures on the Trans-Canada highway in Banff National Park, Alberta. Wildlife Biology. 7:117-124.

Haas, C.D. 2000. Distribution, relative abundance, and roadway underpass responses of carnivores throughout the Puente-Chino Hills. MS Thesis, California State Polytechnic University, Pomona, CA. 110 pp.

Jackson, S.D. 1999. Overview of transportation related wildlife problems. Proceedings of the Third International Conference on Wildlife Ecology and Transportation. FL-ER-73-99. Florida Department of Transportation, Tallahassee, Florida.

Jackson, S. D., and C.R. Griffin. 1998. Toward a practical strategy for mitigating highway impacts on wildlife. Proceedings of the International Conference on Wildlife Ecology and Transportation. FL-ER-69-98. Florida Department of Transportation, Tallahassee, Florida.

Kerr, R.A. 2008. Climate change hot spots mapped across the United States. Science. 321: 909.

Morrison, S., and W. Boyce. 2009. Conserving connectivity: some lessons from mountain lions in Southern California. Conservation Biology. 23(2):275-285.

Ng, S., J. Dole, R. Sauvajot, S. Riley, and T. Valone. 2004. Use of highway undercrossings by wildlife in Southern California. Biological Conservation. 115:499-507.

Noss, R. 1987. Corridors in real landscapes: a reply to Simberloff and Cox. Conservation Biology. 1(2):159-164.

Penrod, K., C. Cabanero, P. Beier, et al. 2005a. South Coast Missing Linkages: A linkage design for the San Bernardino-San Jacinto Connection. South Coast Wildlands, Idyllwild, CA. www.scwildlands.org.

Penrod, K., C. Cabanero, P. Beier, et al. 2005b. South Coast Missing Linkages: A linkage design for the San Bernardino-Little San Bernardino Connection. South Coast Wildlands, Idyllwild, CA. www.scwildlands.org.

Reed, D.F., T.N. Woodard, and T.M. Pojar. 1975. Behavioral response of mule deer to a highway underpass. Journal of Wildlife Management. 39(2):361-367.

Rodriguez, A., G. Crema, and M. Delibes.1996. Use of non-wildlife passages across a high speed railway by terrestrial vertebrates. Journal of Applied Ecology. 33(6): 1527-1540.

Saunders, D., and R.J. Hobbs. 1991. Nature conservation 2: The role of corridors. Surrey Beatty and Sons, Chipping Norton, New South Wales, Australia.

Tigas, L., D. Van Vuren, and R. Sauvajot. 2002. Behavioral responses of bobcats and coyotes to habitat fragmentation and corridors in an urban environment. Biological Conservation. 108:299-206.

van der Ree, R., E. van der Grift, N. Gulle, K. Holland, C. Mata, and F. Suarez. 2007. Overcoming the barrier effect of roads–how effective are mitigation strategies? An international review of the use and effectiveness of underpasses and overpasses designed to increase the permeability of roads for wildlife. Proceedings of the International Conference on Ecology and Transportation. Center for Transportation and Environment, North Carolina State University, Raleigh, North Carolina.

Yanes, M., J.M. Velasco, and F. Suarez. 1995. Permeability of roads and railways to vertebrates: the importance of culverts. Biological Conservation. 71:217-222.

Appendix 3
Table of Acquisitions for Conservation in 2013

CVMSHCP 2013 Annual Report - Parcels Acquired for Conservation

Sum of Acres	Acquisition Made by	
Conservation Areas	Coachella Valley Conservation Commission	Friends of the Desert Mountains
Dos Palmas		**42**
731110001		42
Desert Tortoise and Linkage	**202**	**100**
601100004		40
668190007	20	
707190004	40	
707270002		20
707410009		10
713120007		10
713150008	20	
715090016	8	
717110011		5
745320010		15
753330013	39	
753330020	76	
Highway 111/I10	**1**	
522080003	1	
Indio Hills/Joshua Tree National Park	**5**	**93**
647410013	5	
741140003		39
741140006		54
Mecca Hills / Orocopia Mountains		**250**
709420048		21
709570003		10
719080033		85
719080039		84
719090015		20
719090065		30
Morongo Wash Special Provision Areas	**2**	
664090013	0	
665090016	1	
Stubbe and Cottonwood Canyons		**26**
520030006		5
520030011		5
520060007		5
520060008		5
520070001		5

Santa Rosa and San Jacinto Mountains	**145**	**416**
513320014	39	
635310003		27
635310004		53
635310005		70
635310006		46
636072026	1	
636072027	1	
636082034	1	
715090020	30	
715090026	33	
715190022	39	
753040001		77
753050001		77
753150003		10
753200009		19
753250003		10
753260009		19
753310023		7
Thousand Palms	**5**	
648020005	5	
Upper Mission Creek / Big Morongo Canyon	**71**	**908**
661020002		38
661020003		1
663230020	1	
663240016	11	
663260015	20	
663260016	20	
663260017	16	
671120001		264
671130002		220
671190001		16
671190002		17
671190003		21
671190004		12
671190005		33
671190006		58
671190007		21
671190008		78
671190009		1
671200002		65
671200010		10
671200011		3
671200012		50
753330021	3	

Willow Hole	**55**	**51**
657280014		51
659230029	1	
665190008	2	
665190011	3	
665210002	1	
669110002	5	
669110005	5	
669110006	5	
669130002	10	
669130005	5	
669130006	8	
669130007	2	
669130008	3	
669130010	2	
669130011	2	
Whitewater Canyon		**0**
516056002		0
Grand Total	**485**	**1886**

