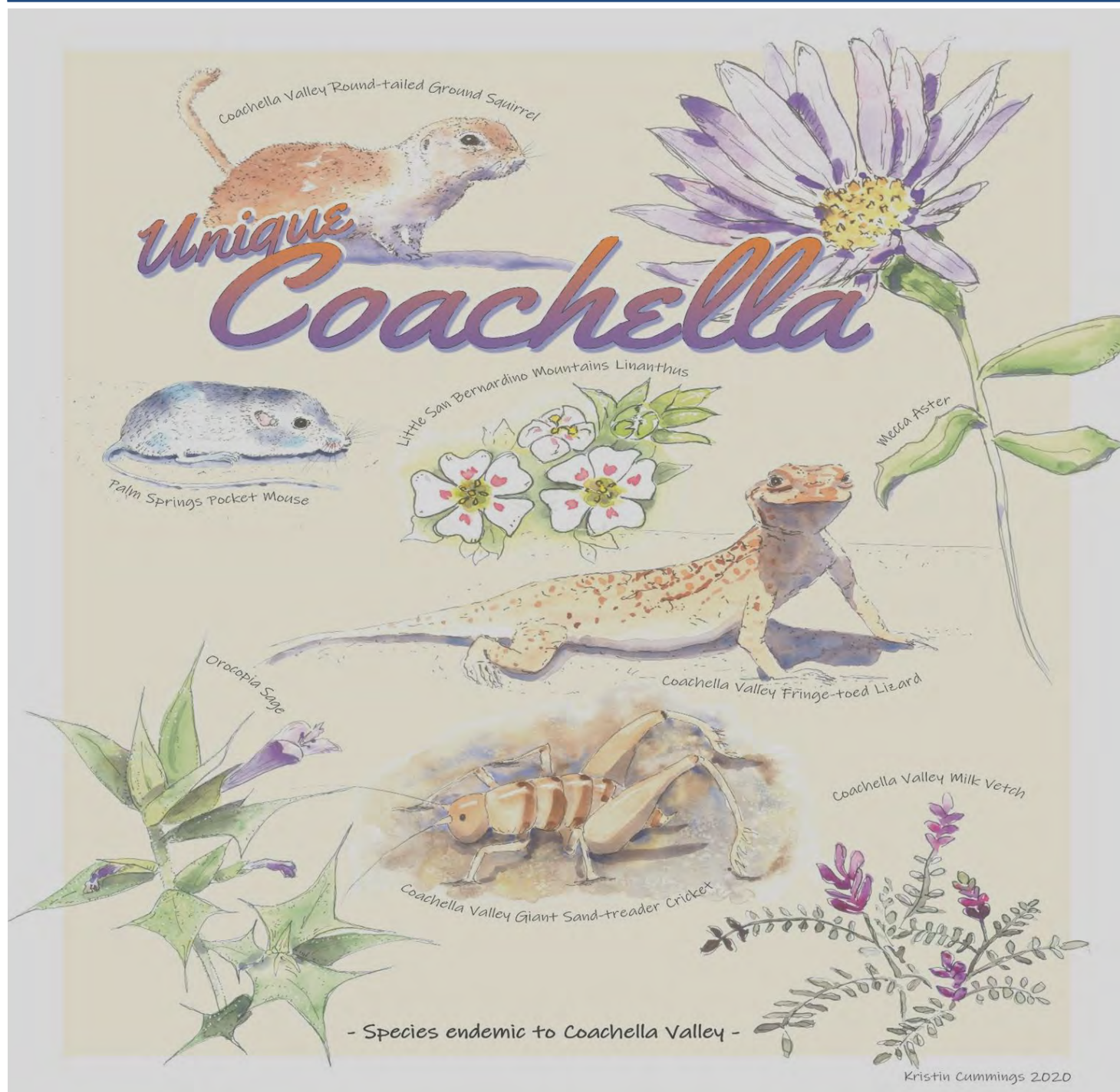


# Coachella Valley

## Multiple Species Habitat Conservation Plan/ Natural Community Conservation Plan

### 2019 Annual Report



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*We gratefully acknowledge Kristin Cummings whose beautiful artwork is our cover this year. Kristin submitted this poster as her capstone project for the California Naturalist program at UC Riverside - Palm Desert.*

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# 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. Significant progress has been made in plan implementation since state and federal permits were issued in September and October 2008. The term of the permits is 75 years, which is the length of time required to fully fund implementation of the CVMSHCP. This report describes the progress made on plan implementation for the 2019 calendar year.

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, Mission Springs 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). A major amendment to include the City of Desert Hot Springs and Mission Springs Water District as Permittees was approved by the CVCC in March 2014 and all local Permittees approved the Major Amendment in 2014. The US Fish and Wildlife Service (USFWS) approved the Major Amendment in December 2015. The final approval of the Major Amendment by California Department of Fish and Wildlife (CDFW) was in August 2016.

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 other acquisition partners 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, 2019 toward the land acquisition goals identified in Table 4-1 of the CVMSHCP.

**Figure 1: CVMSHCP Progress Toward Conservation Goals**

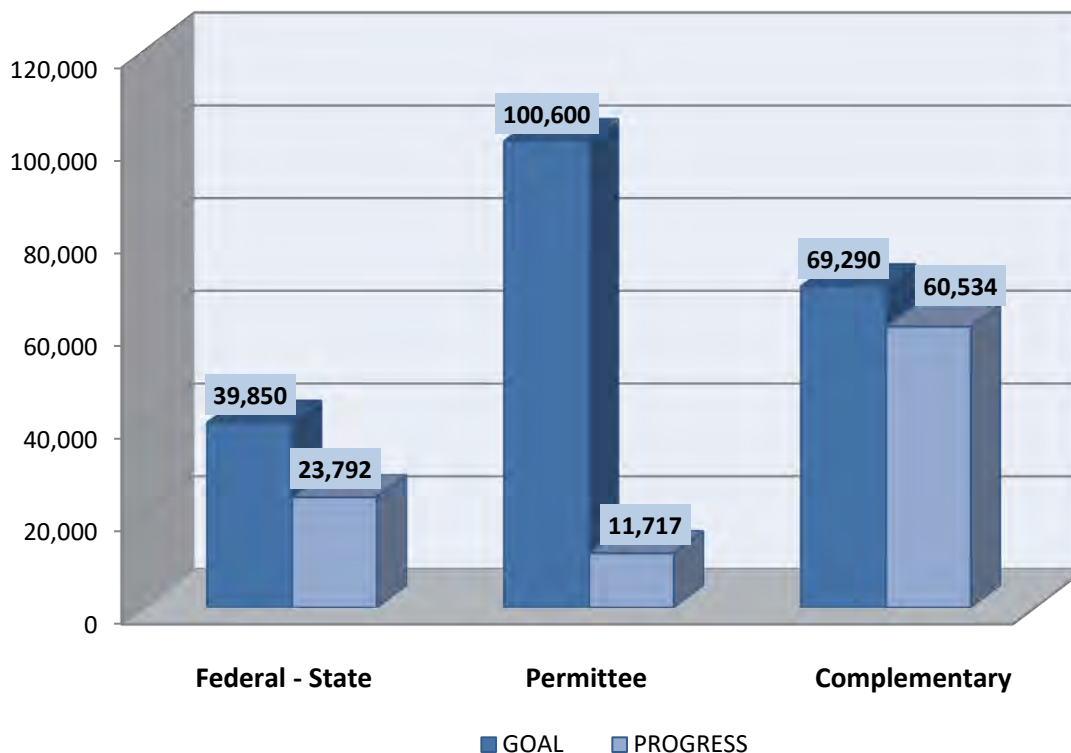


Table 1 demonstrates our progress on reserve assembly by showing the acres of conservation land protected since the issuance of the federal permit in October 2008. Significant progress has been made with over 96,043 acres of conservation lands acquired by various local, state and federal partners since 1996.

CVCC completed a major update of the land acquisition database in cooperation with the Coachella Valley Mountains Conservancy, CDFW and USFWS in 2013. 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. Additional updates were made in early 2016 which are reflected in this report. As a result, some corrections to the numbers reported in Table 1 in prior annual reports have been made. All acquisition records and the acreage figures used throughout the 2019 Annual Report have now been updated and made consistent with the rules shown in Appendix 1.

**Table 1: Summary of Annual Progress on Reserve Assembly**

Conservation Credit	Goal	Total Progress	1996 - 2011	2012	2013	2014	2015	2016	2017	2018	2019
<b>Federal - State</b>	39,850	23,792	17,012	1,819	1,102	1,681	296	319	525	814	224
<b>Permittee</b>	100,600	11,717	7,654	261	576	241	424	799	793	578	391
<b>Complementary</b>	69,290	60,534	51,904	1,799	698	957	1,445	612	1,703	906	510
<b>Total</b>	<b>209,740</b>	<b>96,043</b>	<b>76,570</b>	<b>3,879</b>	<b>2,376</b>	<b>2,879</b>	<b>2,165</b>	<b>1,730</b>	<b>3,021</b>	<b>2,298</b>	<b>1,125</b>

Once acquired, lands within the Conservation Areas are held in public or private ownership and are managed for conservation and/or open space values. Management of these lands contributes to the conservation of the Covered Species and the conserved natural communities included in the Plan. Table 2 identifies the allocation of land management responsibility, based on the entity that ultimately holds title to the land.

**Table 2: Acres of Management Credit**

Management Credit	Progress (acres)
<b>Federal - State</b>	60,632
<b>Permittee</b>	13,955
<b>Complementary</b>	21,456
<b>Total</b>	<b>96,043</b>

### Reporting Requirements:

This Annual Report describes the activities for the period from January 1, 2019 to the end of the calendar year on December 31, 2019. As required by Section 6.4 of the CVMSHCP, this Annual Report will be presented at the CVCC meeting of May 14, 2020, where the report will be made available to the public. The report is also posted on the CVMSHCP website, [www.cvmshcp.org](http://www.cvmshcp.org).

## II. Status of Conservation Areas: Conservation and Authorized Disturbance

The CVMSHCP identifies both qualitative and quantitative conservation goals and objectives that must be met to ensure the persistence of the Covered Species and natural communities. The quantitative approach 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,

2019. 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, 2019 and December 31, 2019 (see Appendix IV).

Table 3 provides a summary of the amount of conservation and the acres of disturbance authorized within Conservation Areas in 2019. Authorized disturbance results from development projects in the Conservation Areas. In 2019, there was zero (0) acres of Authorized Disturbance reported. The Total Authorized Disturbance in Table 3 includes Authorized Disturbance since 1996.

**Table 3: Conservation and Authorized Disturbance Within Conservation Areas**

Conservation Area	Conservation Goal	Conserved in 2019	Conserved Since 1996	Allowed Authorized Disturbance	Authorized Disturbance in 2019	Total Authorized Disturbance since 1996
Cabazon	2,340	0	0	260	0	0
CV Stormwater Channel and Delta	3,870	79	871	430	0	5
Desert Tortoise and Linkage	46,350	224	5,378	5,150	0	2
Dos Palmas	12,870	0	4,283	1,430	0	0
East Indio Hills	2,790	0	35	310	0	0
Edom Hill	3,060	0	2,077	340	0	2
Highway 111/I-10	350	0	54	40	0	0
Indio Hills Palms	2,290	0	1,039	250	0	0
Indio Hills/Joshua Tree National Park Linkage	10,530	0	9,000	1,170	0	6
Joshua Tree National Park	35,600	0	13,326	1,600	0	0
Long Canyon	0	0	0	0	0	0
Mecca Hills/Orocopia Mountains	23,670	0	7,140	2,630	0	0
Santa Rosa and San Jacinto Mountains	55,890	464	32,848	5,110	0	10
Snow Creek/Windy Point	2,340	46	935	260	0	0
Stubbe and Cottonwood Canyons	2,430	10	1,056	270	0	1
Thousand Palms	8,040	140	4,519	920	0	55

Conservation Area	Conservation Goal	Conserved in 2019	Conserved Since 1996	Allowed Authorized Disturbance	Authorized Disturbance in 2019	Total Authorized Disturbance since 1996
Upper Mission Creek/Big Morongo Canyon	10,810	73	7,386	990	0	21
West Deception Canyon	1,063	0	1,833	100	0	0
Whitewater Canyon	1,440	0	956	160	0	1
Whitewater Floodplain	4,140	0	908	460	0	33
Willow Hole	4,920	89	2,399	540	0	6
<b>Total</b>	234,793	1,125	96,043	22,420	0	142

### III. Biological Monitoring Program

The CVMSHCP outlines a 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 identifying threats and stressors; 2) performing focused monitoring including threats and stressors, once they are determined; and 3) conducting adaptive management actions whereby the scientific method is employed to develop and implement best management practices.

The Reserve Management Unit Committee and Biological Working Group (RMUC/BWG) meet regularly to discuss updates on biological issues and adaptive management strategies. One of the tasks of these meetings is to assess current monitoring protocols to align them with research goals and management needs outlined within the CVMSHCP, as well as vetting completed monitoring activities. During the spring, the RMUC/BWG assess the monitoring priorities to be brought forth to the Reserve Management Oversight Committee as the recommended annual work plan, and each year they recommend a suite of species for monitoring that should be added in year's with or following above average rainfall. The CVCC Conservation Management Analyst facilitates these meetings of the Reserve Management Unit Committees and the Biological Working Group to better manage biological monitoring contracts, pursue funding opportunities for further research, and organize logistics for monitoring and land management efforts throughout the year.

To support these goals, CVCC staff actively pursue grant funding for monitoring programs. CVCC received funding for a project from the Natural Community Conservation Planning Local Assistance Grant (LAG) program, in the amount of \$55,230 for "Restoration of Ecosystem Processes: Sand Dune Restoration in the Coachella Valley MSHCP." The primary focus of this project is to analyze the feasibility of collecting sand that has been deposited on roadways and move it to locations where it can enhance habitat quality and benefit sand starved preserve locations. The Coachella Valley Association of Governments (CVAG) operates a street-sweeping program to maintain air quality and remove PM10. The sand collected in these operations is available for the proposed project. The project will also analyze the sand to evaluate if it needs to be cleaned of large contaminants such as extraneous road and construction debris. A second,

finer scale evaluation, will determine if there are micro contaminants such as petroleum or asbestos residue. The study will continue through 2020.

In June 2019, a contract with UC Riverside (UCR) Center for Conservation Biology was approved for monitoring of aeolian sand species, triple-ribbed milkvetch, burrowing owl, Palm Springs pocket mouse, and Jerusalem cricket, as well as updating vegetation maps for the Dos Palmas and Valley Floor Conservation Areas to document any rapid shifts in vegetation alliances. In coordination with the RMUC and Biological Working Group, UCR provides regular 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 monitoring reports can be found in Appendices V, VI, VII, VIII, IX, and X respectively. Last year, CVCC partnered with San Diego Institute for Conservation Research on a CDFW Local Assistance Grant and California Energy Commission Grant to determine how active and passive trans-location affect burrowing owls displaced by development. In 2018 and 2019, translocated owls were fitted with GPS backpacks that track their movement as they establish nests throughout the breeding season. UCR and CVCC staff provided support by providing and checking wildlife cameras placed at nests in Cabazon and the Coachella Valley Stormwater Channel. Cameras documented nest productivity, prey items, and visits to the nests by other species, including predators. The final report for this study is available in Appendix XI. CVCC also contracted with the United States Geological Survey to monitor tortoise populations and demography within a focal plot south of Interstate 10 in the Desert Tortoise and Linkage Conservation Area, using radiotelemetry to locate the tortoises, and provide population estimates as they did previously for the population north of Interstate 10 in Cottonwood Wash (2017 Annual Report). The final report for the tortoise study is found in Appendix XII. Tortoises captured in the Desert Tortoise and Linkage Conservation Area, the Santa Rosa and San Jacinto Mountains Conservation Area and the Whitewater Canyon Conservation Area have had blood taken and genetic analysis is pending. Published analyses of the genetic sampling for all conservation areas will be available in the 2020 Monitoring Report. The San Diego Natural History Museum (SDNHM) implemented monitoring of both the Crissal and LeContes Thrasher in 2019. Their monitoring reports can be found in Appendices XIII and XIV respectively.

Peninsular bighorn sheep monitoring continued with tracking GPS telemetry collars that were fitted to sheep in the Santa Rosa and San Jacinto Mountains Conservation Area in October 2014 and November 2015. Additional GPS collars were placed on bighorn sheep in November 2017, funded in part by CVCC and USFWS. During these bighorn captures, blood and serum samples were collected from each bighorn sheep to provide data on health and genetic status. In 2018 CDFW placed 12 additional Lotek GPS collars on bighorn in the San Jacinto and Santa Rosa Mountains Conservation Area. Also that same year, CVCC received \$94,250 to support *“Determining habitat use and response to human recreation activities of Peninsular bighorn sheep (Ovis canadensis nelsoni) in a shared landscape.”* USGS biologists have been collecting data through 2019 for the pilot study to examine recreational use along trails within Peninsular bighorn sheep (PBS) habitat in the Santa Rosa and San Jacinto Mountains Conservation Area, including near PBS lambing areas and watering holes. Levels of trail use were collected by using remotely deployed Trafx infrared counters operating continuously at the trailhead and interior along the trail network and scored on their heaviness of use and type of use, as recorded by infrared counters (raw counts). Recreational use was documented through long-term deployments of these trail counters that have been placed on 26 trails from 2015 to the present. Of these, 16 have collected trail use data 24 hours a day for at least a full year. From these 16 trails, biologists selected nine of these trails to represent low, medium, and high-use areas near trailheads and approximately one kilometer from trailheads. After the initial analysis, BLM deployed 15 more infrared counters for further analysis of their use, bringing the total to 35 active counters throughout the study area. Observers in the form of citizen scientists were also deployed to test the protocol during lambing



season in winter and spring of 2019 /2020. Also, once the protocol was developed, several human observers (citizen scientists) were deployed to document behavior (running, jumping, shouting) and record the numbers of dogs, bikes, up-and-back hikers, and other types of recreational users that the counters cannot detect. The final reports for this study will be included in the 2020 Annual Report.

### 2019 Biological Monitoring Activities





## **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. Because many of the same staff members are involved in both the Reserve Management Unit Committee (RMUC) and Biological Working Group (BWG), meetings were combined to reduce demands on staff time and provide for better coordination between management and monitoring teams. The RMUC / BWG met on March 26, June 11, and September 10, 2019. The group discussed prioritizing invasive species and off-road vehicle control management efforts, increasing volunteer opportunities, priorities for monitoring and research, coordination on grant opportunities, and monitoring results.

## **Trails Management Subcommittee**

The Trails Management Subcommittee (TMS) meetings were held on January 16, March 20, September 18, and November 20, 2019. Working groups in 2019 included Dog Enforcement and Ordinances, Trail Maintenance, Schey trail reroute, and Trails Research. The TMS working groups report on progress for their tasks and discuss significant issues, management, and funding opportunities at the quarterly TMS meetings. CVCC partners, Friends of the Desert Mountains and their volunteer crew continued to work closely with BLM and the cities to fix trail hazards and install clear directional and safety signage. Friends' volunteers are taking the lead on trail restoration throughout the valley. CVCC staff also worked with the Greater Palm Springs Convention & Visitors Bureau, Friends of the Desert Mountains, and other volunteers from the TMS to update trail apps and websites, and provide wayfinding signage along roadways to highlight trailheads in the Coachella Valley. A Prohibition of Dogs ordinance was also passed in Palm Springs, and several signs were provided at city trailheads to increase awareness of responsible use and appropriate recreational activities on the trails.

## **Land Improvement: Acquisition Cleanups**

In 2019 the CVCC Acquisitions Manager performed pre-acquisition site inspections and job walks on 65 parcels/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. After closing, CVCC monitors the sites at least annually for ongoing management/fencing requirements. This year, CVCC was directly responsible for removing an estimated 57.91 tons of refuse, including 33 tires and two structures, from the Coachella Valley, covering more than 937.01 acres and generating over \$71,524.63 in contractor revenue from sellers' property sales.



## Property Management & Monitoring

Monitoring the status of CVCC conservation lands is an essential and ongoing activity. Site visits and patrols are conducted on a monthly basis to various CVCC properties. Illegal dumping, OHV use and shooting continue to be a problem on some of the Reserve lands. In 2019, CVCC's maintenance contractor installed 8,610 linear feet of post and cable fencing, signs and gates to protect mesquite dunes in the Willow Hole Conservation Area. Working in partnership to secure adjacent state lands, the Coachella Valley Mountains Conservancy paid to clean up and fence their property and reimbursed CVCC \$33,833.75 for the state portion of the fencing project. CVCC also closely monitored and maintained approximately 12 miles of fencing and signage installed previously within the Upper Mission Creek and Big Morongo Canyon, Sky Valley, Indio Hills/Joshua Tree National Park Linkage, and Stubbe and Cottonwood Canyon Conservation Areas. The continuous monitoring of the fencing and gates continues to dissuade further dumping or OHV activity in these conservation areas.

In addition to fencing and signage, CVCC staff worked with the Urban Conservation Corps and Coachella Valley Mountains Conservancy to control invasive vegetation on properties in the Willow Hole and Stormwater Channel and Delta Conservation Area. CVCC also received a Proposition 1 Local Assistance Grant through Coachella Valley Mountains Conservancy in the amount of \$295,974 for *“Wetlands Restoration, Tamarisk Removal, and Rail Habitat Enhancement”* at North Shore Ranch in the Stormwater Channel and Delta Conservation Area. CVCC contracted with the San Diego Natural History Museum again in 2019 to continue to control invasive cowbirds in the Coachella Valley Stormwater Channel and Delta, and Dos Palmas Conservation Areas. The 2019 Cowbird Management Report can be found in Appendix XV.

## 2019 Land Management Activities





Photos: 1 – Urban Conservation Corps crew preparing to remove tamarisk from a ravine at the Willow Hole Conservation Area; 2 – Urban Conservation Corps pulling removed tamarisk out of the ravine to protect and restore the oasis at Willow Hole Conservation Area; 3 – Urban Conservation Corps sawyers work with chainsaws to fell a large patch of Athel tamarisk threatening mesquite water sources ; 4 –Fencing installed at Willow Hole Conservation Area to protect mesquite dunes; 5 – Urban Conservation Corps remove invasive tamarisk from North Shore Ranch in the Stormwater Channel and Delta Conservation Area

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

In 2019, CVCC completed 26 transactions acquiring 58 parcels totaling 391 acres at a cost of \$1,945,825 in CVCC funds, these acquisitions are listed in Table 4. Friends of the Desert Mountains acquired 3 parcels totaling 220 acres with \$88,456 in funds from Coachella Valley Mountains Conservancy (CVMC). They also acquired 40 acres with \$19,000 from the Resources Legacy Fund Foundation (RLFF). One of the most notable acquisitions was at Snow Creek where CVCC acquired 4 parcels totaling 479 acres with \$964,305 in matching funds from Coachella Valley Mountains Conservancy, along with \$1,790,695 from Federal Endangered Species Act Section 6 Funds.

A table of CVCC acquisitions and otherwise conserved lands recorded during the period from January 1, 2019 to December 31, 2019 can be found in Appendix II. Parcels acquired are listed



by Assessor Parcel Number (APN) and the acreage listed is the recorded acreage from the Riverside County Assessor.

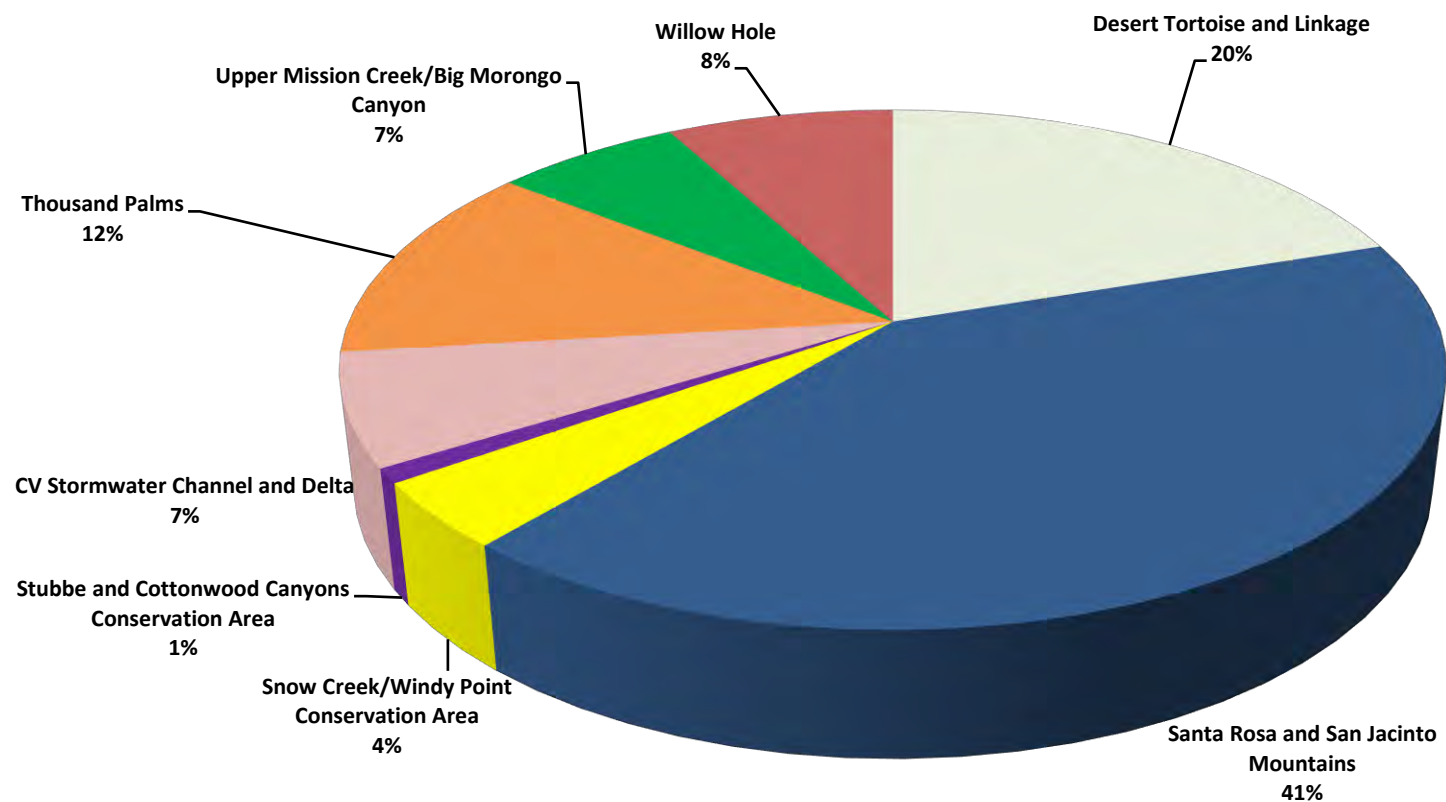
**Table 4: Lands Acquired by CVCC in 2019**

Project	Acres	Conservation Area	Purchase Price
Barry & Roger Jones	10.04	Thousand Palms	\$ 75,000
Bernstein	0.48	Thousand Palms	\$ 160,000
Bernstein	10.88	Thousand Palms	\$ 0
Bernstein	5.24	Thousand Palms	\$ 0
Bernstein	3.07	Thousand Palms	\$ 0
Bernstein	6.05	Thousand Palms	\$ 0
Bernstein	10.66	Thousand Palms	\$ 0
Bernstein	3.26	Thousand Palms	\$ 0
Bernstein	0.08	Thousand Palms	\$ 0
Bodgin	5.05	Thousand Palms	\$ 5,000
Chavez	20.42	Thousand Palms	\$ 40,000
Corey	2.50	Willow Hole	\$ 9,000
Cynthia Lou Pontious	1.89	Thousand Palms	\$ 8,640
Durst	5.10	Stubbe and Cottonwood Canyons	\$ 6,000
Durst	5.11	Stubbe and Cottonwood Canyons	\$ 6,000
Filippone -Schwab	9.88	Thousand Palms	\$ 359,100
Filippone -Schwab	9.95	Thousand Palms	\$ 0
George and Janice Southworth	4.98	Thousand Palms	\$ 22,500
Gwendolyn Lou Pontious	1.10	Thousand Palms	\$ 18,585
Gwendolyn Lou Pontious	2.71	Thousand Palms	\$ 0
Lara	0.44	Willow Hole	\$ 1,394
Lara	0.54	Willow Hole	\$ 1,606
Larry L. Klein	7.17	Thousand Palms	\$ 32,000
Lewis	5.04	Willow Hole	\$ 15,000
Lucom - Clark	14.71	Willow Hole	\$ 285,000
Lucom - Clark	14.63	Willow Hole	\$ 0
Lucom - Clark	7.30	Willow Hole	\$ 0
Lucom - Clark	2.75	Willow Hole	\$ 0
Lucom - Clark	7.49	Willow Hole	\$ 0
Lucom - Clark	2.95	Willow Hole	\$ 0
Mccann	0.14	Thousand Palms	\$ 4,000
Mccann	0.14	Thousand Palms	\$ 0
Mccann	0.28	Thousand Palms	\$ 0
Mccann	0.12	Thousand Palms	\$ 0
Mccann	0.12	Thousand Palms	\$ 0
Mccann	0.13	Thousand Palms	\$ 0
Mccann	0.12	Thousand Palms	\$ 0

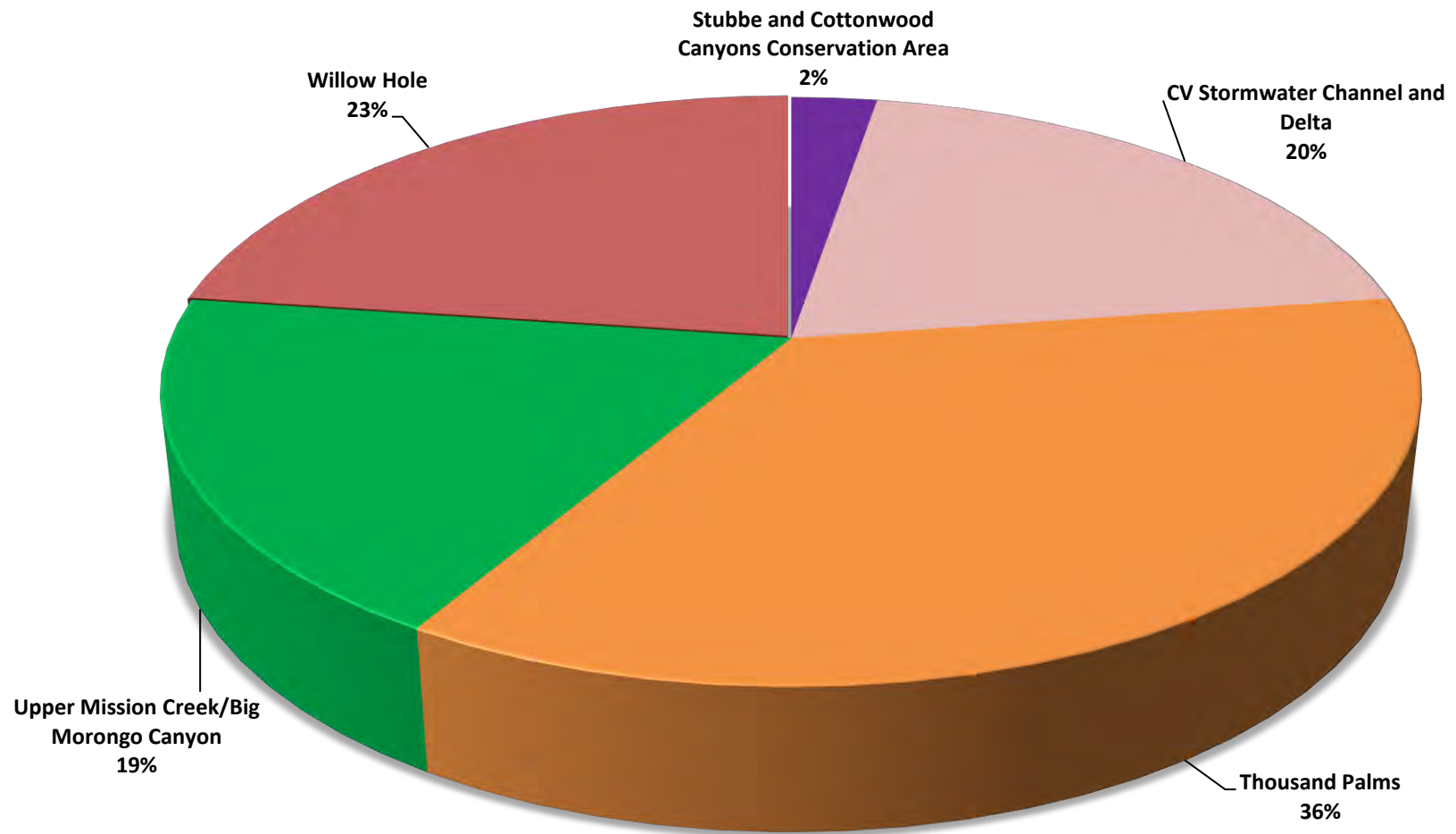
<b>Mccann</b>	0.12	Thousand Palms	\$ 0
<b>Mccann</b>	0.12	Thousand Palms	\$ 0
<b>Mccann</b>	0.13	Thousand Palms	\$ 0
<b>Mccann</b>	0.12	Thousand Palms	\$ 0
<b>Mccann</b>	0.12	Thousand Palms	\$ 0
<b>Mccann</b>	0.13	Thousand Palms	\$ 0
<b>Nores</b>	4.02	Willow Hole	\$ 12,000
<b>North Shore Ranch 2</b>	77.38	Stormwater Channel	\$ 515,000
<b>North Shore Ranch 2</b>	1.23	Stormwater Channel	\$ 0
<b>Pavich</b>	5.01	Thousand Palms	\$ 18,000
<b>Reid</b>	19.48	Willow Hole	\$ 59,000
<b>Shackelford</b>	2.36	Willow Hole	\$ 9,000
<b>Shovlin</b>	73.10	Upper Mission Creek/Big Morongo Canyon	\$ 200,000
<b>Smith</b>	4.95	Willow Hole	\$ 15,000
<b>Snowcloud Enterprises</b>	5.38	Thousand Palms	\$ 69,000
<b>Snowcloud Enterprises</b>	9.94	Thousand Palms	\$ 0
<b>Snowcloud Enterprises</b>	5.00	Thousand Palms	\$ 0
<b>Total Purchases</b>	391.11		\$ 1,945,825

Figure 2 shows the acquisitions completed by all local, state, and federal acquisition partners in 2019 by Conservation Area. Figure 3 shows the acquisitions by CVCC. Funding for land acquisition and CVMSHCP Reserve Assembly comes from a variety of sources including local, state, and federal agencies. CVCC acquires lands with funding from CVMSHCP development mitigation fees and CVAG contributions to mitigate for regional roads and other transportation projects. In addition, as shown in Figure 4, funding from land acquisition partners continues to be an important source of land acquisition dollars. Significant federal funding has been provided through the U.S. Fish and Wildlife Service's Cooperative Endangered Species Conservation Fund, referred to as Section 6. State funding comes from several sources. The Coachella Valley Mountains Conservancy contributes significantly to the acquisition of conservation lands through grants to various organizations, including CVCC. The state Wildlife Conservation Board/California Department of Fish and Wildlife is another major source of funding. The non-profit Friends of the Desert Mountains has acquired lands using grants from CVMC, private donations, and other sources; many of these lands have been transferred to CVCC. Other agencies and non-profits have provided funds for land conservation. Figure 5 shows the lands acquired in 2019 by all acquisition partners. CVCC gratefully acknowledges the support from our partners.

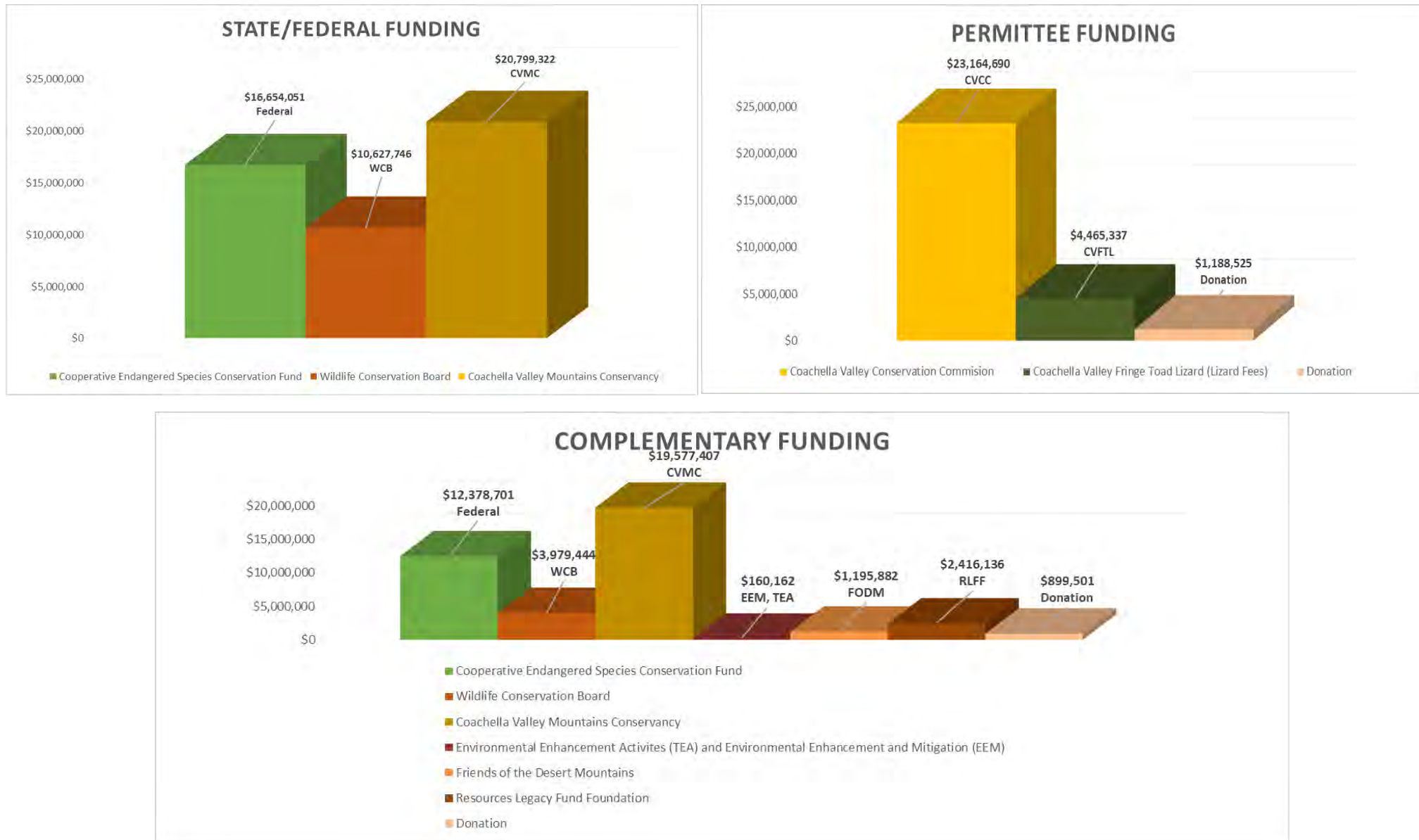
**Figure 2: Total Acquisitions in 2019 by Conservation Area**



**Figure 3: CVCC Acquisitions in 2019 by Conservation Area**

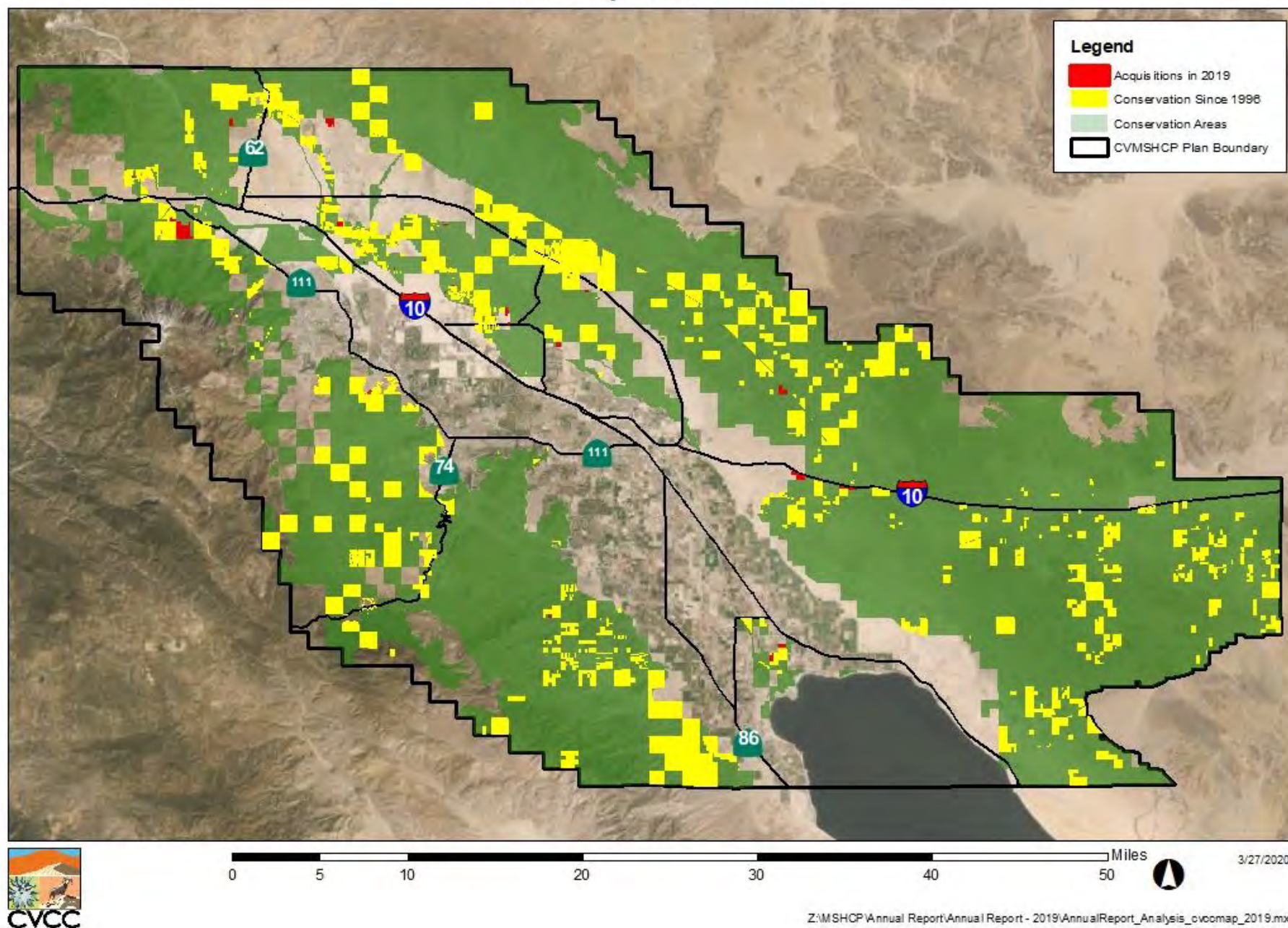


**Figure 4: Funding Sources for Land Acquisition and Reserve Assembly**





## Land Acquisitions in 2019



## **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, 2019.

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

## **VII. Covered Activities Outside Conservation Areas**

The CVMSHCP allows for development and other Covered Activities outside the Conservation Areas which do 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 V. 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 2016.