Appendix 4
Status of Conservation Objectives by Conservation Area

CVMSHCP Annual Report 2013 - Conservation Objectives by Conservation Area

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2013	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
Cabazon Conservation Area - Riverside County								
Peninsular Bighorn Sheep - Essential Habitat	264	181	83	0	0	0%	0	18
Mesquite hummocks	13	1	12	0	0	0%	0	0
Southern sycamore-alder riparian woodland	9	1	9	0	0	0%	0	0
Sand Source	7,683	181	1,629	0	0	0%	0	18
Sand Transport	4,538	0	0	0	0	0%	0	0
Fornat Wash Corridor	641	10	631	0	0	0%	0	1
Coachella Valley Stormwater Channel and Delta Conservation Area - Riverside County								
Desert Pupfish - Core Habitat	25	0	25	0	0	0%	0	0
Crissal Thrasher - Core Habitat	896	87	781	0	0	0%	5	4
California Black Rail - Other Conserved Habitat	62	6	52	0	0	0%	0	1
Yuma Clapper Rail - Other Conserved Habitat	62	6	52	0	0	0%	0	1
Le Conte's Thrasher - Other Conserved Habitat	784	78	706	0	0	0%	5	3
Mesquite hummocks	74	7	67	0	0	0%	0	1
Coastal and valley freshwater marsh	61	6	63	0	0	0%	0	1
Desert sink scrub	1,349	114	1,026	0	0	0%	0	11
Desert saltbush scrub	792	79	713	0	0	0%	5	3

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2013	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
Desert Tortoise and Linkage Conservation Area - Coachella								
Desert Tortoise - Core Habitat	300	30	270	0	0	0%	0	3
Le Conte's Thrasher - Other Conserved Habitat	300	30	270	0	0	0%	0	3
Desert dry wash woodland	121	12	109	0	0	0%	0	1
Desert Tortoise and Linkage Conservation Area - Riverside County								
Desert Tortoise - Core Habitat	88,878	4,998	44,978	3,528	269	8%	0	853
Orocopia Sage - Core Habitat	779	44	398	0	0	0%	0	4
Mecca Aster - Core Habitat	4,731	206	1,852	211	14	11%	0	42
Le Conte's Thrasher - Other Conserved Habitat	49,114	2,813	25,319	1,361	135	5%	0	417
Desert dry wash woodland	13,443	752	6,771	535	68	8%	0	129
Desert Tortoise and Linkage Corridor	26,122	1,572	14,144	819	134	6%	0	239

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2013	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
Dos Palmas Conservation Area - Riverside County								
Crissal Thrasher - Core Habitat	536	38	343	141	0	41%	0	18
Desert Pupfish - Refugia Locations	0	0	0	0	0	0%	0	0
California Black Rail - Other Conserved Habitat	597	37	334	270	0	81%	0	31
Le Conte's Thrasher - Other Conserved Habitat	14,882	743	6,689	1,063	33	16%	0	181
Yuma Clapper Rail - Other Conserved Habitat	682	42	374	270	0	72%	0	31
Predicted Flat-tailed Horned Lizard - Other Conserved Habitat	5,537	403	3,631	265	0	7%	0	67
Desert fan palm oasis woodland	125	6	50	29	0	58%	0	4
Arrowweed scrub	277	13	121	0	0	0%	0	1
Mesquite bosque	482	36	320	131	0	41%	0	17
Desert sink scrub	7,195	487	4,381	837	0	19%	0	132
Desert dry wash woodland	1,856	83	746	170	0	23%	0	25
Cismontane alkali marsh	321	23	205	200	0	98%	0	22
Mesquite hummocks	55	3	23	10	0	43%	0	1
East Indio Hills Conservation Area - Coachella								
Le Conte's Thrasher - Other Conserved Habitat	62	6	56	0	0	0%	0	1
Palm Springs Pocket Mouse - Other Conserved Habitat	8	1	7	0	0	0%	0	0
Coachella Valley Round-tailed Ground Squirrel - Other Conserved Habitat	6	1	5	0	0	0%	0	0
Predicted Flat-tailed Horned Lizard - Other Conserved Habitat	6	1	5	0	0	0%	0	0

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2013	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
East Indio Hills Conservation Area - Indio								
Le Conte's Thrasher - Other Conserved Habitat	120	12	105	0	0	0%	0	1
Palm Springs Pocket Mouse - Other Conserved Habitat	117	11	1,031	0	0	0%	0	1
Coachella Valley Round-tailed Ground Squirrel - Other Conserved Habitat	117	11	103	0	0	0%	0	1
Predicted Flat-tailed Horned Lizard - Other Conserved Habitat	114	11	100	0	0	0%	0	1
Mesquite hummocks	2	0	2	0	0	0%	0	0
Stabilized shielded sand fields	114	11	1,001	0	0	0%	0	1
East Indio Hills Conservation Area - Riverside County								
Le Conte's Thrasher - Other Conserved Habitat	1,960	139	1,253	38	0	3%	0	18
Mecca Aster - Core Habitat	1,594	116	1,045	48	0	5%	0	16
Coachella Valley Round-tailed Ground Squirrel - Other Conserved Habitat	1,353	100	896	21	0	2%	0	12
Predicted Flat-tailed Horned Lizard - Other Conserved Habitat	525	46	415	0	0	0%	0	5
Palm Springs Pocket Mouse - Other Conserved Habitat	1,526	105	944	21	0	2%	0	13
Active desert dunes	5	1	5	0	0	0%	0	0
Desert saltbush scrub	8	1	7	0	0	0%	0	0
Stabilized desert sand fields	331	33	295	0	0	0%	0	3
Mesquite hummocks	43	4	39	0	0	0%	0	0
Stabilized shielded sand fields	401	28	256	7	0	3%	0	3