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 III.

## **IX. Significant Issues in Plan Implementation**

A significant project is the La Quinta Peninsular Bighorn Sheep Barrier Project. In 2019, the Final Environmental Impact Report for the project was completed. The primary objective of the La Quinta Peninsular Bighorn Sheep Barrier Project is to protect PBS by preventing them from accessing and coming to harm from using urban lands, including golf courses and landscaping, artificial water bodies, and roadways. This project was initiated in 2014 in response to a letter from the U.S. Fish and Wildlife Service and the California Department of Fish and Wildlife expressing their concerns about bighorn sheep using artificial sources of food and water in unfenced areas in the City of La Quinta. Terra Nova Planning and Research, Inc. of Palm Desert worked with CVCC on the state and federal environmental review for this project. The Draft Environmental Impact Report (EIR) was released in early January 2017 with a 45-day public comment period. During the public review period, 37 comments were received, including 21 from individuals; written responses were prepared as part of the Final EIR and sent to all those who submitted comments prior to the public hearing. The CVCC held a public hearing on April 26, 2019 where they certified the Final EIR and approved the proposed fence route. A federal Environmental Assessment was also prepared in coordination with the Bureau of Reclamation as fencing associated with the Coachella Canal will require their approval in the form of a license agreement. The Bureau of Reclamation completed the environmental review process on April 26 as well. Since CVCC does not control the land needed for a fence a next step has been to work with property owners on access agreements for construction and permanent installation. Agreements are in progress with PGA West, Coachella Valley Water District, and the U.S. Bureau of Reclamation. CVCC staff continues to work with the City of La Quinta, U.S. Fish and Wildlife Service, California Department of Fish and Wildlife, Riverside County Parks and Open Space District (Lake Cahuilla Veterans Park) and BLM to coordinate the project. A request for bids was prepared for release in early 2020 for a fencing contractor. Once the fence contractor is in place, the fence route will be staked so that it can be reviewed by relevant property owners. Construction is anticipated in fall 2020, with some work potentially beginning in late spring 2020.



## X. Expenditures for CVMSHCP - 2019/20 Budget

Full budget available at:

[http://cvag.org/library/pdf\\_files/admin/CVCC%20Financials%20Reports%20FY\\_2019\\_2020/CVCC\\_Budget.pdf](http://cvag.org/library/pdf_files/admin/CVCC%20Financials%20Reports%20FY_2019_2020/CVCC_Budget.pdf)

### **BUDGET BY PROGRAMS - FY 2019/2020**

	MANAGEMENT AND MONITORING	GENERAL ADMINISTRATION	LAND ACQUISITION	ENDOWMENT	LIZARD ENDOWMENT	TRAVERTINE MANAGEMENT	MANAGEMENT CONTINGENCY	IN-LIEU FEE	TOTAL
BEGINNING FUND BALANCE	\$ 740,585	\$ 472,556	\$ 7,514,716	\$ 7,851,526	\$ 320,212	\$ 522,932	\$ 4,875,209	\$ 39,411	\$ 22,337,147
<b>REVENUES:</b>									
Development Mitigation Fees	\$ 306,000	\$ -	\$ 1,494,000	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 1,800,000
Agencies Mitigation Fees	-	-	-	500,000	-	-	-	-	500,000
Tipping Fees	-	432,300	-	-	-	-	-	-	432,300
Contributions	-	-	-	-	-	-	-	-	-
Grants	355,320	-	2,374,056	-	-	-	-	-	2,729,376
Other Revenue	-	-	-	-	-	-	-	-	-
Investment Income	8,660	7,375	100,000	140,000	6,000	9,800	70,000	10	341,845
Total Revenues	\$ 669,980	\$ 439,675	\$ 3,968,056	\$ 640,000	\$ 6,000	\$ 9,800	\$ 70,000	\$ 10	\$ 5,803,521
<b>EXPENDITURES:</b>									
Administrative Fees	\$ 3,060	\$ -	\$ 14,940	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 18,000
Accounting / Bank Service Charges	-	4,165	-	-	-	-	-	575	4,740
Comprehensive Insurance	-	9,295	-	-	-	-	-	-	9,295
Per Diem Payments	-	10,200	-	-	-	-	-	-	10,200
Per Diem Taxes	-	882	-	-	-	-	-	-	882
Office Supplies	-	3,000	-	-	-	-	-	-	3,000
Printing	-	2,000	-	-	-	-	-	-	2,000
Land Improvements	2,000,000	-	500,000	-	-	-	-	-	2,500,000
Legal Services	2,000	30,000	6,500	-	-	-	-	-	38,500
Professional Services	3,000	9,903	170,000	-	-	-	-	-	182,903
Consultants (Regular funds)	762,266	285,913	315,741	-	-	-	-	37,971	1,401,891
Consultants (Grant funds)	373,320	-	-	-	-	-	-	-	373,320
Interest	-	-	-	-	-	-	-	-	-
Miscellaneous	500	1,000	500	-	-	-	-	200	2,200
Land Acquisitions	-	-	8,000,000	-	-	-	-	-	8,000,000
Furniture and Equipment	-	-	-	-	-	-	-	-	-
Sub-Total Expenditures	\$ 3,144,146	\$ 356,358	\$ 9,007,681	\$ -	\$ -	\$ -	\$ -	\$ 38,746	\$ 12,546,931
<b>OTHER</b>									
Operating Transfers Out	\$ -	\$ -	\$ -	\$ 39,581	\$ -	\$ -	\$ 2,000,000	\$ -	\$ 2,039,581
Operating Transfers In	(2,039,581)	-	-	-	-	-	-	-	(2,039,581)
Sub-Total Other	\$ (2,039,581)	\$ -	\$ -	\$ 39,581	\$ -	\$ -	\$ 2,000,000	\$ -	\$ -
Total Expenditures and Other	\$ 1,104,565	\$ 356,358	\$ 9,007,681	\$ 39,581	\$ -	\$ -	\$ 2,000,000	\$ 38,746	\$ 12,546,931
Net Excess (Deficit)	\$ (434,585)	\$ 83,317	\$ (5,039,625)	\$ 600,419	\$ 6,000	\$ 9,800	\$ (1,930,000)	\$ (38,736)	\$ (6,743,410)
ENDING FUND BALANCE	\$ 306,000	\$ 555,873	\$ 2,475,091	\$ 8,451,945	\$ 326,212	\$ 532,732	\$ 2,945,209	\$ 675	\$ 15,593,737

## **XI. Compliance Activities of Permittees**

All Permittees are in compliance with requirements of the CVMSHCP. CVCC completed two Joint Project Reviews for Permittees in 2019.

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. In 2019, a total of \$4,519,796 was collected under the LDMF program, an over 200%% increase over the 2018 calendar year. This was mainly the result of the largest LDMF payment ever, \$2.26M for a photovoltaic solar project. The LDFM total collected has increased every year since FY 16/17.

## **XII. Annual Audit**

CVCC approved their Fiscal Year 2019/2020 budget at the June 13, 2019 meeting.

The audit of the expenditures for the period July 1, 2018 to June 30, 2019 was approved by CVCC on February 13, 2020. 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 additional financial information can be obtained by contacting the CVCC Auditor, at 73-710 Fred Waring Drive, Suite 200, Palm Desert, CA 92260. Annual CVCC audits are available at [http://www.cvag.org/cvcc\\_financial\\_reports.htm](http://www.cvag.org/cvcc_financial_reports.htm).

## **XIII. Unauthorized Activities and Enforcement**

Off-highway vehicles, dumping and vandalism of fencing continue to be issues. In 2019, areas where these problems were reported included Stubbe/Cottonwood Canyon, Willow Hole, Upper Mission Creek/Big Morongo Canyon, and Thousand Palms Conservation Areas. Further discussion of management of these issues is included in section IV. Currently CVCC forwards reports of OHVs and dumping to the appropriate law enforcement agency. CVCC is working to develop an agreement with Sheriffs Department under which CVCC would contribute funds to hire additional law enforcement deputies to focus on the illegal activity in Conservation Areas.

## **XIV. In-Lieu Fee Program**

In 2014, CVCC completed the Enabling Instrument for an In-Lieu Fee Program (ILFP) with the U.S. Army Corps of Engineers (ACOE). The ILFP would allow organizations that need to mitigate for unavoidable Impacts to Waters of the U.S. that result from activities authorized under section 404 of the Clean Water Act and section 401 of the Clean Water Act water quality certifications to do so by paying a fee to CVCC. CVCC will perform restoration projects that are pre-approved as mitigation by ACOE and the cost of these



projects, including endowment, contingency, planning and staff time would be paid from the ILFP. Much like the CVMSHCP, the ILFP will replace piecemeal mitigations that often require years to be approved with a coordinated approach that complements other conservation efforts.

The In-Lieu Program is an Army Corps of Engineers project that does not receive coverage under the CVMSHCP. Fortunately, CVCC acquired several hundred acres in the Stormwater Channel in 2017, and we expect to use a portion of that acreage without difficulty. CVCC is now processing an Instrument Modification to extend the time to begin the actual construction of the migration by another year.

The In-Lieu Fee Program Enabling Instrument allows CVCC to sell 50 acres of Advance Credits, with the actual restoration project to begin within three growing seasons of the first sale of an Advance Credit. The first Advance Credit was sold in May 2016. Table 5 lists the Advance Credit purchases completed through December 31, 2019.

**Table 5: In-Lieu Fee Program Advance Credit Purchases ICF is completing this table**

Applicant	Mitigation Type	Acres Purchased	Date of Purchase
Caltrans	Enhancement	0.18	12/2/2016
Caltrans	Enhancement	498	9/16/2018
CVAG	Restoration	2.08	11/7/2019
Indio	Enhancement	1	10/21/2019
Palm Springs	Restoration	0.35	5/31/2016
Riverside County	Enhancement	0.199	5/25/2018
Riverside County	Enhancement	0.03	9/5/2017
Southern California Edison	Restoration	1.26	3/28/2018

# Appendix I

## Rules for Land Acquisition and Management Credit

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## 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 the following Conservation Areas: Joshua Tree National Park, the Santa Rosa and San Jacinto Mountains, the Mecca Hills and Orocopia Mountains, and Snow Creek/Windy Point. 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).
  - 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 2015 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). However, as “mitigation” cannot be used as a match for Section 6 grants, Permittees cannot receive acre credit for Section 6 matches.
- 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.

## Appendix II

### Table of Acquisitions for Conservation in 2019

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### CVMSHCP Annual Report 2019 - Parcels Acquired for Conservation

Conservation Area	Acq_Agency	APN	Total
Desert Tortoise and Linkage Conservation Area	Coachella Valley Mountains Conservancy	707220020	121.09
	Coachella Valley Mountains Conservancy Total		121.09
	Friends of the Desert Mountains	717050004	18.66
		717060001	83.76
	Friends of the Desert Mountains Total		102.42
<b>Desert Tortoise and Linkage Conservation Area Total</b>			<b>223.51</b>
Stubbe and Cottonwood Canyons Conservation Area	Coachella Valley Conservation Commission	520040015	5.10
		520040016	5.11
	Coachella Valley Conservation Commission Total		10.21
<b>Stubbe and Cottonwood Canyons Conservation Area Total</b>			<b>10.21</b>
Snow Creek/Windy Point Conservation Area	Coachella Valley Mountains Conservancy	522060010	0.48
		522060011	19.01
		522060015	26.78
	Coachella Valley Mountains Conservancy Total		46.27
<b>Snow Creek/Windy Point Conservation Area Total</b>			<b>46.27</b>
Santa Rosa and San Jacinto Mountains Conservation Area	Coachella Valley Mountains Conservancy	522100037	423.96
	Coachella Valley Mountains Conservancy Total		423.96
	Friends of the Desert Mountains	753120013	40.23
	Friends of the Desert Mountains Total		40.23
<b>Santa Rosa and San Jacinto Mountains Conservation Area Total</b>			<b>464.19</b>
Coachella Valley Stormwater Channel and Delta Conservation Area	Coachella Valley Conservation Commission	729040009	77.38
		729040010	1.23
	Coachella Valley Conservation Commission Total		78.61
<b>Coachella Valley Stormwater Channel and Delta Conservation Area Total</b>			<b>78.61</b>
Thousand Palms Conservation Area	Coachella Valley Conservation Commission	647020002	5.38
		647020009	9.94
		647020010	5.01
		647020011	5.00
		648030011	4.98
		648110007	10.04
		648230015	1.10
		648230018	2.71
		648230032	1.89
		651040012	9.88
		651040025	9.95
		651050016	7.17
		659260007	5.05
		695050007	0.14
		695050008	0.14
		695050009	0.28
		695050010	0.12
		695050011	0.12
		695050012	0.13
		695050013	0.12
		695050014	0.12
		695050015	0.12
		695050016	0.13
		695050018	0.12
		695050019	0.12
		695050020	0.13
		750090004	20.42
		752010006	0.48
		752010007	10.88
		752010008	5.24
		752010009	3.08
		752010010	6.05
		752010011	10.66
		752010012	3.26
		752010013	0.08
	Coachella Valley Conservation Commission Total		140.04
<b>Thousand Palms Conservation Area Total</b>			<b>140.04</b>

Upper Mission Creek/Big Morongo Canyon Conservation Area	Coachella Valley Conservation Commission	667020001	73.10
	Coachella Valley Conservation Commission Total		73.10
Upper Mission Creek/Big Morongo Canyon Conservation Area Total			73.10
Willow Hole Conservation Area	Coachella Valley Conservation Commission	659220014	4.95
		659230027	0.44
		659230028	0.54
		660020003	14.71
		660020004	14.63
		660020005	7.30
		660020006	2.75
		660020007	7.49
		660020008	2.95
		660170011	4.02
		660200027	2.50
		660320003	2.36
		660340006	5.04
		665190006	19.48
	Coachella Valley Conservation Commission Total		89.16
Willow Hole Conservation Area Total			89.16
Grand Total			1,125.09



# Appendix III

## Status of Conservation Objectives by Conservation Area

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## CVMSHCP Annual Report 2019 - 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 2019	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
<b>Cabazon Conservation Area - Riverside County</b>								
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
<b>Coachella Valley Stormwater Channel and Delta Conservation Area - Riverside County</b>								
Desert Pupfish - Core Habitat	25	0	25	0	0	0%	0	0
Crissal Thrasher - Core Habitat	896	87	781	371	76	48%	5	41
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	371	76	53%	5	40
Mesquite hummocks	74	7	67	20	0	30%	0	3
Coastal and valley freshwater marsh	61	6	51	0	0	0%	0	1
Desert sink scrub	1,349	114	1,026	44	0	4%	0	16
Desert saltbush scrub	792	79	713	351	76	49%	5	38

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2019	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
<b>Desert Tortoise and Linkage Conservation Area - Coachella</b>								
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
<b>Desert Tortoise and Linkage Conservation Area - Riverside County</b>								
Desert Tortoise - Core Habitat	88,878	4,998	44,977	4,795	224	11%	14	965
Orocopia Sage - Core Habitat	779	44	398	0	0	0%	0	4
Mecca Aster - Core Habitat	4,731	206	1,855	300	0	16%	0	51
Le Conte's Thrasher - Other Conserved Habitat	49,114	2,813	25,319	1,409	74	6%	14	408
Desert dry wash woodland	13,443	752	6,771	633	7	9%	6	132
Desert Tortoise and Linkage Corridor	26,122	1,572	14,143	1,319	102	9%	0	289

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2019	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
<b>Dos Palmas Conservation Area - Riverside County</b>								
Crissal Thrasher - Core Habitat	536	38	343	235	0	69%	0	27
Desert Pupfish - Refugia Locations	0	0	0	0	0	0%	0	0
California Black Rail - Other Conserved Habitat	597	37	334	281	0	84%	0	32
Le Conte's Thrasher - Other Conserved Habitat	14,882	743	6,689	2,460	0	37%	0	320
Yuma Clapper Rail - Other Conserved Habitat	682	42	374	301	0	80%	0	35
Predicted Flat-tailed Horned Lizard - Other Conserved Habitat	5,537	403	3,631	681	0	19%	0	108
Desert fan palm oasis woodland	125	6	50	29	0	59%	0	4
Arrowweed scrub	277	13	121	0	0	0%	0	1
Mesquite bosque	482	36	320	225	0	70%	0	26
Desert sink scrub	7,195	487	4,381	1,179	0	27%	0	167
Desert dry wash woodland	1,856	83	746	245	0	33%	0	33
Cismontane alkali marsh	321	23	205	200	0	98%	0	22
Mesquite hummocks	55	3	23	12	0	51%	0	2
<b>East Indio Hills Conservation Area - Coachella</b>								
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 2019	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
<b>East Indio Hills Conservation Area - Indio</b>								
Le Conte's Thrasher - Other Conserved Habitat	120	12	105	0	0	0%	0	1
Palm Springs Pocket Mouse - Other Conserved Habitat	117	11	103	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	100	0	0	0%	0	1
<b>East Indio Hills Conservation Area - Riverside County</b>								
Le Conte's Thrasher - Other Conserved Habitat	1,960	139	1,253	35	0	3%	0	17
Mecca Aster - Core Habitat	1,594	116	1,045	0	0	0%	0	12
Coachella Valley Round-tailed Ground Squirrel - Other Conserved Habitat	1,353	100	896	1	0	0%	0	10
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	33	0	3%	0	14
Active desert dunes	5	1	4	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	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 2019	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
<b>Edom Hill Conservation Area - Cathedral City</b>								
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
<b>Edom Hill Conservation Area - Riverside County</b>								
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	1,029	0	85%	0	116
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	1,115	0	86%	0	126
Palm Springs Pocket Mouse - Other Conserved Habitat	1,228	104	935	794	0	85%	0	90
Le Conte's Thrasher - Other Conserved Habitat	2,238	194	1,745	1,334	0	76%	1	152
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	1,468	0	83%	0	167
Sand Transport	628	63	565	377	0	67%	1	43

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2019	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
<b>Highway 111/I-10 Conservation Area - Riverside County</b>								
Coachella Valley Round-tailed Ground Squirrel - Other Conserved Habitat	389	39	350	54	0	15%	0	9
Coachella Valley Jerusalem Cricket - Other Conserved Habitat	372	37	335	51	0	15%	0	9
Le Conte's Thrasher - Other Conserved Habitat	389	39	350	54	0	15%	0	9
Coachella Valley Milkvetch - Other Conserved Habitat	372	37	335	51	0	15%	0	9
Palm Springs Pocket Mouse - Other Conserved Habitat	389	39	350	54	0	15%	0	9
<b>Indio Hills Palms Conservation Area - Riverside County</b>								
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
<b>Indio Hills/Joshua Tree National Park Linkage Conservation Area - Riverside County</b>								
Desert Tortoise - Core Habitat	10,308	859	7,735	6,557	0	85%	0	741
Le Conte's Thrasher - Other Conserved Habitat	6,396	606	5,457	5,469	0	100%	0	607
Sand Transport	7,304	681	6,132	5,791	0	94%	5	642
Sand Source	5,823	460	4,135	3,205	0	77%	0	367
Indio Hills / Joshua Tree National Park Corridor	13,127	1,141	10,267	8,996	0	88%	5	1,009

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2019	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
<b>Joshua Tree National Park Conservation Area - Riverside County</b>								
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	104	0	47%	0	13
Desert Tortoise - Core Habitat	127,161	1,708	15,367	12,690	0	83%	0	1,440
Desert dry wash woodland	2,195	13	119	192	0	100%	0	20
Mojave mixed woody scrub	57,099	800	7,195	6,349	0	88%	0	715
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
<b>Mecca Hills/Orocopia Mountains Conservation Area - Riverside County</b>								
Desert Tortoise - Core Habitat	112,575	2,624	23,617	6,714	0	28%	0	934
Le Conte's Thrasher - Other Conserved Habitat	17,467	652	5,866	1,401	0	24%	0	205
Orocopia Sage - Core Habitat	66,180	1,803	16,227	4,303	0	27%	0	611
Mecca Aster - Core Habitat	31,655	465	4,181	1,222	0	29%	0	169
Desert fan palm oasis woodland	1	0	0	0	0	0%	0	0
Desert dry wash woodland	9,317	318	2,861	1,212	0	42%	0	153
<b>Santa Rosa and San Jacinto Mountains Conservation Area - Cathedral City</b>								
Desert Tortoise - Other Conserved Habitat	107	11	95	0	0	0%	0	1
Le Conte's Thrasher - Other Conserved Habitat	13	1	11	0	0	0%	0	0
Peninsular Bighorn Sheep - Rec Zone 2 - Essential Habitat	112	11	97	0	0	0%	0	1
Desert dry wash woodland	20	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 2019	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
<b>Santa Rosa and San Jacinto Mountains Conservation Area - Indian Wells</b>								
Desert Tortoise - Other Conserved Habitat	4,375	111	999	36	0	4%	0	15
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	36	0	3%	0	15
Desert dry wash woodland	128	7	66	0	0	0%	0	1
<b>Santa Rosa and San Jacinto Mountains Conservation Area - La Quinta</b>								
Desert Tortoise - Other Conserved Habitat	5,936	157	1,409	375	0	27%	7	46
Le Conte's Thrasher - Other Conserved Habitat	683	43	387	122	0	31%	0	16
Peninsular Bighorn Sheep - Rec Zone 3 - Essential Habitat	6,185	159	2,545	391	0	15%	0	38
Desert dry wash woodland	147	8	76	15	0	20%	0	2
<b>Santa Rosa and San Jacinto Mountains Conservation Area - Palm Desert</b>								
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 2019	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
<b>Santa Rosa and San Jacinto Mountains Conservation Area - Palm Springs</b>								
Le Conte's Thrasher - Other Conserved Habitat	793	103	560	554	174	99%	0	102
Peninsular Bighorn Sheep - Rec Zone 1 - Essential Habitat	9,195	226	2,511	2,220	219	88%	0	202
Desert Tortoise - Other Conserved Habitat	22,571	1,317	8,856	5,396	219	61%	0	854
Peninsular Bighorn Sheep - Rec Zone 2 - Essential Habitat	18,426	866	4,700	4,149	0	88%	0	775
Gray Vireo - Other Conserved Habitat	8,416	431	3,883	1,837	0	47%	0	227
Desert dry wash woodland	40	4	36	41	0	100%	0	5
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	4	0	7%	0	0
Desert fan palm oasis woodland	218	9	76	52	0	69%	0	6
Southern arroyo willow riparian forest	16	0	0	0	0	0%	0	0
<b>Santa Rosa and San Jacinto Mountains Conservation Area - Rancho Mirage</b>								
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 2019	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
<b>Santa Rosa and San Jacinto Mountains Conservation Area - Riverside County</b>								
Peninsular Bighorn Sheep - Rec Zone 2 - Essential Habitat	14,558	647	4,269	3,043	0	71%	0	480
Le Conte's Thrasher - Other Conserved Habitat	9,123	911	5,508	5,338	0	97%	0	886
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	1,221	0	17%	0	209
Gray Vireo - Other Conserved Habitat	58,985	881	7,930	6,042	0	76%	0	692
Peninsular Bighorn Sheep - Rec Zone 3 - Essential Habitat	50,972	683	5,359	5,245	40	98%	0	670
Desert Tortoise - Other Conserved Habitat	86,875	2,950	23,856	16,025	40	67%	7	2,071
Peninsular Bighorn Sheep - Rec Zone 4 - Essential Habitat	34,597	258	2,325	7,522	0	100%	0	777
Southern sycamore-alder riparian woodland	518	12	117	5	0	4%	0	2
Red shank chaparral	12,514	253	2,274	1,810	0	80%	0	207
Semi-desert chaparral	16,869	233	2,093	928	0	44%	0	116
Peninsular juniper woodland & scrub	29,547	418	2,899	3,305	0	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	1,276	0	100%	0	305
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 2019	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
<b>Snow Creek/Windy Point Conservation Area - Palm Springs</b>								
Coachella Valley Milkvetch - Core Habitat	910	91	816	256	0	31%	0	35
Peninsular Bighorn Sheep - Essential Habitat	180	16	144	22	0	15%	0	4
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	256	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	260	0	100%	0	28



	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2019	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
<b>Snow Creek/Windy Point Conservation Area - Riverside County</b>								
Coachella Valley Milkvetch - Core Habitat	1,700	134	1,210	592	46	49%	0	72
Coachella Valley Round-tailed Ground Squirrel - Core Habitat	1,880	152	1,371	653	46	48%	0	80
Coachella Valley Fringe-toed Lizard - Core Habitat	625	55	502	346	13	69%	0	40
Peninsular Bighorn Sheep - Essential Habitat	525	49	443	0	0	0%	0	5
Coachella Valley Giant Sand-treader Cricket - Core Habitat	625	56	501	346	13	69%	0	40
Le Conte's Thrasher - Other Conserved Habitat	1,924	162	1,453	698	46	48%	0	86
Coachella Valley Jerusalem Cricket - Core Habitat	782	60	538	360	13	67%	0	42
Ephemeral sand fields	468	45	409	351	13	86%	0	39
Stabilized shielded sand fields	157	10	93	157	0	100%	0	16
Highway 111 - Whitewater River Biological Corridor	474	46	415	145	0	35%	0	19
<b>Stubbe and Cottonwood Canyons Conservation Area - Riverside County</b>								
Desert Tortoise - Core Habitat	5,735	253	2,276	1,000	10	44%	29	96
Le Conte's Thrasher - Other Conserved Habitat	1,265	123	1,111	824	10	74%	0	94
Desert dry wash woodland	289	26	229	137	7	60%	0	17
Sonoran cottonwood-willow riparian forest	267	3	25	0	0	0%	0	0
Sand Transport	1,375	125	1,129	828	10	73%	0	95
Stubbe Canyon Wash Corridor	1,181	117	1,058	877	10	83%	0	99

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2019	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
<b>Thousand Palms Conservation Area - Riverside County</b>								
Coachella Valley Round-tailed Ground Squirrel - Core Habitat	8,295	450	2,886	1,988	78	69%	39	285
Coachella Valley Milkvetch - Core Habitat	4,403	111	1,001	1,019	5	100%	5	108
Desert Pupfish - Refugia Locations	0	0	0	0	0	0%	0	0
Coachella Valley Fringe-toed Lizard - Core Habitat	3,962	93	834	694	2	83%	0	79
Le Conte's Thrasher - Other Conserved Habitat	10,539	505	3,671	1,977	103	54%	34	261
Predicted Flat-tailed Horned Lizard - Core Habitat	4,118	94	870	775	20	89%	1	84
Mecca Aster - Core Habitat	11,540	277	2,623	1,346	3	51%	5	151
Coachella Valley Giant Sand-treader Cricket - Core Habitat	3,962	93	834	695	2	83%	0	79
Palm Springs Pocket Mouse - Core Habitat	11,167	468	3,399	1,958	86	58%	38	251
Desert dry wash woodland	748	4	34	3	2	9%	0	1
Active sand fields	3,543	91	820	689	2	84%	0	78
Active desert dunes	421	2	14	6	0	43%	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	12,011	519	3,615	1,911	103	53%	52	247
Sand Source	12,952	402	3,227	2,202	27	68%	5	282
Thousand Palms Linkage	24,965	919	7,238	4,093	130	57%	57	503
<b>Thousand Palms Conservation Area - City of Indio</b>								
Mecca Aster - Core Habitat	205	20	53	204	0	100%	0	71
Predicted Flat-tailed Horned Lizard - Core Habitat	30	3	7	0	0	0%	0	0
Le Conte's Thrasher - Other Conserved Habitat	519	47	208	323	0	100%	0	70

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2019	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
Coachella Valley Round-tailed Ground Squirrel - Core Habitat	218	18	88	48	0	55%	0	11
Palm Springs Pocket Mouse - Core Habitat	540	50	189	344	0	100%	0	87
Sand Transport	539	54	485	386	0	80%	0	44
Sand Source	104	10	94	104	0	100%	0	11
Thousand Palms Linkage	642	64	578	490	0	85%	0	55

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2019	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
<b>Upper Mission Creek/Big Morongo Canyon Conservation Area - Desert Hot Springs</b>								
Coachella Valley Jerusalem Cricket - Other Conserved Habitat	49	0	49	40	0	82%	1	-1
Le Conte's Thrasher - Other Conserved Habitat	1,832	288	1,409	1,029	0	73%	2	216
Palm Springs Pocket Mouse - Core Habitat	1,748	270	1,403	1,018	0	73%	2	201
Little San Bernardino Mountains Linanthus - Core Habitat	1,020	53	967	653	0	68%	0	38
Desert Tortoise - Core Habitat	3,554	0	1,429	1,018	7	71%	0	0
Desert dry wash woodland	135	6	58	27	5	47%	0	3
Sand Transport	1,869	286	1,399	1,063	26	76%	2	222
Sand Source	343	0	6	0	0	0%	0	0
Highway 62 Corridor	73	7	66	313	0	100%	0	31
<b>Upper Mission Creek/Big Morongo Canyon Conservation Area - Palm Springs</b>								
Le Conte's Thrasher - Other Conserved Habitat	24	2	22	0	0	0%	0	0
Palm Springs Pocket Mouse - Other Conserved Habitat	24	2	22	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 2019	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
<b>Upper Mission Creek/Big Morongo Canyon Conservation Area - Riverside County</b>								
Desert Tortoise - Core Habitat	24,122	887	7,984	5,302	0	66%	23	596
Triple-ribbed Milkvetch - Core Habitat	819	47	426	421	0	99%	0	46
Coachella Valley Jerusalem Cricket - Other Conserved Habitat	666	52	460	43	0	9%	11	-1
Le Conte's Thrasher - Other Conserved Habitat	1,871	146	1,323	634	0	48%	3	75
Palm Springs Pocket Mouse - Core Habitat	1,937	151	1,363	765	0	56%	2	89
Little San Bernardino Mountains Linanthus - Core Habitat	1,390	122	1,100	677	0	62%	0	80
Southern sycamore-alder riparian woodland	104	6	52	60	0	100%	0	7
Desert dry wash woodland	125	8	76	49	0	64%	0	5
Sonoran cottonwood-willow riparian forest	100	8	76	78	0	100%	0	8
Sand Transport	2,279	168	1,509	846	0	56%	0	102
Sand Source	19,789	721	6,488	4,698	0	72%	0	542
Highway 62 Corridor	907	79	715	276	0	39%	0	35
<b>West Deception Canyon Conservation Area - Riverside County</b>								
Sand Source	1,302	118	1,063	904	40	85%	0	102
<b>Whitewater Canyon Conservation Area - Desert Hot Springs</b>								
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 2019	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
<b>Whitewater Canyon Conservation Area - Riverside County</b>								
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
<b>Whitewater Floodplain Conservation Area - Cathedral City</b>								
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 2019	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
<b>Whitewater Floodplain Conservation Area - Palm Springs</b>								
Coachella Valley Round-tailed Ground Squirrel - Core Habitat	5,825	328	2,955	875	0	30%	42	78
Coachella Valley Milkvetch - Core Habitat	5,432	297	2,671	851	0	32%	37	78
Palm Springs Pocket Mouse - Core Habitat	6,173	347	3,122	892	0	29%	61	63
Coachella Valley Fringe-toed Lizard - Core Habitat	5,418	295	2,659	851	0	32%	37	77
Coachella Valley Giant Sand-treader Cricket - Core Habitat	5,418	295	2,659	851	0	32%	37	77
Le Conte's Thrasher - Other Conserved Habitat	6,495	381	3,433	907	0	26%	61	68
Ephemeral sand fields	2,873	132	1,185	518	0	44%	10	55
Stabilized desert sand fields	577	44	394	5	0	1%	0	5
Active sand fields	436	44	392	327	0	83%	0	37
Whitewater River Corridor	1,183	90	809	50	0	6%	13	1

	Total Acres in Conservation Area	Acres of Disturbance Authorized (1996)	Remaining Acres To Be Conserved (1996)	Acres Conserved Since 1996	Acres Conserved in 2019	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
<b>Whitewater Floodplain Conservation Area - Riverside County</b>								
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 2019	Percentage of Required Conservation Acquired	Acres of Permitted Disturbance	Acres of Rough Step
<b>Willow Hole Conservation Area - Cathedral City</b>								
Coachella Valley Round-tailed Ground Squirrel - Core Habitat	1,485	140	1,256	701	11	56%	0	84
Coachella Valley Milkvetch - Core Habitat	938	87	782	267	6	34%	0	35
Coachella Valley Fringe-toed Lizard - Core Habitat	264	24	212	156	2	74%	0	18
Palm Springs Pocket Mouse - Core Habitat	1,147	107	959	698	14	73%	0	81
Le Conte's Thrasher - Other Conserved Habitat	1,795	167	1,505	725	20	48%	0	89
Ephemeral sand fields	227	20	178	119	2	67%	0	14
Active sand fields	37	4	33	46	0	100%	0	5
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	682	14	85%	0	77
Sand Source	833	79	710	43	6	6%	0	12

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<b>Willow Hole Conservation Area - Desert Hot Springs</b>								
Coachella Valley Milkvetch - Core Habitat	959	96	863	419	50	49%	0	52
Coachella Valley Fringe-toed Lizard - Core Habitat	3	0	3	0	0	0%	0	0
Le Conte's Thrasher - Other Conserved Habitat	1,666	167	1,499	689	69	46%	0	86
Coachella Valley Round-tailed Ground Squirrel - Core Habitat	3	0	3	0	0	0%	0	0
Palm Springs Pocket Mouse - Core Habitat	1,713	171	1,542	712	69	46%	0	88
Ephemeral sand fields	610	61	549	260	43	47%	0	32
Stabilized desert dunes	139	14	125	51	0	41%	0	7
Stabilized desert sand fields	54	5	49	9	7	18%	0	1
Mesquite hummocks	30	3	27	16	0	58%	0	2
Sand Transport	1,713	171	1,542	712	69	46%	0	88
Mission Creek / Willow Wash Biological Corridor	308	31	277	140	19	51%	0	17

# Appendix IV

## Covered Activity Impact Outside Conservation Areas

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## CVMSHCP Annual Report 2019 - Covered Activity Impact Outside Conservation Areas

Conservation Objective / Jurisdiction	Estimated Acres Disturbed Outside Conservation Areas
<b>Arroyo Toad</b>	
Riverside County	0
<b>Arroyo Toad Total</b>	<b>0</b>
<b>California Black Rail</b>	
Coachella	0
Indio	0
Riverside County	0
<b>California Black Rail Total</b>	<b>0</b>
<b>Coachella Valley Fringe-toed Lizard</b>	
Cathedral City	568
Coachella	9
Indian Wells	589
Indio	960
La Quinta	542
Palm Desert	874
Palm Springs	1,362
Rancho Mirage	936
Riverside County	580
<b>Coachella Valley Fringe-toed Lizard Total</b>	<b>6,420</b>



<b>Coachella Valley Giant Sand-Treader Cricket</b>	
Cathedral City	568
Coachella	9
Indian Wells	589
Indio	960
La Quinta	542
Palm Desert	874
Palm Springs	1,362
Rancho Mirage	936
Riverside County	580
<b>Coachella Valley Giant Sand-Treader Cricket Total</b>	<b>6,420</b>
<b>Coachella Valley Jerusalem Cricket</b>	
Cathedral City	577
Desert Hot Springs	5
Palm Desert	6
Palm Springs	1,368
Rancho Mirage	887
Riverside County	107
<b>Coachella Valley Jerusalem Cricket Total</b>	<b>2,950</b>

<b>Coachella Valley Milkvetch</b>	
Cathedral City	499
Desert Hot Springs	8
Indian Wells	493
La Quinta	1
Palm Desert	862
Palm Springs	956
Rancho Mirage	936
Riverside County	329
<b>Coachella Valley Milkvetch Total</b>	<b>4,084</b>
<b>Coachella Valley Round-tailed Ground Squirrel</b>	
Cathedral City	804
Coachella	23
Desert Hot Springs	494
Indian Wells	918
Indio	1,475
La Quinta	1,409
Palm Desert	1,218
Palm Springs	1,646
Rancho Mirage	1,089
Riverside County	1,999
<b>Coachella Valley Round-tailed Ground Squirrel Total</b>	<b>11,075</b>

<b>Crissal Thrasher</b>	
Cathedral City	0
Coachella	35
Desert Hot Springs	0
Indian Wells	21
Indio	236
La Quinta	670
Riverside County	253
<b>Crissal Thrasher Total</b>	<b>1,215</b>
<b>Desert Pupfish</b>	
Indian Wells	0
<b>Desert Pupfish Total</b>	<b>0</b>
<b>Desert Tortoise</b>	
Cathedral City	15
Coachella	0
Desert Hot Springs	488
Indian Wells	220
Indio	0
La Quinta	438
Palm Desert	458
Palm Springs	32
Rancho Mirage	169
Riverside County	576
<b>Desert Tortoise Total</b>	<b>2,396</b>

<b>Gray Vireo</b>	
Palm Springs	0
Riverside County	29
<b>Gray Vireo Total</b>	<b>29</b>

<b>Le Conte's Thrasher</b>	
Cathedral City	943
Coachella	45
Desert Hot Springs	1,053
Indian Wells	1,176
Indio	1,476
La Quinta	1,767
Palm Desert	1,828
Palm Springs	1,601
Rancho Mirage	1,179
Riverside County	3,189
<b>Le Conte's Thrasher Total</b>	<b>14,257</b>

<b>Least Bell's Vireo - Breeding Habitat</b>	
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
<b>Least Bell's Vireo - Breeding Habitat Total</b>	<b>86</b>

<b>Least Bell's Vireo - Migratory Habitat</b>	
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
<b>Least Bell's Vireo - Migratory Habitat Total</b>	<b>832</b>

<b>Little San Bernardino Mountains Linanthus</b>	
Desert Hot Springs	1
Riverside County	0
<b>Little San Bernardino Mountains Linanthus Total</b>	<b>1</b>

<b>Mecca Aster</b>	
Indio	1
Riverside County	0
<b>Mecca Aster Total</b>	<b>1</b>
<b>Orocopia Sage</b>	
Riverside County	7
<b>Orocopia Sage Total</b>	<b>7</b>

<b>Palm Springs Pocket Mouse</b>	
Cathedral City	809
Coachella	15
Desert Hot Springs	515
Indian Wells	937
Indio	1,367
La Quinta	1,268
Palm Desert	1,292
Palm Springs	1,682
Rancho Mirage	1,136
Riverside County	2,109
<b>Palm Springs Pocket Mouse Total</b>	<b>11,130</b>



<b>Peninsular Bighorn Sheep</b>	
Cathedral City	4
Indian Wells	2
La Quinta	126
Palm Desert	209
Palm Springs	5
Rancho Mirage	5
Riverside County	23
<b>Peninsular Bighorn Sheep Total</b>	<b>374</b>
<b>Potential Flat-tailed Horned Lizard</b>	
Cathedral City	0
Desert Hot Springs	0
Palm Springs	12
Riverside County	7
<b>Potential Flat-tailed Horned Lizard Total</b>	<b>19</b>

<b>Predicted Flat-tailed Horned Lizard</b>	
Cathedral City	538
Coachella	3
Indian Wells	2
Indio	589
La Quinta	842
Palm Desert	545

Palm Springs	874
Rancho Mirage	1,360
Riverside County	924
<b>Predicted Flat-tailed Horned Lizard Total</b>	<b>5,677</b>

<b>Southern Yellow Bat</b>	
Cathedral City	0
Desert Hot Springs	1
Palm Springs	0
Rancho Mirage	0
Riverside County	0
<b>Southern Yellow Bat Total</b>	<b>1</b>

<b>Southwestern Willow Flycatcher - Breeding Habitat</b>	
Cathedral City	0
Coachella	0
Desert Hot Springs	0
Indio	0
Palm Springs	0
Rancho Mirage	0
Riverside County	0
<b>Southwestern Willow Flycatcher - Breeding Habitat Total</b>	<b>0</b>

<b>Southwestern Willow Flycatcher - Migratory Habitat</b>	
Cathedral City	5
Coachella	35
Desert Hot Springs	2
Indian Wells	209
Indio	236
La Quinta	731
Palm Desert	194
Palm Springs	7
Rancho Mirage	46
Riverside County	253
<b>Southwestern Willow Flycatcher - Migratory Habitat Total</b>	<b>1,718</b>

<b>Summer Tanager - Breeding Habitat</b>	
Cathedral City	0
Coachella	0
Desert Hot Springs	0
Indio	0
Palm Springs	0
Rancho Mirage	0
Riverside County	0
<b>Summer Tanager - Breeding Habitat Total</b>	<b>0</b>

<b>Summer Tanager - Migratory Habitat</b>	
Cathedral City	5
Coachella	35
Desert Hot Springs	2
Indian Wells	209
Indio	236
La Quinta	731
Palm Desert	194
Palm Springs	7
Rancho Mirage	46
Riverside County	253
<b>Summer Tanager - Migratory Habitat Total</b>	<b>1,718</b>
<b>Triple-ribbed Milkvetch</b>	
Palm Springs	0
Riverside County	0
<b>Triple-ribbed Milkvetch Total</b>	<b>0</b>
<b>Yellow Warbler - Breeding Habitat</b>	
Cathedral City	0
Coachella	0
Desert Hot Springs	0
Indio	0
Palm Springs	0

Rancho Mirage	0
Riverside County	0
<b>Yellow Warbler - Breeding Habitat Total</b>	<b>0</b>

<b>Yellow Warbler - Migratory Habitat</b>	
Cathedral City	5
Coachella	35
Desert Hot Springs	2
Indian Wells	209
Indio	238
La Quinta	731
Palm Desert	194
Palm Springs	7
Rancho Mirage	46
Riverside County	253
<b>Yellow Warbler - Migratory Habitat Total</b>	<b>1,720</b>

<b>Yellow-breasted Chat - Breeding Habitat</b>	
Cathedral City	0
Coachella	0
Desert Hot Springs	0
Indio	0
Palm Springs	0

Rancho Mirage	0
Riverside County	0
<b>Yellow-breasted Chat - Breeding Habitat Total</b>	<b>0</b>
<b>Yellow-breasted Chat - Migratory Habitat</b>	
Cathedral City	5
Coachella	35
Desert Hot Springs	2
Indian Wells	209
Indio	236
La Quinta	731
Palm Desert	194
Palm Springs	7
Rancho Mirage	46
Riverside County	253
<b>Yellow-breasted Chat - Migratory Habitat Total</b>	<b>1,718</b>

<b>Yuma Clapper Rail</b>	
Coachella	0
Indio	0
Riverside County	0
<b>Yuma Clapper Rail Total</b>	<b>0</b>



<b>Active desert dunes</b>	
Palm Springs	0
Riverside County	2
<b>Active desert dunes Total</b>	<b>2</b>
<b>Active sand fields</b>	
Cathedral City	0
Palm Springs	0
Riverside County	256
<b>Active sand fields Total</b>	<b>256</b>

<b>Arrowweed scrub</b>	
Riverside County	0
<b>Arrowweed scrub Total</b>	<b>0</b>
<b>Chamise chaparral</b>	
Riverside County	0
<b>Chamise chaparral Total</b>	<b>0</b>

<b>Cismontane alkali marsh</b>	
Riverside County	0
<b>Cismontane alkali marsh Total</b>	<b>0</b>

<b>Coastal and valley freshwater marsh</b>	
Coachella	0
Indio	0
Riverside County	0
<b>Coastal and valley freshwater marsh Total</b>	<b>0</b>

<b>Desert dry wash woodland</b>	
Cathedral City	0
Coachella	0
Desert Hot Springs	2
Indian Wells	187
Indio	0
La Quinta	55
Palm Desert	167
Palm Springs	0
Rancho Mirage	45
Riverside County	268
<b>Desert dry wash woodland Total</b>	<b>724</b>

<b>Desert fan palm oasis woodland</b>	
Cathedral City	0
Desert Hot Springs	0
Palm Springs	0

Rancho Mirage	0
Riverside County	0
<b>Desert fan palm oasis woodland Total</b>	<b>0</b>

<b>Desert saltbush scrub</b>	
Coachella	4
Indio	173
La Quinta	0
Riverside County	52
<b>Desert saltbush scrub Total</b>	<b>229</b>

<b>Desert sink scrub</b>	
Riverside County	60
<b>Desert sink scrub Total</b>	<b>60</b>
<b>Ephemeral sand fields</b>	
Cathedral City	0
Palm Springs	72
Riverside County	7
<b>Ephemeral sand fields Total</b>	<b>79</b>

<b>Interior live oak chaparral</b>	
Palm Springs	0
Riverside County	0
<b>Interior live oak chaparral Total</b>	<b>0</b>

<b>Mesquite bosque</b>	
Riverside County	0
<b>Mesquite bosque Total</b>	<b>0</b>
<b>Mesquite hummocks</b>	
Cathedral City	0
Coachella	2
Desert Hot Springs	0
Indian Wells	21
Indio	568
La Quinta	30
Riverside County	3
<b>Mesquite hummocks Total</b>	<b>624</b>

<b>Mojave mixed woody scrub</b>	
Desert Hot Springs	0
Riverside County	0
<b>Mojave mixed woody scrub Total</b>	<b>0</b>

<b>Mojavean pinyon &amp; juniper woodland</b>	
Riverside County	0
<b>Mojavean pinyon &amp; juniper woodland Total</b>	<b>0</b>
<b>Peninsular juniper woodland &amp; scrub</b>	
Palm Springs	0
Riverside County	0
<b>Peninsular juniper woodland &amp; scrub Total</b>	<b>0</b>
<b>Red shank chaparral</b>	
Riverside County	0
<b>Red shank chaparral Total</b>	<b>0</b>
<b>Semi-desert chaparral</b>	
Palm Springs	0
Riverside County	0
<b>Semi-desert chaparral Total</b>	<b>0</b>

<b>Sonoran cottonwood-willow riparian forest</b>	
Coachella	0
Indio	0
Palm Springs	0
Riverside County	0
<b>Sonoran cottonwood-willow riparian forest Total</b>	<b>0</b>
<b>Sonoran creosote bush scrub</b>	
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
<b>Sonoran creosote bush scrub Total</b>	<b>1,215</b>

<b>Sonoran mixed woody &amp; succulent scrub</b>	
Cathedral City	9
Desert Hot Springs	0
Indian Wells	0
Indio	1
La Quinta	7
Palm Desert	0
Palm Springs	242
Rancho Mirage	0
Riverside County	413
<b>Sonoran mixed woody &amp; succulent scrub Total</b>	<b>672</b>
<b>Southern arroyo willow riparian forest</b>	
Palm Springs	0
Riverside County	0
<b>Southern arroyo willow riparian forest Total</b>	<b>0</b>
<b>Southern sycamore-alder riparian woodland</b>	
Palm Springs	0
Riverside County	0



<b>Southern sycamore-alder riparian woodland Total</b>	<b>0</b>
<b>Stabilized desert dunes</b>	
Cathedral City	0
Riverside County	0
<b>Stabilized desert dunes Total</b>	<b>0</b>

<b>Stabilized desert sand fields</b>	
Cathedral City	0
Indio	0
Palm Springs	0
Riverside County	0
<b>Stabilized desert sand fields Total</b>	<b>0</b>

<b>Stabilized shielded sand fields</b>	
Cathedral City	356
Coachella	0
Indian Wells	589
Indio	358
La Quinta	402
Palm Desert	315
Palm Springs	260
Rancho Mirage	534
Riverside County	67
<b>Stabilized shielded sand fields Total</b>	<b>2,881</b>

# Appendix V

## 2019 Aeolian Sand Species Monitoring Report

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# Coachella Valley Multiple Species Habitat Conservation Plan

## Aeolian Sand Species Trends

2019



Prepared by The University of California's Center for Conservation Biology  
For The Coachella Valley Conservation Commission

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## Introduction

Prior to the 1950s, the dominant landscape feature of the Coachella Valley floor was aeolian sand fields. Once covering over 100 mi<sup>2</sup>, with plant and animal associations that were often restricted to these habitats, and in several cases found nowhere else on earth. Sand fields (including sand dunes) are a challenging place to live; the strong winds that create these habitats are abrasive with sands that are shifting, building, and eroding at scales ranging from hours, days, weeks, and years. Nevertheless, animals and plants that have found a way to live here often thrive, occurring at densities that can far exceed that of similar species living on adjacent, more stable alluvial and upland habitats. Reasons for the increased abundances include food resources (seeds and insects) that are blown in with same winds that created and maintain the aeolian sand habitats, and perhaps surprisingly, available water. Unlike alluvial soils which act more like a sieve, sand dunes can act as enormous sponges, absorbing rainfall and holding in below the surface, but within reach of animals and plants, for months after a rainfall event. These resources facilitate survival on an otherwise inhospitable landscape, but also require specialized adaptations. Species that have evolved to thrive on sand dunes are typically restricted to that aeolian habitat. Every dune system within the temperate latitudes has species that are restricted to that particular system. The Coachella Valley is no exception; beetles, crickets, rodents, plants and lizards occur here and nowhere else on earth. With advances in genetic analyses, new species endemic to this aeolian sand landscape will undoubtedly be described.

Along with species abundance and richness, there is also diversity within the aeolian sand landscape itself (Table 1). At the western end of the valley floor, most of the sands destined to build sand dunes and hummocks enter this system through periodic flood events from the Whitewater, Mission Creek and Morongo watersheds. This is also the windiest portion of the valley, with west winds so strong that the sands are quickly transported further east. With sand-delivering flood events being episodic and the winds more continuous, the result is a “wave” of sand moving from west to east and ultimately southeast. The “wave” is initiated with a sand deposition event (a flood). While within the “wave”, aeolian sands are 1-2 m or more deep and extensive, but over months and years, as that wave moves east, the landscape is left with more isolated sand hummocks, partially protected from the wind behind shrubs. We refer to this habitat as “ephemeral sand fields” due to its changing temporal character catalyzed by infrequent flood-sand delivery events. Further east, winds don’t have the same energy so sands have a longer residence time, and in areas where sand delivery is high build into “active sand dunes”, sometimes as crescent-shaped Barchan dunes with avalanche faces that are 5-20 m high. Peripheral to the active dunes and the main sand delivery corridors, once again sand hummocks form, which we refer to as “stabilized sand fields”. Aeolian sand captured in the Indio Hills occur as “sand ramps”. Finally, where there is, or once was a high water table, honey mesquite, *Prosopis glandulosa*, var. *torreyana*, can become established and capture aeolian sand. These habitats form yet another aeolian sand type, “mesquite hummocks (smaller) or dunes (larger)”. Each of these aeolian sand landscape types includes a unique association of plant and animal species.

The Coachella Valley’s aeolian sand landscape was irrevocably changed with the expansion of residential and resort developments onto the valley floor, beginning in the 1950s and 60s. Prior

to that time developments clustered along the edges of the San Jacinto and Santa Rosa Mountains, outside of the active aeolian sand landscape. As those area filled, housing and resort construction efforts focused on stabilizing the aeolian sands to facilitate further development. By the early 1980s no more than 5% of that original aeolian sand landscape remained intact. **No other species assemblage or natural community now protected under the Coachella Valley Multiple Species Habitat Conservation Plan (CVMSHCP) has been so severely fragmented, lost so much habitat area, and had its ecosystem processes (sand transport systems) so compromised.**

In 1980 one of the Coachella Valley's aeolian sand flagship species, the Coachella Valley fringe-toed lizard, *Uma inornata*, was listed as threatened under the federal Endangered species Act (ESA) and endangered under the California ESA. Those listings did not result in even a slight pause in the rate of aeolian sand habitat loss to development. In 1982 the federal ESA was ammended (Section 10a) to facilitate collaborative efforts to find mechanisms to both protect listed species and at the same time preserve the ability of local communities to maintain economic viability – named Habitat Conservation Plans (HCPs). That “promise” brought key stakeholders to the table, self-referred to as the “Lizard Club”, to craft what they hoped to be a permanent solution for balancing conservation and economic prosperity. The Coachella Valley fringe-toed lizard HCP was signed in April, 1986, and was the first HCP in the nation that had been initated and completed after the 1982 ammendment to the ESA. Three aeolian sand preserves were designated, the largest of which was entirely in private ownership, divided into dozens of small parcels with separate ownerships. A funding mechanism was put together for both land acquisition and on-going management activities that included private donations, developer fees, the State of California, and the federal government. This first in the nation HCP was ground breaking in many ways, however in their desire to keep costs managable, the Lizard Club made assumptions about the directions of future development and argued land did not need to be purchased if it was not within a likely future development footprint. Those assumptions proved to be naïve. Development did expand into those “undevelopable lands” threatening to shut down key sand transport corridors.

To resolve this problem, stakeholders decided in 1996 to expand the single species lizard HCP into the CVMSHCP that would ultimately protect 27 species, six of which reside within the aeolian sand habitats. Signed in 2008, the CVMSHCP subsumed the original lizard HCP and its generated funds, and expanded protection to five aeolian sand preserves; the CVMSHCP is explicit regarding the annual need to monitor the fringe-toed lizard populations so that it is not “lost” in an effort to address each of the other 26 species as well.

Without the initial “Lizard HCP” and then the CVMSHCP, the host of species endemic to the Coachella Valley's aeolian sand habitats would almost certainly be extinct today. Continued housing and resort development, blocking sand corridors, fragmentation, and off-road vehicle recreation would have taken their toll and extinguished these species. Still, even with these conservation plans in place, there are still substantial threats to these species. Are the sand corridors sufficiently intact? In areas where the sand corridors are clearly compromised (such as the west Indio Hills, Willow Hole, Stebbins Dune and Snow Creek areas) are there management



techniques to keep the existing habitats suitable for the covered species? Does the existing level of fragmentation compromise population viability? Are translocations needed, and if so how do we make them effective? Will the invasive weed Sahara mustard, *Brassica tournefortii*, collapse the food web that the native species depend on? How effective are mustard control methods? Will modern climate change render the aeolian sand landscape uninhabitable? Are there locations that will provide refugia for climate aeolian species? (see Table 2 for additional details).



## Monitoring Structure

Monitoring for monitoring sake, to fulfill minimum plan requirements, is a waste of finite resources. Monitoring results should be able to address an identified potential threat, lead to a management action, or indicate no change in current management is required at that time. The framework for this approach is the Scientific Method; ask a question (is this weed a threat impacting this population or community?), develop an hypothesis that identifies appropriate metrics (this weed may reduce habitat suitability by reducing food availability – so measure weed density vs food resources vs the target species' population response). Then design and implement a sampling approach that collects the appropriate data. Based on those results decisions can be made and management actions can be focused and prioritized. This approach to monitoring represents, like the original lizard HCP, a new and more effective methodology to meet conservation objectives.

One of the challenges for understanding the impacts of threats in hyper-arid environments such as the Coachella Valley is that rainfall, its timing and however much or little there is in a critical season is often the primary driver of population fluctuations. Partitioning the effect of potential threats from rainfall effects is necessary for informing management actions. Based on the monitoring timing and/or the breeding strategy of the covered species the effect of rainfall may be the same year as the monitoring occur, or there may be a lag of a year before those rainfall effects are apparent. Rainfall is a critical variable to be included; Figure 1 shows the patterns of rainfall on the Coachella Valley floor since 1979. The figure represents the Standard Precipitation Index (SPI) that illustrates the departure from long-term mean rainfall levels, showing the relative degree of drought or wet condition in any given year.

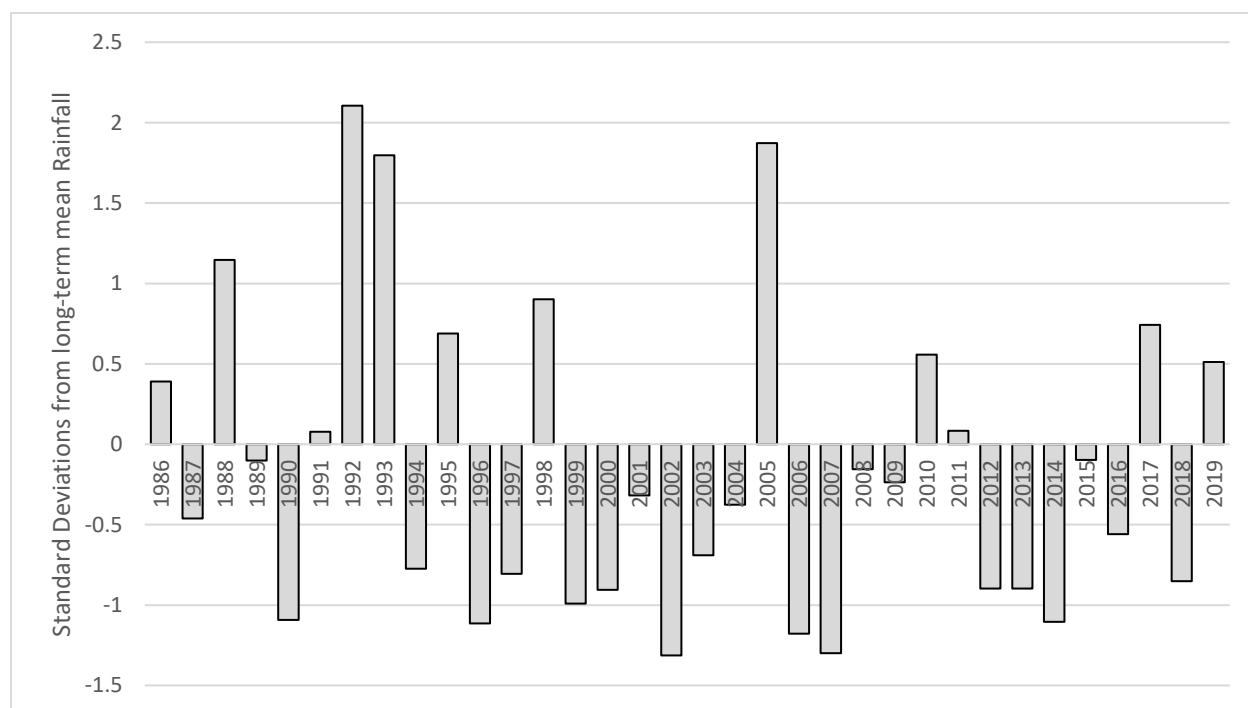


Figure 1. Standard Precipitation Index for the Coachella Valley floor for annual rainfall (July-June). Values more  $\geq$  1 standard deviation below the mid line were considered drought years.



Figure 2. Standard Precipitation Index for the Coachella Valley floor for winter-springs rainfall (November through March). Rainfall during these months catalyzes germination and growth of annual plants, which then fuel the Aeolian sand habitats' food web. Years with negative SPI values typically have little or no annual plant growth.

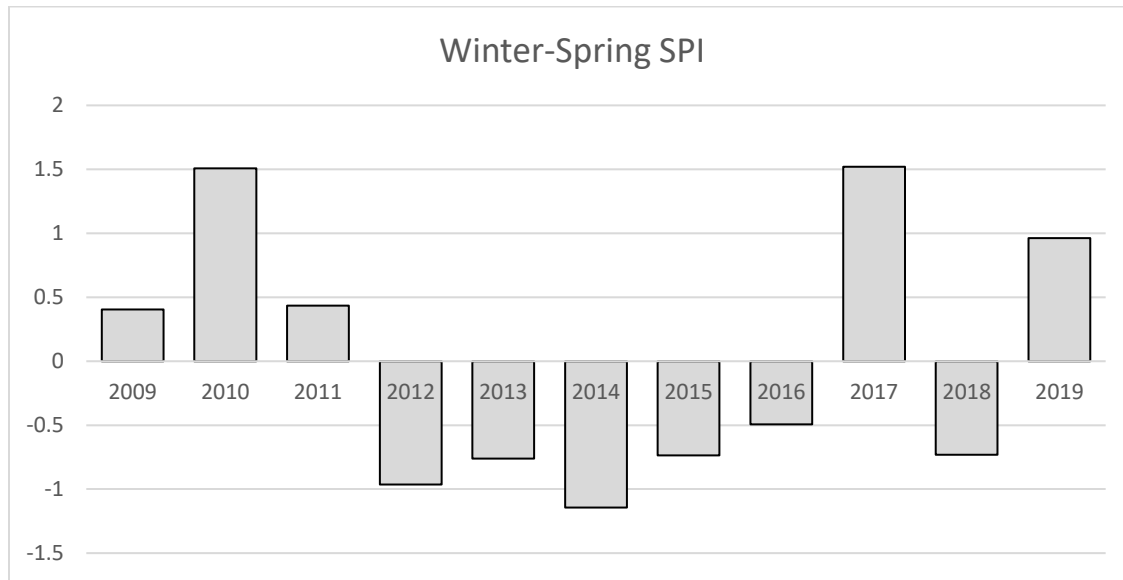


Table 1. The number and distribution of aeolian sand survey plots across the aeolian sand categories surveyed in 2019

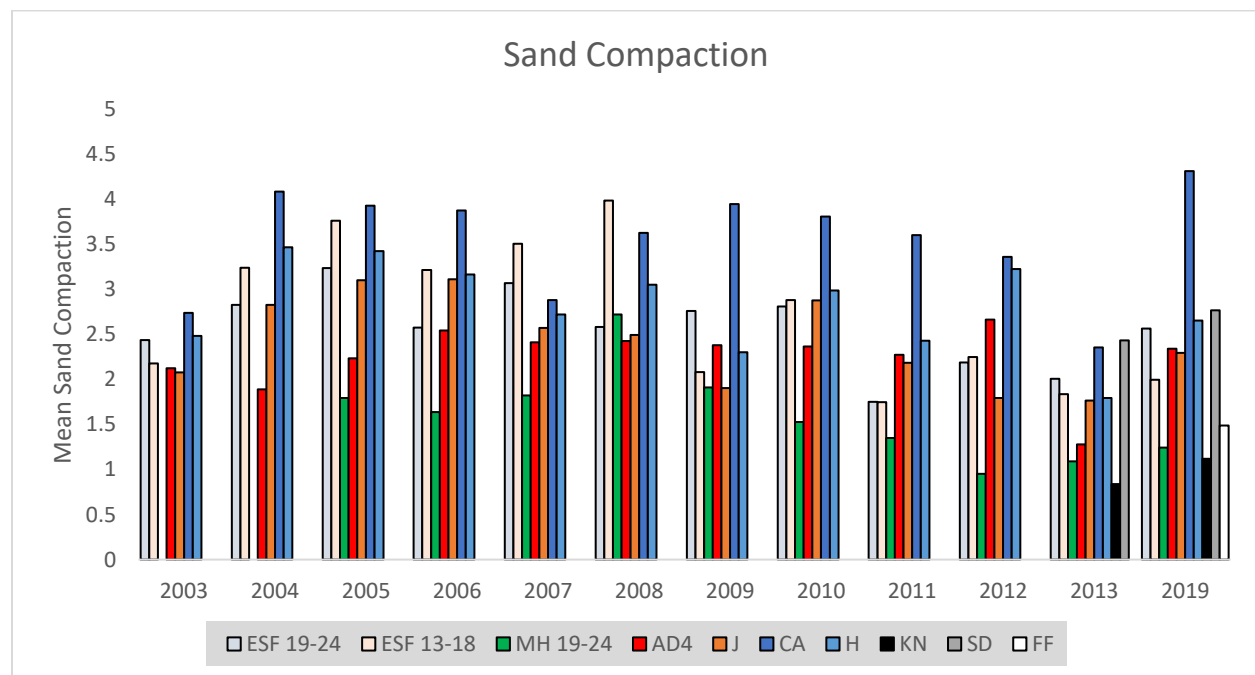
Plot Clusters	Number of Plots	Aeolian Sand Category
AD2	6	Active Dune
AD4	6	Active Dune
J100-250	4	Active Dune
MH 11-12	2	Active Dune
H	7	Stabilized Sand Field
L	7	Stabilized Sand Field
MH7-10	5	Stabilized Sand Field
J0-50	3	Stabilized Sand Field
MH 19-24	6	Mesquite Dunes
MH 25-29	5	Mesquite Dunes
ESF 7-12	6	Ephemeral Sand Field
ESF 13-18	6	Ephemeral Sand Field
ESF 19-24	6	Ephemeral Sand Field
SD 2-6	5	Ephemeral Sand Field
FF1-3	3	Ephemeral Sand Field
KN 1-3	3	Sand Ramp
Total	80	

Table 2 .Current questions regarding the covered species of the Coachella Valley aeolian sand habitats.

Question	Hypothesis	Metrics	Potential Management Actions	Concerns	Key Plot Clusters for Management
Has habitat fragmentation resulted in reduced genetic heterogeneity in the fringe-toed lizard?	Smaller, more isolated habitats should show reduced genetic heterogeneity first.	Check patterns of genetic heterogeneity on a decadal cycle. Continued erosion of heterogeneity could be an indication for management action	Translocate lizards to reconstruct historic genetic patterns	Genetic shifts may represent local adaptation. Translocation could be counterproductive.	All
		Follow population dynamics. If populations decline despite sufficient rainfall, it could indicate inbreeding depression		Translocation techniques require refinement to improve success.	
Are compromised sand transport corridors causing habitat and then population declines?	Sand stabilizes where sand delivery is insufficient.	Using a sand penetrometer, record compaction values annually	To the extent possible secure all sand transport corridors  Mechanical de-stabilization of the sand		SD KN MH 19-29 ESF 7-24
		Follow population dynamics. Are declines associated with measured stabilization?	Transport sand from non-preserve areas	Introduction of new weeds	
Is Sahara mustard (or other weeds) reducing the sustainability of aeolian sand species?	The mustard crowds out native plants, stabilizes aeolian sands, and are not palatable to native invertebrates or vertebrates	Follow population dynamics with respect to mustard densities. Check for increased sand stabilization Check for arthropod declines	Hand pulling works but only in relatively small areas  Chemical applications may be needed	Chemicals may have non-target impacts  Continued drought may keep the mustard at low densities, obviating the need for control efforts	AD2 AD4 J MH 7-12 H L C
Will modern climate change cause the extinction of some or all the covered species?	Climate change will impact smaller and more eastern habitat patches first	Follow population dynamics. Are declines associated with warmer/drier conditions	Build shade structures to provide cool refugia. Add water – artificial irrigation		All

Another metric that can influence species' abundance and occurrence on aeolian sands is sand compaction. Factors that influence sand compaction include sand depth, and the sand transportation dynamics of the site (newly arrived or recently disturbed sands are less compacted, while stationary sands become incrementally more compacted). Therefore, sites where sand transport processes are blocked have more compacted sands (unless disturbed by rodent burrowing or ORVs). We measured sand compaction with a "Sand Penetrometer", taking measurements every 4 m along the center line of each 0.1 ha plot (25 measurements/plot) and calculating the mean value for the plot cluster (3-7 plots clustered within an aeolian sand community type). Values on the penetrometer range from 0 (no resistance) to 5 (no penetration), and convert to kg/sq cm when multiplied by 16 (a conversion factor used with the foot adapter necessary in loose aeolian sand habitats). Sands that are less compacted (mean  $\leq 2.5$  on the compaction scale) are more suitable for supporting fringe-toed lizard populations, whereas more compacted sands (mean 2.5 - 4 on the compaction scale) are typically more suitable for flat-tailed horned lizards, and values greater than 4 are unsuitable for both lizard species. Figure 3 shows the distribution of mean compaction values across the plot clusters and the years when compaction was measured.

Figure 3. Mean sand compaction measures by plot cluster



Over the years, the location and number of plots have varied depending on questions asked or condition of the plots. At the Coachella Valley National Wildlife Refuge – Thousand Palms Preserve, due to concerns about habitat fragmentation, additional plots addressed whether there was an edge effect, and if so, what was its cause? There was an edge effect, but only for flat-tailed horned lizards, *Phrynosoma mcallii*. American kestrels, *Falco sparverius*, nesting in an adjacent golf resort community, were preying upon the lizards by hunting from power lines along the preserve edge (Barrows et al. 2006). We placed eight clusters of seven plots each along the preserve edge to answer that question; once the question was answered five of those clusters were then retired. In other cases, plot clusters were retired because of the lack of covered species occurring on them. We retired plot clusters at the north end of the Coachella Valley Preserve, at the fault line dunes, along Snow Creek Road, and at the Dos Palmas ACEC for that reason. In 2018 we added plot clusters at Stebbins Dune (SD 2-6) and the Kim Nicol Trail (KN 1-3), and in 2019 we added three new plots at the far west end of the CVMSHCP aeolian habitats, north of the San Gorgonio wash across from Fingal’s Finger (FF1-3).

We used 0.1 ha plots (10 m x 100 m) to evaluate relative species abundances across the aeolian sand habitats of the Coachella Valley. This size is large enough to give relatively stable counts spanning repeated sampling, allows us to sample more plots (with repeated and replicated surveys) within a short weather-window (+/- six weeks), than would a larger size, and so facilitates statistical testing for the significance of between year shifts in abundance. Using a marked population of flat-tailed horned lizards in 2001 through 2003 we compared density estimates from 0.1 ha plot counts versus actual densities and found a high within year correlation ( $r^2 = 0.9 - 0.81$  for each year). For each plot, we correlate rainfall, annual and perennial vegetation, arthropods, and vertebrate use at that location. This allows us to start with the driver of primary productivity (rainfall), responses to rainfall (native and non-native invasive annual and perennial plants), responses to primary productivity (arthropods), and responses to food resources and well as interspecific interactions (the co-occurrence of predators, competitors, and target species). We distributed these plots across the aeolian sand categories as shown in Table 1.

## Monitoring Results

### Plants

#### Coachella Valley Milkvetch

Coachella Valley milkvetch, *Astragalus lentiginosus* var *coachellae*, occurs in its greatest abundance on the ephemeral sand fields, which are represented on the Whitewater Floodplain Preserve south of the railroad and between Indian Avenue and Gene Autry Trail, and just west of Windy Point. Populations with fewer numbers occur farther east on the Thousand Palms Preserve, possibly due to finer sand particles, reducing their seed scarification capacity, and/or reduced average rainfall. At habitats with reduced sand movement, including stabilized sand fields and mesquite dunes this species is much rarer and less predictable in its occurrence.

Figure 4 illustrates the changing patterns of milkvetch abundance over the past decade. Two patterns emerge; first, rainfall did not positively correlate with high milkvetch abundance. Rather their appeared to be a negative correlation. Second, plots with the highest milkvetch densities shifted after 2014 from the Windy Point region (ESF 19-24) to the Whitewater Floodplain Preserve (ESF 7-12). Sand scarification of the milkvetch seeds may explain these patterns. Wet years (without flooding) stabilize the aeolian sand habitats, and so reduce sand scarification. The Windy Point-Snow Creek region is west of the Whitewater River sand source; that region is dependent on sand input from the San Gorgonio wash further west. The San Gorgonio has received considerable development and it is unclear if future floods will be able to transport new sands. This may be an early indication of the effects of a compromised sand corridor for this protected area.

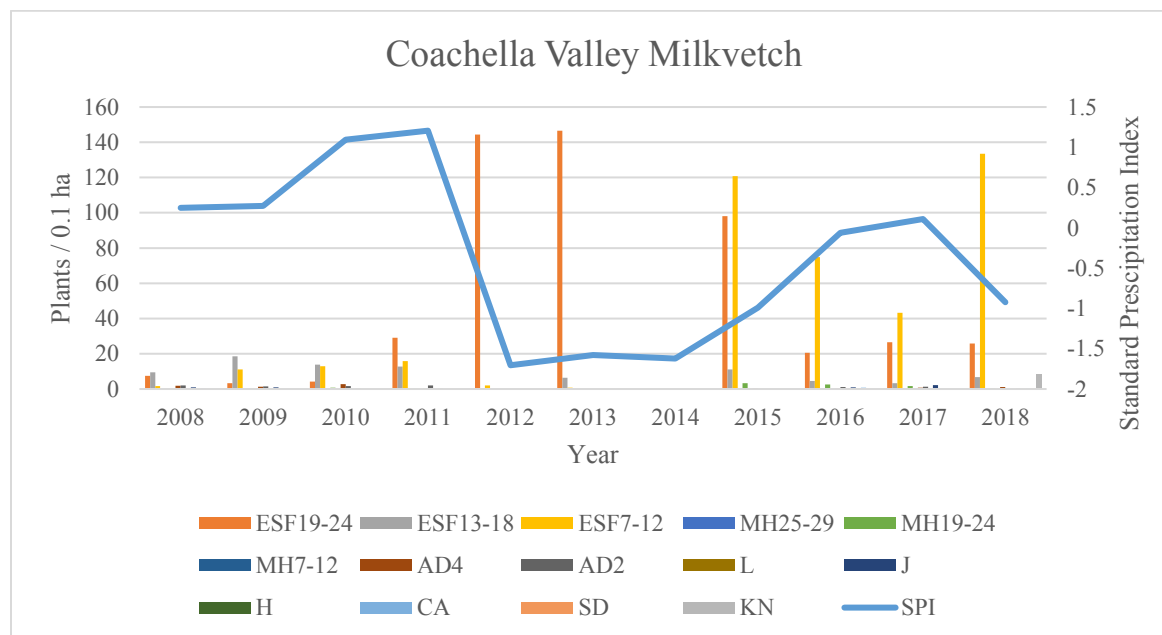


Figure 4: Coachella Valley Milkvetch population density/0.1 ha across the 14 surveyed plot clusters over time. The blue line represents winter Standard Precipitation Index. See Table 1 for plot names and their habitat types. We did not collect data in 2014 at the request of the wildlife agencies.

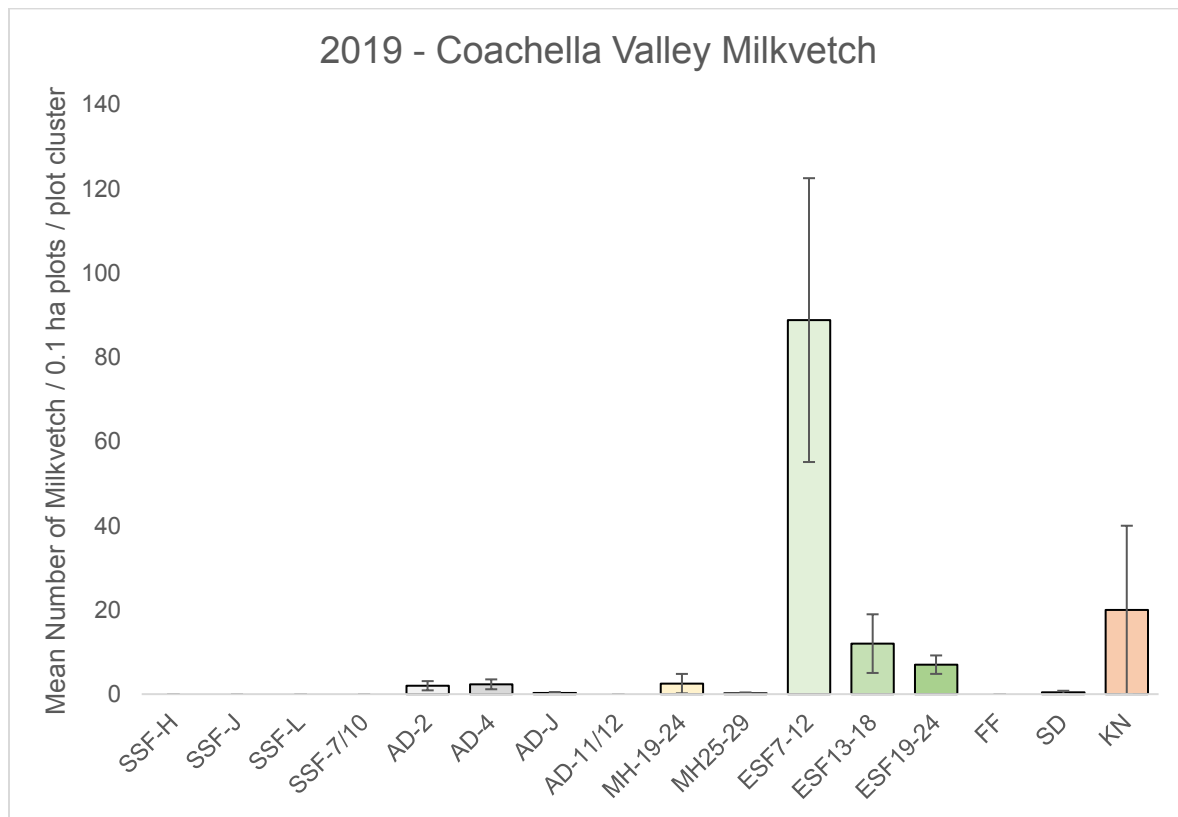


Figure 5. 2019 monitoring results – all sites

The 2019 patterns are a continuation of those shown in Figure 5, with the Tipton Road (ESF 19-24) falling behind the Whitewater Floodplain Preserve (ESF 7-18), and the Kim Nicol trail (KN) sites. The lack of new sand inputs, and the subsequent aeolian loss of existing fine sands is ongoing. While no new sands are entering the Kim Nicol plots, they are not leaving either. The moderate sand disturbance by off road vehicles appears to be sufficient to keep the sands from stabilizing.

## Annual Plant Monitoring

We surveyed native and invasive annual plant abundance and coverage 1 m x 1 m quadrats arranged along our 0.1 ha plots (Figure 6). Following an extremely successful year for native annuals on the CVP in 2017, overall percent cover of both native and invasive annuals has predictably returned to historically low levels due to lower winter precipitation this year (Figure 1). The high coverage of invasive annuals from 2008 to 2011, particularly on the CVP (AD and SSF), was mostly comprised of Sahara Mustard and is a result of consecutively early winter rains which this plant favors (Figure 7). In contrast, the high coverage of annuals on the CVP in 2017 was the result of above-average amounts of late winter precipitation, which the native plants favor. A combination of drier conditions and later winter rains since 2012 has resulted in an overall reduced coverage of invasive annuals.



Figure 6. Schematic of plot design. The twelve small squares show the layout of the  $m^2$  frames where annual vegetation density and cover is measured. The three solid circles represent where arthropod pitfalls are placed. The center lined running the length of the plot is used as a line intercept to quantify perennial plant cover on the plot.

From 2008 to 2011, there was significantly higher invasive annuals coverage on the mesquite dune, active dune and stabilized sand field sites (Figure 4). Those same community types increased their species richness in 2016 through 2019, when there was less coverage of non-natives (Figure 5). Also notable is the steady increase in species richness at our westernmost

survey site, ESF19-24, since 2012. The cause of this increase in diversity was not associated with reductions in non-native species and is unknown, but may be due to changes in precipitation patterns, temperatures, and/or changes in levels of sand activity.

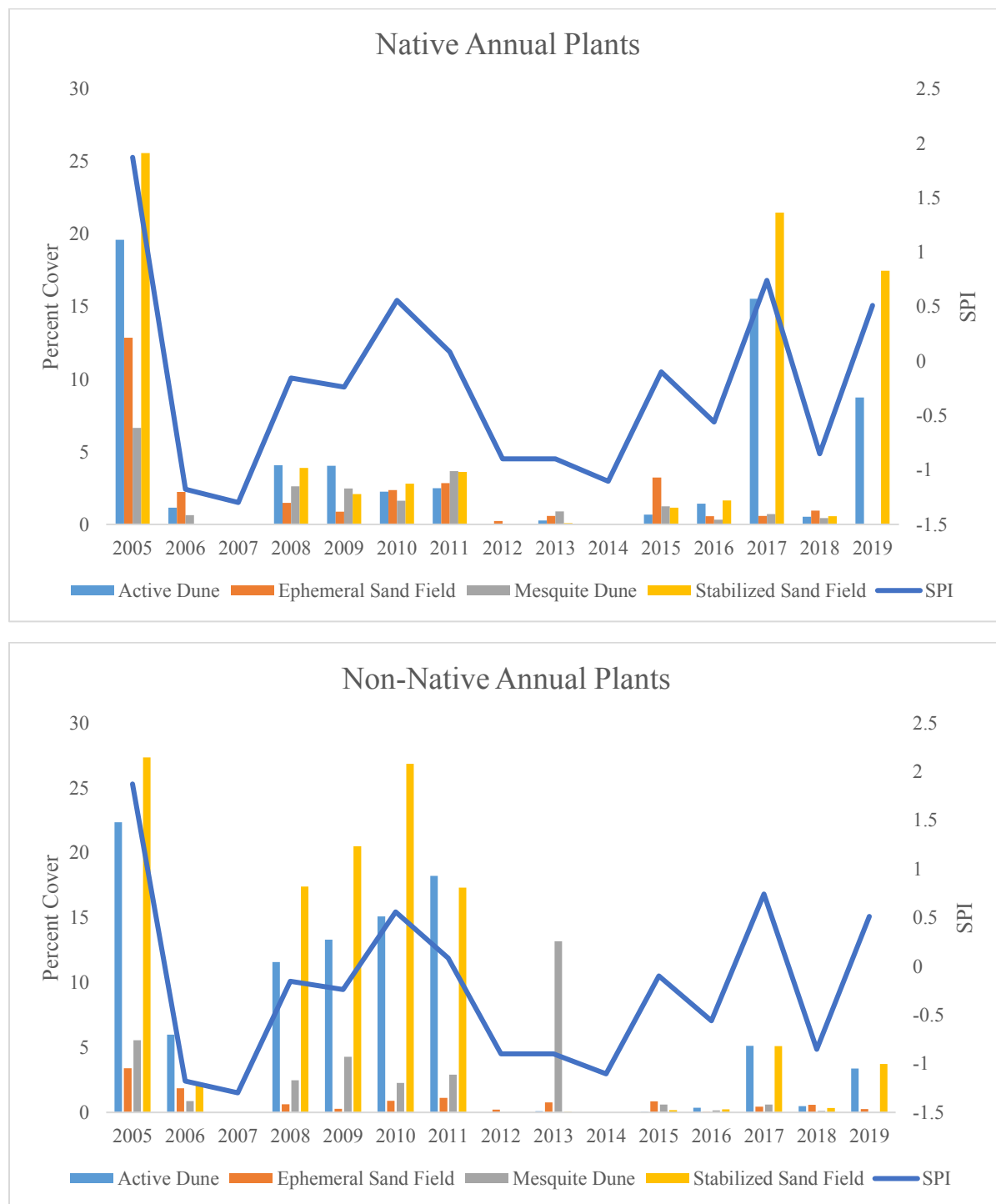


Figure 7. Mean percent coverage of native and invasive annuals across four aeolian habitats over time. ESF = ephemeral sand field, MH = mesquite hummock, AD = active dune, SSF = stabilized sand field. We did not collect data in 2014 at the request of the wildlife agencies.



## Arthropod Monitoring

### Ants and Beetles

We monitored ground-dwelling arthropod communities throughout the Coachella Valley's aeolian habitats from mid-June to mid-July. These surveys utilize non-lethal pitfalls set at regular intervals along our 10 x 100m aeolian habitat transects. We placed three pitfalls along each transect (one at both ends and one in the center), which equates to 9 to 21 pitfalls per plot cluster. We installed them on days preceding a night with mild wind to ensure the traps would not be filled with sand, and we checked them the following morning. Our primary objectives are to 1.) identify arthropod species or species assemblages that we can use to help characterize habitat types, 2.) document how these species' abundance changes over time and correlate this to changing landscapes, specifically loss of sand, and 3.) monitor changes in harvester ant abundance, a critical food source for flat-tailed horned lizards (*Phrynosoma mcallii*) and Coachella Valley fringe-toed lizards (*Uma inornata*).

### Darkling Beetles

Our pitfalls sample a large diversity of arthropods, but the two insect groups that dominate in abundance are darkling beetles (family Tenebrionidae) and ants (family Formicidae). Within Tenebrionidae, two closely-related species, the smooth death-feigning beetle (*Asbolus laevis*) and the blue death-feigning beetle (*Asbolus verrucosus*) are the most commonly collected beetles. *Asbolus laevis* appears to be mostly restricted to aeolian habitats with abundant loose, active sand, such as active dunes and mesquite hummocks. By contrast, *A. verrucosus* prefers more stabilized landscapes with a denser shrub canopy, such as stabilized sand fields. While these two species share some overlap in habitat selection, this general distinction may be a useful indicator when tracking changes in sand habitat over time, as we expect *A. laevis* abundance will decrease as sand leaves an area, and *A. verrucosus* abundance should increase.