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2013	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
Edom Hill Conservation Area - Cathedral City								
Coachella Valley Round-tailed Ground Squirrel - Other Conserved Habitat	134	13	121	102	0	84%	0	11
Coachella Valley Milkvetch - Other Conserved Habitat	151	15	136	102	0	75%	0	12
Palm Springs Pocket Mouse - Other Conserved Habitat	114	11	103	87	0	84%	0	9
Le Conte's Thrasher - Other Conserved Habitat	344	34	310	224	0	72%	0	26
Sand Source	345	34	310	224	0	72%	0	26
Edom Hill Conservation Area - Riverside County								
Coachella Valley Giant Sand-treader Cricket - Other Conserved Habitat	103	5	40	43	0	100%	0	5
Coachella Valley Milkvetch - Other Conserved Habitat	1,637	134	1,205	1,020	0	85%	0	115
Coachella Valley Fringe-toed Lizard - Other Conserved Habitat	103	5	40	43	0	100%	0	5
Coachella Valley Round-tailed Ground Squirrel - Other Conserved Habitat	1,701	145	1,302	1,107	0	85%	0	125
Palm Springs Pocket Mouse - Other Conserved Habitat	1,228	104	935	791	0	85%	0	90
Le Conte's Thrasher - Other Conserved Habitat	2,238	194	1,745	1,323	0	76%	1	151
Active sand fields	73	4	37	41	0	100%	0	4
Stabilized desert sand fields	29	1	3	2	0	67%	0	1
Sand Source	2,665	197	1,770	1,450	0	82%	0	165
Sand Transport	628	63	565	366	0	65%	1	42

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2013	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
Highway 111/I-10 Conservation Area - Riverside County								
Coachella Valley Round-tailed Ground Squirrel - Other Conserved Habitat	389	39	350	52	1	15%	0	9
Coachella Valley Jerusalem Cricket - Other Conserved Habitat	372	37	335	49	1	15%	0	9
Le Conte's Thrasher - Other Conserved Habitat	389	39	350	52	1	15%	0	9
Coachella Valley Milkvetch - Other Conserved Habitat	372	37	335	49	1	15%	0	9
Palm Springs Pocket Mouse - Other Conserved Habitat	389	39	350	52	1	15%	0	9
Indio Hills Palms Conservation Area - Riverside County								
Mecca Aster - Core Habitat	6,091	255	2,290	1,039	0	45%	0	130
Le Conte's Thrasher - Other Conserved Habitat	106	1	7	0	0	0%	0	0
Desert fan palm oasis woodland	93	5	42	7	0	17%	0	1
Desert dry wash woodland	79	4	33	36	0	100%	0	4
Mesquite hummocks	3	1	1	0	0	0%	0	0
Indio Hills/Joshua Tree National Park Linkage Conservation Area - Riverside County								
Desert Tortoise - Core Habitat	10,308	859	7,735	6,476	88	84%	0	733
Le Conte's Thrasher - Other Conserved Habitat	6,396	606	5,457	5,426	0	99%	0	603
Sand Transport	7,304	681	6,132	5,747	8	94%	5	638
Sand Source	5,823	460	4,135	3,164	86	77%	0	363
Indio Hills / Joshua Tree National Park Corridor	13,127	1,141	10,267	8,910	93	87%	5	1,000

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2013	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
Joshua Tree National Park Conservation Area - Riverside County								
Gray Vireo - Other Conserved Habitat	30,653	134	1,208	1,822	0	100%	0	195
Le Conte's Thrasher - Other Conserved Habitat	4,330	25	222	76	0	34%	0	10
Desert Tortoise - Core Habitat	127,161	1,708	15,367	11,743	2	76%	0	1,345
Desert dry wash woodland	2,195	13	119	192	0	100%	0	20
Mojave mixed woody scrub	57,099	800	7,195	5,772	2	80%	0	658
Desert fan palm oasis woodland	5	0	0	0	0	0%	0	0
Mojavean pinyon & juniper woodland	30,653	134	1,208	1,822	0	100%	0	195
Mecca Hills/Orocopia Mountains Conservation Area - Riverside County								
Desert Tortoise - Core Habitat	112,575	2,624	23,617	5,534	251	23%	0	816
Le Conte's Thrasher - Other Conserved Habitat	17,467	652	5,866	1,377	5	23%	0	203
Orocopia Sage - Core Habitat	66,180	1,803	16,227	3,905	71	24%	0	571
Mecca Aster - Core Habitat	31,655	465	4,181	435	1	10%	0	90
Desert fan palm oasis woodland	1	0	0	0	0	0%	0	0
Desert dry wash woodland	9,317	318	2,861	1,018	0	36%	0	134
Santa Rosa and San Jacinto Mountains Conservation Area - Cathedral City								
Desert Tortoise - Other Conserved Habitat	107	11	95	4	0	4%	0	2
Le Conte's Thrasher - Other Conserved Habitat	13	1	11	4	0	36%	0	0
Peninsular Bighorn Sheep - Rec Zone 2 - Essential Habitat	112	11	97	4	0	4%	0	2
Desert dry wash woodland	20	2	18	2	0	11%	0	0

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2013	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
Santa Rosa and San Jacinto Mountains Conservation Area - Indian Wells								
Desert Tortoise - Other Conserved Habitat	4,375	111	999	0	0	0%	0	11
Le Conte's Thrasher - Other Conserved Habitat	419	23	206	0	0	0%	0	2
Peninsular Bighorn Sheep - Rec Zone 3 - Essential Habitat	4,617	114	1,158	0	0	0%	0	11
Desert dry wash woodland	128	7	66	0	0	0%	0	1
Santa Rosa and San Jacinto Mountains Conservation Area - La Quinta								
Desert Tortoise - Other Conserved Habitat	5,936	157	1,409	362	153	26%	0	52
Le Conte's Thrasher - Other Conserved Habitat	683	43	387	112	32	29%	0	16
Peninsular Bighorn Sheep - Rec Zone 3 - Essential Habitat	6,185	159	2,545	376	153	15%	0	37
Desert dry wash woodland	147	8	76	15	0	20%	0	2
Santa Rosa and San Jacinto Mountains Conservation Area - Palm Desert								
Le Conte's Thrasher - Other Conserved Habitat	43	4	33	0	0	0%	0	0
Desert Tortoise - Other Conserved Habitat	581	48	436	783	0	100%	0	82
Peninsular Bighorn Sheep - Rec Zone 3 - Essential Habitat	78	7	65	0	0	0%	0	1
Peninsular Bighorn Sheep - Rec Zone 2 - Essential Habitat	492	7	65	761	0	100%	0	74
Desert dry wash woodland	38	3	29	1	0	3%	0	0