As expected, our results demonstrate that *A. laevis* occurs in highest abundance on active dunes (Fig 8). This species is also abundant on the Kim Nicol Trail plots, indicating that this area may most closely resemble an active sand dune community. However, the 2019 pitfalls on the Kim Nicol plots also yielded high amounts of *A. verrucosus*, which would seemingly contradict this assessment. This discrepancy is likely explained by the easternmost plot at Kim Nicol, which produced the majority of the *A. verrucosus*, being more stabilized and having higher plant cover than the remaining plots in that area. Abundance of *A. verrucosus* is low and *A. laevis* is entirely absent at the ephemeral sand field plots (data not shown), at Stebbin's Dune, and at Fingal's Finger, indicating that Stebbin's Dune and Fingal's Finger may share characteristics of an ephemeral sand field. *A. laevis* abundance may be showing a weak downward trend on active dunes, indicating that stabilization may be taking place. 2019 efforts yielded low numbers of both species across the CVNWR, perhaps due to 2018 being a very dry year. These beetles may take close to a year to reach maturity (and thus be detectable by pitfalls), so the above-average rainfall seen in late 2018 and early 2019 may result in a rebound of the population by 2020.

*A. laevis* abundance appears to be a good indicator of Coachella Valley fringe-toed lizard habitat suitability, with both species preferring active sand landscapes. An exception exists at the ephemeral sand fields throughout the White Water Floodplain Preserve, where both species of *Asbolus* are very rare or absent but fringe-toed lizards are common.

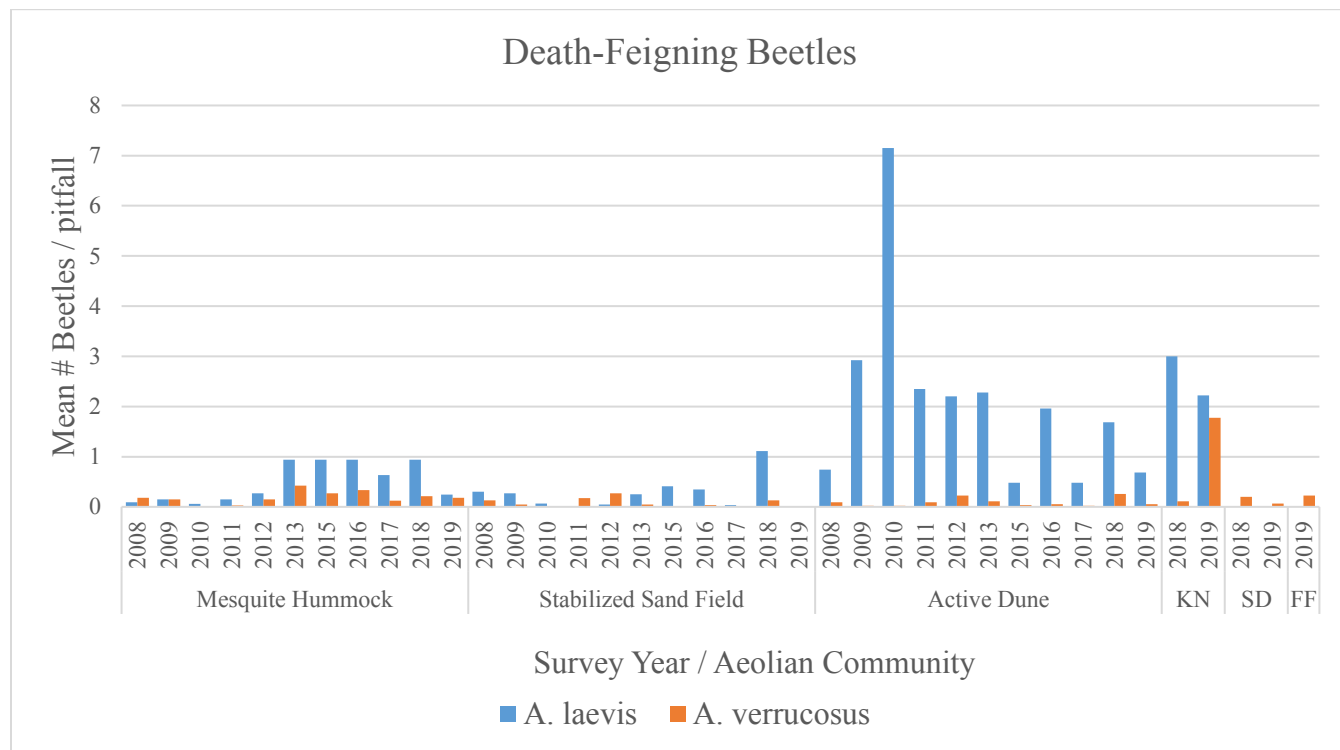


Figure 8: pitfall survey results for death-feigning beetles (*Asbolus laevis* and *A. verrucosus*) since 2008. KN = Kim Nicol Trail, SD = Stebbin's Dune, FF = Fingal's Finger.



*Asbolus laevis*



*Asbolus verrucosus*

## Ants

Harvester ants are the most commonly collected arthropods across all aeolian habitat types and serve as an essential food source for flat-tailed horned lizards and Coachella Valley fringe-toed lizards. As their name suggests, they are also prodigious seed predators and thus play critical roles in regulation of plant abundance and plant dispersal. The ubiquitous California bearded harvester ant (*Pogonomyrmex californicus*) is extremely abundant throughout stabilized sand fields and active dunes and is present in moderate amounts through mesquite hummocks. The congeneric *P. magnacanthus* generally co-occurs with *P. californicus* in much lower abundance. However, both of these species are relatively rare on the White Water Floodplain ephemeral sand fields, their niche filled instead by the smooth harvester ant (*Veromessor pergandei*).

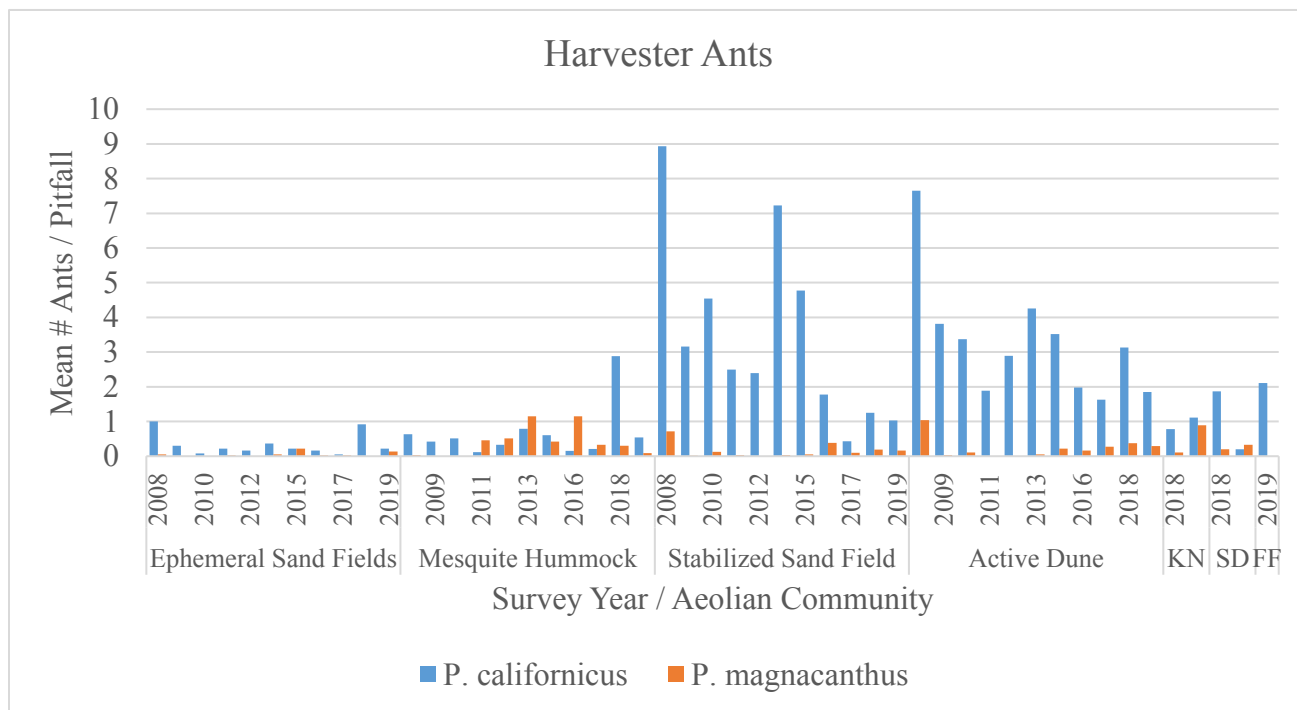


Figure 9: pitfall survey results for bearded harvester ants (*Pogonomyrmex californicus* and *P. magnacanthus*) since 2008. KN = Kim Nicol Trail, SD = Stebbin's Dune, FF = Fingal's Finger.



*Pogonomyrmex californicus*

In 2019, *P. californicus* abundance was at its second lowest level since 2008 and third lowest on active dunes, supporting a general downward-trend of *P. californicus* populations in these habitat types (figure 9). This species should not be affected by dune stabilization, so the cause for decline is currently unknown. However, we hypothesize that severe invasion of these habitat types, particularly throughout stabilized sand fields, by Sahara mustard (*Brassica tournefortii*) may be a contributing factor. Sahara mustard aggressively competes with native annuals and may lead to a reduction of native seeds available to harvester ants. While there are now massive amounts of mustard seeds available to the ants, it is unknown if these seeds are palatable or able to sustain a colony to the same degree as native seeds. We are currently conducting laboratory-based diet experiments using *P. californicus* colonies to determine what effect a diet heavy in Sahara mustard has on colony founding and sustainability.

We have investigated the usefulness of differences in ant species composition and abundance as a tool for aeolian community categorization. Using a DCA ordination analysis, we illustrated the relatedness between the major aeolian communities (active dune, stabilized sand field, ephemeral sand field, and mesquite hummock) based on the mean number of six ant species collected per pitfall since 2008 (Figure 10). We also included data from our new plots at the Kim Nicol Trail, Stebbin's Dune, and Fingal's Finger to assess if ant species composition data are useful for determining which of the major community types these areas most closely represent. The plots at Tipton Road (ESF 19-24) and the White Water Floodplain Preserve (represented here by ESF 13-18) are both considered to be ephemeral sand fields, but for the purposes of this analysis we chose to split them based on in-field observation of differences in ant species composition.

Four main groups emerge from the DCA ordination analysis:

- Stabilized sand fields and active dunes (dominated by *P. californicus*)
- Mesquite hummocks/stable dunes (high in *Myrmecocystus kennedyi* and *Dorymyrmex* abundance and fairly high *P. californicus* abundance)
- Westernmost ephemeral sand fields, near Tipton Road (high in *Dorymyrmex* sp. and *M. kennedyi*, fairly low *P. californicus* abundance)
- White Water Floodplain Preserve, (high in *Veromessor pergandei*, *Forelius pruinosus*, and *Myrmecocystus tenuinodis* abundance, low abundance of other species)

Based on the results of this analysis, it appears that Kim Nicol, Stebbin's Dune, and Fingal's Finger fall somewhere between an active dune/stabilized sand field and a mesquite hummock/stabilized dune. However, we have only surveyed Kim Nicol and Stebbin's Dune twice, and Fingal's Finger only once, so it is likely that the addition of more data from these plots will help add resolution to this analysis. Also, we recently determined that *P. californicus* found at the mesquite hummocks around Willow Hole are largely a concolorous red morph, unlike the surrounding areas which are the typical distinctive red-and-black morph. This may have led to mistakes in the amount of *P. magnacanthus* recorded from this area in the past, as these ants are also concolorous red and can be very difficult to tell apart from a concolorous red *P. californicus*. We decided to exclude this species from the analysis, although inclusion of *P.*

*magnacanthus* in the analysis still supported the same general groupings (results not shown). The analysis also clearly supports our suspected separation between the White Water Floodplain Preserve and the westernmost ephemeral sand fields based on ant species composition and abundance.

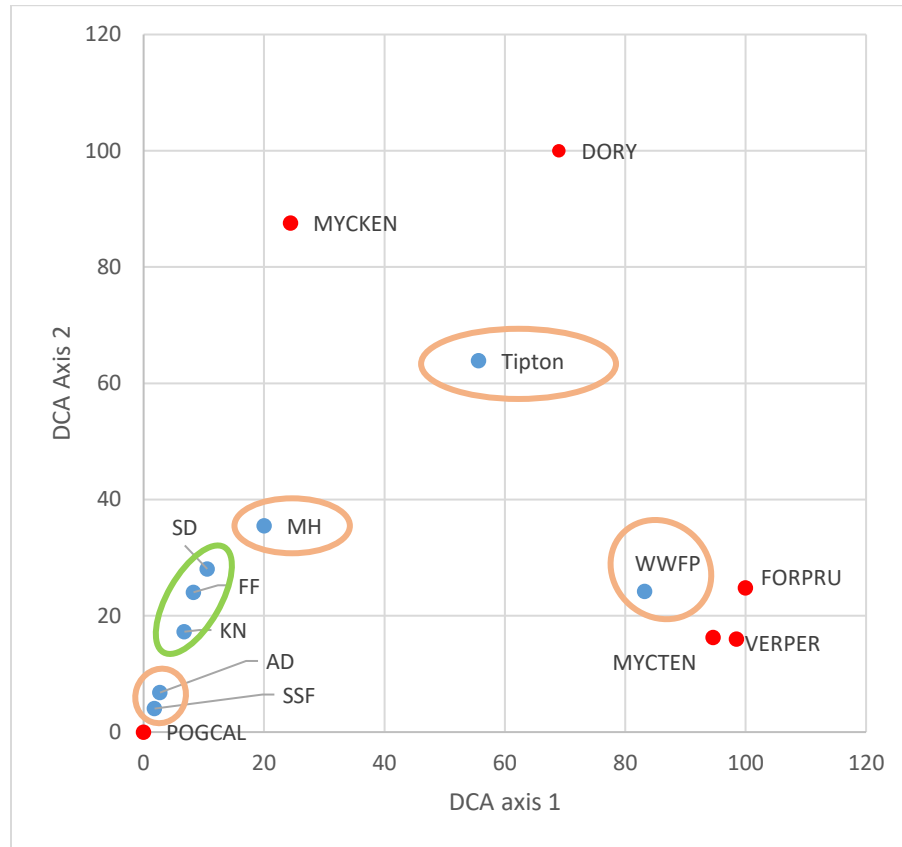


Figure 10: DCA ordination analysis showing separation between eight plot clusters based on mean ants per pitfall data for six ant species since 2008. Proposed groupings are circled. Groups with data collected since 2008 are circled in orange. The group containing newly-monitored plots is circled in green. SSF = stabilized sand fields, AD = active dune, KN = Kim Nicol, FF = Fingal's Finger, SD = Stebbin's Dune, MH = mesquite hummock, Tipton = Tipton Road ephemeral sand fields, WWFP = White Water Floodplain Preserve, POGCAL = *Pogonomyrmex californicus*, MYCKEN = *Myrmecocystus kennedyi*, DORY = *Dorymyrmex* sp., FORPRU = *Forelius pruinosus*, MYCTEN = *Myrmecocystus tenuinodis*, VERPER = *Veromessor pergandei*.

Aalbu, R. L. (1985). *Systematics and biology of the Cryptoglossini (Coleoptera, Tenebrionidae)* (Doctoral dissertation, The Ohio State University).

Barrows, C. W., Allen, E. B., Brooks, M. L., & Allen, M. F. (2009). Effects of an invasive plant on a desert sand dune landscape. *Biological Invasions*, 11(3), 673-686.

Barrows, C. W., & Allen, M. F. (2010). Patterns of occurrence of reptiles across a sand dune landscape. *Journal of Arid Environments*, 74(2), 186-192.

MacMahon, J. A., Mull, J. F., & Crist, T. O. (2000). Harvester ants (*Pogonomyrmex* spp.): their community and ecosystem influences. *Annual Review of Ecology and Systematics*, 31(1), 265-291.

## Coachella Valley Giant Sand-treader Cricket

The Coachella Valley Giant Sand-Treader Cricket (*Macrobaenetes valgum*, or CVGST) is a large raphidophorid camel cricket endemic to the Coachella Valley. This cricket is found only in areas with an abundance of loose, well-sorted sand, such as active sand dunes and ephemeral sand fields. The lifecycle of this species is closely tied to rainfall, with nymphs (juveniles) reaching a size large enough to be easily observed (roughly a bit under half-grown) around December to January after the arrival of winter rains. They reach adulthood around late spring and disappear almost completely by July with the onset of the hottest and driest part of the year, leaving behind eggs and small nymphs that appear to remain largely dormant through summer.

CVGST forage at night and take refuge throughout the day in burrows constructed into sand banks, which reach down to moist soil. Their excavating behavior produces a diagnostic “deltoid” or fan-shaped, pile of sand tailings at the mouth of their burrows. We counted these easily recognized deltoid tailings as a metric to estimate population density throughout our series of 0.1ha aeolian habitat plots. We surveyed each 0.1ha plot once during the monitoring season for presence of CVGST burrows. They dig a new burrow every morning, we took care to differentiate old, unoccupied burrows from occupied burrows by whether the burrow entrance is open (unoccupied) or closed (occupied).

This year, as with previous years, we conducted monitoring of CVGST on the Coachella Valley National Wildlife Refuge throughout February and March (Figure 11). CVGST densities on the CVNWR are comparable to previous years, with the exception of lower-than-normal densities on the CA plot cluster. That decline, which is explained by the flooding that occurred in that area, resulted in the removal of almost all of the sand on those plots, leaving behind a packed silt layer that is likely too hard for the crickets to construct burrows into. The cricket densities on active dunes throughout the CVNWR in 2019 are almost identical to 2018 (Fig.12), but the other aeolian habitat types showed a slight decrease in average cricket density. This may be due to sampling these sites in April, later than we sampled them last year, the difference of which may have been enough time for the cricket populations to noticeably decline.

We have previously demonstrated that CVGST abundance correlates closely to changes in annual rainfall. However, even on the CVNWR, the cricket populations do not appear to have notably increased since 2018 in spite of much higher rainfall in 2019 (40 mm in 2018 versus 110 mm in 2019, Figure 2). In addition, similar to last year, we did not detect CVGST during our pitfall surveys in 2019. The likely explanation includes the low rainfall in 2018, reducing the number of individuals that survived to 2019. We expect to see higher population numbers next year due to the high precipitation and annual plant growth present in winter/spring 2019, which should greatly facilitate a productive breeding season. Also, large sand dunes can retain moisture for long periods, so it is possible that these dunes can act as a temporary refuge against drought (assuming there is at least one good rainfall) and still maintain healthy CVGST populations even in dry years

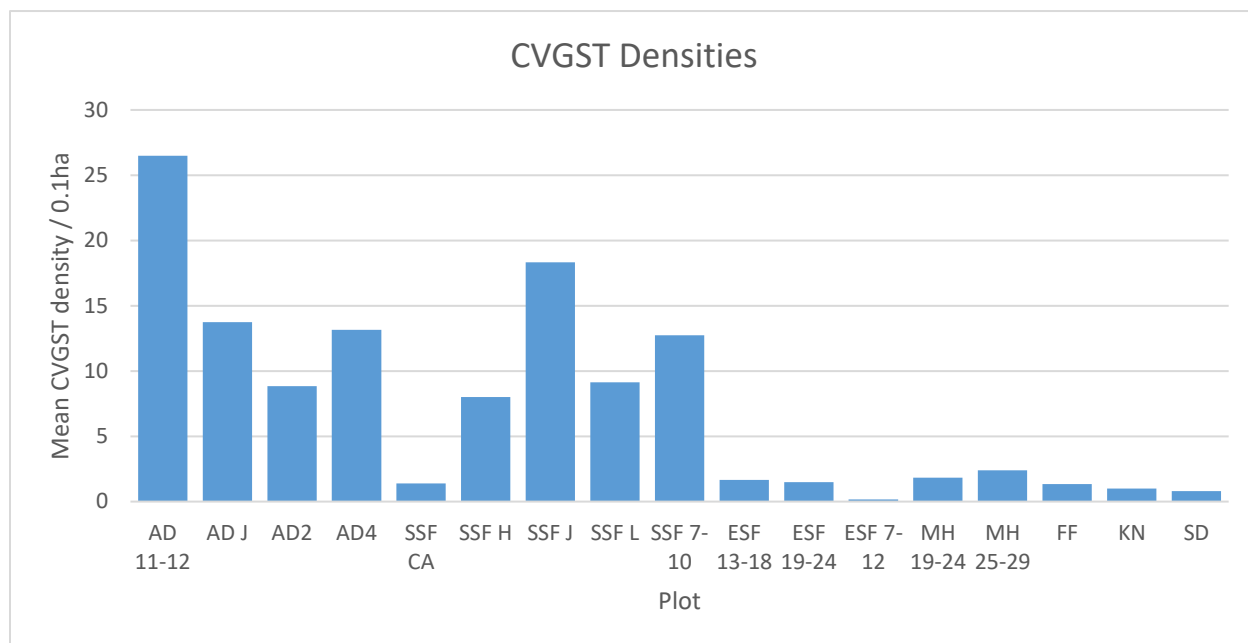


Figure 11: Results of 2019 CVGST monitoring across aeolian habitats, by plot cluster. AD = Active Dune, ESF = Ephemeral Sand Field, SSF = Stabilized Sand Field, MH = Mesquite Hummock, FF = Fingal's Finger, SD = Stebbin's Dune, KN = Kim Nicol Trail

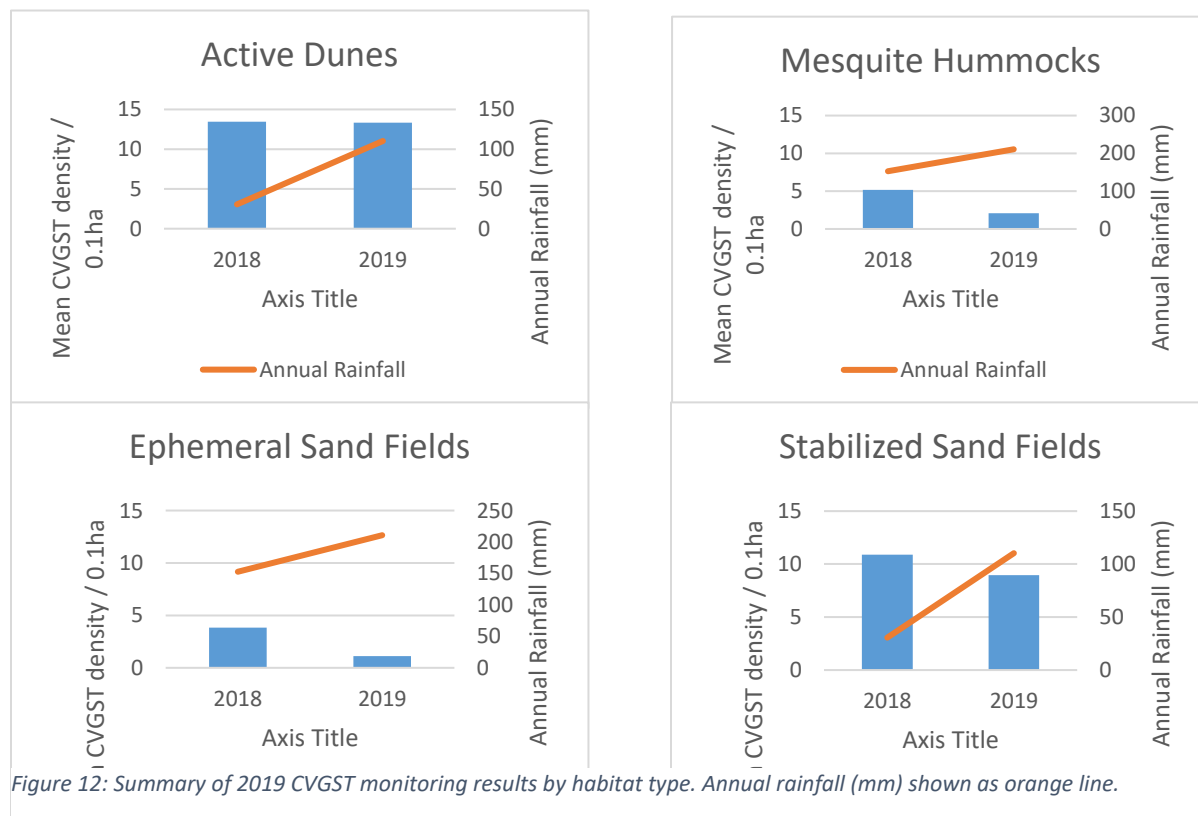


Figure 12: Summary of 2019 CVGST monitoring results by habitat type. Annual rainfall (mm) shown as orange line.



Human activity on Avenue 38, along the southern border of the CVNWR, appears to play an unexpected positive role in CVGST densities. The shoulders on this road are periodically cleared of encroaching sand from the large dune on the CVNWR, leaving behind deep berms of fine sand that often host relatively high numbers of CVGST (Figure 13, plots J 000 and L 000). These berms also likely experience additional water runoff from the road, contributing to the formation of desirable CVGST habitat. However, it is unknown how the crickets respond to repeated clearing; the process of sand clearing may cause high cricket mortality of individuals occupying the existing berm, as one would expect with such a violent disturbance, and the resulting newly formed berm may have to be reoccupied after each clearing.



Figure 13: CVGST counts for 2018 and 2019 of two plot clusters on the CVNWR that parallel Avenue 38. Distance from road is indicated in the plot name (e.g. J 050 is 50 meters from the road). Plots J 000 and L 000 border Ave 38 and include portions of the sand bank created by road clearing.



Barrows, C. W. (2012). Temporal patterns of abundance of arthropods on sand dunes. *The Southwestern Naturalist*, 57(3), 262-267.



## Vertebrate Surveys

### Palm Springs Pocket Mouse

Palm Springs pocket mice, *Perognathus longimembris bangsi*, (PSPM) occur in fine-textured sandy areas of the Coachella Valley. They are not restricted to aeolian sands, but do occur throughout the valley's aeolian sand communities. Our survey method, similar with all the vertebrates included here, is to quantify their abundance based on the mean number to their distinctive track ways left within our 0.1 ha plots. The only other pocket mouse that commonly occurs within the aeolian communities is the desert pocket mouse, *Chaetodipus penicillatus*, whose tracks are typically nearly double the size of a PSPM track.

Figure 14 reveals a substantial increase in PSPM starting in 2015 and continuing to increase through 2018. This increase corresponds with a drought period, so do PSPM prefer conditions that are more arid? Possibly, but our data support an alternative hypothesis, that the hyper arid conditions resulted in reduced population densities of kangaroo rats and desert pocket mice; all are probable competitors to PSPM, especially desert pocket mice. With a decline in competitors, the PSPM flourished, despite (or indirectly because of) the drought. Another alternative hypothesis is that with the drought-related reduction of Sahara mustard (see Figure 7); PSPM had access to ground that is more open and a wider array of annual plant seeds. The problem with that hypothesis is that some of the large increases in PSPM occurred on the western plots, where the mustard has never been a problem. Palm Springs pocket mouse abundances in 2019 are shown in Figure 15.

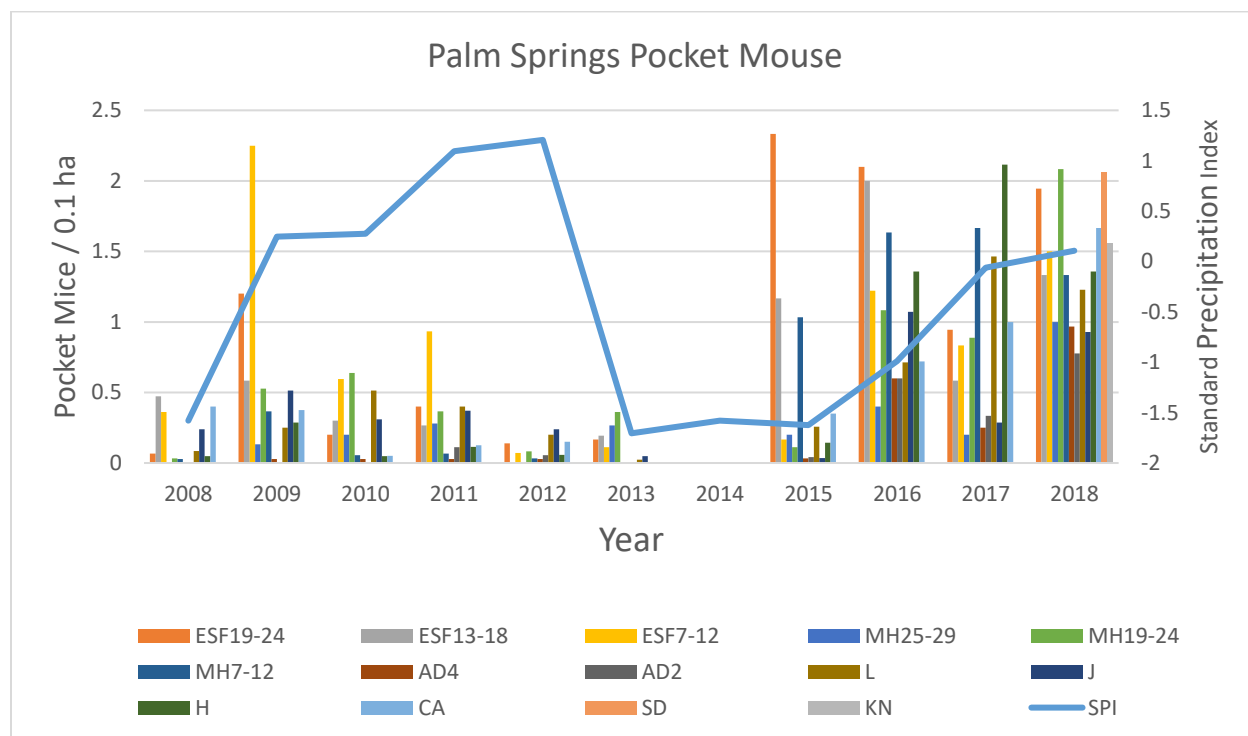


Figure 14. Temporal patterns of abundance of Palm Springs pocket mice across the Aeolian sand habitats of the Coachella Valley. The SPI is off-set by one year to account for the one year lag time most vertebrate show between rain and population responses. We did not collect data in 2014 at the request of the wildlife agencies.

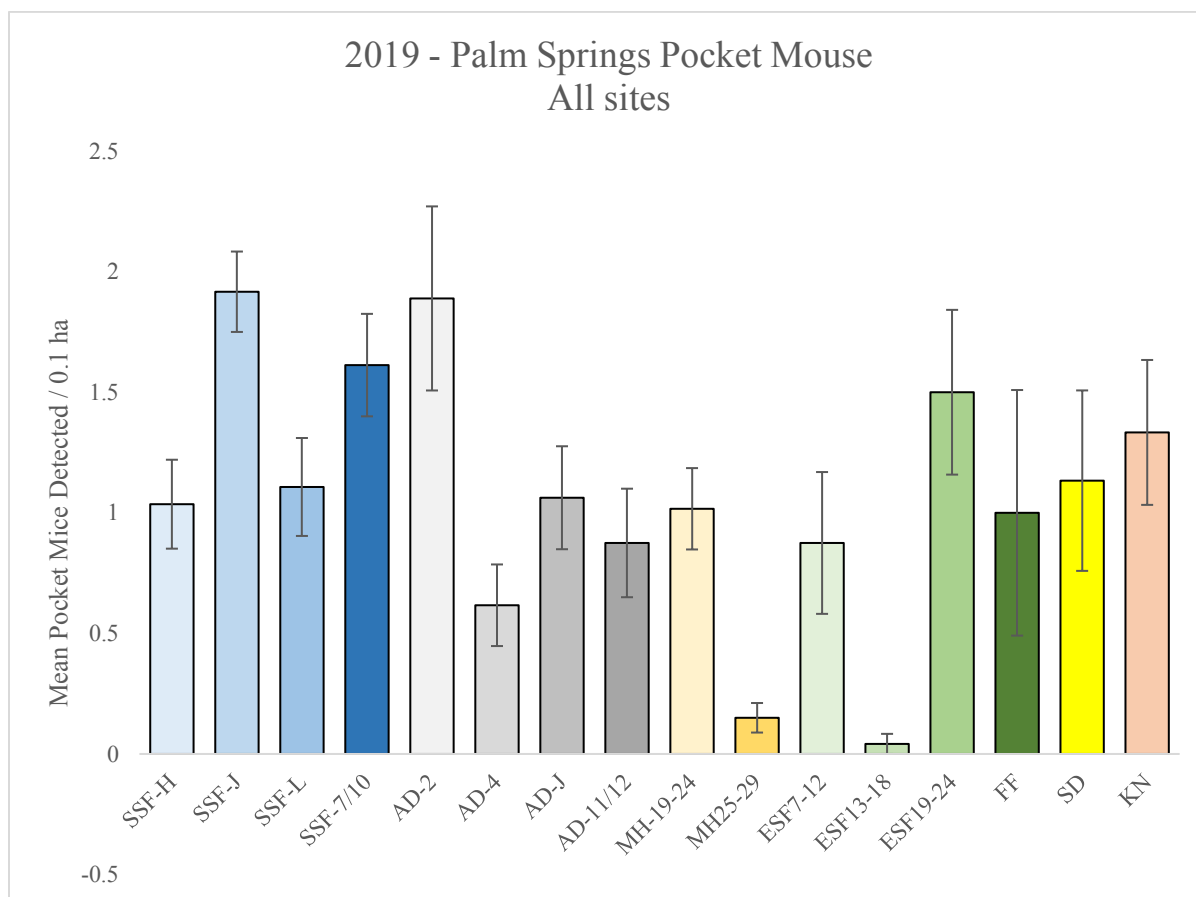


Figure 15. Palm Springs pocket mouse abundance across all plot clusters in 2019.

## Round-tailed Ground Squirrel

Round-tailed ground squirrels (RTGS), *Xerospermophilus tereticaudus chlorus*, occur in fine-textured sandy areas of the Coachella Valley. Antelope ground squirrels replace RTGS in gravelly and rocky soils. RTGS are mostly restricted to aeolian sands, and occur throughout the valley's aeolian sand communities, as well as in urban gardens along wildland-urban interfaces where soils are appropriate. Our survey method, similar with all the vertebrates included here, is to quantify their abundance based on the mean number to their distinctive track ways left within our 0.1 ha plots. Unlike other (non-avian) vertebrates, RTGS are quite vocal when occurring at high densities; there we use their distinctive alarm calls and tracks (whichever provides the higher number) to tabulate occurrences within our plots. However, at low densities, they rarely vocalize and we can only use their tracks for surveys.

Except for in the mesquite dune plots, RTGS are sensitive to drought (Figure 16). Within the mesquite dunes, they show year-to-year variation in numbers that roughly correlate with annual in precipitation (Figure 17). The explanation for the lack of a stronger rainfall response is that the mesquite are typically tapped into aquifer-based water sources and not reliant on annual rainfall. In areas where the mesquite have died, RTGS densities drop to match those on non-mesquite aeolian communities.

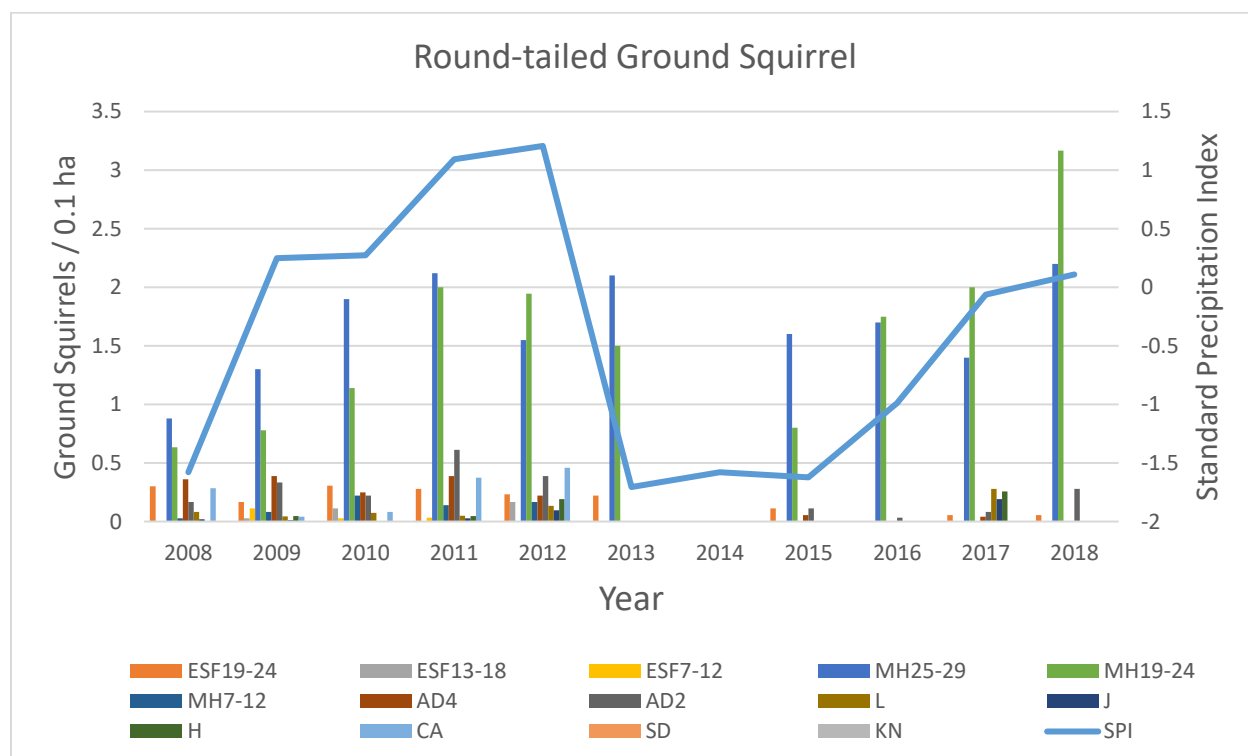


Figure 16. Temporal patterns of abundance of round-tailed ground squirrels across the aeolian sand habitats of the Coachella Valley. The SPI is off-set by one year to account for the one year lag time most vertebrate show between rain and population responses. We did not collect data in 2014 at the request of the wildlife agencies.

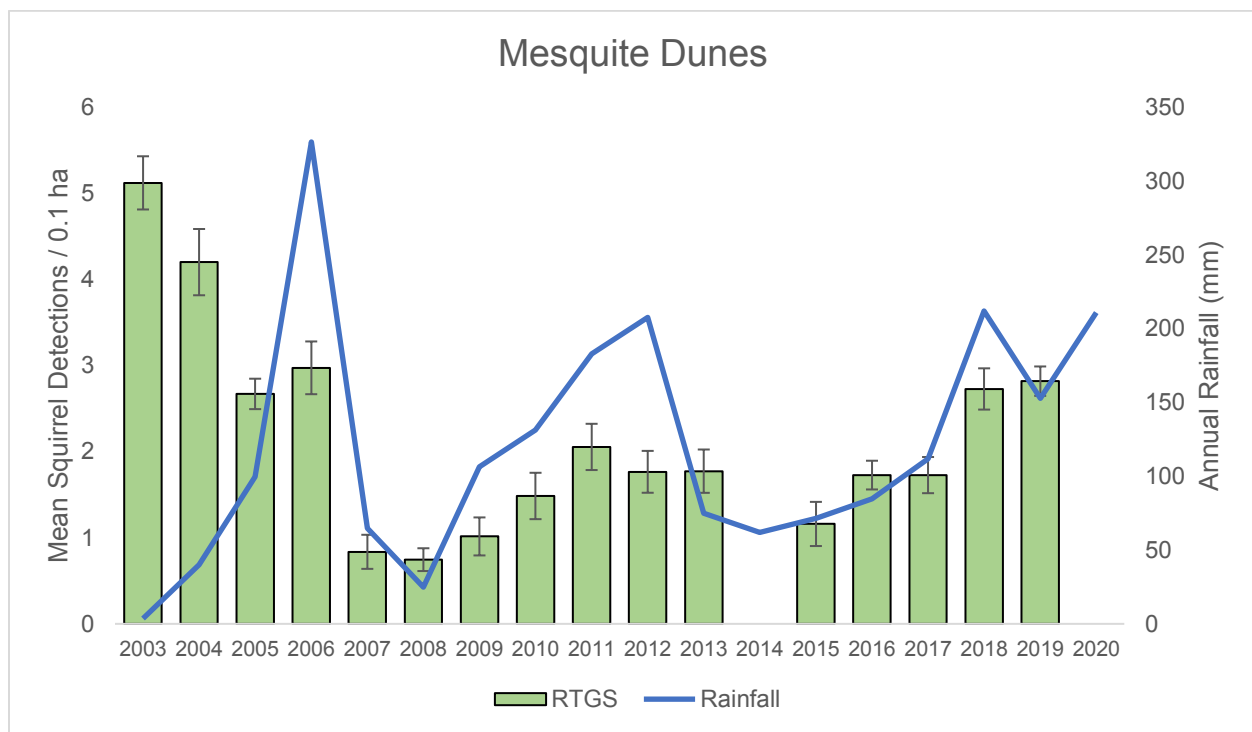


Figure 17. Annual variation in Coachella Valley round-tailed ground squirrels occurring on the Willow Hole Mesquite dunes in relation to rainfall (offset by one year).

## Flat-tailed Horned Lizard

Flat-tailed horned lizards (FTHL), *Phrynosoma mcallii*, occur at their northern-most edge of their range in the Coachella Valley. Historically there was likely continuous habitat connecting the Coachella Valley FTHL populations to populations in the Borrego Valley and perhaps East Mesa regions of San Diego and Imperial counties. Those connections were severed by agricultural development in the southern Coachella Valley and throughout Imperial County. Within the Coachella Valley, as recently as the 1980s and early 1990s FTHL were much more broadly distributed in the Coachella Valley, occurring as far west as the Whitewater Floodplain Preserve, the southern flanks of Edom Hill and east to the east end of the Indio Hills. At the Whitewater Floodplain Preserve, they co-occurred with desert horned lizards (DHL), *P. platyrhinos*. Today DHL remain on that site, as well as on the Stebbins' Dune site (southwestern flank of Edom Hill), and are common throughout the Indio Hills. DHL are apparently less sensitive to the stressors that have affected FTHL here. There are no sightings of FTHL at any of those locations since the early 1990s. Additionally, stabilized sand fields within the Dos Palmas ACEC have provided habitat for an isolated FTHL population east of the railroad right of way. Located and surveyed by BLM biologist Mark Massar in 2005, we established plots there in 2014 and surveyed those plots from 2014 through 2017 (Figure 13). In 2017, we found no FTHL on our seven Dos Palmas plots; the FTHL population at Dos Palmas appears to be below detection levels. We have temporarily retired those plots in the hope that wetter/normal weather conditions will return and bring that population back to levels where surveys can be effective. Despite land protection efforts beginning in the 1980s, along with the CV Jerusalem cricket, FTHL are one of the only species, indigenous to the Coachella Valley's valley floor, which are now absent from preserved lands within its original range here. It is not entirely clear why they are gone from those sites, but habitat fragmentation, climate change (drought and heat being especially severe at the below sea level lands of the Dos Palmas ACEC) and off-road vehicle recreation all appear to be contributing factors.