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2013	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
Santa Rosa and San Jacinto Mountains Conservation Area - Palm Springs								
Le Conte's Thrasher - Other Conserved Habitat	793	103	560	378	41	68%	0	73
Peninsular Bighorn Sheep - Rec Zone 1 - Essential Habitat	9,195	226	2,511	1,809	139	72%	0	169
Desert Tortoise - Other Conserved Habitat	22,571	1,317	8,856	4,190	139	47%	0	692
Peninsular Bighorn Sheep - Rec Zone 2 - Essential Habitat	18,426	866	4,700	3,491	0	74%	0	666
Gray Vireo - Other Conserved Habitat	8,416	431	3,883	1,837	0	47%	0	227
Desert dry wash woodland	40	4	36	39	0	100%	0	4
Peninsular juniper woodland & scrub	7,682	353	3,177	1,837	0	58%	0	219
Semi-desert chaparral	733	51	571	0	0	0%	0	5
Southern sycamore-alder riparian woodland	30	2	24	0	0	0%	0	0
Sonoran cottonwood-willow riparian forest	58	0	58	0	0	0%	0	0
Desert fan palm oasis woodland	218	9	76	52	0	68%	0	6
Southern arroyo willow riparian forest	16	0	0	0	0	0%	0	0
Santa Rosa and San Jacinto Mountains Conservation Area - Rancho Mirage								
Desert Tortoise - Other Conserved Habitat	5,249	147	1,326	1,205	0	91%	0	135
Le Conte's Thrasher - Other Conserved Habitat	19	2	17	0	0	0%	0	0
Peninsular Bighorn Sheep - Rec Zone 2 - Essential Habitat	5,262	42	450	1,209	0	100%	0	106
Desert dry wash woodland	19	1	9	4	0	44%	0	1

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2013	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
Santa Rosa and San Jacinto Mountains Conservation Area - Riverside County								
Peninsular Bighorn Sheep - Rec Zone 2 - Essential Habitat	14,558	647	4,269	2,932	170	69%	0	465
Le Conte's Thrasher - Other Conserved Habitat	9,123	911	5,508	5,348	7	97%	0	887
Triple-ribbed Milkvetch - Known Locations	0	0	0	0	0	0%	0	0
Peninsular Bighorn Sheep - Rec Zone 1 - Essential Habitat	24,840	830	7,252	1,267	39	17%	0	214
Gray Vireo - Other Conserved Habitat	58,985	881	7,930	6,039	42	76%	0	692
Peninsular Bighorn Sheep - Rec Zone 3 - Essential Habitat	50,972	683	5,359	4,657	211	87%	0	602
Desert Tortoise - Other Conserved Habitat	86,875	2,950	23,856	15,377	363	64%	7	1,999
Peninsular Bighorn Sheep - Rec Zone 4 - Essential Habitat	34,597	258	2,325	7,196	0	100%	0	744
Southern sycamore-alder riparian woodland	518	12	117	5	0	4%	0	2
Red shank chaparral	12,514	253	2,274	1,806	3	79%	0	206
Semi-desert chaparral	16,869	233	2,093	928	0	44%	0	116
Peninsular juniper woodland & scrub	29,547	418	2,899	3,306	39	100%	0	471
Southern arroyo willow riparian forest	16	2	15	0	0	0%	0	0
Desert dry wash woodland	3,566	298	1,244	1,245	3	100%	0	298
Desert fan palm oasis woodland	716	45	404	0	0	0%	0	5

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2013	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
Snow Creek/Windy Point Conservation Area - Palm Springs								
Coachella Valley Milkvetch - Core Habitat	910	91	816	256	0	31%	0	35
Peninsular Bighorn Sheep - Essential Habitat	180	16	144	0	0	0%	0	2
Coachella Valley Round-tailed Ground Squirrel - Core Habitat	934	93	838	260	0	31%	0	35
Coachella Valley Fringe-toed Lizard - Core Habitat	749	75	672	249	0	37%	0	33
Coachella Valley Giant Sand-treader Cricket - Core Habitat	749	75	672	249	0	37%	0	33
Coachella Valley Jerusalem Cricket - Core Habitat	908	90	815	255	0	31%	0	34
Palm Springs Pocket Mouse - Core Habitat	934	93	838	260	0	31%	0	35
Le Conte's Thrasher - Other Conserved Habitat	864	86	775	218	0	28%	0	30
Ephemeral sand fields	680	68	610	207	0	34%	0	28
Active desert dunes	69	7	62	42	0	68%	0	5
Highway 111 - Whitewater River Biological Corridor	276	27	247	0	0	0%	0	3

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2013	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
Snow Creek/Windy Point Conservation Area - Riverside County								
Coachella Valley Milkvetch - Core Habitat	1,700	134	1,210	633	0	52%	0	76
Coachella Valley Round-tailed Ground Squirrel - Core Habitat	1,880	152	1,371	802	0	58%	0	95
Coachella Valley Fringe-toed Lizard - Core Habitat	625	55	502	335	0	67%	0	39
Peninsular Bighorn Sheep - Essential Habitat	525	49	443	0	0	0%	0	5
Coachella Valley Giant Sand-treader Cricket - Core Habitat	625	56	501	335	0	67%	0	39
Le Conte's Thrasher - Other Conserved Habitat	1,924	162	1,453	848	0	58%	0	101
Coachella Valley Jerusalem Cricket - Core Habitat	782	60	538	349	0	65%	0	41
Ephemeral sand fields	468	45	409	335	0	82%	0	38
Stabilized shielded sand fields	157	10	93	0	0	0%	0	1
Highway 111 - Whitewater River Biological Corridor	474	46	415	0	0	0%	0	5
Stubbe and Cottonwood Canyons Conservation Area - Riverside County								
Desert Tortoise - Core Habitat	5,735	253	2,276	835	26	37%	29	80
Le Conte's Thrasher - Other Conserved Habitat	1,265	123	1,111	635	18	57%	0	76
Desert dry wash woodland	289	26	229	112	1	49%	0	14
Sonoran cottonwood-willow riparian forest	267	3	25	0	0	0%	0	0
Sand Transport	1,375	125	1,129	639	18	57%	0	76
Stubbe Canyon Wash Corridor	1,181	117	1,058	680	26	64%	0	79

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2013	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
Thousand Palms Conservation Area - Riverside County								
Coachella Valley Round-tailed Ground Squirrel - Core Habitat	8,513	468	2,974	1,563	0	53%	39	229
Coachella Valley Milkvetch - Core Habitat	4,403	111	1,001	733	0	73%	5	79
Desert Pupfish - Refugia Locations	0	0	0	0	0	0%	0	0
Coachella Valley Fringe-toed Lizard - Core Habitat	3,962	93	834	667	0	80%	0	76
Le Conte's Thrasher - Other Conserved Habitat	11,058	552	3,879	1,979	0	51%	31	278
Predicted Flat-tailed Horned Lizard - Core Habitat	4,148	97	877	698	0	80%	1	78
Mecca Aster - Core Habitat	11,745	297	2,676	951	0	36%	5	120
Coachella Valley Giant Sand-treader Cricket - Core Habitat	3,962	93	834	667	0	80%	0	76
Palm Springs Pocket Mouse - Core Habitat	11,707	518	3,588	1,950	0	54%	37	268
Desert dry wash woodland	748	4	34	0	0	0%	0	0
Active sand fields	3,543	91	820	664	0	81%	0	75
Active desert dunes	421	2	14	5	0	36%	0	1
Desert fan palm oasis woodland	137	0	0	0	0	0%	0	0
Sonoran cottonwood-willow riparian forest	4	0	0	0	0	0%	0	0
Mesquite hummocks	58	0	0	0	0	0%	0	0
Sand Transport	12,550	573	4,100	1,995	0	49%	49	259
Sand Source	13,056	412	3,712	1,635	5	44%	5	200
Thousand Palms Linkage	25,607	983	7,816	3,630	5	46%	54	455

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2013	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
Upper Mission Creek/Big Morongo Canyon Conservation Area - Desert Hot Springs								
Coachella Valley Jerusalem Cricket - Other Conserved Habitat	49	0	49	33	17	67%	1	-1
Le Conte's Thrasher - Other Conserved Habitat	1,832	288	1,409	712	126	51%	2	158
Palm Springs Pocket Mouse - Core Habitat	1,748	270	1,403	700	116	50%	2	146
Little San Bernardino Mountains Linanthus - Core Habitat	1,020	53	967	389	65	40%	0	24
Desert dry wash woodland	135	6	58	0	0	0%	0	1
Sand Transport	1,869	286	1,399	719	126	51%	2	159
Sand Source	343	0	6	0	0	0%	0	0
Highway 62 Corridor	73	7	66	0	0	0%	0	1
Upper Mission Creek/Big Morongo Canyon Conservation Area - Palm Springs								
Le Conte's Thrasher - Other Conserved Habitat	24	2	22	0	0	0%	1	-1
Palm Springs Pocket Mouse - Other Conserved Habitat	24	2	22	0	0	0%	1	-1

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2013	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
Upper Mission Creek/Big Morongo Canyon Conservation Area - Riverside County								
Desert Tortoise - Core Habitat	24,122	887	7,984	4,970	869	62%	21	565
Triple-ribbed Milkvetch - Core Habitat	819	47	426	420	91	99%	0	46
Coachella Valley Jerusalem Cricket - Other Conserved Habitat	666	52	460	42	0	9%	10	-1
Le Conte's Thrasher - Other Conserved Habitat	1,871	146	1,323	725	345	55%	0	87
Palm Springs Pocket Mouse - Core Habitat	1,937	151	1,363	747	347	55%	0	90
Little San Bernardino Mountains Linanthus - Core Habitat	1,390	122	1,100	735	344	67%	0	86
Southern sycamore-alder riparian woodland	104	6	52	60	0	100%	0	7
Desert dry wash woodland	125	8	76	55	10	72%	0	6
Sonoran cottonwood-willow riparian forest	100	8	76	78	4	100%	0	8
Sand Transport	2,279	168	1,509	899	358	60%	0	107
Sand Source	19,789	721	6,488	4,476	512	69%	21	499
Highway 62 Corridor	907	79	715	308	225	43%	0	39
West Deception Canyon Conservation Area - Riverside County								
Sand Source	1,302	118	1,063	789	0	74%	0	91
Whitewater Canyon Conservation Area - Desert Hot Springs								
Desert Tortoise - Core Habitat	56	0	0	0	0	0%	0	0
Sand Source	56	0	0	0	0	0%	0	0

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2013	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
Whitewater Canyon Conservation Area - Riverside County								
Desert Tortoise - Core Habitat	4,438	120	1,084	742	0	68%	1	85
Arroyo Toad - Core Habitat	2,082	78	706	676	0	96%	0	75
Little San Bernardino Mountains Linanthus - Other Conserved Habitat	579	39	348	277	0	80%	0	32
Triple-ribbed Milkvetch - Core Habitat	1,295	41	368	277	0	75%	0	32
Desert fan palm oasis woodland	1	0	0	0	0	0%	0	0
Sonoran cottonwood-willow riparian forest	166	11	107	105	0	98%	0	11
Sand Transport	1,392	48	435	338	0	78%	0	38
Sand Source	12,616	94	850	618	0	73%	1	70
Whitewater Canyon Corridor	223	22	201	0	0	0%	1	1
Whitewater Floodplain Conservation Area - Cathedral City								
Coachella Valley Milkvetch - Core Habitat	107	7	61	0	0	0%	0	1
Coachella Valley Round-tailed Ground Squirrel - Core Habitat	105	7	59	0	0	0%	0	1
Coachella Valley Fringe-toed Lizard - Core Habitat	107	7	61	0	0	0%	0	1
Le Conte's Thrasher - Other Conserved Habitat	107	7	61	0	0	0%	0	1
Palm Springs Pocket Mouse - Core Habitat	107	7	61	0	0	0%	0	1
Coachella Valley Giant Sand-treader Cricket - Core Habitat	107	7	61	0	0	0%	0	1
Active sand fields	49	5	43	0	0	0%	0	1
Whitewater River Corridor	28	2	18	0	0	0%	0	0