The CV Refuge / CVP is the only habitat within the CVMSHCP where FTHL continue to thrive. Its large size, relative to the other protected areas, may be the primary reason FTHL have persisted there. Nevertheless, there on-going stressors affecting FTHL at this site. These include enhanced predation levels from subsidized predators including American kestrels, *Falco sparverius*, and greater roadrunners, *Geococcyx californicus*. The subsidizing component is that for both predators there are no suitable nest sites within the protected habitat; nest sites, provided through planting of non-native trees outside (and inside – by CDFW on CDFW lands) the protected lands, allow these predators to take high numbers of FTHL within a 100-150 m border of the preserve. FTHL are now rare to absent altogether from this border area (Figure 19). We identified this stressor in 2005-2006. Solutions include removing trees suitable for nesting, or trimming them to remove nest sites; both include working with adjacent private landowners. Edge impacts such as these fall under the broader effects of habitat fragmentation. The larger the protected area the less important (influences to population sustainability) are negative edge influences.

A second, more broadly reaching stressor is Sahara mustard (SM), *Brassica tournefortii*. The effect of SM include the reduction of native plant species, the related reduction of native

arthropod species (especially harvester ants, the primary food for FTHLs, Figures 7 and 9), and the canopy closing of what were otherwise open sand fields. Control efforts have included hand pulling and chemical treatments. Both are effective but the scope of the problem is so large, that efforts to date have had impacts to a small proportion of the extent of the SM infestation. The best treatment for SM has been drought (Figure 7).

The substantial decline of FTHL on stabilized sand fields in 2019 (Figure 18), is alarming, and likely represents the effect of much of their habitat having been inundated by flooding during the 2019 winter rains. No similar decline was apparent on the adjacent active dunes that are elevated above the flood zone. Monitoring in coming years will determine how well this population and their habitat will recover.

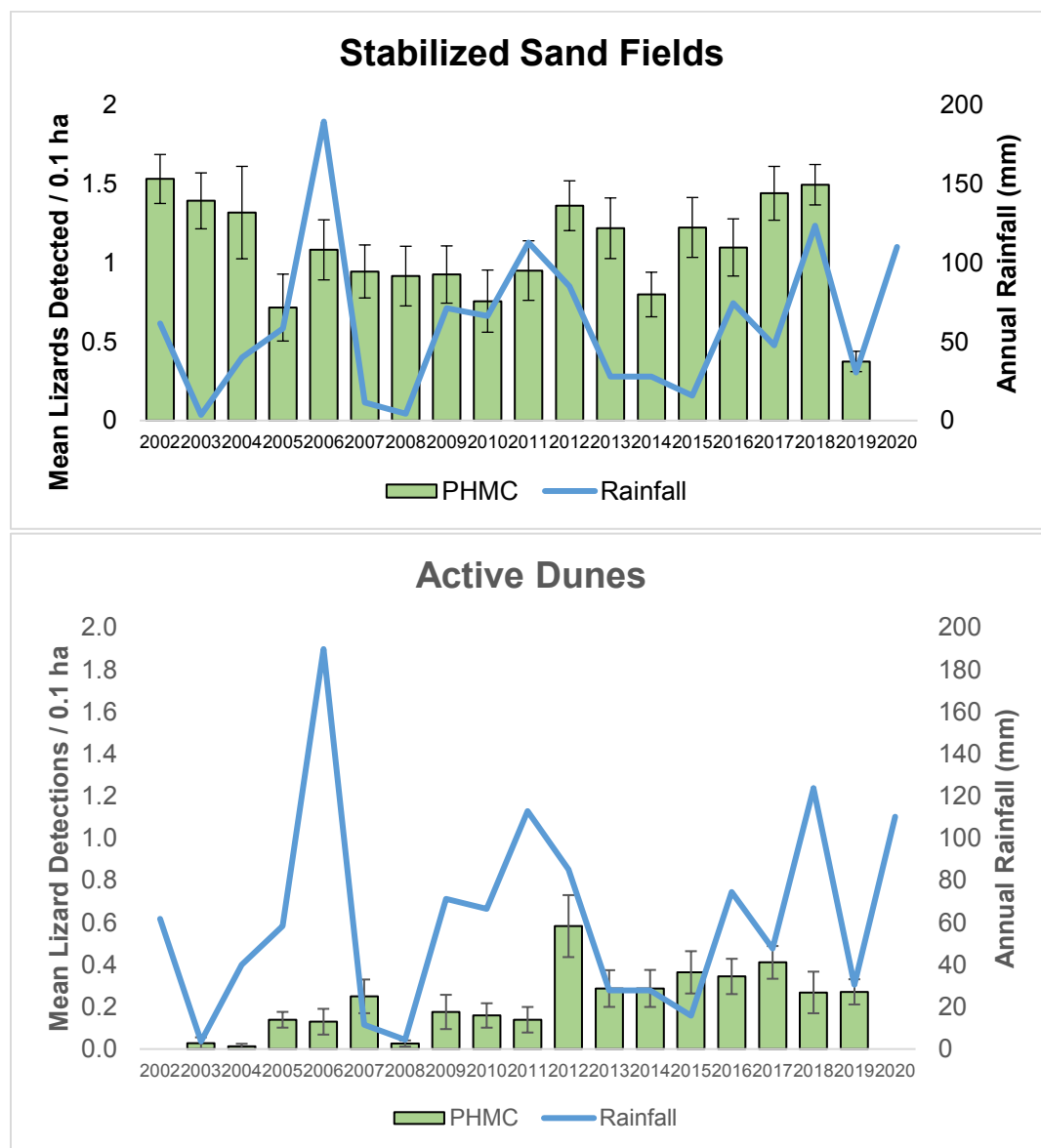


Figure 18. Temporal patterns of abundance of flat-tailed horned lizards across the aeolian sand habitats of the Coachella Valley. The rainfall is off-set by one year to account for the one year lag time most vertebrate show between rain and population responses.

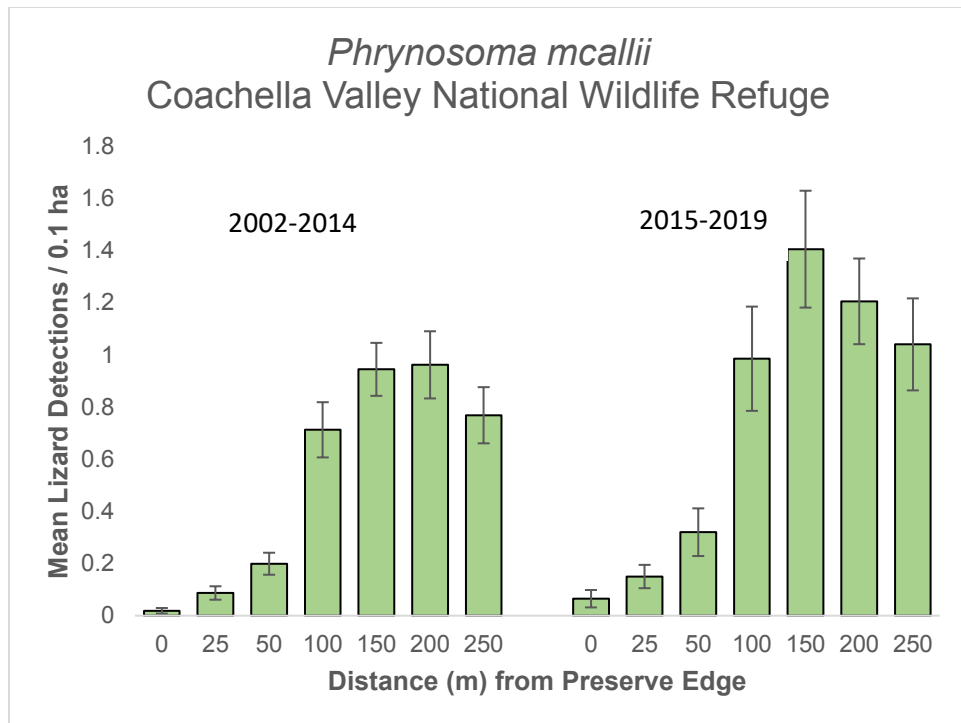


Figure 19. Abundance of flat-tailed horned lizards relative to the Refuge/Preserve edge.



## Coachella Valley Fringe-toed Lizard

Coachella Valley fringe-toed lizards (CVFTL), *Uma inornata*, are the flagship species for the conservation of aeolian sand habitats of the Coachella Valley (see Introduction). CVFTL have what appear to be persistent, if not thriving, populations on each of the five areas that have been set aside to protect this species (CV Refuge / CVP, Willow Hole, West Indio Hills / Kim Nicol Trail, Whitewater Floodplain Preserve, and the Windy Point Preserve) (Figure 14). Nevertheless, there are long-term stressors that need to be monitored, and if warranted, managed. Those stressors include:

- Habitat and population fragmentation. There is little or no genetic communication between the five protected areas. Empirically, other than direct habitat loss, fragmentation is implicated in the loss of unprotected CVFTL populations across the Coachella Valley more than any single stressor. Even when new sand delivery has been blocked to large unprotected lands, CVFTL have been able to sustain populations. On the other hand, if the site is small, unless sand delivery is on-going, extirpation has occurred 100% of the time. Is inbreeding depression occurring (no evidence so far)? Is translocation warranted? If translocation is warranted, what are the most effective means of implementing this tool?
- Compromised sand transport corridors. All of the protected areas' sand transport corridors are compromised to some degree. No new sand has entered Willow Hole, Stebbins' Dune, or the West Indio Hills sites since before the initial CVFTL HCP. Willow Hole, the CV Refuge and Windy Point all have housing developments within their sand delivery corridors. The Whitewater Floodplain Preserve's sand corridor is blocked by the CVWD's percolation ponds. Sand delivery is episodic, stochastic, and flood dependent. Determining the efficacy of these corridors is dependent of observing post flood sand movements. If determined to be insufficient, can we deliver sand to the up-wind portions of protected areas? Are there tools for mechanically destabilizing Aeolian sands without "take" of protected species? Stebbins' Dune is in dire need of new sand or mechanical destabilization.
- Sahara mustard continues to be a threat. So far, the best control has been drought and late winter rains. This infestation is episodic, and has been here for many decades. A threshold for management question is whether these episodic threats, over the long-term, threaten population viability. Figure 14 illustrates the "dampening" effect of the mustard on CVFTL populations on the CV Refuge. 2009-2011 were wet years with dense mustard; since then the mustard has stayed at lower levels and the CVFTL population has rebounded.
- Climate Change. The big question is how bad will it get, and what are the threshold climate levels for CVFTLs. We don't know, and modeled projections are inadequate. On-going monitoring is critical to address this question. Vegetation provides critical shading, cooling and insect food; could perennial vegetation plantings help?



In 2019, Coachella Valley Fringe-toed lizards declined on the CVNWR (active dunes and stabilized sand fields) and mesquite dunes, as expected due to the dry conditions in 2018. The decline on the stabilized sand fields was exacerbated by flooding across much of those habitats in the winter of 2019 (Figure 20). There was a moderate increase of fringe-toed lizards on the ephemeral sand fields. This habitat is less tied to annual rainfall due to the lizards' use of deep-rooted perennial shrubs (especially *Psoralea arborescens*) for food, cover and for foraging on insects attracted to these shrubs when they are in bloom and leafed out. The shrubs can bloom even in dry years as long as there is sufficient ground water. Another factor affecting fringe-toed lizard activity on the ephemeral sand fields is the abundance of sand – new sand arrived on to this habitat because of the winter 2019 flooding. The 2019 comparison of lizard abundances across sites (Figure 21) showed the lizards on ephemeral sand fields to be essentially the same in abundance to the active sand dunes, and exceeded only by the lizards on the Kim Nicol trail.

Reduced aeolian sands explained the very low lizard abundance on Stebbin's Dune, Windy Point (ESF 19-24) and several of the stabilized sand field sites (Figure 21). This hypothesis is supported by the higher sand compaction values measured on those sites (Figure 3). For Stebbins Dune and Windy Point, the lack of new sand reflects a compromised sand delivery corridor; for the stabilized sand fields it is the result of flooding covering this habitat with a layer of silt/mud.

Those stabilized sand field habitats are clustered along the southern edge of the CVNWR. There for the first time we measured a significant negative edge effect there (Figure 22). While the flooding/siltation doesn't explain that edge effect, the recent arrival of a nesting pair of roadrunners (*Gecoccyx californicus*) does. The roadrunners nest in tamarisk trees immediately south of the Refuge, but then forage on the Refuge. Roadrunners are efficient lizard predators, but require dense trees for nesting. The only sites where roadrunners occur naturally are the mesquite dunes, and their occurrence there contributes to the perennially low number of fringe-toed lizards detected there.



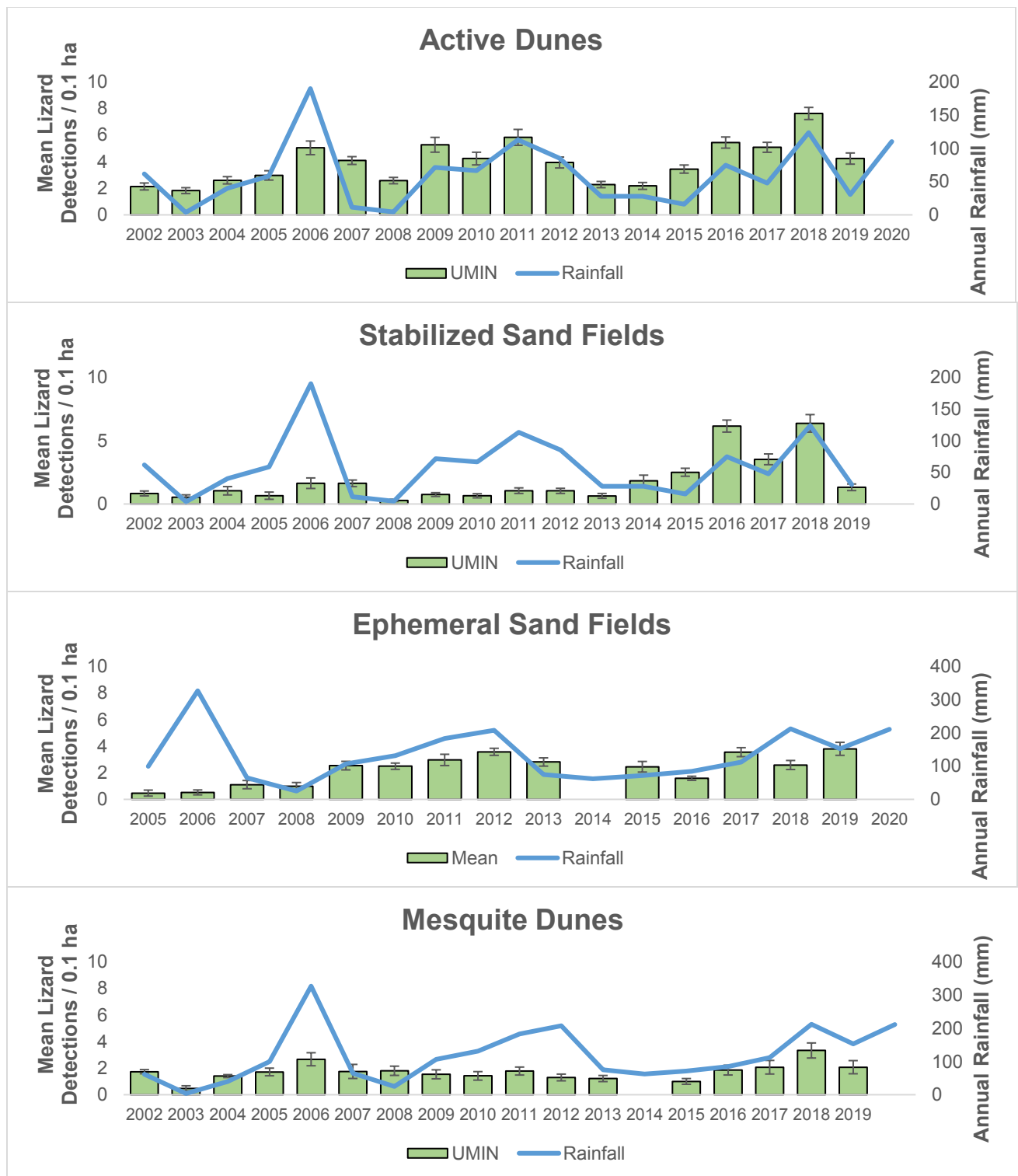


Figure 20. Temporal patterns of abundance of Coachella Valley fringe-toed lizards across the aeolian sand habitats of the Coachella Valley. Precipitation is offset by one year to identify rainfall-lizard recruitment feedbacks. Error bars represent one standard error.

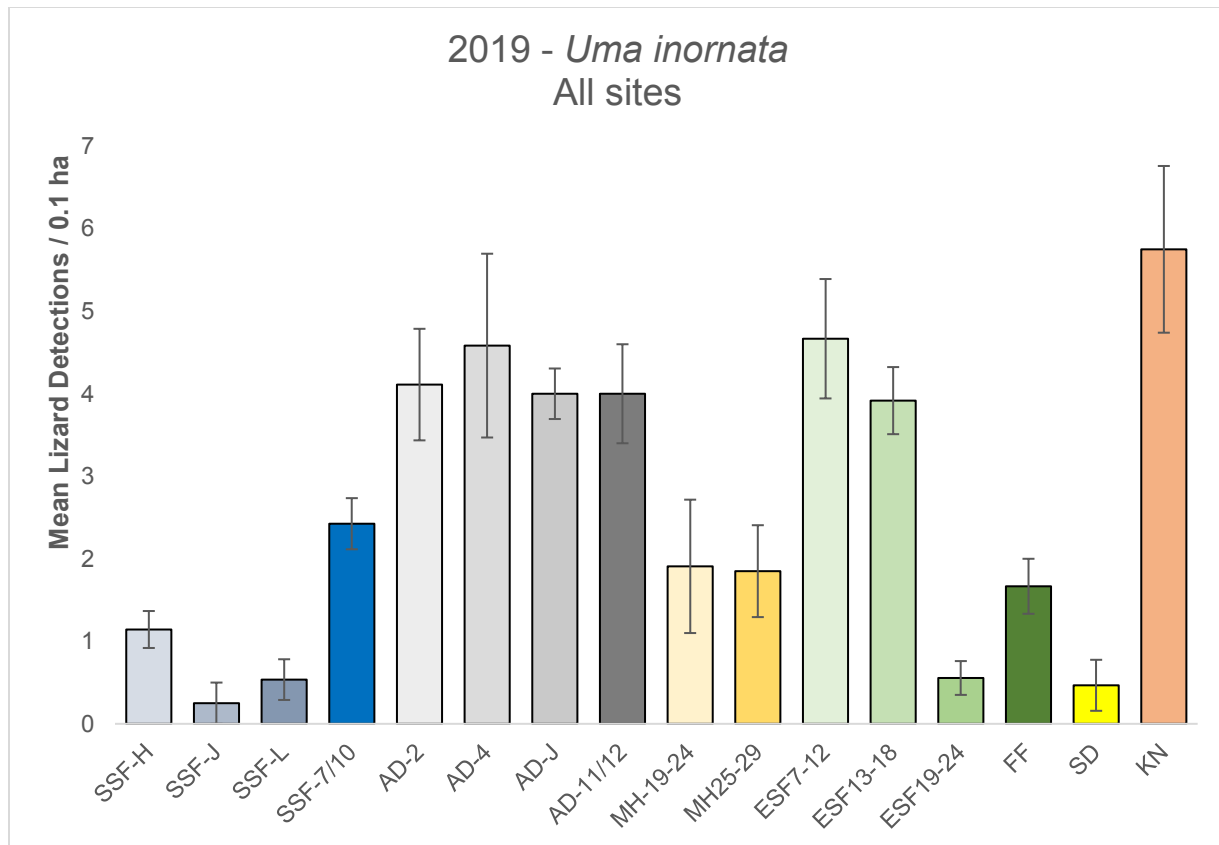


Figure 21. Comparisons of 2019 CVFTL population abundances across each of the monitoring plot clusters and habitat types of the Coachella Valley.

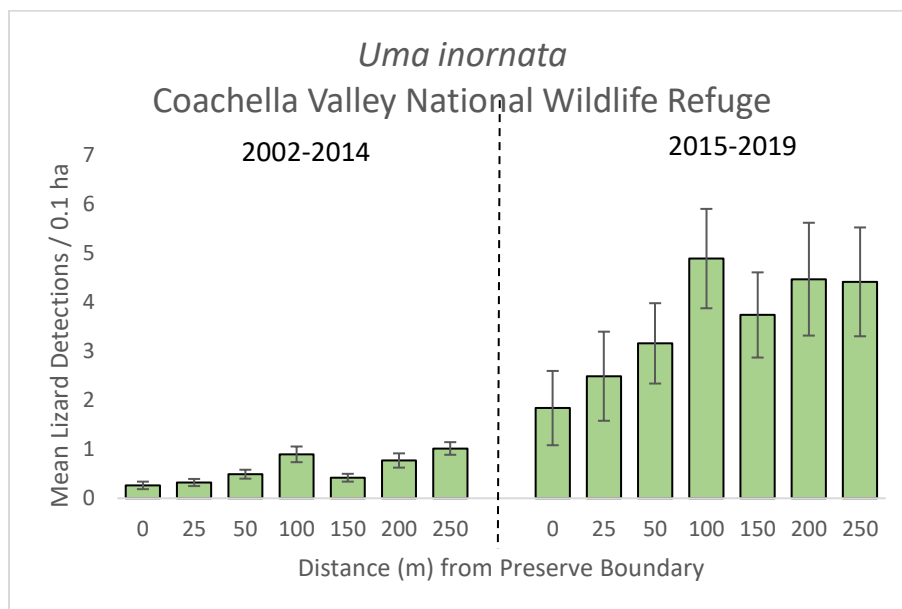


Figure 22. The emergence of a edge effect, limiting the CVFTL occupancy of habitats along the southern edge of the CVNWR.

## Literature

- Vandergast, A.G., Wood, D.A., Thompson, A.R., Fisher, M., **Barrows, C.W.**, Grant, T.J. 2015. Drifting to oblivion? Rapid genetic differentiation in an endangered lizard following habitat fragmentation and drought. *Diversity and Distributions*: (2015) 1-14.
- Robinson, M.D., and **C.W. Barrows**. 2013. Namibian and North American sand-diving lizards. *Journal of Arid Environments* 93:116-125
- Barrows, C.W.** 2013. An Ecosystem Approach to Defining Conservation Boundaries: Concepts and a Case Study. *Natural areas Journal* 33:344-347.
- Hulton, H.L., A.M. Hansen, **C.W. Barrows**, Q. Latif, M.W. Simon, and K. E. Anderson. 2013. Shifts in arthropod community structure during an invasion of desert ecosystems by Sahara mustard (*Brassica tournefortii*). *Biological Invasions* 16:1675-1687.
- Barrows, C.W.** 2012 Temporal abundance of arthropods on desert sand dunes. *Southwestern Naturalist* 57:263-266.
- 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.**, 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.** 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.**, 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.**, 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. 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. 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. Community complexity: stratifying monitoring schemes within a desert sand dune landscape. *Journal of Arid Environments* 69:315-330.
- 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.

- 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.
- 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.** 2006. Population dynamics of a threatened dune lizard. *Southwestern Naturalist* 51:514-523.
- 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.** 2004. Indicator species and time series images reveal progress of dune habitat restoration. *Ecological Restoration* 22(1): 56.
- 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.W.** 1997. Habitat relationships of the Coachella Valley fringe-toed lizard, *Uma inornata*. *Southwestern Naturalist* 42(2): 218-223.
- Barrows, C.W.** 1996. An ecological model for the protection of a dune ecosystem. *Conservation Biology* 10(3): 888-891.

## Appendix VI – Triple Ribbed Milkvetch

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# 2019 Monitoring Results for the triple ribbed milkvetch (*Astragalus tricarinatus*) within the Coachella Valley MSHCP Area



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Riverside's  
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## TRIPLE RIBBED MILK VETCH MONITORING

Triple-ribbed milkvetch, *Astragalus tricarlinatus* A. Gray (Fabaceae) is a short-lived perennial herb endemic to southern California, occurring along the ecotone of the Mojave and Colorado Deserts in the San Bernardino and Little San Bernardino Mountains, although there is a disjunct population in the Santa Rosa Mountains (USFWS 2009; Fraga and Pilapil 2012; Jepson Flora Project 2017). It has also been reported from further east in the Orocopia Mountains by Barneby (1959, 1964), but there is no known specimen for authentication (USFWS 2009; Bell et al. 2017). In 1998, triple-ribbed milkvetch was listed as endangered by the United States Fish and Wildlife Service based in part on the state of knowledge about the species at the time-- that it occurred as small, ephemeral populations on benches along desert washes and canyon bottoms; such occurrences are now known to be waif or deme populations (Barneby 1959; Sanders 1999; USFWS 2009; Fraga et al. 2015). Core habitat is now recognized as further upland in topographically rugged, friable soils, often in upper watersheds, and so difficult to reach (White 2004; USFWS 2009; Fraga et al. 2015; Bell et al. 2017).

We initiated study of this species as part of the monitoring of protected species, including triple-ribbed milkvetch, under the Coachella Valley Multiple Species Habitat Conservation Plan (CVMSHCP), with the aim of collecting data that will contribute to the long-term persistence of self-sustaining populations (Coachella Valley Conservation Commission, 2016). Our broad objective is to evaluate threats to persistence of the populations of this species in the San Bernardino and Santa Rosa Mountains, within the CVMSHCP. Such threats may include human disturbance, invasive species, natural stochastic events, and climate change. Past research by the University of California, Riverside Center for Conservation Biology (CCB) found that invasive plants may reduce flowering and seed set in this species (Heintz et al. 2018). Further knowledge about the degree to which such threats impact triple-ribbed milkvetch can lead to appropriate land management protocols and an update of the listing status of this species (Amsberry and Meinke 2007; Fraga and Pilapil 2012; Fraga et al. 2015).

This study also aims to contribute information to the next USFWS 5-year review of this species, a recovery plan (none has been produced to our knowledge) and as a follow up to a genetic analysis done by Fraga and others (2015). New genetic information and analysis may help determine a) population genetic variation and viability of populations and b) to determine what function, if any, that the waif (bottomland) populations serve in terms of their contribution to local and regional gene flow. Is the Santa Rosa population in decline and of low genetic variability? We seek to find out what the genetic structure is between these distinct, isolated, small populations, and what is their relatedness to the waif populations. Are the waifs functioning as “genetic bridges” or are they simply a genetic dead end, not contributing further to sustained, permanent source populations? As well, sampling and determining the presence and type of root symbionts (rhizobia, nitrogen-fixing bacteria), and contrasting these among upland and waif populations may help elucidate the factors causing fluctuations in the populations of waifs, as suggested by Amsberry and Meinke (2007). This information will aid in the determination to what extent waifs are necessary for population viability, and further, if threats to waif populations represent in fact any threat to the recovery of the species.

## Objectives

Surveys for triple-ribbed milkvetch were carried out in order to meet monitoring and management goals within the CVMSHCP by the University of California, Riverside Center for Conservation Biology (CCB). The outcome of this multi-year project is expected to identify whether populations are genetically isolated, whether various populations appear to be viable, and how the waif populations are related to upland populations. This information will help in recovery of the species by identifying whether any significant threats to waif occurrences pose any danger to the recovery of the species, an important focus, identified by Fraga and others (2015). It may be that the waif individuals are not self-sustaining populations, and that identified threats (per USFWS 2009) to these pose no danger to the sustainability of populations as a whole. Or, these waif individuals may be a key linkage between isolated upland populations. Information about the isolated upland and bottomland Santa Rosa occurrences, in particular, will help guide future monitoring and management of that population. If this population has genetic variation comparable to other populations and apparent population sizes appearing to be steady since other surveys by Bell and others (2017), there may be reason to be less concerned about the sustainability of this population.

This first year of sampling was aimed at relocating and sampling populations for genetic analysis, developing regional partnerships (for example, with Joshua Tree National Park, Rancho Santa Ana Botanic Garden, and the Sachs genetics laboratory at UC Riverside). The search for support for analysis of samples collected is ongoing.

## Methods

### Background

In the fall of 2018, we applied for a USFWS Recovery Permit to permit sampling in support of our conservation research on triple-ribbed milkvetch, as well as permission to carry out the research within designated BLM and USFS Wilderness. The Recovery Permit and Letters of Authorization were received in spring, 2019.

### Survey Area

Field surveys focused on visiting as many known occurrences (populations) as possible within the known range of the species in order to document their status and collect leaf tissue and seedling samples (for isolation of symbionts). Surveys were conducted within the Upper Mission Creek/Big Morongo Canyon Conservation Area (UMCBMC) and the Santa Rosa and San Jacinto Mountains Conservation Area (SRSJM). Partner surveys in support of this and other studies were performed by the National Park Service were conducted in the Joshua Tree Conservation Area (JTCA), and by the Rancho Santa Ana Botanic Garden in UMCBMC, especially east of Hwy 62 and along with our team in SRSJM Conservation Area (Fig. 1).

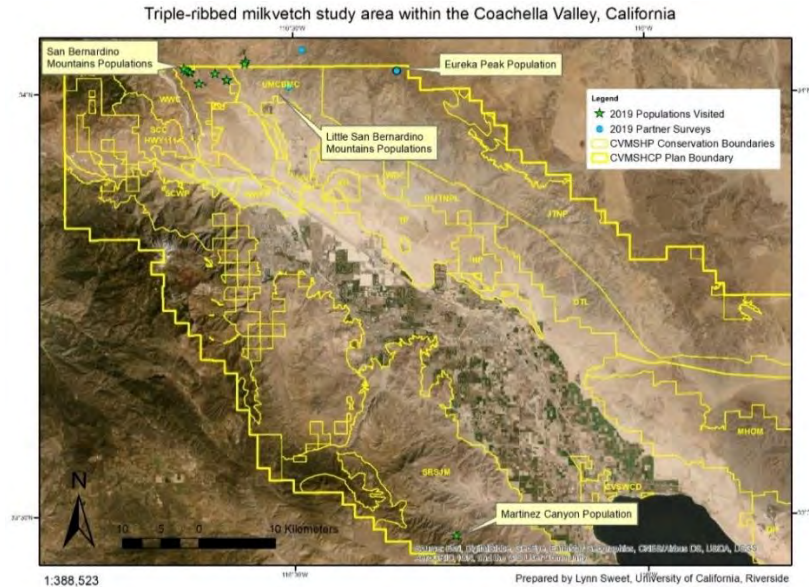


Fig. 1: Triple-ribbed milkvetch populations visited during 2019 within the known range of the species. Also shown are surveys by study partners that may contribute information to the range-wide genetic study.

Our primary focus for 2018-2019 was to visit and sample milkvetch populations in the southeast portion of the San Bernardino Mountains within UMBCBMC; the eastern portion of the transverse range, which exhibits the typical “distressed granite” soil that triple-ribbed milkvetch appears to thrive in (White 2004). Populations are found scattered in and around/below hilltop ridges, and this year, as in the past, we searched between known populations within suitable habitat (Fig. 2). As well, older known locations were accessed with local experts knowledgeable about historic occurrences, including within Big Morongo Canyon and Dry Morongo Wash. Due to the focus on the importance of “waii” plants, we made strong efforts to search for these individuals within wash bottoms, either enroute to upland populations or as focal areas themselves.

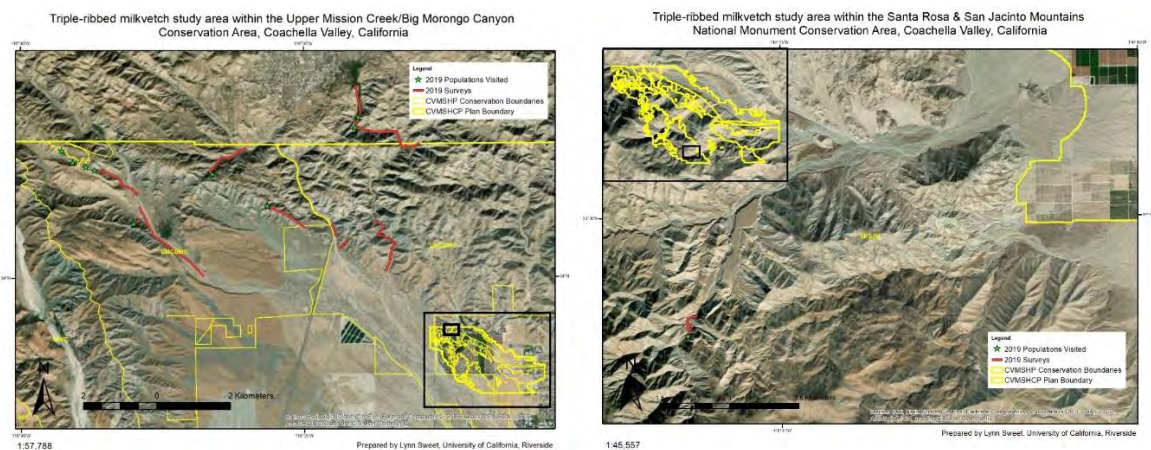


Fig. 2: Triple-ribbed milkvetch surveys and populations visited during 2019 within the northwest range of the species, Upper Mission Canyon and Big Morongo Canyon (left) and within the southwest range of the species, a disjunct population within the Santa Rosa and San Jacinto National Monument Conservation Area (right).

## Data Collection

Between March and May of 2019, we located the plants for study. When surveying a population every attempt was made not to disturb the area more than was necessary. In accordance with the details of our Permit and Letter of Authorization, we surveyed for areas supporting groups/populations of plants for sampling (Table 1). For each survey, we noted a start and end point between which we searched for seedlings and mature plants. For each population, we noted the number of individuals we could safely count onsite. Where there were adequate plants present, we sampled leaf tissue from mature plants or plants with >10 leaves and/or sampled a whole seedling, including root tissue. Samples were kept fresh on ice within a vacuum-insulated canister with (water) ice. We took a photo of each study plant, noted the life stage, GPS coordinates and PDOP. Samples were transferred to a standard freezer (-18°C) and then transported on dry ice to a -80°C freezer in the lab of research partners Professor Joel Sachs and Dr. Lorena Torres-Martinez at the UCR main campus. It should be noted that we also collected a few additional samples that were immediately dried in silica, but this was determined to be an inferior method due to fragmentation of the DNA. Dr. Torres-Martinez worked to isolate the symbionts from seedlings sampled, and we are discussing and planning the genetic analysis.

## Results

All of the upland populations that we revisited from previous surveys supported plants in spring 2019. We located/confirmed 10 areas supporting groups/populations of plants during the survey period (Table 1). Many seedlings were noted at multiple sites. Despite searches at wash and bottomland locations known to support plants in the past, and perhaps due to the heavy rainfall and apparent scouring of wash bottoms, we did not locate any of these “waif” plants these areas separated from upland populations (Figure 2). We gathered 39 leaf tissue samples for analysis, from 7 populations spanning the range of the species. An additional 3 populations were sampled by partners, adding an additional 17 samples that are available for analysis. Symbionts were isolated from one sample of root tissue, and analysis is in progress.

Table 1: Groups/populations observed during the study period and approximate population sizes.

Location name	Number of plants	Samples	New CCB Location	Location description/comments
Big Morongo Cyn-North	1	No		Single mature plant near the bottom of an east-facing bank in Big Morongo Canyon
Big Morongo Cyn-North2	3	Yes	Yes	Several mature plants on a very steep west-facing bank in Big Morongo Canyon
Dry Morongo (WW)	~100	Yes		Many mature plants and seedlings on the south side of southern branch of Dry Morongo Canyon. Plants uphill in a side canyon.
Martinez Canyon, Santa Rosa Mountains	~5	Yes		Several plants on rocky, west-facing slope, south branch of Martinez Canyon.
Mission Creek (NF)	30-100	Yes		Many adults and some seedlings scattered on a rocky hillslope, and onto highly eroded opposite adjacent slope, high invasive grass density.
Mission Creek (SH)	20-40	Yes		Individuals scattered on south-facing slope, most inaccessible, all in flower, no seedlings or waifs.
Devils Garden	3	No		Two mature plants inaccessible on cliff; one seedling on road with <10 leaves. Despite search, did not locate more individuals.
Mission Creek (SM)	50-100	Yes	Yes	Many mature plants and seedlings, outcrop wrapping the top of the hillside in both directions, potentially further. Estimate likely low.
Mission Creek-West (DP)	35+	Yes		Many mature individuals (counted at 35), most very high on steep, decomposing outcrop, likely many more, including seedlings, which were not counted.
Mission Creek West (Not Accessed)	5+	No		Did not access, noted individuals from a distance.

Source populations from previous years appeared healthy and we suspect that these populations are fairly stable, with some variation in wet and dry cycles (Figure 3), although intensive demographic surveys would be necessary to fully ascertain population status over time (similar to that recommended by Fraga et al. 2015). Some recorded localities that we searched out based on either CNDDDB location data or local expert information, particularly in Big Morongo Canyon, showed scant numbers of plants unlikely to be sustainable. Though we do not have past survey data for the Martinez Canyon population, fewer individuals were relocated at that location than in the previous visits by RSABG (Duncan Bell, personal communication). At least two recorded localities that we searched out were not relocated at all (Dry Morongo Wash, south end and a population near the county line in Big Morongo Canyon).

At some sites, seedlings were very abundant, more so than previous years. We did not revisit the Wathier Landing site where we found a large number of seedlings in 2018, due to time and funding constraints needed to access this remote population. Most individuals were generally healthy with many flowers/fruits. Insect species were noted in a couple instances: aphids were noted with heavy infestations on a few individuals especially around the flowers; and an unidentified plant bug (family Miridae) was seen feeding on plants, mainly stressing a few individuals, rather than whole populations. Where insects were seen feeding on the plants, the health and seed output of those affected individuals would be reduced, but these instances were fairly auto-correlated, not spread throughout. It would be advisable to positively identify whether these are invasive, non-native aphids. No diseases were noted, nor were pollinators, per se, although time was not allocated for observation. Canyon wrens were observed foraging and accessing cracks within the substrate that supported plants at several sites (Devils Garden, Mission Creek-West (DP), Mission Creek (NF)).



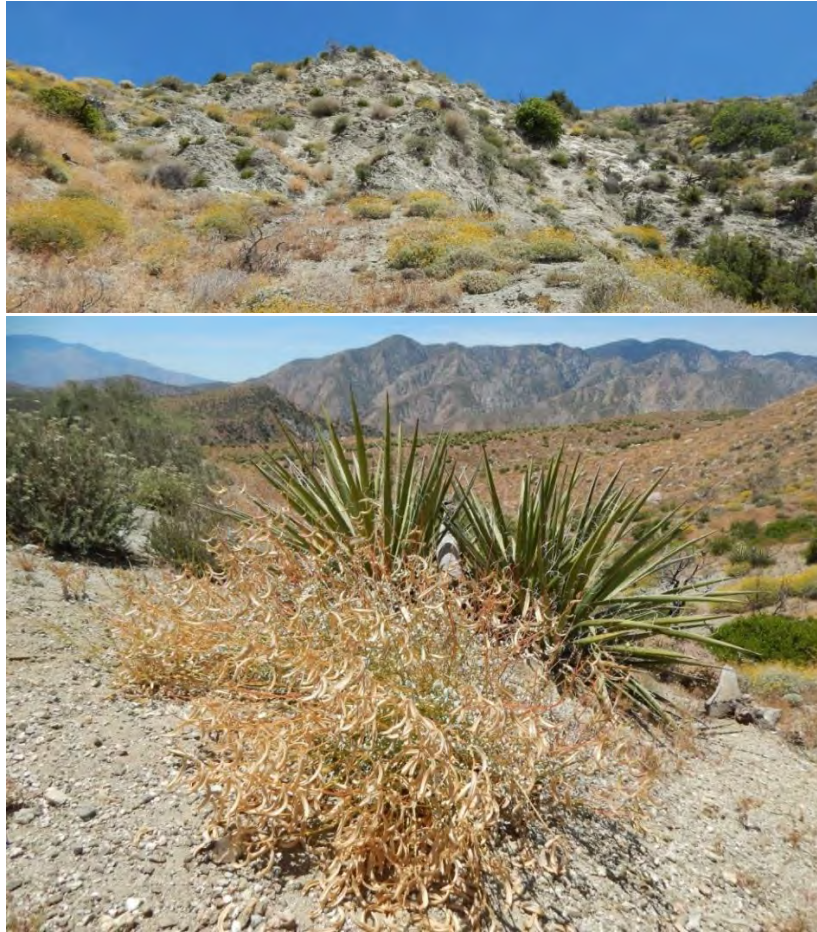


Figure 3: The hillslope at the Mission Creek-North (SM) site, supporting many individuals that appeared light tan in color in May due to the coverage of fruit (top), and a plant in full fruit viewed from upslope (bottom).

## Discussion

Federally-endangered triple-ribbed milkvetch (*Astragalus tricarinatus*) population dynamics, reproductive biology, and ecological relationships are not well understood for several reasons: populations are typically isolated, the plants are cryptic and difficult to detect even under the best circumstances and they typically grow in places that are topographically rugged and difficult to reach (USFWS 2009). The goal of this study was to further document status of extant populations in the Plan area, and sample genetic material to determine regional population structure, and relatedness of the Santa Rosa Mountains group. As stated, many upland populations appeared to be thriving and recruiting new individuals. New threats to the species were not noted. Observations of canyon wrens within the habitat may indicate granivory and dispersal, but there is no direct evidence of this occurring. Genetic analysis in partnership with the Sachs Lab at UCR, as well as Rancho Santa Ana Botanic Garden and Joshua Tree National Park will be essential to answer questions related to conservation genetics.

## Recommendations

As with last study year, major questions regarding the species remain. One major question is whether the bottomland “waif” plants (observed in years prior), those found in the canyon bottoms, contribute at all to maintaining population size. Are the waifs key connections between canyon populations? This issue is highly relevant to the species’ conservation, as waifs occur in the canyon bottoms, and upland populations high on canyon walls, and the threats to each respective type differ regarding Endangered Species listing status. To this end, we recommend supporting genetic analysis of the samples to understand the fine and coarse-scale genetic structure of these populations. Known populations of the species were sampled from a broad swath of the species’ range, following on the 2015 Joshua tree study (Fraga *et al.*), including those in the Santa Rosa Mountains. This study should provide information on relatedness between upland and waif populations, and some insight into regional dynamics, in addition to the genetic relationship between the Transverse Range and the Peninsular Range populations. In addition, our partners have indicated the importance of symbionts to species like these that occur on poor soils. Symbiotic bacteria occurring in nodules on the roots (rhizobia) may be the key to the species’ population or re-population of a given area. Understanding these symbiotic obligations will help determine limitations to species success. We recommend that the sampling from this year be expanded to additional populations.

As has been noted, this species seems to occur on particular soil types, and although soil samples have been collected by various entities, results have not been disseminated (Fraga & Palapil 2012). Thus it would be prudent to resample areas that have self-sustaining, stable populations as well as ephemeral waif and deme populations to identify the properties of the soils on which triple-ribbed milkvetch occurs.

As with our previous year’s recommendations, to better understand the lifecycle we recommend a pollination study coupled with a seed dispersal study. The seed dispersal study could possibly be done with wildlife cameras based on the observation of the scat and the seeds in 2017. We are working in collaboration with rare plant biologists in adjacent Joshua Tree National Park as well as Rancho Santa Ana Botanic Garden in order to share data about triple-ribbed milkvetch occurrence and biology as well as to standardize rare plant monitoring protocols with the aim of providing useful information for effective management. A meeting with partners has been set for August, 2019. This information will enable surveys to be timed effectively, cited appropriately and allow for continued evaluation of OHV recreational activity, development and invasive species impacts to this species.

## Literature Cited

Amsberry, K., and R.J. Meinke, report preparers. 2007. Status evaluation of *Astragalus tricarlinatus* (triple-ribbed milk-vetch). Agreement No. PO485100. California Department of Fish and Game, Sacramento, California.

Bell, D. S., N. S. Fraga, and S. J. De Groot, 2017. Surveys for *Astragalus tricarlinatus* (Fabaceae, triple-ribbed milkvetch) in the Chuckwalla Mountains, Orocopia Mountains, and Santa Rosa Wilderness. Report prepared for Bureau of Land Management, Sacramento, CA.

CPC (2017). CPC Best Practices for Collecting Seeds from Wild Rare Plant Populations. Available at: <https://saveplants.org/cpc-best-practices-collecting-seeds-wild-rare-plant-populations/>. Accessed 8/20/18

Fraga, N., and J. Pilapil. 2012. Surveys for *Astragalus tricarinatus* (Triple-rib milkvetch, Fabaceae). Bureau of Land Management Cooperative agreement L10AC16219. Habitat Conservation Plan. Available at: [www.blm.gov/ca/pdfs/cdd\\_pdfs/Triplerib1.PDF](http://www.blm.gov/ca/pdfs/cdd_pdfs/Triplerib1.PDF) accessed July 18, 2018.

Fraga, N., T. La Doux, L. Prince, M. Harding, and J. Hoines. 2015. Conservation assessment for triple-ribbed milkvetch (*Astragalus tricarinatus*, Fabaceae) in Joshua Tree National Park. Natural Resource Report NPS/JOTR/NRR—2015/999. National Park Service, Fort Collins, Colorado.

Heintz, J.G.C, L. C. Sweet, and C. W. Barrows. 2018. Microhabitat Characteristics and Impacts Of Invasive Species for The Triple-Ribbed Milkvetch (*Astragalus tricarinatus* [Fabaceae]) in the San Bernardino Mountains, California. *Madroño*. 65(4): 175-183.

Jepson Flora Project (eds.) 2017. Jepson eFlora, <http://ucjeps.berkeley.edu/eflora/> [accessed on Jul 20, 2017].

Sanders, A.C. 1999. Triple-ribbed milkvetch - species account for the West Mohave Desert

USFWS (United States Fish and Wildlife Service). 2009. 5- Year review: summary and evaluation. *Astragalus tricarinatus* (triple-ribbed milk-vetch).

White, S. D. 2004. Noteworthy collections – California. *Crossosoma* 30:23-25.



Appendix VII –  
Burrowing Owls and Palm Springs  
Pocket Mice

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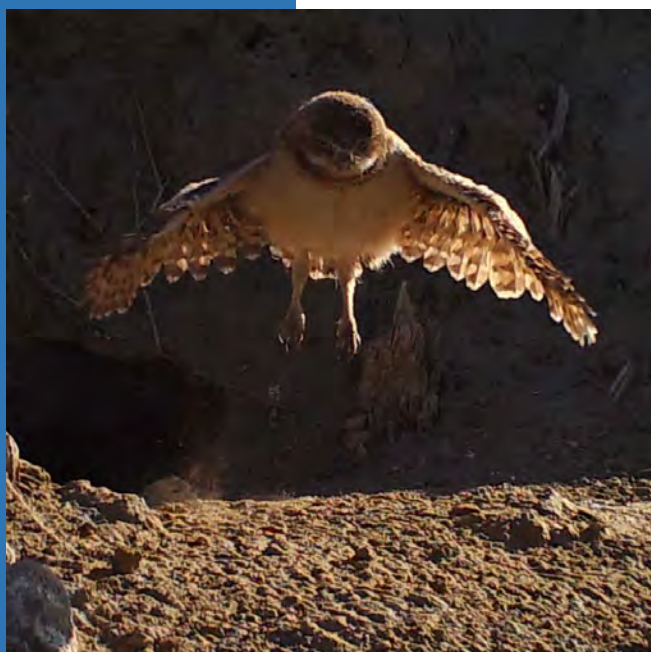
Coachella Valley Conservation Commission

2019

Coachella Valley Multiple Species Habitat Conservation Plan

& Natural Community Conservation Plan

## 2019 Monitoring Results for Burrowing Owls and Palm Springs Pocket Mice



## BURROWING OWL AND PALM SPRINGS POCKET MOUSE MONITORING

In California, burrowing owl (*Athene cunicularia*, BUOW) populations have declined as wildland landscapes have shifted to urban uses, increasingly relegating BUOW populations to anthropogenic habitats such as airports and agricultural lands, landscapes with relatively fewer predators but also a potentially depauperate vertebrate prey base (Trulio and Higgins 2012). Whereas in wildlands BUOW diets are a mix of vertebrate and invertebrate prey (Barrows 1989), within those agricultural landscapes, arthropods dominate burrowing owl diets, leading to questions as to how those diets affect their recruitment success (Trulio and Higgins 2012; Haley and Rosenberg 2013). Barrows (1987) found a positive correlation between breeding successes in northern spotted owls (*Strix occidentalis*) with larger (vertebrate) prey in their diet. If true for spotted owls, does the same prey size – reproductive success pattern exist in BUOWs? What has been lacking in addressing this question are temporal and spatially relevant comparisons of diets and recruitment between BUOW populations occurring in natural versus anthropogenic landscapes.

In southern California's Coachella Valley nesting burrowing owls are still relatively common on natural as well as anthropogenic habitats (Latif et al. 2012), habitats that include aeolian sand fields, alluvial fans, agriculture fields, and especially along ephemeral watercourses. Two regions where we have found BUOWs at high densities include the Morongo and Mission Creek washes within the city limits of Desert Hot Springs (DHS), and in the Eastern Valley, within the cities of Indio and Coachella, along the Whitewater storm channel and drains feeding that channel. In both areas, BUOW nests are located in embankments along the washes or levees that constrain flow within the storm channel. In spite of these similarities, the Desert Hot Springs BUOWs exist on a largely natural landscape whereas the eastern valley owls occur in a matrix of agricultural lands. These locations allow us the opportunity to compare BUOW diets and breeding success as well as other potential stressors that could affect the sustainability of these populations.

Rather than valley-wide surveys that lack context for observed changes, our objectives are to:

- Identify BUOW owl production rates for the Desert Hot Springs versus East Valley populations
- Compare diets between those two populations
- Identify sources of nest disturbance and hypothesize degrees of severity
- Suggest management options, assuming the data indicate a need for modifying current stewardship activities.

## Site Descriptions

In Desert Hot Springs, our study nests were all located within the Little Morongo Wash, mostly south of Ironwood Drive and north of 15th Avenue (Figure 1). One burrow was located in the wash just south of 18th Avenue. Vegetation within the wash consists primarily of black-banded rabbitbrush (*Ericameria paniculata*), cheesebush (*Ambrosia salsola*), and scattered desert willow (*Chilopsis linearis*). Creosote bush (*Larrea tridentata*) and burro bush (*Ambrosia dumosa*) dominate the upland areas above the wash. The above-average winter precipitation in 2019 produced extremely dense annual plant coverage, including abundant large Sahara mustard (*Brassica tournefortii*). The wash is subject to occasional flooding but does not support permanent water. All nests here were located on conserved land, but in spite of this, OHV activity, illegal dumping, and homeless encampments are persistent issues. Scattered commercial structures exist within close proximity to some nests (ca. 100m), but all nests are otherwise surrounded with significant amounts of habitat supporting natural vegetation.

Nests in the East Valley were located on Twentynine Palms Band of Mission Indian land (access was provided in cooperation with the Twentynine Palms Band of Mission Indians and the San Diego Zoo) near the I-10 and within the Coachella Valley Water District wastewater diversion channel Wasteway Two near Avenue 52. The burrows on reservation land were located on a fine silt flat just south of the Coachella Valley Storm Channel. The Avenue 52 burrows were surrounded by a small flat of highly disturbed, sparsely vegetated land, with scattered bush seepweed (*Sueda nigra*). However, the nearby storm channel supported a thriving riparian ecosystem, especially since the removal of all tamarisk in 2018 and flooding in the winter of 2019. The channel consisted mainly of large cottonwood trees (*Populus fremontii*) and cattails (*Typha domingensis*). One burrow in this area (29P-312-128) is an artificial burrow. The nests located at Wasteway Two were located along the inner embankment of the channel. The bottom of the channel supported a dense stand of cattail, and north of the channel was a small saltbush flat (*Atriplex* sp.). Isolated stands of honey mesquite (*Prosopis glandulosa*) also existed nearby. Scattered residential plots and active agricultural fields supporting annual crops dominated habitats outside the channel. Dumping, OHV activity, and homeless encampments are present nearby.

We also surveyed a population of owls on BLM land north of Thousand Palms Oasis and south of Dillon Road. These burrows existed mostly on an alluvial cliff face bordering a wash, with one burrow located on the upland area above it. This area supports Schott's indigo (*Psoralea schottii*) and cheesebush within the wash, and creosote bush, burro bush, and brittlebush (*Encelia farinosa*) surrounding. This area experiences the least amount of human disturbance, with minimal OHV activity, dumping, and human visitation. As such, we conducted a small amount of monitoring at these burrows to serve as a definite representation of a natural, undisturbed landscape.

Using all burrow locations monitored from 2015 to 2018, and assuming a 600m foraging radius, we determined that owls in DHS hunt primarily over a range that is roughly 80% natural habitat (creosote scrub, natural wash), while owls in the East Valley only have access to less than 10% natural habitat (honey mesquite thicket, saltbush scrub). The remaining 20% of the

landscape in DHS was comprised of scattered industrial and residential buildings. The bulk of the landscape in the East Valley consisted of agricultural land (mostly active, and some abandoned), followed by urban structures, stormwater channel, and major highways.

## **Data Collection**

We monitored BUOW nests using camera “traps” (heat and motion triggered wildlife cameras) (Bushnell NatureView Cam HD (Model 119740) and Trophy Camera (Model 119436)). We used Bushnell NatureView cameras for all DHS and East Valley burrows, and the Trophy Cameras at Sky Valley burrows. We began installation of the camera traps in late April to mid May 2019 at burrows in DHS and in the East Valley. To mount the cameras we drove metal t-posts into the ground roughly 1 to 3 meters away from the burrow entrances and then placed cameras into locked security boxes which were fastened to the tops of the t-posts using two screws into pre-drilled holes. Since there was a very low risk of theft at the Sky Valley sites, we instead attached unlocked security boxes to wooden stakes at these nests. We always placed cameras in front of the nest entrance to avoid providing an unseen perch for predatory birds. For 2019, in total we monitored 6 burrows in DHS, 5 in East Valley, and 3 in Sky Valley (Figure 1, Table 1). We removed all cameras from the field in late June except for two cameras that were stolen from East Valley in mid-May (29P-312-128 and 29P-409-092) and one that was removed from DHS in mid-May due to security concerns (DHS-448-102).

We visited burrows weekly for camera maintenance and SD card collection. During these visits we also collected pellets from around the nest entrance and perching sites. At the end of the camera monitoring in late June to July, we dissected the pellets and identified all prey items by quantifying the diagnostic animal remnants that commonly survive the digestion process (e.g. mammal mandibles, beetle heads, earwig pincers, etc.). We excluded the first pellet collections from each nest from analyses because we could not be sure how old these pellets were, and including them in analyses may have led to inaccurate temporal representation of caught prey items. We compiled and analyzed all photos taken by the camera traps and recorded daily observed maximum number of owlets present, the number and species of animals that visited the burrows, prey items, and other interesting events such as owlet predation and deaths.



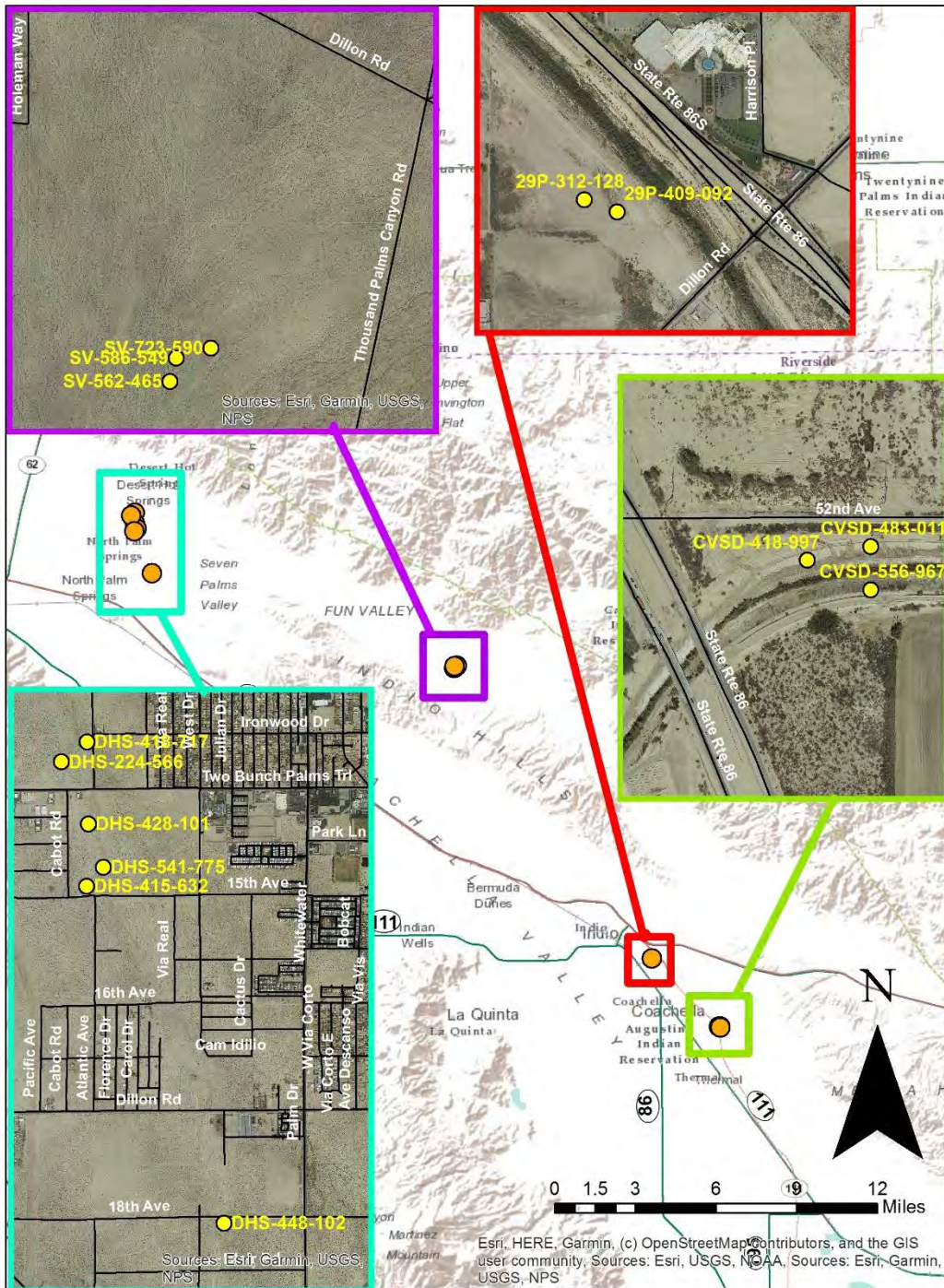


Figure 1: map showing locations of all BUOW nests in Desert Hot Springs, East Valley, and Sky Valley that we monitored in 2019.

## Burrowing Owl Breeding Success and Diets

We have summarized reproductive rates and pellet dissection results for all monitored burrows for 2015, 2017, 2018, and 2019 in Table 1. We chose to exclude the East Valley burrow of 29P-312-128 from breeding rate analyses due to the ambiguity of the number of families occupying this artificial burrow. Similarly, we excluded all Sky Valley burrows from these analyses because we did not obtain adequate reproductive data at this site (we installed cameras late in the season), although pellets were collected here and included in diet analyses where appropriate.

*Table 1: Summary of monitored BUOW nest sites, maximum observed owlets, and pellet dissection results for 2015, 2017, 2018, and 2019. NC = no camera. "N+" max owlets indicates that there may be more owlets that were not observed. DHS sites are shaded orange; East Valley sites are shaded green; and Sky Valley sites are shaded blue.*

Burrow ID	Study Year	Location	Max Owlets Observed	# Prey Items	% Vertebrates	% PSPM
DHS-224-566	2019	DHS	8	631	7	3
DHS-415-632	2019	DHS	7	424	14	10
DHS-418-717	2019	DHS	0	594	3	1
DHS-428-101	2019	DHS	6	932	4	1
DHS-448-102	2019	DHS	10	691	4	0.4
DHS-541-775	2019	DHS	8	567	11	3
29P-312-128*	2019	East Valley	6	1000	11	0.1
29P-409-092	2019	East Valley	4	964	13	0
CVSD-418-997	2019	East Valley	2	1357	5	0.1
CVSD-483-011	2019	East Valley	3	196	15	0
CVSD-556-967	2019	East Valley	7	1003	5	0.1
SV-586-549	2019	Sky Valley	6	103	18*	7
SV-562-465	2019	Sky Valley	0	75	15*	6
SV-723-590	2019	Sky Valley	NC	239	14	1
DHS-224-566	2018	DHS	5	790	8	2
DHS-415-632	2018	DHS	8	357	18	8
DHS-418-717	2018	DHS	6+	94	10	5
DHS-426-714	2018	DHS	3+	217	11	4
DHS-428-101	2018	DHS	5	538	7	3
29P-203-400	2018	East Valley	5	1719	2	0
29P-312-128	2018	East Valley	4	878	10	0
29P-409-092	2018	East Valley	2	852	3	0
CVSD-231-829	2018	East Valley	0	651	3	0
CVSD-334-724	2018	East Valley	NC	848	2	0
CVSD-382-712	2018	East Valley	7	290	2	0
CVSD-418-997	2018	East Valley	0	413	3	0
CVSD-589-787	2018	East Valley	NC	328	12	0
DHS03	2017	DHS	9	31	81	48
DHS04	2017	DHS	8	54	74	44
DHS12	2017	DHS	8	27	67	48
DHS14	2017	DHS	NC	20	85	60
DHS15	2017	DHS	NC	46	76	56
DHS19	2017	DHS	NC	6	83	67
DHSXX	2017	DHS	NC	31	55	35
CVSD10	2017	East Valley	3	10	20	0
CVSD13	2017	East Valley	5	64	22	0
LMW2A	2015	DHS	0	24	4	4
LMW2B	2015	DHS	0	53	7	6
LMW2E1-3	2015	DHS	3	56	27	23
CVWD1	2015	East Valley	1	46	2	0
CVWD2	2015	East Valley	2	16	6	0
CVWD3	2015	East Valley	2	46	11	0
CVWD5	2015	East Valley	0	54	5	0
CVWD6	2015	East Valley	4+	14	29	0



## Diet

BUOWs in DHS have diets that are more diverse. Their diet includes Palm Springs pocket mice (*Perognathus longimembris bangsii*, PSPM) and desert pocket mice (*Chaetodipus pencillatus*). Merriam's kangaroo rats (*Dipodomys merriami*) and wood rats (*Neotoma* sp.) are also common in the diet. Darkling beetles (family Tenebrionidae) are a major part of the invertebrate prey base in DHS, including large species such as *Eleodes armata*, *Asbolus verrucosus*, *Cryptoglossa muricata*, and *Edrotes ventricosus*. Small tenebrionids such as *Notibius puberulus* are also well represented, and in 2019, small native scarabs (family Scarabaeidae) were frequently encountered in pellets, likely catalyzed by the high winter precipitation. We occasionally found tiny fire ants (*Solenopsis* ca. *xyloni*) in DHS pellets in 2018, but we found them in large numbers in some cases in 2019, with potentially dozens of individuals in a single pellet. Since these ants are extremely small and have the potential to inflict painful stings, we believe they were unintentionally digested after they infested the owls' food cache. Another ant species, the smooth harvester ant (*Veromessor pergandei*) were occasionally taken in large quantities (in some cases over 200 individuals in a single pellet) in DHS, which was not observed in previous monitoring years. These ants are much larger and potentially more palatable than fire ants, so the owls were likely intentionally taking them, although the possibility remains that these ants were also infesting their food cache similar to the fire ants.



In the East Valley, desert pocket mice constitute the majority of the vertebrate prey base. Pocket gophers (*Thomomys bottae*) are occasionally taken in the East Valley, whereas only one gopher has been found from pellets in DHS. This is likely due to the prevalent agricultural and urban landscapes in the East Valley, which are more hospitable to gophers than open natural desert. No PSPM have been collected in any pellets from the East Valley until 2019, when four specimens were recovered. The invertebrate prey base of East Valley owls is fairly diverse, but includes potentially many ruderal/nonnative species or native species that otherwise reach unnaturally high population levels when in contact with anthropogenic landscapes. These species include a wide variety of scarab beetles which likely thrive in crop systems and ornamental plants. Other beetles that are associated with woody plants, likely thriving largely due to ornamental plants, are large longhorn beetles (family Cerambycidae) and horned powderpost beetles (*Apatides fortis*, family Bostrichidae). Crickets (family Gryllidae) and earwigs (order Dermaptera) are also important components of these owls' diets.

Scorpions, wind scorpions (order Solifugae, or solifuges), and the darkling beetle *Edrotes ventricosus* are important dietary components in both DHS and the East Valley. Reptiles and birds were only rarely detected in the owls' diets, regardless of location.



We collected pellets from three burrows in Sky Valley in an attempt to describe a more “natural” habitat, as the Sky Valley burrow site has by far the fewest human-caused disturbances. Two of the burrows produced very few pellets, but one burrow yielded 40 usable pellets, and in combination with the other burrows, we found that the diets of owls from Sky Valley most closely resemble the diets of DHS owls. Sky Valley owls appear to take large portions of desert pocket mice, Palm Springs pocket mice, and Merriam’s kangaroo rats, along with scorpions, and wind scorpions. Large beetles were notably rare in the Sky Valley owls’ pellets, but we needed more collections at this site to determine if this is a real difference or an artifact of under sampling.

We conducted a detrended correspondence analysis (DCA) ordination using Pcord6 (Wild Blueberry Media LLC, Corvallis, OR) to explore the differences between the diets of owls from DHS, the East Valley, and Sky Valley sampled in 2018 and 2019 (Figure 2). We used mean per-pellet abundance data for 40 taxonomic categories of prey items found in the owls’ diets to generate a special representation of between-burrow diet similarities. A category was excluded if it was represented at only one burrow. Our results show that there is no overlap of DHS with East Valley, supporting the hypothesis that the different landscapes these owls occupy support quantifiably different prey bases. Importantly, the pellet data sampled from Sky Valley places these burrows within the DHS burrows, indicating that while the DHS site is subject to regular human disturbances, the prey base still represents a native assemblage of alluvial fan habitat species. Interestingly, four East Valley burrows sampled in 2018 appear isolated from the other East Valley burrows (bottom group, orange outline), caused mostly by a roughly 5 times more crickets/grasshoppers in their diet. A few outliers exist, such as the 2019 sampling of CVSD-418-997, which in this case was caused by an excessive (roughly 6 times more than any other burrow) consumption of earwigs. The red arrows in the graph indicate the shift in position of burrows that were sampled in both 2018 and 2019, although no clear pattern can yet be discerned with these shifts, as three of the burrows appear to shift drastically, while three others do not. Overall, the points representing DHS burrows appear to stay mostly clustered regardless of sampling year, possibly indicating that the prey base at this location remains relatively stable year to year, although more sampling is required to verify this.

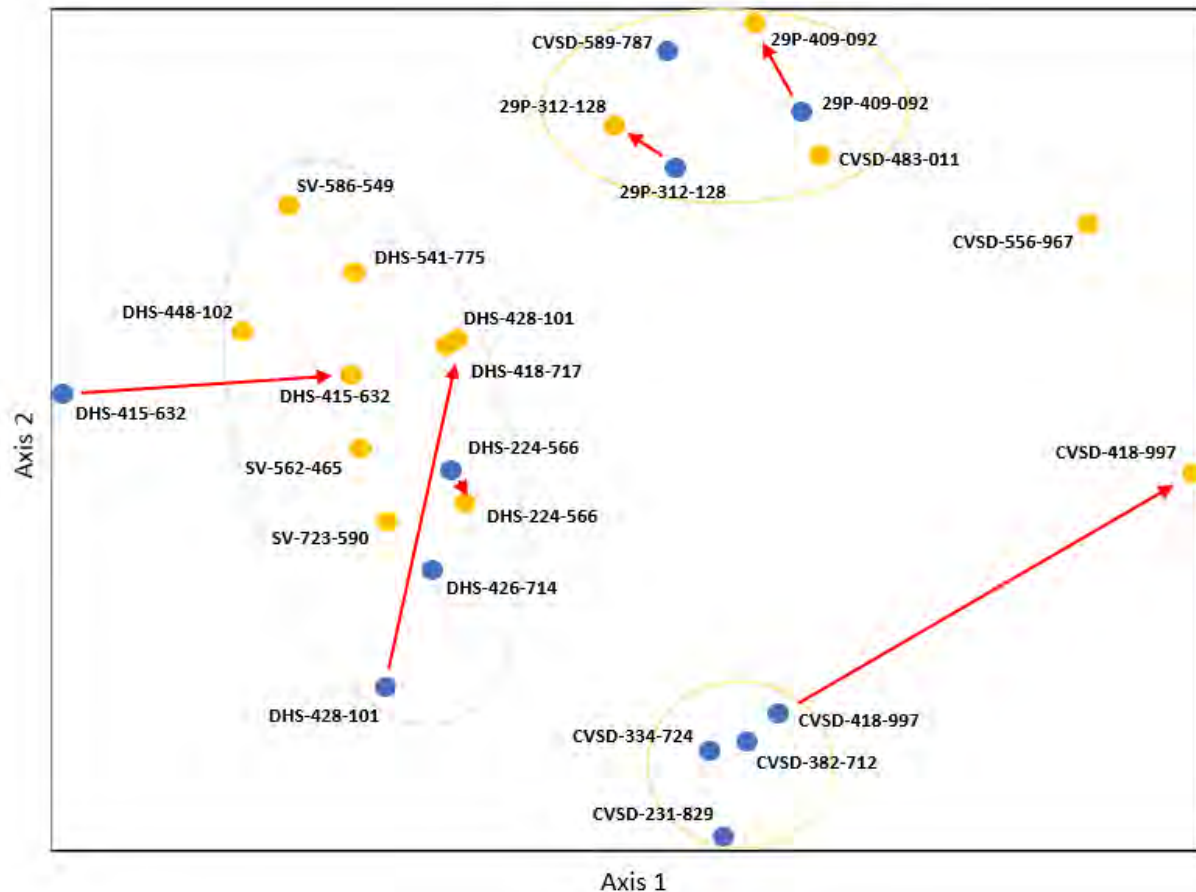


Figure 2: graph of DCA ordination analysis utilizing mean per-pellet data for 40 taxonomic categories of prey items recovered from 11 burrows in 2018 and 14 burrows in 2019. Blue points represent burrows from 2018; orange points are from 2019. Red arrows indicate the positional shift of resampled burrows. The light blue outline encompasses the DHS/Sky Valley cluster and the two light orange outlines encompass East Valley clusters.

## Reproductive Success

DHS yielded a higher mean reproductive rate (mean number of owlets per burrow) in 2017 and 2018, than did the East Valley (Table 2). This same pattern repeated again in 2019, although the cause of this is not as clear as in previous years. We have previously linked rates of owlet production to winter rainfall, with higher rainfall likely producing a larger and more diverse vertebrate prey base that is capable of sustaining more owlets (Figure 3b), possibly due to a more favorable energetic cost ratio when hunting fewer large prey items versus many more small prey items. Winter rainfall was well below average in 2015 and 2018. 2015 was at the tail end of a 4-year drought and saw the lowest owlet production, while 2018 was preceded by above-average winter rainfall in 2017, which probably contributed to the higher owlet production in spite of low winter rainfall. However, in 2019 we were unable to find a sufficient correlation between the amount of vertebrate prey items in the diet and owlet production for either DHS or East Valley families (Figure 3a,  $P=0.03$ ,  $R^2 = 0.0741$ ). While this regression analysis produced a significant p-value, the  $R^2$  indicates an extremely poor fit of the data to the regression line and therefore we consider these results inconclusive. We expect to see a higher owlet production at

DHS versus East Valley due to the more natural and presumably more abundant prey base here. However, this hypothesis may not be true in years of extreme drought, such as 2015, where we speculate that areas of irrigation and wastewater runoff found in the East Valley may provide a refuge for the owls' vertebrate prey base, while no such refuge exists in the less disturbed landscapes of DHS.

The cause of the lack of sufficient correlation between amount of vertebrates in the diet and owlet production in 2019 remains unclear. In spite of consuming more vertebrates on average and experiencing fewer nest disturbances, the owls in the East Valley still produced a lower mean number of owlets than in DHS. Perhaps in years with abundant rainfall that are not immediately preceded by multiple years of drought, such as in 2019, the advantages of a more abundant vertebrate prey base are somehow diminished due to an increase in the invertebrate prey base, including many large insects and arachnids, that the energetic cost benefits of hunting vertebrates over invertebrates becomes negligible. Also, we observed significant and regular erosion damage to the fine clay and silt embankments that the East Valley owls occupy as a result of the multiple powerful winter storms in 2019. On several occasions we noted the complete destruction of burrows that were occupied in previous years due to this erosion. The structural changes to the landscape these owls occupy may have contributed to their lower reproductive output. On a similar note, we did not observe a significant shift in prey item preference between owl families with pre-fledged owlets and those with fledged owlets. In 2018 we described a significant ( $P = 0.0371$ ) shift toward decreased vertebrate consumption and increased invertebrate consumption after owlets had fledged, likely due to the decreased energetic cost benefit of hunting vertebrate prey after owlets have begun hunting on their own. However, we were unable to support this conclusion using our 2019 diet data, which might be attributed to the same rainfall pattern effects described above.

*Table 2: comparison of the mean number of maximum observed owlets, % vertebrates in diet, and % PSPM in diet between DHS and east valley BUOW. Data from burrows occupied by a single owl were excluded.*

<b>Location</b>	<b>Study Year</b>	<b>Mean # Owlets</b>	<b>Mean % Vertebrates</b>	<b>Mean % PSPM</b>
DHS	2019	6.5	7.2	3.1
East Valley	2019	4	9.5	0.06
DHS	2018	6	11	4.3
East Valley	2018	3.6	4.4	0
DHS	2017	8.3	74	46.7
East Valley	2017	4	21	0
DHS	2015	0.8	18.4	15.8
East Valley	2015	1.7	10.6	0

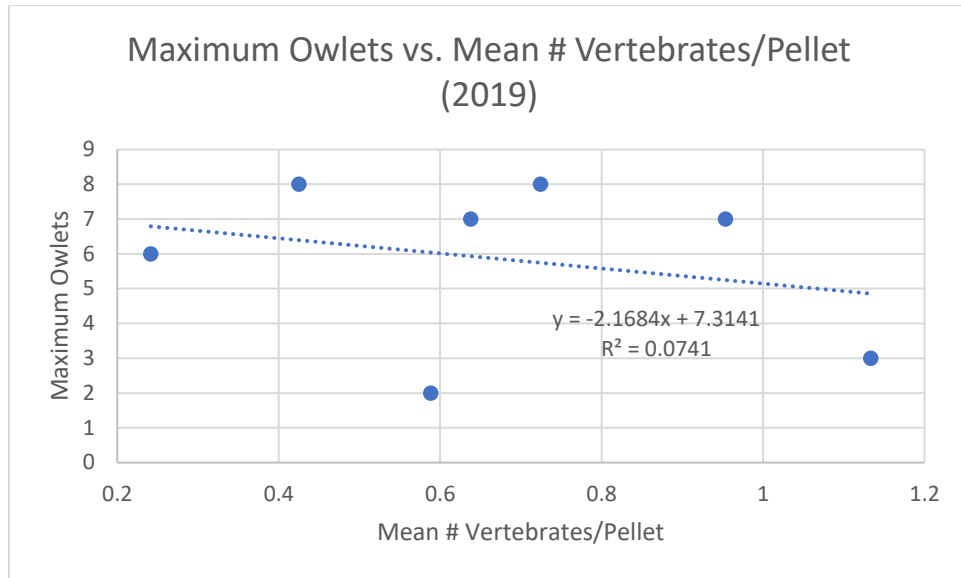
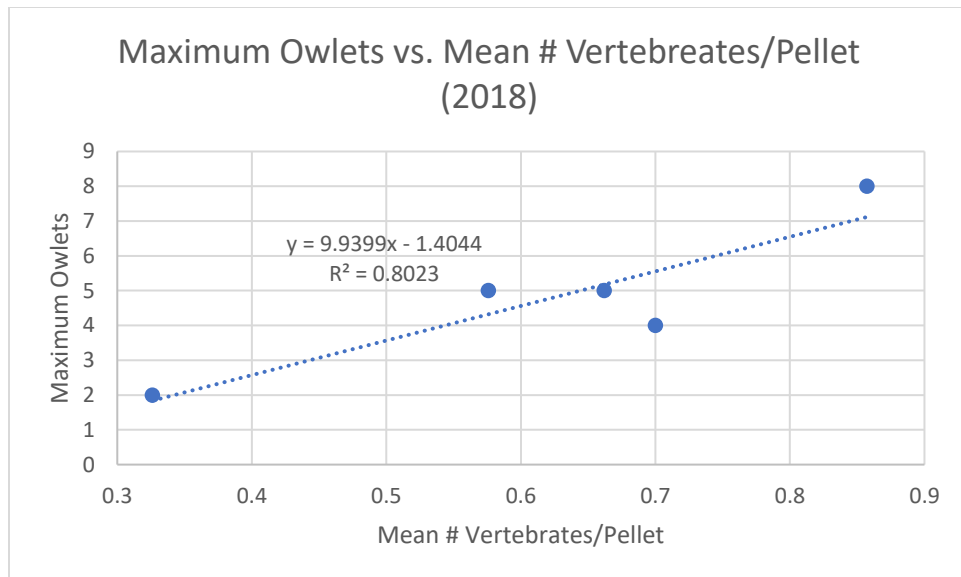
**a****b**

Figure 3: Regression analysis of mean number of vertebrates per pellet vs. maximum owlets observed for 2019 (a;  $DF=1$ ,  $F=0.40$ ,  $p=0.03$ ) and 2018 (b;  $DF=1$ ,  $F=12.17$ ,  $p=0.04$ ). Analysis includes only pre-fledged pellet data from burrows in DHS and the east valley that were confirmed to have produced owlets and were observed during the entire pre-fledge time period.

## Burrow Disturbances

We summarized burrow disturbances (visitations to burrows by animals potentially harmful to owls) observed in 2017, 2018, and 2019 in Table 3. Ravens (*Corvus corax*) are easily the most prevalent in DHS, and probably have the greatest impact on owl health and reproductive success. In 2018 one burrow in DHS experienced 43 visits by individual ravens, while a burrow in 2019 experienced 33. Ravens are known to steal food from burrowing owl caches, which we have observed periodically since 2017. In 2019, we documented the first instances of raven predation on owlets in this area at two burrows in DHS (DHS-224-566 and DHS-428-101, one owlet predated per burrow). Previously, we had only observed one instance of predation on an owl when a coyote was filmed digging out a burrow in DHS in 2018. We did not commonly observe ravens at owl burrows at either DHS or the East Valley in 2017, and they remain relatively uncommon at all Sky Valley and East Valley burrows (except 29P-312-128 in 2019). This may be explained by the significant increase in homeless activity that developed in an area in DHS known as “the airport” (roughly 544752E 3755575N). This area, which is a now-defunct dirt airstrip in close proximity to many of the monitored burrows, became popular for vagrant activity and illegal dumping, peaking in size in 2018. Many ravens were likely drawn to this area by the activity and ample garbage, exposing the nearby owl burrows to unusually high levels of raven visitations. While the homeless inhabitants of this area were relocated in 2018, illegal dumping is still commonplace here and elsewhere along the Little Morongo Wash.



Coyotes frequently visit owl burrows, often digging out the entrance of the burrow in an attempt to gain access to the owls inside. However, they usually appear to be unsuccessful and their visits result in no significant lasting damage. Roadrunners also often visit burrows but have not been observed to steal food or predate owlets. Two humans visited burrows in DHS in 2019: one man visited a burrow regularly during mid-morning hours, often attempting to investigate or remove the camera from its security box, and another individual was twice seen walking his dog past a second burrow in DHS. Neither appeared interested in the owls or burrows.

Table 3: list of disturbances (animal visitations) documented at monitored burrows for 2017, 2018, and 2019. Only animals that are potentially harmful to owl health are included. DHS sites are shaded orange; East Valley sites are shaded green; and Sky

Burrow	Days observed by camera	Raven	Roadrunner	Dog	Coyote	Human
<b>2019</b>						
DHS-418-717	4/26-6/26	14	4	2	1	2
DHS-428-101	4/26-6/26	14	4	0	4	0
DHS-541-775	4/26-6/19	7	1	0	3	9
DHS-448-102	4/26-5/12	7	0	0	0	0
DHS-224-566	5/2-6/26	33	12	0	6	0
DHS-415-632	5/12-6/26	3	2	0	2	0
SV-562-465	5/16-6/21	0	0	0	0	0
SV-586-549	5/20-6/12	0	0	0	0	0
29P-312-128	4/24-5/20	17	1	0	10	0
29P-409-092	4/25-5/20	0	0	0	0	0
CVSD-418-997	5/20-6/26	0	6	0	2	0
CVSD-483-011	5/20-6/26	0	1	0	1	0
CVSD-556-967	5/20-6/26	0	0	0	3	0
<b>2018</b>						
DHS-415-632	5/21-6/27	43	2	1	0	0
DHS-224-566	6/4-7/6	10	2	0	0	0
DHS-428-101	5/22-6/20	9	2	0	0	0
DHS-418-717	5/18-6/26	26	2	0	1	0
DHS-426-714	5/23-6/25	3	0	0	0	0
29P-312-128	5/11-5/17, 5/23-7/27	7	5	0	3	0
29P-203-400	5/23-6/25	2	4	0	1	2
29P-409-092	5/11-5/17, 5/23-6/4, 6/7-6/29	0	0	0	0	0
CVSD-418-997	5/18-6/29	0	0	0	0	0
CVSD-382-712	5/17-6/5	0	3	0	1	0
CVSD-231-829	5/17-6/4	2	0	0	0	1
<b>2017</b>						
DHS03	4/17-7/31	3	2	0	5	0
DHS04	4/17-5/7, 5/15-7/31	5	0	0	9	0
DHS12	4/24-5/7, 5/15-6/25, 7/03-7/31	2	1	1	5	0
CVSD10	5/8-5/22, 5/29-7/31	1	2	0	0	0
CVSD13	5/8-7/31	1	2	0	1	2

## Palm Springs Pocket Mice

The results of our 2019 Palm Springs pocket mouse monitoring effort, as part of our annual Aeolian Sand Species Trends report, are shown in Figure 4. This monitoring effort relies on an estimate of abundance based on the counting of PSPM tracks over a collection of 0.1 ha plots. These plots are all situated within fine, wind-blown sand landscapes, allowing for tracking of all animals that cross within the plot boundaries. However, PSPM also occur across other habitats, such as stabilized desert scrubland and alluvial flats, where aeolian sand is scarce or absent and thus tracking is impossible. We have developed a secondary PSPM monitoring protocol based on the abundance of PSPM remains recovered from the pellets of owls that hunt across these unsampled habitats. By comparing the amount of PSPM taken by owls over successive years, we are able to extrapolate how PSPM populations in these areas change over time. Also, we are able to compare the amount of PSPM taken as prey between owls occupying

vastly different habitat, such as DHS compared to the East Valley, to investigate how anthropogenic pressures (i.e. urban development and agriculture) affect PSPM populations.

Palm Springs pocket mouse can be a significant part of the BUOW diet. In previous years, PSPM have been completely absent from pellets collected from burrows in the East Valley, however, in 2019 they were present in small numbers (4 specimens total, Tables 1 & 2). While it still appears that PSPM are greatly affected by urbanization and agriculture and populations thrive in the comparatively natural habitat of the bajadas near DHS, the 2019 pellet analyses show that PSPM are present to some degree in the anthropogenic landscapes of the East Valley. It could be that BUOWs in the East Valley are increasing or changing hunting range into more suitable PSPM habitat, however, with 2019 being a wet year, BUOWs probably did not need to range far in search of prey. Ultimately, this remains an unknown, but what can be concluded is that while PSPM are present in East Valley pellets this year, their numbers remain extremely low relative to DHS pellets, indicating that human development has a severe impact on PSPM populations.

Figure 5 illustrates PSPM population trends alongside annual SPI (standardized precipitation index). We have found that the average number of PSPM has decreased in DHS and aeolian habitats from 2018 to 2019. This decrease corresponds to an increase in precipitation, which supports the hypothesis we have previously drawn that PSPM thrive in conditions that are more arid -- in dryer years there is a decrease of competition from kangaroo rats and desert pocket mice, as well as a decrease in Sahara mustard cover, giving PSPM more access to food. At least in DHS, our pellet analyses corroborate our results from aeolian tracking, showing a decrease in PSPM abundance in spite of increased rainfall. However, many mammals, including PSPM, are known to exhibit a one-year “lag-time” in response to precipitation, so PSPM populations may increase in 2020 as a result of the high winter precipitation in 2019.