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2013	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
Whitewater Floodplain Conservation Area - Palm Springs								
Coachella Valley Round-tailed Ground Squirrel - Core Habitat	5,825	328	2,955	538	0	18%	37	50
Coachella Valley Milkvetch - Core Habitat	5,432	297	2,671	514	0	19%	37	44
Palm Springs Pocket Mouse - Core Habitat	6,173	347	3,122	555	0	18%	40	50
Coachella Valley Fringe-toed Lizard - Core Habitat	5,418	295	2,659	514	0	19%	37	44
Coachella Valley Giant Sand-treader Cricket - Core Habitat	5,418	295	2,659	514	0	19%	37	44
Le Conte's Thrasher - Other Conserved Habitat	6,495	381	3,433	569	0	17%	40	55
Ephemeral sand fields	2,873	132	1,185	213	0	18%	9	26
Stabilized desert sand fields	577	44	394	0	0	0%	0	4
Active sand fields	436	44	392	296	0	76%	0	34
Whitewater River Corridor	1,183	90	809	50	0	6%	3	11

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2013	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
Whitewater Floodplain Conservation Area - Riverside County								
Coachella Valley Milkvetch - Core Habitat	96	6	58	0	0	0%	0	1
Coachella Valley Round-tailed Ground Squirrel - Core Habitat	185	11	100	0	0	0%	0	1
Coachella Valley Giant Sand-treader Cricket - Core Habitat	92	6	57	0	0	0%	0	1
Coachella Valley Fringe-toed Lizard - Core Habitat	92	6	57	0	0	0%	0	1
Palm Springs Pocket Mouse - Core Habitat	701	53	477	0	0	0%	10	-5
Le Conte's Thrasher - Other Conserved Habitat	706	53	480	0	0	0%	10	-5
Ephemeral sand fields	86	6	52	0	0	0%	0	1
Stabilized desert sand fields	5	1	4	0	0	0%	0	0
Whitewater River Corridor	701	53	475	0	0	0%	10	-5

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2013	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
Willow Hole Conservation Area - Cathedral City								
Coachella Valley Round-tailed Ground Squirrel - Core Habitat	1,485	140	1,256	596	1	47%	0	74
Coachella Valley Milkvetch - Core Habitat	938	87	782	173	1	22%	0	26
Coachella Valley Fringe-toed Lizard - Core Habitat	264	24	212	113	0	53%	0	14
Palm Springs Pocket Mouse - Core Habitat	1,147	107	959	596	0	62%	0	71
Le Conte's Thrasher - Other Conserved Habitat	1,795	167	1,505	609	1	40%	0	78
Ephemeral sand fields	227	20	178	91	0	51%	0	11
Active sand fields	37	4	33	22	0	67%	0	3
Stabilized desert sand fields	57	6	51	0	0	0%	0	1
Stabilized desert dunes	1	0	1	0	0	0%	0	0
Sand Transport	966	89	798	581	0	73%	0	67
Sand Source	833	79	710	28	1	4%	0	11

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2013	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
Willow Hole Conservation Area - Riverside County								
Coachella Valley Fringe-toed Lizard - Core Habitat	633	50	454	385	0	85%	6	37
Coachella Valley Milkvetch - Core Habitat	2,228	195	1,751	1,190	42	68%	6	133
Palm Springs Pocket Mouse - Core Habitat	3,465	298	2,684	1,585	54	59%	6	182
Le Conte's Thrasher - Other Conserved Habitat	3,601	298	2,677	1,570	54	59%	6	181
Desert saltbush scrub	169	17	152	137	0	90%	0	15
Mesquite hummocks	125	11	98	94	0	96%	0	11
Desert fan palm oasis woodland	1	0	0	0	0	0%	0	0
Stabilized desert sand fields	144	14	128	70	0	55%	2	6
Stabilized desert dunes	383	35	319	249	0	78%	4	24
Ephemeral sand fields	906	81	728	236	42	32%	0	32
Sand Transport	3,500	304	2,734	1,585	54	58%	6	183
Sand Source	186	2	17	8	0	47%	0	1
Mission Creek / Willow Wash Biological Corridor	509	44	397	11	11	3%	0	5

Appendix 5
Covered Activity Impact Outside Conservation Areas

CVMSHCP Annual Report 2013 - Covered Activity Impact Outside Conservation Areas

Conservation Objective / Jurisdiction	Estimated Acres Disturbed Outside Conservation Areas
Arroyo Toad	
Riverside County	0
Arroyo Toad Total	**0**
California Black Rail	
Coachella	0
Indio	0
Riverside County	0
California Black Rail Total	**0**
Coachella Valley Fringe-toed Lizard	
Cathedral City	237
Coachella	0
Indian Wells	424
Indio	358
La Quinta	402
Palm Desert	394
Palm Springs	332
Rancho Mirage	534
Riverside County	198
Coachella Valley Fringe-toed Lizard Total	**2879**
Coachella Valley Giant Sand-treader Cricket	
Cathedral City	237
Coachella	0
Indian Wells	424
Indio	358
La Quinta	402
Palm Desert	394
Palm Springs	332
Rancho Mirage	534
Riverside County	198
Coachella Valley Giant Sand-treader Cricket Total	**2879**