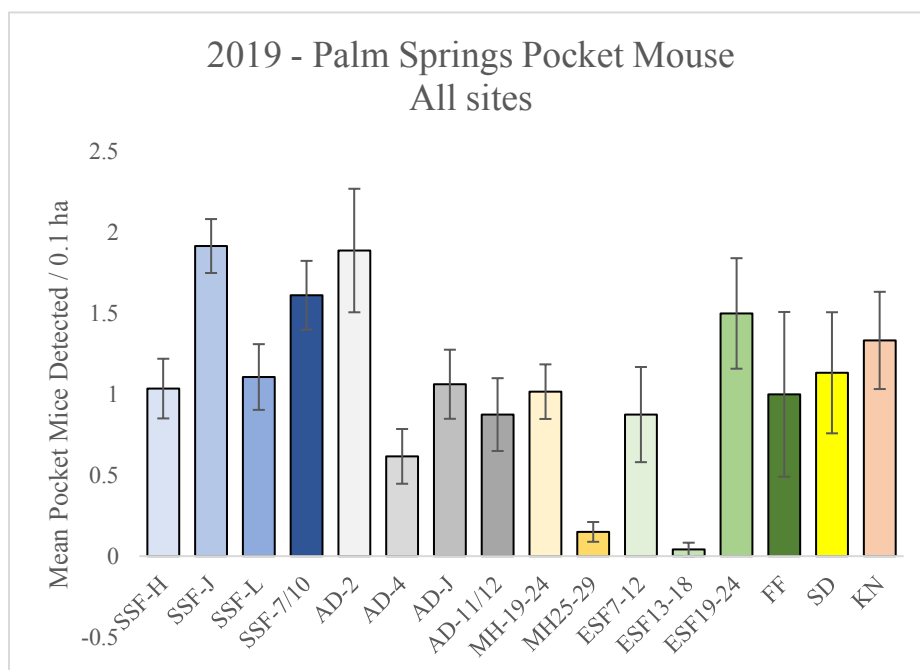


Figure 4: Figure 15. Palm Springs pocket mouse abundance across all plot clusters in 2019.

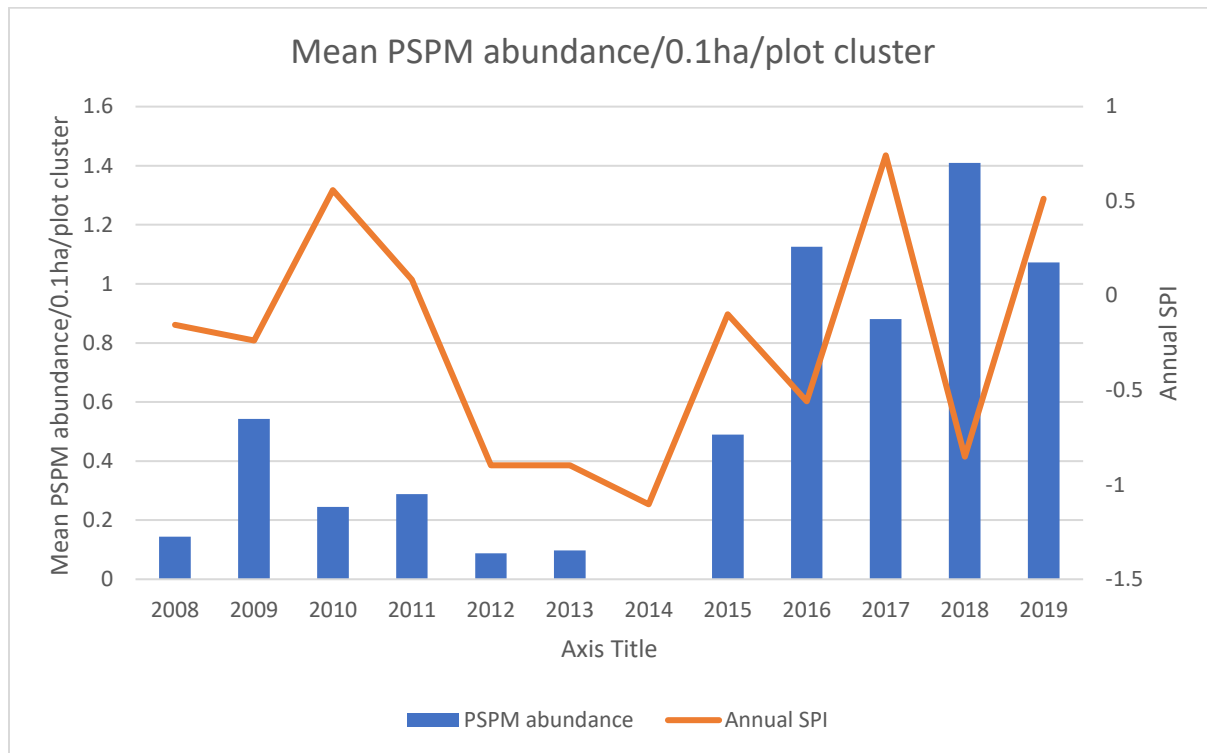


Figure 5: PSPM population densities (mice / 0.1 ha) in aeolian habitats over time. Winter SPI is offset forward by one year to better demonstrate the lag time observed with vertebrate population increases with increased rainfall. Monitoring was not conducted in 2014.



## Conclusions

- Burrowing owl diets consist of a diverse assemblage of vertebrate and invertebrate prey items. Owl diets in DHS are characterized by more large darkling beetles, PSPM, and other vertebrates. East Valley diets contain abundant desert pocket mice and a wide range of insects that thrive in anthropogenic environments. Scorpions and solifuges are common prey items at both localities.
- A DCA ordination analysis of prey item abundance reveals dissimilarities between the diets of owls from DHS and from East Valley. Overall, the diets of owls in DHS appear to exhibit less change from year to year.
- The DCA ordination analysis reveals that the owls in Sky Valley appear to share a similar prey base with the owls in DHS, indicating that, in spite of excessive illegal dumping, DHS still supports a relatively natural prey base. However, more sampling is needed to verify this similarity.
- Our hypothesis that increased vertebrate prey intake allows for increased owlet production does not seem to be true in 2019. Owls in DHS consumed on average fewer vertebrates than owls in the East Valley, but still produced a higher mean number of owlets. This may be due to several factors, including compromised nesting habitat in the East Valley due to flooding, and the possibility of a decrease in the energetic cost benefits of vertebrate hunting in years that are not experiencing the immediate or delayed effects of drought conditions.
- Ravens continue to be a significant source of stress for burrowing owl families. In 2019, we observed the first instances of owlet predation by ravens. Both instances were in DHS, which has the highest frequency of raven visitations, likely due to the excessive illegal dumping that takes place near burrows.
- The abundance of PSPM in owl pellets from DHS is lower this year than from 2018. Again, this may be due to an unforeseen shift in prey preference during years that experience very wet winters, leading to an overabundance of invertebrate prey and a decrease in the energetic cost benefit of favoring vertebrate prey. However, a decrease in the PSPM population may also coincide with increased competition from other small mammals whose populations have rebounded after the favorable winter conditions.
- We documented PSPM in owl pellets for the first time from the East Valley. This may be due to owls exploring new hunting habitat that is able to support PSPM, or it may be a result of the extremely wet winter of 2019 which has allowed the PSPM populations in that area to expand into the owls' hunting range.



### ***Possible Management Actions***

- Increase the number of burrows monitored at Sky Valley, which will provide critical information on owls that occupy mostly undisturbed, natural habitat.
- Eliminate garbage associated with homeless encampments and illegal dumping to reduce raven numbers, especially in DHS.

### **Literature cited**

Barrows, C.W. 1989. Diets of five species of desert owls. *Western Birds* 20: 1-10.

Barrows, C.W. 1987. Diet shifts in breeding and non-breeding Spotted Owls. *Raptor Research* 21(3): 95-97.

Haley, K. L. and D. Rosenberg. 2013. The influence of food limitation on reproductive performance of burrowing owls. *Raptor Research* 47(4):365-376

Latif, Q.S., K.D. Fleming, C.W. Barrows, and J.T. Rotenberry. 2012. Modeling seasonal detection patterns for burrowing owl surveys. *Wildlife Society Bulletin* 36-1: 155-160. doi: 10.1002/wsb.97

Trulio, L.A. and P. Higgins. 2012. The diet of western burrowing owls in an urban landscape *Western North American Naturalist* 72: 348-356.

## Appendix VIII – Coachella Valley Jerusalem Cricket

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# 2019 Monitoring Results for the Coachella Valley Jerusalem Cricket (*Stenopelmatus caluilaensis*) within the Coachella Valley MSHCP Area



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

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# COACHELLA VALLEY JERUSALEM CRICKET MONITORING

The Coachella Valley Jerusalem Cricket (*Stenopelmatus cahuilaensis* Tinkham 1968, or CVJC) is a large, ground-dwelling insect endemic to the cooler-wetter western end of the Coachella Valley Multiple Species Habitat Conservation Plan area. Many questions remain about the biology of this insect. What we know is that: 1) it appears to require habitat with abundant loose sands in or along the San Gorgonio River and nearby dune systems, and 2) it spends the majority of the year underground, only reliably coming to the surface during cool winter or spring nights following sufficient rainfall (Prentice et al. 2011, Tinkham 1968, Weissman 2001).

CVJC are rarely encountered in the wild by chance. In order to effectively monitor this species Prentice and others (2011) devised a passive detection method employs 2'x2' plywood "coverboards" as shelters for CVJC to occupy which can be easily checked for presence of the animal during the day. Using this method, we have been able to estimate the current range of this species. Historically, this insect's range extended well into Thousand Palms, Palm Springs, and the Whitewater Floodplain Preserve (Fig 1, orange line), but it is now thought to be restricted to a relatively small area between Snow Creek and Cabazon, south of Interstate 10 (Fig 1, red line). The reasons behind this apparent westward range contraction are unknown, but are likely the result of both habitat destruction and climate change. Large amounts of suitable habitat in Palm Springs has been developed or fragmented, and the remaining habitat in the Whitewater Floodplain and Thousand Palms has likely become too dry and hot to continue supporting this species which likely requires cooler weather and increased moisture.

This westward contraction of the CVJC's range was determined during the initial surveys in 2003 and 2009 by Prentice and others. Monitoring has since been conducted in 2015, 2018, and 2019. The 2015 survey yielded only a single cricket, likely due to prolonged drought conditions. However, monitoring in 2018 and 2019 produced a CVJC detection rate comparable to the results of the 2003 and 2009 surveys, demonstrating that the CVJC populations, at least in the Snow Creek area, have remained fairly stable.

The status of CVJC in the Whitewater Hill area remains somewhat ambiguous. Prentice and others reported finding four CVJC at a demolished homestead at Whitewater Hill, along with another undescribed Jerusalem cricket species of similar morphological character (hereafter "Whitewater species"). Since 2003, only small numbers of this undescribed species have been detected on Whitewater hill, and no CVJC have been found here. This failure to detect CVJC on Whitewater Hill may indicate that it has since been extirpated from this area, however it is also possible that the four CVJC found in 2003 were confused with the undescribed species, and CVJC have never existed on Whitewater Hill.

## Objectives

Previous CVJC monitoring efforts have identified Snow Creek and Fingal's Finger as supporting high cricket densities. As such, we chose these locations to serve as the focal point of our continued coverboard-based survey since they may represent important potential environmental refuges for this species. We performed the initial assessment of the CVJC population density on a small parcel of recently acquired conserved land near Fingal's Finger which we have recently selected to contain our western-most cluster of aeolian community monitoring plots. We measured soil moisture at all coverboard and debris sites that yielded a cricket to gain a better insight into preferred microhabitat conditions. We also investigated the status of CVJC on Whitewater Hill, as well as obtained more information about the biology of the sympatric undescribed species in this area. We have collaborated with Dr. David Weissman at the California Academy of Science, Department of Entomology, to clarify the taxonomy of this Whitewater Hill population

## Methods

For the 2019 survey effort, we monitored 48 focus sites across four broad localities: Snow Creek North and Snow Creek South (located within the broader Snow Creek area along Snow Creek Rd., about 1km separated), Fingal's Finger, and Whitewater Hill (Figure 1). A "focus site" is a coverboard or debris location that we checked on a weekly basis. Five sites were comprised of box springs and mattresses, all others were plywood coverboards. Other non-focus sites consist of debris and litter, which we overturned when opportunistically encountered, but did not visit regularly. We re-used 36 focus sites, in their original positions, from previous surveys. We installed eight new coverboard sites at Whitewater Hill and four at Fingal's Finger. We checked each focus site for the presence of Jerusalem crickets once per week for seven weeks, beginning January 4 and ending February 19.

Upon finding a cricket, we placed the individual into a large glass vial where we photographed it, sexed it if possible, and measured its length (Figure 2). We focused the photographs on the minute patterning of dark blotches that constitute the abdominal bands, which we have determined to be useful for identifying resampled adult crickets due to their fingerprint-like uniqueness (Figure 3). We identified species based on variation in the width and shape of the dark dorsal abdominal banding, as opposed to the previous method of species diagnosis that involved counting tibial spurs which is now known to be unreliable (Weissman pers. comm.). CVJC possess abdominal bands which are narrow, often more weakly defined, and taper and fade laterally. Other species found at Whitewater Hill and Cabazon have wider, bolder, more well-defined abdominal banding. We recorded soil underneath each coverboard that yielded a cricket in an attempt to characterize their preferred microhabitat conditions. We used a General MMH800 moisture meter for soil moisture readings. Each instrument was used six times per sampling effort -- once in the middle of where the board would lay, once about 3 inches in



from each corner, and once close to the exact spot where the specimen was located -- in order to obtain an average. After data collection, we replaced the coverboard/debris and released the cricket back under the coverboard via a small depression made at the coverboard's margin.

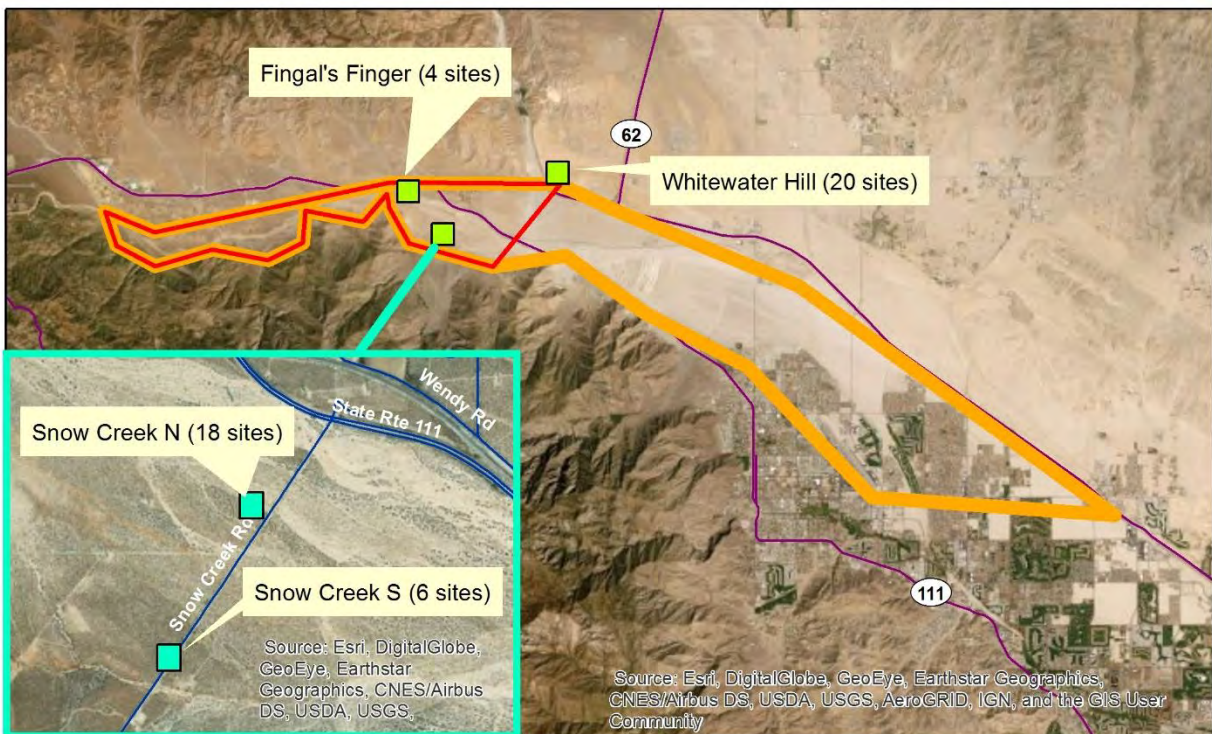


Figure 1: Map of broad localities monitored for CVJC in 2019. Survey sites are indicated by green squares. Each survey site consisted of multiple cover board and debris sites. The orange outline represents the CVJC historical population boundaries. The inset red outline represents the estimated current boundaries of CVJC. Inset map shows the monitoring sites within the Snow Creek area.



Figure 2: (a) Soil beneath a 2'x2' plywood cover board where Jerusalem crickets are observed. (b) Debris in the San Geronio River at Fingal's Finger which yielded a CVJC in 2018. (c) CVJC undergoing measurements and photographs.



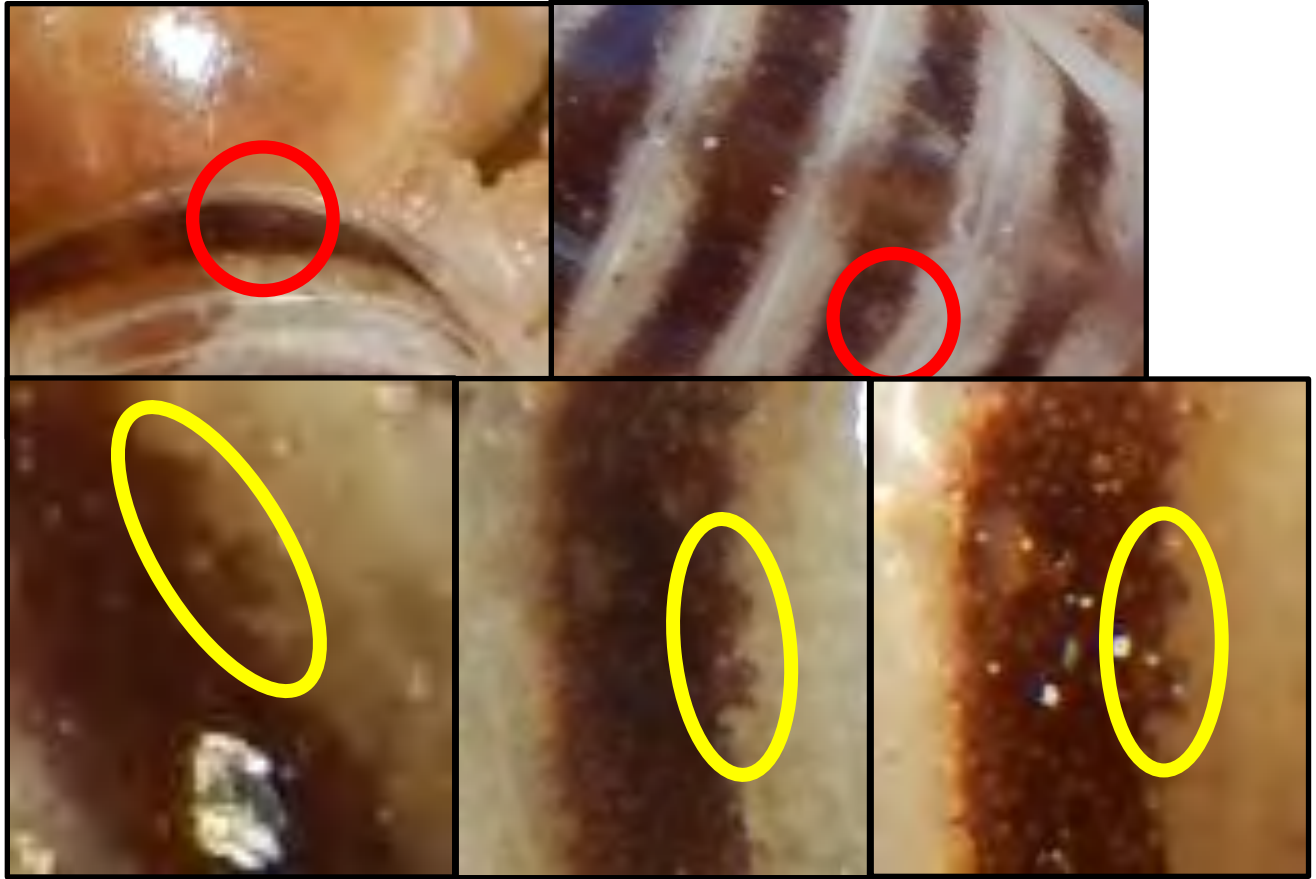


Figure 3: Comparisons of two unique CVJC (top and bottom) identified as resamples through the use of our photographic “fingerprinting” method. Each photo represents a different sampling event.

## Results

We observed a total of 24 CVJCs and 2 undescribed Whitewater JC species during our 2019 monitoring effort. Using our photographic “fingerprinting” method, we confirmed 7 instances of resampling involving 3 CVJC individuals, resulting in a maximum of 17 unique CVJC and 2 “Whitewater species” individuals encountered (Table 1). The location with the highest detection rate at focus sites was Snow Creek South, which had over twice the detection success of the nearby Snow Creek North set of focus sites. Two CVJC and both of the Whitewater species were found under pieces of debris, with the remaining CVJC detections occurring at focus sites. We did not find CVJC at Whitewater Hill. Compared to the detection rates of 2018 (Table 2), the detection rate of Jerusalem crickets has increased substantially at all sites except Snow Creek South. Considering total CVJC detections at plywood coverboards only,

the number of observations from 2019 (17) is higher than any of the previous years, although it is very similar to 2003, 2009, and 2018 (Figure 4).

<b>Location</b>	<b># Focus Sites</b>	<b># Searches</b>	<b># Jerusalem Crickets (Focus Sites)</b>	<b># Jerusalem Crickets (Debris)</b>	<b>Detection Rate (Focus Sites)</b>
Snow Creek North	18	126	7	0	5.6%
Snow Creek South	6	42	6	0	14.3%
Fingal's Finger	4	28	2	2	7.1%
Whitewater Hill	20	136	0	2	0%

Table 1: Results of 2019 CVJC monitoring showing the maximum number of unique individuals observed. Table includes both CVJC and the undescribed Whitewater species.

<b>Location</b>	<b># Jerusalem Crickets</b>	<b>Detection Rate</b>
Snow Creek North	11	8.1%
Snow Creek South	4	8.2%
Fingal's Finger	3	3.4%
Whitewater Hill	0	0%

Table 2: Results of 2018 CVJC monitoring showing the maximum number of unique individuals observed. Table includes only CVJC.

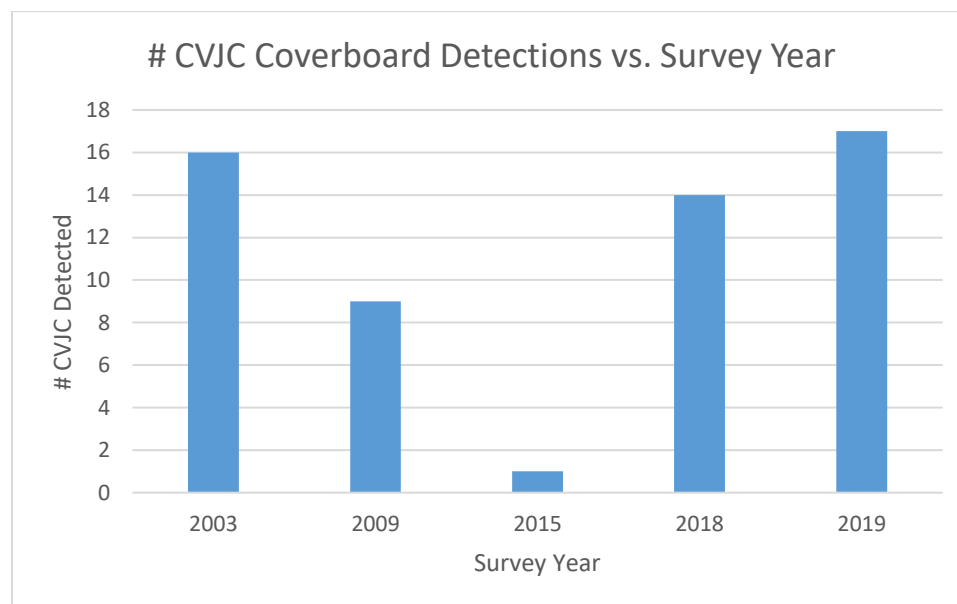


Figure 4: Total CVJC detections per survey year at plywood coverboards only.

Similar to our findings in 2018, Jerusalem cricket activity in 2019 appears to decline as winter progresses (Figure 5). Surveys in 2018 and 2019 began at roughly the same time (January 9 and January 4, respectively), and both years saw JC detections at most sites approach zero by the sixth week of surveys, with the exception of Snow Creek South in 2019. This decline in activity over time is likely related to a decrease in soil moisture as rainfall becomes rarer later in winter. As indicated by (Figure 5), Jerusalem crickets appear to favor fairly moist microhabitats, roughly around 20% soil moisture content, to take shelter in during the day to avoid desiccation.

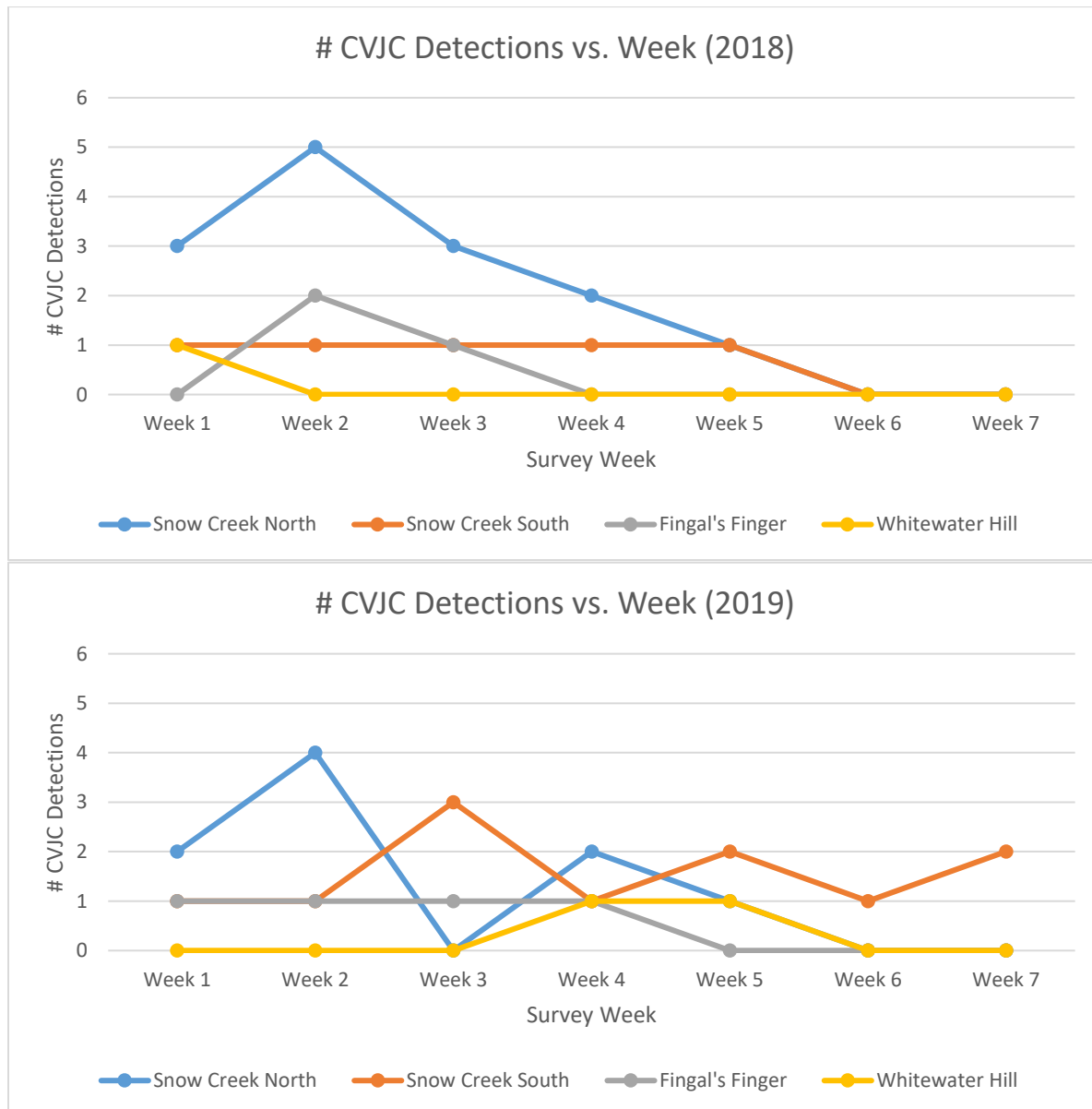


Figure 5: number of Jerusalem cricket detections (CVJC and undescribed species) at each survey site per week for 2018 (top) and 2019 (bottom). Monitoring in 2018 concluded at week 6 for all sites except Whitewater Hill.

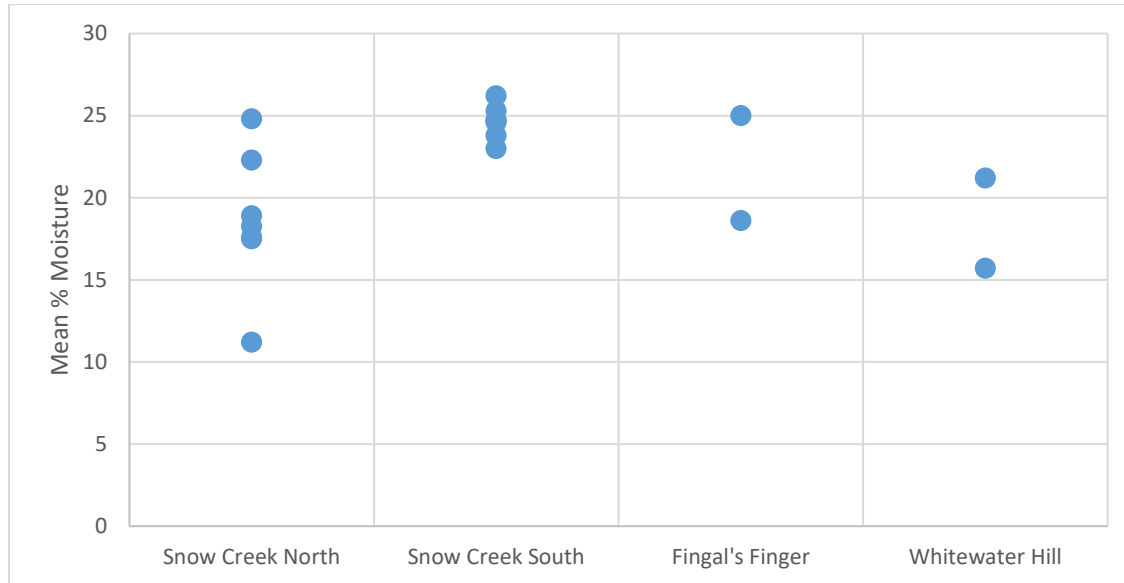


Figure 4: Mean percent soil moisture under sites where Jerusalem crickets were found in 2019.

## Discussion

As with our monitoring efforts last year, our photographic tracking technique has proven valuable for refining our understanding of Jerusalem cricket behavior and distribution. This technique has limitations, however. Namely, once a cricket molts, its abdominal patterns change with the formation of its new exoskeleton, and therefore can no longer be tracked by this method. This technique is always accurate when tracking adult crickets, however, since adults cease molting once they reach adulthood. Extrapolating from the frequency of resampled adult crickets, it may be possible to construct an overall estimate of resampling across all age classes, although this would require an assumption that all age classes behave similarly to adults, which may not be the case. The number of resampled individuals in 2019 was the same as 2018 (3 individuals per year), further indicating that rates of CVJC resampling may be fairly predictable. Also, all resampled individuals from 2018 and 2019 were observed at their original shelter locations. In one case in 2019, a female cricket was resampled at the same location five times. Most individuals we encounter are never sampled again, unless they have molted and are not recognized. This may indicate that the crickets either disperse over large areas and/or they have a tendency to abandon a shelter if they have been disturbed. Further investigation is required to determine what causes some crickets to return to a shelter while most others do not.

The detection rates for focus sites at different locations in 2019 revealed that Snow Creek North had a much lower detection success rate than Snow Creek South, in spite of these locations being very similar habitat and located less than a kilometer apart (Table 1). Further, the detection rates in 2018 between these two areas were almost identical. We believe this discrepancy is due to flooding that occurred across portions of the Snow Creek North site at roughly the same time that the detection rate here began to decrease (Fig 5). The affected areas were covered with fine silt that dried into a hard crust, including in some cases underneath coverboards, which is likely inhospitable for Jerusalem crickets and may explain the decreased detection rate. Monitoring in 2018 yielded a similar maximum number of Jerusalem crickets, but lower overall detection rates at most sites (Table 2). This may be due to less winter rain in 2018 compared to 2019, resulting in a decreased amount of aboveground activity, but not necessarily a decrease in population density. Similarly, the overall total detections of Jerusalem crickets in 2015 was drastically lower than any other survey year, with only one specimen found during the entire season (Figure 4). This is explained by 2015 being in the midst of a serious drought, with the remaining years seeing at least some appreciable winter rainfall. A discrepancy also exists between the number of detected Jerusalem crickets over time. In 2018, Jerusalem cricket activity appeared to nearly cease by the sixth week of surveys, but in 2019, at least in the Snow Creek South area, activity appears to continue past this time. Again, this may be explained by rainfall, with the above-average winter rains in the winter of 2019 likely keeping the ground moist for a longer time than the below-average rains experienced in 2018, and thus allowing the crickets to be active above-ground for longer.

Jerusalem crickets engage in a drumming behavior which can be used to diagnose species due to the species-specific patterns of drumming (Weissman 2001). Two individuals were found on Whitewater Hill, both of which were diagnosed as the undescribed species from that area based on morphological features. We sent one live specimen to Dr. David Weissman at the California Academy of Science so its drumming pattern can be used to further validate this diagnosis. The status of CVJC on Whitewater Hill remains unclear. No specimens have been found in this location since the original surveys by Prentice in 2003 and 2009, but it remains unclear whether the CVJC found by Prentice in this location were misidentified and actually represented the Whitewater species. In spite of drastically increased sampling efforts on Whitewater Hill, only two individuals were discovered. This may indicate that this population is much lower density than the CVJC in the Snow Creek area, or possibly we have been unknowingly sampling in the fringes of suitable habitat and have yet to determine their center of highest population density.

## Recommendations

The Snow Creek conservation area remains a bastion for high CVJC density. This population likely extends westward along the San Geronio River, as indicated by the regular CVJC encounters at Fingal's Finger. Therefore, any conservation efforts involving CVJC should be focused in the Snow Creek area. However, based on repeated monitoring efforts since 2003,

the population in this area appears to be stable. The effects of stressors such as increasing invasive plant cover, flooding, and OHV activity are not known and may be important to understand to ensure this population remains healthy. Thanks to roadside fencing, OHV activity should be minimal in this area, and the high invasive plant cover already present here, namely *Erodium cicutarium* and *Brassica tournefortii*, does not seem to have a severe effect on the CVJC population here since their density appears to be stable. As shown by the strikingly lowered detection rate at Snow Creek North (which borders the San Geronio River), CVJC may not have the ability to withstand severe flooding, but this should only be an issue in the northern, lower elevation parts of the Snow Creek area that are within the flood zone.

More extensive monitoring efforts are required on Whitewater Hill and the surrounding area north of the I-10 in order to understand the range, density, and biology of the Whitewater species. No CVJC have been observed on Whitewater Hill since 2009, and it remains unclear whether they were ever there (perhaps initially misidentified), if they have since been extirpated, or if they are present in densities below our detection threshold.

## Literature Cited

- Tinkham, E. R. (1968). Studies in Nearctic desert sand dune Orthoptera: Part XI. A new arenicolous species of *Stenopelmatus* from Coachella Valley with Key and biological notes. *The Great Basin Naturalist*, 28(3), 124-131.
- Prentice, T. R., Redak, R. A., & Barrows, C. W. (2011). Survey methodology and distribution of a cryptic Jerusalem cricket species, *Stenopelmatus californicus* Tinkham (Orthoptera: Stenopelmatae: Stenopelmatinae). *The Pan-Pacific Entomologist*, 87(1), 1-14.
- Weissman, D. B. (2001). North and Central America Jerusalem crickets (Orthoptera: Stenopelmatae): taxonomy, distribution, life cycle, ecology and related biology of the American species. *The Biology of Wetas, King Crickets and Their Allies*. CABI Pub., Wallingford, NY, 57-72.

Appendix IX-  
Valley Floor Reserve Units  
2013 & 2018 Vegetation Map Report

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**Coachella Valley Conservation Commission**

**September 30<sup>th</sup>, 2019**

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

**Valley Floor Reserve Units  
2013 & 2018 Vegetation Map Report**



**Lynn C. Sweet, Cameron Barrows, Scott Heacox, Melanie Davis, Robert Johnson**

**University of California Riverside, Center for Conservation Biology**

**Final report**



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## EXECUTIVE SUMMARY

The University of California Riverside's Center for Conservation Biology (CCB) has created fine-scale vegetation maps for a number of Conservation Areas under the jurisdiction of the Coachella Valley Multiple Species Habitat Conservation Plan (CVMSHCP) under contract with the Coachella Valley Conservation Commission (CVCC). The primary purpose for creating these maps is provide a landscape-scale approach to monitoring changes due to land use, invasive species, recreation, hydrology, and climate. These digital maps, documenting changes and their causes, are then tools for prioritizing future conservation actions. The vegetation classification follows Federal Geographic Data Committee (FGDC) and National Vegetation Classification Standards (NVCS; Federal Geographic Data Committee 2008). The classification is meant to align with previous and concurrent efforts previous survey and classification work done by California Department of Fish and Wildlife's Vegetation Classification and Mapping Program (VegCaMP) and Aerial Information Systems (AIS) for the Desert Renewable Energy Conservation Plan Area as well as the southeastern Salton Sea Mid-Desert Area, and by the National Park Service for Joshua Tree National Park. This unit was mapped using the California Department of Fish and Wildlife (CDFW) and California Natural Plant Society Combined (CNPS) Vegetation Classification and Mapping Program protocol (CNPS 2014).

The primary purpose was to develop a dynamic and accurate vegetation map for the Coachella Valley Floor Reserve Management Unit (Figure 1), so that it may be applied to further conservation efforts and assist with management of the 27 species and 27 natural communities listed within the plan. Map polygons were assessed for vegetation type, percent cover, presence of exotics, anthropogenic disturbance, and roadedness.

This map and report describes a map correction for the year 2013 as well as an updated map for the year 2018 for the area within the 95,000 acres that fall within the 18 CVMSHCP Management Units on the Coachella "Valley Floor." Within the study areas, rapid assessment protocol vegetation plots, basic vegetation assessment plots and supplemental reconnaissance observations were obtained within the study at pre-determined points in order to document the plant community, disturbances, and invasive species across space and types. Heads-up photo-interpretation of 2013 local flight true-color imagery, fine-scale National Agriculture Imagery Project (NAIP) imagery (USDA, 2012, 2014, 2016 and 2018) and field information were combined to produce delineations of vegetation alliances and associations according to the California Department of Fish and Wildlife classification system, outlined in the Manual of California Vegetation (MCV) Second Edition (Sawyer *et al.* 2009).

The first version of the Valley Floor final vegetation map was completed in 2014, however, the map will be referred to as a corrected 2013 map to match the imagery date. For the present 2013 map correction, the classification of the original map was updated to match alliance and association names used in the MCV online (<http://vegetation.cnps.org/>). For the 2018 map update, additional field data was collected in 2018, which was incorporated into the both the 2013 map correction (as appropriate) and the 2018 map update. The 2018 map delineation was done by photo-interpretation of updated imagery, with a focus on stand changes, mortality, cover and land use changes, and other anthropogenic changes. There were 187 total vegetation

assessments done in 2014, documenting plant community cover generally following the guidelines in the CNPS 2011 Vegetation Rapid Assessment Protocol (CNPS 2011). For the 2013 map correction and the 2018 map, 116 Rapid Assessments were recorded throughout the area using the updated Rapid Assessment protocol (CNPS 2016) from December 2017 through February 2018.

To better focus on conservation of particular habitats, there are several alliances where the minimum mapping unit (MMU) is less than an acre; including *Prosopis glandulosa* Woodland Alliance, and *Washingtonia fillifera* Shrubland Alliance, as well as wetlands and certain wash types which displayed complexity that would necessitate delineation. In order to better delineate habitat for the aeolian suite of species covered under the Plan, the following provisional alliances were used: *Dicoria canescens*--*Oenothera deltoides* Sparsely Vegetated Active Dune Provisional Alliance; *Larrea tridentata* / *Abronia villosa* Stabilized Sand Fields Provisional Alliance; and *Psoralea arborescens* / *Dicoria canescens* Ephemeral Sand Fields Provisional Alliance.

Because of the very small detectable changes in vegetation cover and the short time period between maps (5 years) as well as the difficulty reliably detecting true changes in live cover due to imagery limitations the following changes should be interpreted as preliminary findings. The largest amount of land cover for both 2013 and 2018 maps is classified under the *Larrea tridentata* -- *Encelia farinosa* Shrubland Alliance, representing over 10,000 hectares followed by the *Larrea tridentata* -- *Ambrosia dumosa* Shrubland Alliance at almost 7,000 hectares. The largest mapped declines in area from 2013-2018 type mapped were the *Larrea tridentata* -- *Ambrosia dumosa*, the *Atriplex canescens* type (-81 ha) and the *Tamarix* spp. type (-27 ha). The largest increases were in the Disturbed/Built-up (+114 ha) and the Non-vegetated Habitat types (Table 1). Shrub cover was characterized by an increase in areas with no or 0-1% cover, and a decrease overall in areas with 1-50% cover overall. In terms of roadedness, development, and anthropogenic alteration, there was a general trend towards an increase in the area demonstrating anthropogenic disturbance overall, and less overall area showing no disturbance.

Overall, an increase in anthropogenic effects and a decrease in shrub cover reflects an area that is still subject to human pressure, despite protection under the CVMSCHP. This map should continue to guide land management efforts in terms of condition and threats to specific habitat, and any necessary changes in management to meet the objectives laid out in the Plan.