Conservation Objective / Jurisdiction	Estimated Acres Disturbed Outside Conservation Areas
Coachella Valley Jerusalem Cricket	
Cathedral City	245
Desert Hot Springs	0
Palm Desert	5
Palm Springs	332
Rancho Mirage	494
Riverside County	58
Coachella Valley Jerusalem Cricket Total	**1134**
Coachella Valley Milkvetch	
Cathedral City	197
Desert Hot Springs	0
Indian Wells	334
La Quinta	0
Palm Desert	394
Palm Springs	301
Rancho Mirage	534
Riverside County	194
Coachella Valley Milkvetch Total	**1954**
Coachella Valley Round-tailed Ground Squirrel	
Cathedral City	372
Coachella	51
Desert Hot Springs	0
Indian Wells	706
Indio	735
La Quinta	500
Palm Desert	518
Palm Springs	340
Rancho Mirage	540
Riverside County	1351
Coachella Valley Round-tailed Ground Squirrel Total	**5113**

Conservation Objective / Jurisdiction	Estimated Acres Disturbed Outside Conservation Areas
Crissal Thrasher	
Cathedral City	0
Coachella	6
Desert Hot Springs	0
Indian Wells	21
Indio	203
La Quinta	30
Riverside County	56
Crissal Thrasher Total	**316**
Desert Pupfish	
Indian Wells	0
NULL	0
Desert Pupfish Total	**0**
Desert Tortoise	
Cathedral City	1
Coachella	0
Desert Hot Springs	0
Indian Wells	212
Indio	0
La Quinta	235
Palm Desert	351
Palm Springs	3
Rancho Mirage	65
Riverside County	637
Desert Tortoise Total	**1504**
Gray Vireo	
Palm Springs	0
Riverside County	5
Gray Vireo Total	**5**

Conservation Objective / Jurisdiction	Estimated Acres Disturbed Outside Conservation Areas
Le Conte's Thrasher	
Cathedral City	250
Coachella	65
Desert Hot Springs	0
Indian Wells	814
Indio	760
La Quinta	661
Palm Desert	755
Palm Springs	348
Rancho Mirage	672
Riverside County	1848
Le Conte's Thrasher Total	**6173**
Least Bell's Vireo - Breeding Habitat	
Cathedral City	0
Coachella	2
Desert Hot Springs	0
Indian Wells	21
Indio	30
La Quinta	30
Palm Springs	0
Rancho Mirage	0
Riverside County	3
Least Bell's Vireo - Breeding Habitat Total	**86**
Least Bell's Vireo - Migratory Habitat	
Cathedral City	0
Coachella	4
Desert Hot Springs	0
Indian Wells	187
Indio	173
La Quinta	55
Palm Desert	167
Palm Springs	0
Rancho Mirage	45
Riverside County	201
Least Bell's Vireo - Migratory Habitat Total	**832**

Conservation Objective / Jurisdiction	Estimated Acres Disturbed Outside Conservation Areas
Little San Bernardino Mountains Linanthus	
Desert Hot Springs	0
Riverside County	0
Little San Bernardino Mountains Linanthus Total	**0**
Mecca Aster	
Indio	1
Riverside County	0
Mecca Aster Total	**1**
Orocopia Sage	
Riverside County	7
Orocopia Sage Total	**7**
Palm Springs Pocket Mouse	
Cathedral City	372
Coachella	44
Desert Hot Springs	0
Indian Wells	724
Indio	679
La Quinta	499
Palm Desert	591
Palm Springs	346
Rancho Mirage	584
Riverside County	1591
Palm Springs Pocket Mouse Total	**5430**
Peninsular Bighorn Sheep	
Cathedral City	1
Indian Wells	1
La Quinta	37
Palm Desert	156
Palm Springs	0
Rancho Mirage	1
Riverside County	134
Peninsular Bighorn Sheep Total	**330**

Conservation Objective / Jurisdiction	Estimated Acres Disturbed Outside Conservation Areas
Potential Flat-tailed Horned Lizard	
Cathedral City	0
Desert Hot Springs	0
Palm Springs	12
Riverside County	7
Potential Flat-tailed Horned Lizard Total	**19**
Predicted Flat-tailed Horned Lizard	
Cathedral City	220
Coachella	22
Indian Wells	424
Indio	401
La Quinta	383
Palm Desert	394
Palm Springs	320
Rancho Mirage	533
Riverside County	395
Predicted Flat-tailed Horned Lizard Total	**3092**
Southern Yellow Bat	
Cathedral City	0
Desert Hot Springs	0
Palm Springs	0
Rancho Mirage	0
Riverside County	0
Southern Yellow Bat Total	**0**
Southwestern Willow Flycatcher - Breeding Habitat	
Cathedral City	0
Coachella	0
Desert Hot Springs	0
Indio	0
Palm Springs	0
Rancho Mirage	0
Riverside County	0
Southwestern Willow Flycatcher - Breeding Habitat Total	**0**

Conservation Objective / Jurisdiction	Estimated Acres Disturbed Outside Conservation Areas
Southwestern Willow Flycatcher - Migratory Habitat	
Cathedral City	0
Coachella	6
Desert Hot Springs	0
Indian Wells	209
Indio	203
La Quinta	86
Palm Desert	167
Palm Springs	0
Rancho Mirage	45
Riverside County	204
Southwestern Willow Flycatcher - Migratory Habitat Total	**920**
Summer Tanager - Breeding Habitat	
Cathedral City	0
Coachella	0
Desert Hot Springs	0
Indio	0
Palm Springs	0
Rancho Mirage	0
Riverside County	0
Summer Tanager - Breeding Habitat Total	**0**
Summer Tanager - Migratory Habitat	
Cathedral City	0
Coachella	6
Desert Hot Springs	0
Indian Wells	209
Indio	203
La Quinta	86
Palm Desert	167
Palm Springs	0
Rancho Mirage	45
Riverside County	204
Summer Tanager - Migratory Habitat Total	**920**

Conservation Objective / Jurisdiction	Estimated Acres Disturbed Outside Conservation Areas
Triple-ribbed Milkvetch	
Palm Springs	0
Riverside County	0
Triple-ribbed Milkvetch Total	**0**
Yellow Warbler - Breeding Habitat	
Cathedral City	0
Coachella	0
Desert Hot Springs	0
Indio	0
Palm Springs	0
Rancho Mirage	0
Riverside County	0
Yellow Warbler - Breeding Habitat Total	**0**
Yellow Warbler - Migratory Habitat	
Cathedral City	0
Coachella	6
Desert Hot Springs	0
Indian Wells	209
Indio	203
La Quinta	86
Palm Desert	167
Palm Springs	0
Rancho Mirage	45
Riverside County	204
Yellow Warbler - Migratory Habitat Total	**920**
Yellow-breasted Chat - Breeding Habitat	
Cathedral City	0
Coachella	0
Desert Hot Springs	0
Indio	0
Palm Springs	0
Rancho Mirage	0
Riverside County	0
Yellow-breasted Chat - Breeding Habitat Total	**0**

Conservation Objective / Jurisdiction	Estimated Acres Disturbed Outside Conservation Areas
Yellow-breasted Chat - Migratory Habitat	
Cathedral City	0
Coachella	6
Desert Hot Springs	0
Indian Wells	209
Indio	203
La Quinta	86
Palm Desert	167
Palm Springs	0
Rancho Mirage	45
Riverside County	204
Yellow-breasted Chat - Migratory Habitat Total	**920**
Yuma Clapper Rail	
Coachella	0
Indio	0
Riverside County	0
Yuma Clapper Rail Total	**0**
Active desert dunes	
Palm Springs	0
Riverside County	2
Active desert dunes Total	**2**
Active sand fields	
Cathedral City	0
Palm Springs	0
Riverside County	121
Active sand fields Total	**121**
Arrowweed scrub	
Riverside County	0
Arrowweed scrub Total	**0**
Chamise chaparral	
Riverside County	0
Chamise chaparral Total	**0**
Cismontane alkali marsh	
Riverside County	0
Cismontane alkali marsh Total	**0**

Conservation Objective / Jurisdiction	Estimated Acres Disturbed Outside Conservation Areas
Coastal and valley freshwater marsh	
Coachella	0
Indio	0
Riverside County	0
Coastal and valley freshwater marsh Total	**0**
Desert dry wash woodland	
Cathedral City	0
Coachella	0
Desert Hot Springs	0
Indian Wells	187
Indio	0
La Quinta	55
Palm Desert	167
Palm Springs	0
Rancho Mirage	45
Riverside County	88
Desert dry wash woodland Total	**542**
Desert fan palm oasis woodland	
Cathedral City	0
Desert Hot Springs	0
Palm Springs	0
Rancho Mirage	0
Riverside County	0
Desert fan palm oasis woodland Total	**0**
Desert saltbush scrub	
Coachella	4
Indio	173
La Quinta	0
Riverside County	52
Desert saltbush scrub Total	**229**
Desert sink scrub	
Riverside County	60
Desert sink scrub Total	**60**

Conservation Objective / Jurisdiction	Estimated Acres Disturbed Outside Conservation Areas
Ephemeral sand fields	
Cathedral City	0
Palm Springs	72
Riverside County	7
Ephemeral sand fields Total	**79**
Interior live oak chaparral	
Palm Springs	0
Riverside County	0
Interior live oak chaparral Total	**0**
Mesquite bosque	
Riverside County	0
Mesquite bosque Total	**0**
Mesquite hummocks	
Cathedral City	0
Coachella	2
Desert Hot Springs	0
Indian Wells	21
Indio	30
La Quinta	30
Riverside County	3
Mesquite hummocks Total	**86**
Mojave mixed woody scrub	
Desert Hot Springs	0
Riverside County	0
Mojave mixed woody scrub Total	**0**
Mojavean pinyon & juniper woodland	
Riverside County	0
Mojavean pinyon & juniper woodland Total	**0**
Peninsular juniper woodland & scrub	
Palm Springs	0
Riverside County	0
Peninsular juniper woodland & scrub Total	**0**

Conservation Objective / Jurisdiction	Estimated Acres Disturbed Outside Conservation Areas
Red shank chaparral	
Riverside County	0
Red shank chaparral Total	**0**
Semi-desert chaparral	
Palm Springs	0
Riverside County	0
Semi-desert chaparral Total	**0**
Sonoran cottonwood-willow riparian forest	
Coachella	0
Indio	0
Palm Springs	0
Riverside County	0
Sonoran cottonwood-willow riparian forest Total	**0**
Sonoran creosote bush scrub	
Cathedral City	0
Coachella	47
Desert Hot Springs	0
Indian Wells	24
Indio	243
La Quinta	172
Palm Desert	183
Palm Springs	2
Rancho Mirage	20
Riverside County	524
Sonoran creosote bush scrub Total	**1215**

Conservation Objective / Jurisdiction	Estimated Acres Disturbed Outside Conservation Areas
Sonoran mixed woody & succulent scrub	
Cathedral City	9
Desert Hot Springs	0
Indian Wells	0
Indio	1
La Quinta	7
Palm Desert	0
Palm Springs	12
Rancho Mirage	0
Riverside County	413
Sonoran mixed woody & succulent scrub Total	**442**
Southern arroyo willow riparian forest	
Palm Springs	0
Riverside County	0
Southern arroyo willow riparian forest Total	**0**
Southern sycamore-alder riparian woodland	
Palm Springs	0
Riverside County	0
Southern sycamore-alder riparian woodland Total	**0**
Stabilized desert dunes	
Cathedral City	0
Riverside County	0
Stabilized desert dunes Total	**0**
Stabilized desert sand fields	
Cathedral City	0
Indio	0
Palm Springs	0
Riverside County	0
Stabilized desert sand fields Total	**0**

Conservation Objective / Jurisdiction	Estimated Acres Disturbed Outside Conservation Areas
Stabilized shielded sand fields	
Cathedral City	237
Coachella	0
Indian Wells	424
Indio	358
La Quinta	402
Palm Desert	315
Palm Springs	260
Rancho Mirage	534
Riverside County	67
Stabilized shielded sand fields Total	**2597**