## INTRODUCTION

### *Conservation Background*

This vegetation map is a tool to aid in species monitoring and management in the Valley Floor area of the Coachella Valley Multiple Species Habitat and Natural Community Conservation Plan (CVMSHCP/NCCP). At the end of the twentieth century, 27 species and 27 vegetation communities in the Coachella Valley were identified as being affected by pressures of land development and conversion of habitats. The most direct threat to the biodiversity of the area is habitat loss. From 1996 to 2008, citizens, scientists, land managers, and federal and state

agencies of the Valley developed a conservation plan that offered protection to these species and preserved over 250,000 acres of open space (Figure 1). The plan was approved by federal and state agencies and was implemented in 2008, all cities involved in the collaborative effort. This comprehensive land planning essentially protects the ecological drivers and processes to enhance sustainability of community biodiversity. The plan is science-based and investigates hypotheses related to the persistence of species on conservation lands through adapting monitoring and management.

The vegetation mapping is funded by the Coachella Valley Conservation Commission to provide data on characteristics of the vegetation within the Plan Area and to complement concurrent species and habitat monitoring. The outdated map, created before 1999, was based on the older Holland classification (Holland 1986). As part of the CVMSHCP/NCCP monitoring program, a phased work plan to remap all 746,000 acres of our Conservation Areas began in 2012.

Updated vegetation maps are an essential element of monitoring for covered species and natural communities and provide a baseline to monitor natural communities and landscape-scale vegetation change. These data are key to conservation of biological diversity in the Plan area, especially given the impacts of increasing periods of drought and the effects of climate change. Understanding habitat requirements, extent and spatial continuity for species will help to guide the development of land management actions that support recovery and sustainability of healthy populations. Data produced under this effort is publicly available and supports concurrent CVMSHCP/NCCP monitoring.

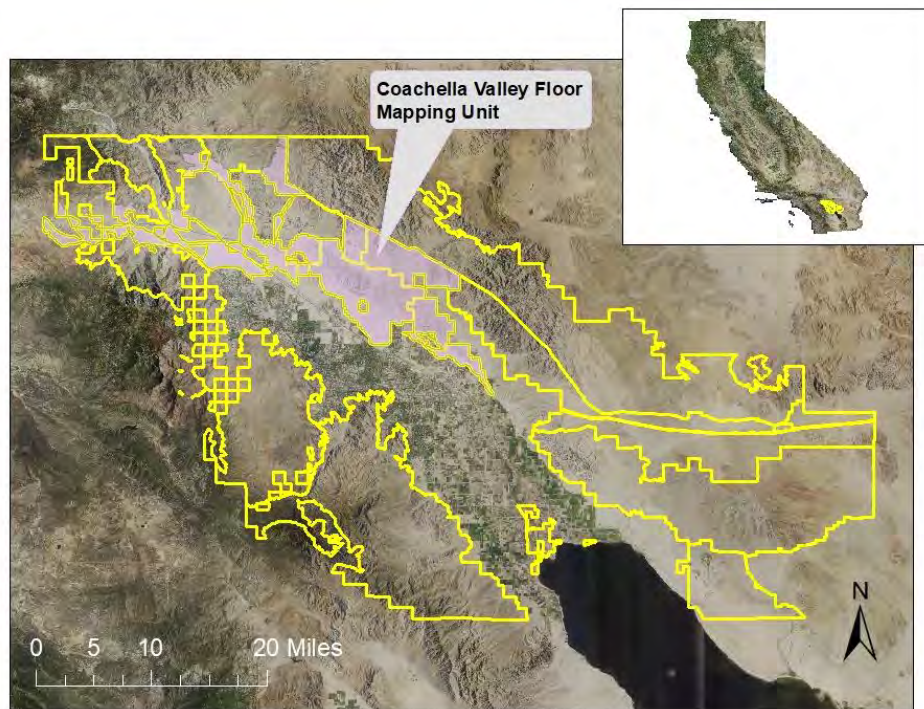


Figure 1: Coachella Valley Multiple Species Habitat Conservation Plan Boundary in relation to Joshua Tree National Park, the Santa Rosa and San Jacinto National Monument, the Coachella Valley USFWS Preserve, Wilderness areas, and the Salton Sea.

### *Geography and Climate*

The Coachella Valley is situated in the Colorado Desert in the northwest portion of the much larger Sonoran Desert, and consists of a variety of habitats. One hundred miles east of Los Angeles, California, it is bordered on the west by the San Jacinto, San Geronio, and Santa Rosa Mountain Ranges. The Valley lies at the northwest end of the Colorado Desert, and to the east of the Valley lies the Salton Sea. The Coachella Valley is an extremely arid desert region that is characterized by aeolian sand communities, fan palm oases, creosote shrub, alluvial fan, and salt scrub communities.

Precipitation is the primary driver for vegetation growth in the Coachella Valley, which experiences both summer and winter precipitation events. Rains are highly variable from year to year, but tend to be more frequent at the far west end of the valley, due to the rain shadow of the San Jacinto, Santa Rosa, and San Bernardino mountain ranges. This causes a gradient of increasing temperature and aridity from west to east, as elevation decreases. During rare monsoonal events in July to September, weather systems that originate in the Gulf of Mexico, bring heavy but isolated thunderstorms to the valley. During average years, the greatest proportion of the annual rainfall comes from winter rains, which originate in the northwest and move into the area in October through May.



**Figure 2.** Areas of conservation within the Multiple Species Habitat Conservation Plan Conservation areas (in yellow) that were described in the Coachella Valley Floor Vegetation Map (in lavender).

#### *The Valley Floor Vegetation Mapping Unit:*



*Cabazon, East Indio Hills, Indio Hills Palms, Indio Hills/Joshua Tree National Park Linkage, West Deception Canyon, Thousand Palms, Edom Hill, Willow Hole, Long Canyon, Whitewater Floodplain and the Highway 111 /I-10, Upper Mission Creek/Big Morongo Canyon, Snow Creek/Windy Point, Stubbe and Cottonwood Canyon Conservation Areas*

The conservation areas in this mapping unit comprise a band of fragmented habitat from the Banning Pass, along the I-10 corridor north of the major urban areas, ending on the eastern end of the Indio Hills, near the base of the Fargo Canyon alluvial plain. The landownership within the conservation areas mapped is a mix of Federal and Tribal Lands (~35%), Private lands (~25%), county and local government (~20%), state government (~10%), private conservation (5%) and utility (1%) (Riverside County Data, 2019) in over 6,000 parcels. The unit abuts several federally-designated wilderness areas, including the San Jacinto Wilderness to the southwest, the Mecca Hills Wilderness to the southeast, the Joshua Tree Wilderness to the north and the San Gorgonio Wilderness to the northwest.

This mapping unit includes wildlife corridors which traverse Interstate 10 and provide a critical corridor between the Peninsular (San Jacinto Wilderness) and Transverse (San Gorgonio and Joshua Tree Wilderness) mountain ranges. The upland areas run into the Mojave Desert transition zone, characterized by oaks and junipers at upper elevations. In the lowland areas, this unit is characterized by desert scrub and annual plant communities typical of the Colorado Desert. Here, these lands encompass the type of aeolian habitats (active dune, and sand fields) that have been heavily reduced from development pressures over the past century. This unit encompasses habitat for many of the Plan's listed species inhabiting the more mesic end of the valley into transition habitats, such as the Le Conte's Thrasher (*Toxostoma lecontei*) and the triple-ribbed milkvetch (*Astragalus tricarlinatus*), as well as species that inhabit the aeolian habitats on the valley floor, such as the Coachella Valley Fringe-Toed Lizard and the Coachella Valley Milkvetch (*Astragalus lentiginosus* var *coachellae*). For details about each of the mapping units, conservation goals and conserved habitat, the interested reader is directed to the Plan documents ([http://www.cvmshcp.org/Plan\\_Documents.htm](http://www.cvmshcp.org/Plan_Documents.htm)).

This group of units also arguably faces the most intense anthropogenic pressures within the Plan area. Even within Conservation Areas, the patchwork of multiple landownership, each with particular regulatory environments creates challenges for management. As well, the pressures of sanctioned and unsanctioned disturbance threaten natural communities, such as development, new roads, maintenance activities, and other anthropogenic change/disturbance (e.g. hydrologic regime). The habitat within these units are pieces of a fragmented landscape, and with an increase in boundary area as compared to land area (wildland-urban interface), these areas face greater threats from abutment of urban and suburban areas, coming as foot traffic, debris, off-highway vehicle tires, and invasive species. Beyond the physical incursions of disturbance, these areas are also under threat from a shift to a hotter and drier climate as a result of climate changes, and deposition of nitrogen from air pollution. Thus, a great effort was made to detect and attribute the updated map with any shifts in natural communities that have occurred.

## RECONNAISSANCE

Field visits throughout the mapping area allowed CCB staff to better match types detected on aerial imagery to the identity of the dominant tree/shrub cover on the ground. Photo interpreters identified photo signatures by evaluating ecological characteristics of each vegetation type relation to landscape characteristics such as topographic features. For the first iteration of the 2013 map, between March 2013 and April 2014, CCB staff trained with Joshua Tree National Park vegetation ecologists and then conducted surveys throughout the mapping area as a reconnaissance of vegetation types. There were 187 total vegetation assessments done in 2014, documenting plant community cover generally following the guidelines in the CNPS 2011 Vegetation Rapid Assessment Protocol (CNPS 2011). For the 2013 map correction and the 2018 map, 116 Rapid Assessments were recorded throughout the area using the updated Rapid Assessment protocol (CNPS 2016) from December 2017 through February 2018. Additional reconnaissance information was drawn from CCB surveys throughout the area in coordination with other monitoring and research activities (Figure 3).

The aim was to gather information from across the mapping unit, especially in a diversity of habitats and in areas where little was known about the vegetation types from previous visits. At each point, a minimum of live cover by perennial species was documented, along with additional information such as disturbance and cardinal photos (available upon request). 2018 Rapid Assessments included the full suite of data required on the Rapid Assessment Protocol form (CNPS 2016).

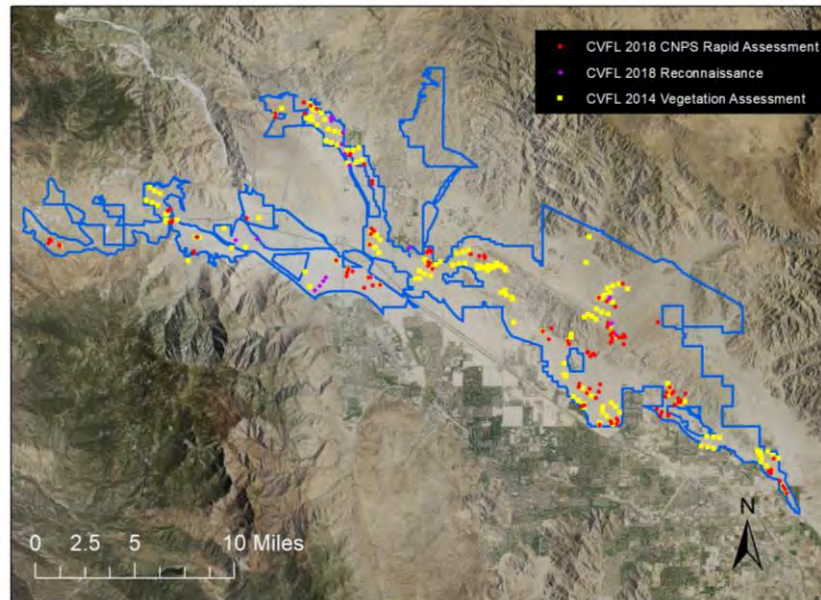


Figure 3: Distribution of 2014 (2013 map) basic Vegetation Assessments, 2018 Rapid Assessments and 2018 reconnaissance visits within the vegetation mapping area, in the Coachella Valley, California.

## DELINEATION

Lines are drawn both to distinguish between alliance and association types and to indicate vegetation cover and landscape variables within a type, generally following Menke and others (2013). Due to the fine resolution of the 2013 aerial imagery provided by the Coachella Valley Conservation Commission (three inch resolution, true-color imagery), the photo interpreter drafted boundaries separating vegetation types (Alliances) at 1:1500 scale and attributed other categories using field information and relevant datasets. Additional information, from color-infrared 2014 fine-scale National Agriculture Imagery Project (NAIP) imagery (USDA, 2014), was used to assess the amount of live cover.

The 2018 map update was begun using the delineations from 2014. The photo interpreter used 2016 and 2018 NAIP RGB and color-infrared imagery to assess each polygon and determine if the boundary, alliance, association, cover class or any other category (as below) had changed sufficiently (as in changed cover or category classes) to warrant a map change. As necessary, further corrections were made to the 2013 map if prior errors or additional field information was significant enough to warrant a change. Unfortunately, there was not adequate funding to acquire for 2018 true-color imagery at a similar (3 inch resolution) resolution to 2013. In addition, the 2018 NAIP flight data were taken in October of 2018 (according to the metadata), whereas the NAIP program flights are usually flown in the springtime and the data itself was available starting April of 2019. These factors led not only a delay of the mapping effort, but also a problem with interpretation of live % cover using the color-infrared data, because of differences



in spring vs. fall phenology. Where indicated, the photo-interpreter used 2016 NAIP data to confirm major changes seen in live % cover. However, the lack of matching and adequate aerial imagery did negatively impact this effort.

Percent cover was attributed to each polygon for tree and shrub cover, and as available from field surveys, for the herbaceous cover. For most of the open desert, cover did not exceed 25% except in smaller polygons delineating riparian areas, Mesquite bosques or California fan palm oases. Additionally, percent cover of exotic species (as available), roadedness, anthropogenic alteration and development were quantified (see Menke 2013 for cover classes/categories). Generally, polygons were mapped to a 2.5 acre minimum mapping unit (MMU), but specialized and important vegetation, Mesquite bosques and California fan palm oases, were mapped with no minimum MMU with the aim of detecting fine-scale change in stand distribution. Therefore, for other purposes, such as comparison with other regional vegetation maps, these types may need to be aligned with other protocols.

## CLASSIFICATION OF VEGETATION FOR THE MAPPING AREA

The map classification is based largely on work done in areas for previous and ongoing projects: Vegetation Mapping of Anza-Borrego Desert State Park and Environs (Keeler-Wolf *et al.* 1998), the Western Riverside County MSHCP Vegetation Map (2004), Vegetation of Joshua Tree National Park (La Doux *et al.* 2013), and the Vegetation Map in Support of the Desert Renewable Energy Conservation Plan (Menke, 2013) and by the UCR Center for Conservation Biology in previous maps (most recently Sweet *et al.* 2017).

There are several new provisional alliances developed from our previous work in the CVMSHCP area, including the Mecca Hills and Orocopia Mountains Map (2016) and the Dos Palmas Conservation Area Map (2016); these new provisional alliances are described in the respective reports. Any provisional alliance that has not been yet adopted into the MCV schema as reflected in the MCV online (<http://vegetation.cnps.org/>, accessed June 2017) are still listed as “Provisional” in this map and geodatabase.

Several dune classifications were required to better delineate between conservation areas in aeolian sand fields, ephemeral sand fields, and stabilized sand fields, as the CVMSHCP identifies these sand-transport areas as vital to the health of the ecosystem. They do not exist as part of the MCV, but are included here to assist with conservation monitoring and management of these types and area extents locally for the federally-endangered Coachella Valley fringe-toed lizard, and Coachella Valley milkvetch and the flat tailed horned lizard. In order to differentiate these areas from a description of the substrate (e.g. “dune”) and general types (e.g. “non-vegetated habitat”), or the *Dicoria canescens*—*Abronia villosa* general type listed in the MCV, the following provisional alliances were used: *Dicoria canescens*--*Oenothera deltoidea* Sparsely

Vegetated Active Dune Provisional Alliance; *Larrea tridentata* / *Abronia villosa* Stabilized Sand Fields Provisional Alliance; and *Psoralea arborescens* / *Dicoria canescens* Ephemeral Sand Fields Provisional Alliance. These types, while likely sampled adequately, need to be summarized and the data analyzed before being proposed to the NVCS.

In some areas, non-native species are so prevalent that they are the dominant cover within the ecosystem and are recognized as distinctive vegetation types in California, including *Bromus rubens* / *Schismus barbatus* Semi-Natural Herbaceous Stands and *Tamarix* spp. Semi-natural Shrubland Stands (Sawyer et al. 2009). In these cases, the “exotic species cover” field was entered, even without field sampling. In all other cases, these were not entered, as the presence of exotic annual species was not adequately documented.

Other than the sand and dune types, the desert pavement type and the exotic annual grass type, there are two other mapping classes that have less than 2% woody vegetation cover: the Disturbed/Built-Up type, and a generic Non-vegetated Habitat type. In cases of cleared/bulldozed land, the photo interpreter chose to generally designate “Disturbed/Built-Up” if the clearing appeared to be thorough and semi-permanent, whereas the Non-vegetated Habitat type would be used if the clearing appeared to be from e.g. OHV’s, fire, or other non-deliberate means. In some cases, especially in the western end of the Coachella Valley, there is sufficient rainfall to support non-native grass stands that meet the *Bromus rubens* / *Schismus barbatus* type, such as in areas that may have been cleared for cattle grazing or ranching. In these cases, the exotic grass type was used. The interpreter recognizes that there is some ambiguity regarding these categories, especially in the western end of the mapping area in this desert region and therefore, these should be interpreted with some caution.

The nested hierarchy, including the Macrogroup and Group, was based on the National Vegetation Classification System (Federal Geographic Data Committee 2008); specifically, the recommendations of Evens (2014) to align the NVCS with the Manual of California Vegetation (Sawyer et al. 2009).

## FINDINGS

The vegetation map for the Valley Floor Mapping Unit of the Coachella Valley Multiple Species Habitat Conservation Plan includes 1183 polygons (2013) and 1214 polygons (2018) with 41 Alliances (2013 and 2018) and 81 (2013) and 82 (2018) Associations (Table 1; Appendix Tables 1 & 2). Because of the very small changes in vegetation cover and the difficulty reliably detecting true changes in live cover, the following changes should be interpreted as preliminary findings. The changes noted here are changes in the amount of area per category; as the attribute data is categorical (the categories are also uneven and not a proxy for continuous

data) analysis showing average changes over space were not possible. Some of the changes found may be artifacts of the mapping process. For instance, for the disturbance categories, these may be affected by changes such as polygons being split or reassigned, and the child polygons containing more or less of the disturbance type assigned to the parent polygon. However, to the degree that multiple indicators agree on the same directionality (increase or decrease), these may be taken as indications of likely changes in the landscape.

The largest amount of land cover for both 2013 and 2018 maps is classified under the *Larrea tridentata* -- *Encelia farinosa* Shrubland Alliance, representing over 10,000 hectares followed by the *Larrea tridentata* -- *Ambrosia dumosa* Shrubland Alliance at almost 7,000 hectares. The largest mapped declines in area from 2013-2018 type mapped were the *Larrea tridentata* -- *Ambrosia dumosa*, the *Atriplex canescens* type (-81 ha) and the *Tamarix* spp. type (-27 ha). The former may be due to conversion to other types, such as the disturbance-responsive *Encelia farinosa* type (+28.5 acres) or conversion to non-vegetated habitat (+60 ha). The latter may be due to invasive plant control and management activities. The largest increases were in the Disturbed/Built-up (+114 ha) and the Non-vegetated Habitat types (Table 1).

Alliance Name	ALLIANCE AREA (ha) 2013	ALLIANCE AREA (ha) 2018	Difference (ha)
Acacia greggii Shrubland Alliance	739.5	729.2	-10.3
Ambrosia dumosa Shrubland Alliance	109.6	113.1	3.5
Ambrosia salsola Shrubland Alliance	1752.1	1749.4	-2.7
Atriplex canescens Shrubland Alliance	727.7	678.8	-48.9
Atriplex canescens--Atriplex polycarpa Shrubland Provisional Alliance	57.3	57.2	-0.1
Atriplex lentiformis Shrubland Alliance	0.4	0.4	0.0
Atriplex polycarpa Shrubland Alliance	35.7	35.7	0.0
Bromus rubens--Schismus (arabicus & barbatus) Herbaceous Semi-Natural Alliance	151.1	133.6	-17.5
Chilopsis linearis Woodland Alliance	344.8	353.6	8.8
Dicoria canescens--Oenothera deltoides Sparsely Vegetated Active Dune Provisional Alliance	174.0	174.4	0.4
Disturbed/built-up	1323.7	1438.1	114.4
Encelia farinosa Shrubland Alliance	978.9	1007.4	28.5
Ephedra californica Shrubland Alliance	99.9	99.9	0.0
Ericameria paniculata Shrubland Alliance	331.9	331.9	0.0
Geraea canescens--Chorizanthe rigida Desert Pavement Annual Herbaceous Alliance	1029.2	1028.2	-1.0
Hyptis emoryi Shrubland Alliance	53.9	53.9	0.0
Isocoma acradenia Shrubland Provisional Alliance	6.1	6.1	0.0
Juniperus californica Woodland Alliance	329.8	329.8	0.0
Larrea tridentata / Abromia villosa Stabilized Sand Fields Provisional Alliance	2146.3	2134.4	-11.9
Larrea tridentata Shrubland Alliance	3163.3	3180.8	17.5

Larrea tridentata--Ambrosia dumosa Shrubland Alliance	7492.4	7411.4	-81.0
Larrea tridentata--Encelia farinosa Shrubland Alliance	10118.0	10115.5	-2.5
Lepidospartum squamatum Shrubland Alliance	820.1	805.4	-14.7
Non-vegetated Habitat (less than 2% absolute cover)	3783.4	3843.6	60.2
Parkinsonia florida--Olneya tesota Woodland Alliance	32.9	32.9	0.0
Peucephyllum schottii Provisional Shrubland Alliance	9.9	9.9	0.0
Phragmites australis Herbaceous Alliance	2.1	2.8	0.7
Pleuraphis rigida Herbaceous Alliance	101.1	101.1	0.0
Pluchea sericea Shrubland Alliance	8.7	9.0	0.3
Populus fremontii Forest Alliance	3.6	3.6	0.0
Prosopis glandulosa Woodland Alliance	169.4	160.7	-8.8
Psorothamnus arborescens / Dicoria canescens Ephemeral Sand Fields Provisional Alliance	358.5	351.9	-6.6
Psorothamnus schottii Shrubland Provisional Alliance	602.6	602.6	0.0
Psorothamnus spinosus Woodland Alliance	107.2	105.8	-1.5
Quercus cornelius-mulleri Shrubland Alliance	28.5	28.5	0.0
Rhus ovata Shrubland Alliance	1.2	1.2	0.0
Salix exigua Shrubland Alliance	1.6	1.6	0.0
Suaeda moquinii Shrubland Alliance	4.0	4.0	0.0
Tamarix spp. Shrubland Semi-Natural Alliance	70.7	43.8	-26.9
Viguiera parishii Shrubland Alliance	2.3	2.3	0.0
Washingtonia filifera Woodland Alliance	26.4	26.2	-0.3

Table 1: Vegetation cover alliance designations in the Coachella Valley Floor Mapping Unit. Shown is the amount of area mapped per alliance in the respective maps (2013 Map Correction, 2018 Map Update), and the absolute change in hectares.

In general, tree cover changes from 2013-2018 were mixed, with less area having no estimated tree cover, an increase in area having 0-1% trees (mainly influenced by an increase in disturbed/built-up areas with 0-1% urban-type tree cover), and with slight declines in the number of hectares with 1-25% cover of trees. Shrub cover was characterized by an increase in areas with no or 0-1% cover, and a decrease overall in areas with 1-50% cover overall (Table 2).

	TREE COVER CATEGORY				SHRUB COVER CATEGORY			
	2013 Area (ha)	2018 Area (ha)	Difference (ha)	Difference (%)	2013 Area (ha)	2018 Area (ha)	Difference (ha)	Difference (%)
none	13300.4	13128.6	-171.8	-0.7	254.7	306.627654	51.9	9.2
>0-1%	22344.8	22582.0	237.2	0.5	4624.2	4894.74620	270.6	2.8
>1-5%	1119.7	1103.7	-16.0	-0.7	14912.7	14719.5052	-193.2	-0.7

					16041.	15932.4663		
>5-15%	482.3	438.6	-43.8	-4.8	0	2	-108.5	-0.3
>15-25%	22.0	16.1	-5.9	-15.4	1106.7	1086.71041	-20.0	-0.9
>25-50%	22.3	22.3	0.0	-0.1	350.0	348.099469	-1.9	-0.3
>50-75%	8.3	8.6	0.3	1.9	5.8	7.231186	1.4	10.7
>75-100%					4.8	4.5	-0.3	0.0

Table 2: Tree and shrub cover categories mapped within the Coachella Valley Floor Mapping Unit and changes, 2013-2018. Shown is the amount of area mapped per category in the respective maps (2013 map correction, 2018 map update), and absolute change in hectares, and the percent change with respect to the category.

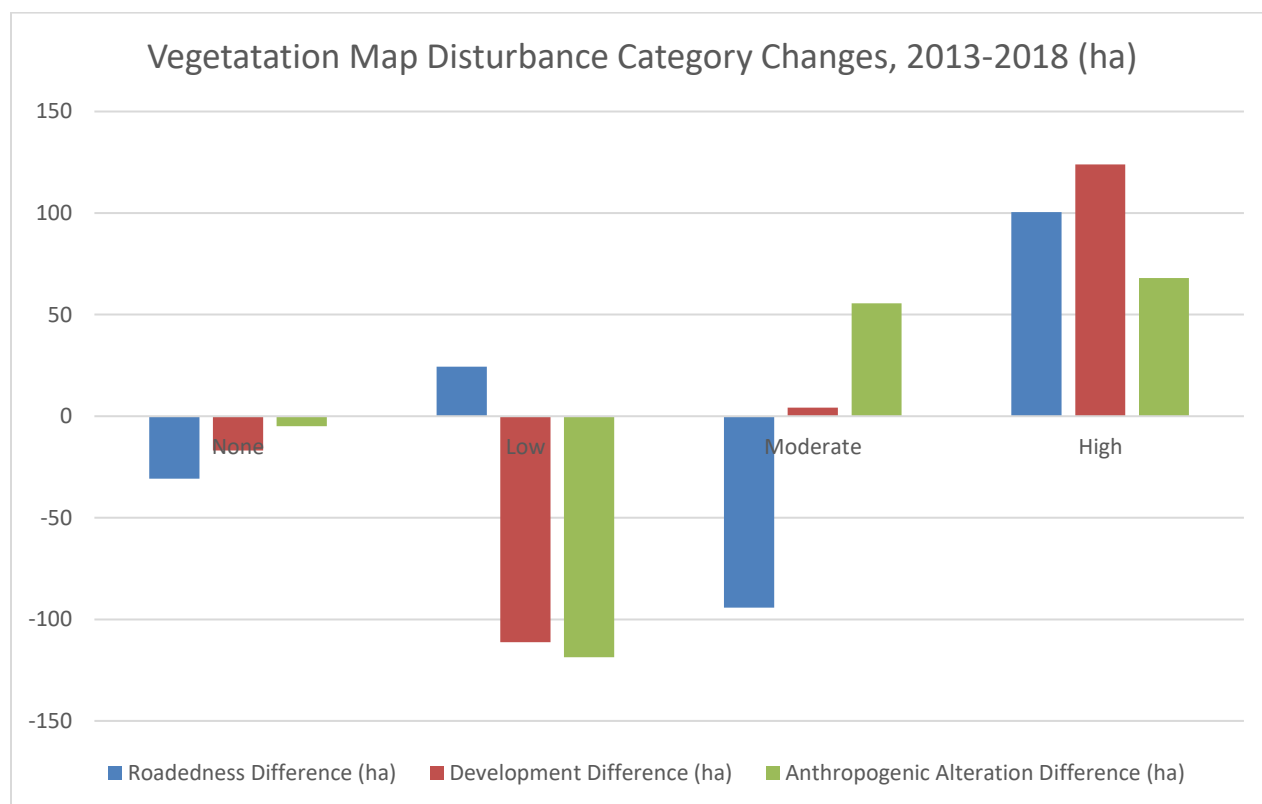


Figure 4: Changes in the area covered by disturbance categories for roadedness, development and anthropogenic alteration in the Coachella Valley Floor Mapping Unit from 2013 to 2018. Shown is the absolute change in hectares mapped per category.

As noted above, changes the area by disturbance type should be interpreted with caution based on artifacts of the mapping process itself. However, there was a general trend towards an increase in the area demonstrating anthropogenic disturbance overall, and less overall area showing no disturbance (Figure 4). While there was less area showing low development and anthropogenic alteration, there was an increase in areas showing moderate or high levels of these

disturbances. In terms of roadedness, the general pattern suggests that areas shifted from “none” to “low,” and from “moderate” to “high.”

## SUMMARY AND RECOMMENDATIONS

The mapping was limited by available imagery, and in the future, fine-scale imagery that matches the original imagery with respect to resolution and phenology would be ideal to detect true change. This map reflects a conservative look at changes that may have occurred as the 2013 color-infrared NAIP is particular to a drought period in spring, and the 2018 NAIP reflects a return to normal precipitation in the fall.

Overall, an increase in anthropogenic effects and a decrease in shrub cover reflects an area that is still subject to human pressure, despite protection under the CVMSCHP. This map should continue to guide land management efforts in several ways. First, as it was intended, this map may be used to target areas of habitat for monitoring of the covered species under the Plan. Secondly, this map may indicate changes to the amount of habitat available, and human pressures/impacts on each specific area of land that may need to be addressed with management. Last, although most of the changes indicated should be investigated further, this map may help guide decisions overall about any broader problems that may indicate the need for new land management or protection that could be afforded.

In the context ongoing climate changes, these maps provide a baseline for further monitoring of the status of vegetation. The changes here indicate occurred as the Valley recovered from the 2011-2015 drought period, and thus are perhaps an optimistic look and not fully reflective of any long-term trajectory. Some types saw increases in cover, and others declined. Vegetation mapping as a tool, especially at scales of 1:1500 is not ideal to detect small, widespread changes. The mapper was only able to identify broad areas of change, and thus this effort should be repeated at a longer interval for these sparsely-vegetated types.

## LITERATURE CITED

CNPS. 2011. California Native Plant Society – Vegetation Rapid Assessment Protocol. CNPS Vegetation Committee (*Revised*). Available online at: [http://www.cnps.org/cnps/vegetation/pdf/protocol-rapid\\_assess.pdf](http://www.cnps.org/cnps/vegetation/pdf/protocol-rapid_assess.pdf)

CNPS. 2016. California Native Plant Society/Department of Fish and Game Protocol for Combined Vegetation and Rapid Assessment and Relevé Sampling Field Form. Available online at: <http://www.cnps.org/cnps/vegetation/pdf/protocol-combined-2016.pdf>

- Evens, Julie M. 2014. Integrating the FGDC National Classification System (NVC) Standard with the CNPS/CDFG *Manual of California Vegetation, second edition*. Agreement Number G12AC20142 Final Report. Available online at: <https://www.fgdc.gov/grants/2012CAP/InterimFinalReports/142-12-5-CA-FinalReport.pdf>
- Federal Geographic Data Committee. 2008. National Vegetation Classification Standard, Version 2. Vegetation Subcommittee, FGDC-STD-005-2008. Available at: [http://usnvc.org/wp-content/uploads/2011/02/NVCS\\_V2\\_FINAL\\_2008-02.pdf](http://usnvc.org/wp-content/uploads/2011/02/NVCS_V2_FINAL_2008-02.pdf)
- Holland, R. 1986. Preliminary descriptions of the terrestrial natural communities of California. Unpublished document, California Department of Fish and Game, Natural Heritage Division. Sacramento, CA.
- Keeler-Wolf, T., K. Lewis, and C. Roye. 1998. Vegetation Mapping of Anza-Borrego Desert State Park and Environs. California Department of Fish and Game, Sacramento, CA. <http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=18246>
- La Doux, T., C. Lea, and E. Babich. 2013. A summary of the Joshua Tree National Park Vegetation Mapping Project: NPS Vegetation Inventory Program. Natural Resource Technical Report NPS/JOTR/NRTR—2013/723. National Park Service, Fort Collins, Colorado.
- Menke, J., E. Reyes, A. Glass, D. Johnson, and J. Reyes. 2013. 2013 California Vegetation Map in Support of the Desert Renewable Energy Conservation Plan. Final Report. Prepared for the California Department of Fish and Wildlife Renewable Energy Program and the California Energy Commission. Aerial Information Systems, Inc., Redlands, CA.
- Sawyer, John O., Todd Keeler-Wolf, and Julie Evens. 2009. Manual of California Vegetation. California Native Plant Society Press.
- Sweet, L.C., C. Barrows, R. Johnson, J. Heintz, R. Merizan. (2017) Coachella Valley Multiple Species Habitat Conservation Plan & Natural Community Conservation Plan: CVMSHCP Areas within Sand to Snow National Monument Vegetation Map Report. Final Report. Prepared for: Coachella Valley Conservation Commission.
- USDA Forest Service - Pacific Southwest Region - Remote Sensing Lab. 2014. EVEG\_SouthInterior\_2000\_2008\_v1. Remote Sensing Lab, McClellan, CA [https://www.fs.fed.us/r5/rsl/projects/gis/data/vegcovs/sinterior/ExistingVegSouthInterior2000\\_2008\\_v1.html](https://www.fs.fed.us/r5/rsl/projects/gis/data/vegcovs/sinterior/ExistingVegSouthInterior2000_2008_v1.html)

**APPENDIX TABLE 1: ALLIANCES IDENTIFIED**

<b>Alliance Name</b>	<b>Common Name</b>
Acacia greggii Shrubland Alliance	Catclaw acacia thorn scrub
Ambrosia dumosa Shrubland Alliance	White bursage scrub
Ambrosia salsola Shrubland Alliance	Cheesebush scrub
Atriplex canescens Shrubland Alliance	Fourwing saltbush scrub
Atriplex canescens--Atriplex polycarpa Shrubland Provisional Alliance	Fourwing saltbush - allscale scrub
Atriplex lentiformis Shrubland Alliance	Quailbush scrub
Atriplex polycarpa Shrubland Alliance	Allscale scrub
Bromus rubens--Schismus (arabicus & barbatus) Herbaceous Semi-Natural Alliance	Red brome or Mediterranean grass grasslands
Chilopsis linearis Woodland Alliance	Desert willow woodland
Dicoria canescens--Oenothera deltoides Sparsely Vegetated Active Dune Provisional Alliance	Desert twinbugs - birdcage primrose active dunes
Disturbed/built-up	Disturbed/built-up
Encelia farinosa Shrubland Alliance	California brittle bush scrub
Ephedra californica Shrubland Alliance	California joint fir scrub
Ericameria paniculata Shrubland Alliance	Black-stem rabbitbrush scrub
Geraea canescens--Chorizanthe rigida Desert Pavement Annual Herbaceous Alliance	Desert Gold -- Spiny Herb Desert Pavement Annual Herbaceous Alliance
Hyptis emoryi Shrubland Alliance	Desert lavender scrub
Isocoma acradenia Shrubland Provisional Alliance	Alkali goldenbush scrub
Juniperus californica Woodland Alliance	California juniper woodland
Larrea tridentata / Abronia villosa Stabilized Sand Fields Provisional Alliance	Creosote bush / sand verbena stabilized sand fields
Larrea tridentata Shrubland Alliance	Creosote bush scrub
Larrea tridentata--Ambrosia dumosa Shrubland Alliance	Creosote bush - white burr sage scrub
Larrea tridentata--Encelia farinosa Shrubland Alliance	Creosote bush - brittle bush scrub
Lepidospartum squamatum Shrubland Alliance	Scale broom scrub
Non-vegetated Habitat (less than 2% absolute cover)	Non-vegetated habitat
Parkinsonia florida--Olneya tesota Woodland Alliance	Blue palo verde - ironwood woodland
Peucephyllum schottii Provisional Shrubland Alliance	Pygmy-cedar scrub
Phragmites australis Herbaceous Alliance	Common reed marshes
Pleuraphis rigida Herbaceous Alliance	Big galleta shrub-steppe
Pluchea sericea Shrubland Alliance	Arrow weed thickets
Populus fremontii Forest Alliance	Fremont cottonwood forest
Prosopis glandulosa Woodland Alliance	Mesquite bosque, mesquite thicket
Psorothamnus arborescens / Dicoria canescens Ephemeral Sand Fields Provisional Alliance	California indigo bush - desert twinbugs ephemeral sand fields
Psorothamnus schottii Shrubland Provisional Alliance	Schott's indigobush scrub
Psorothamnus spinosus Woodland Alliance	Smoke tree woodland
Quercus cornelius-mulleri Shrubland Alliance	Muller oak chaparral



Rhus ovata Shrubland Alliance	Sugarbush chaparral
Salix exigua Shrubland Alliance	Sandbar willow thickets
Suaeda moquinii Shrubland Alliance	Bush seepweed scrub
Tamarix spp. Shrubland Semi-Natural Alliance	Tamarisk thickets
Viguiera parishii Shrubland Alliance	Parish's goldeneye scrub
Washingtonia filifera Woodland Alliance	California fan palm oasis

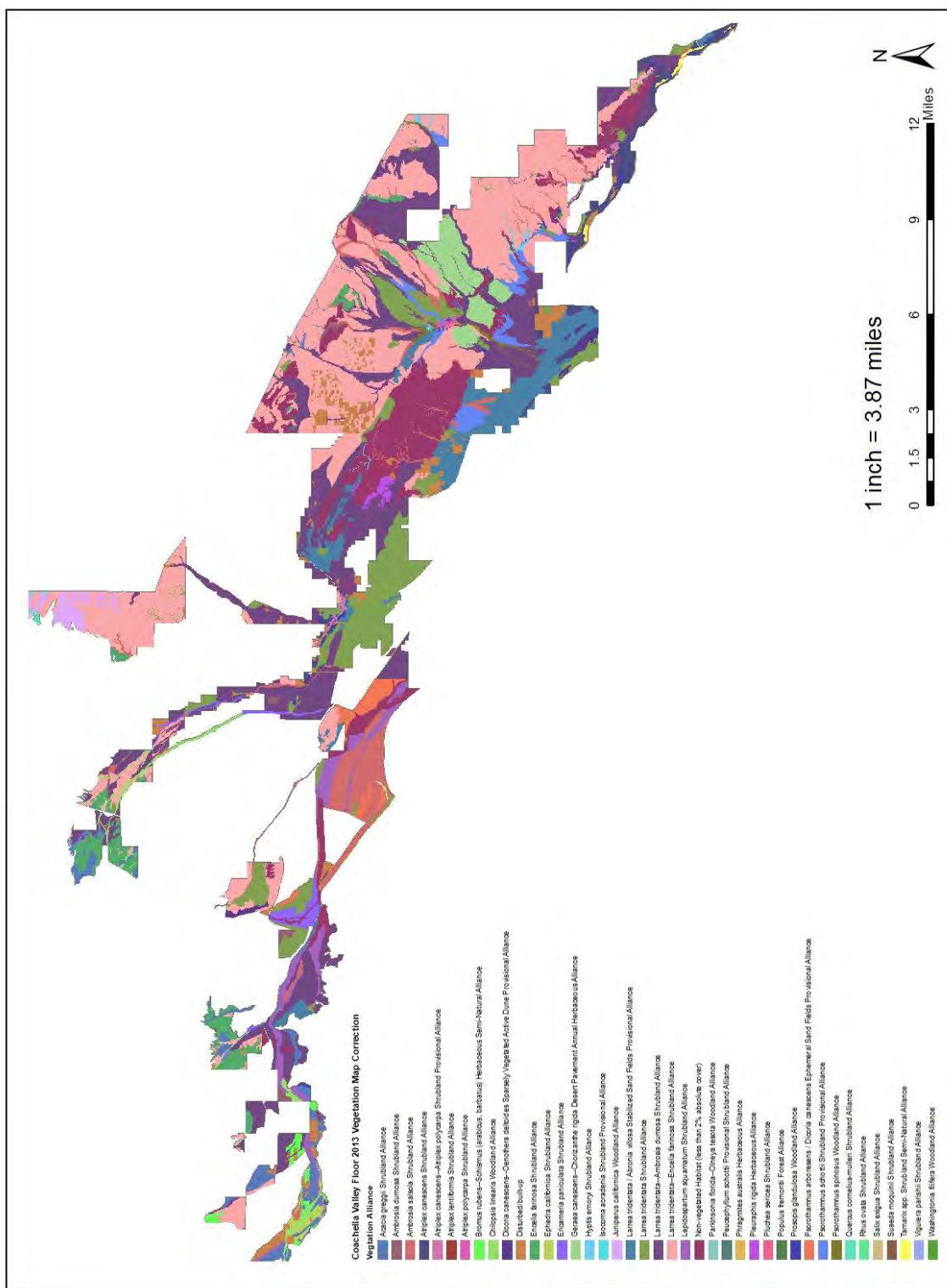
## APPENDIX TABLE 2: ASSOCIATIONS IDENTIFIED

Association Name
Acacia greggii / Chilopsis linearis / Ericameria paniculata--Ambrosia salsola Association
Acacia greggii--Encelia farinosa--Ambrosia dumosa Association
Acacia greggii--Larrea tridentata--Encelia farinosa--Ambrosia dumosa Association
Ambrosia salsola--Bebbia juncea Association
Ambrosia salsola--Hyptis emoryi Association
Ambrosia salsola--Larrea tridentata Association
Ambrosia salsola--Larrea tridentata--Ambrosia dumosa--Psoraleum arborescens Association
Atriplex canescens--Ambrosia salsola Association
Atriplex canescens--Atriplex polycarpa Association
Atriplex canescens--Atriplex polycarpa--Larrea tridentata Association
Atriplex canescens--Larrea tridentata Association
Atriplex canescens--Larrea tridentata--Ambrosia dumosa Association
Atriplex polycarpa--Larrea tridentata Association
Chilopsis linearis / Ephedra californica--Psoraleum arborescens--Ambrosia salsola Association
Chilopsis linearis / Ericameria paniculata--Ambrosia salsola Association
Dicoria canescens--Oenothera deltoides / Atriplex canescens Association
Dicoria canescens--Oenothera deltoides / Larrea tridentata--Atriplex spp. Association
Encelia farinosa--Ambrosia dumosa Association
Encelia farinosa--Ephedra nevadensis Association
Encelia farinosa--Larrea tridentata--Ambrosia dumosa Association
Ephedra californica--Ambrosia salsola Association
Ericameria paniculata--Ambrosia salsola Association
Larrea tridentata / Pleuraphis rigida Association
Larrea tridentata Association
Larrea tridentata--Ambrosia dumosa / Chilopsis linearis Association
Larrea tridentata--Ambrosia dumosa / Pleuraphis rigida Association
Larrea tridentata--Ambrosia dumosa Association
Larrea tridentata--Ambrosia dumosa--Atriplex canescens Association
Larrea tridentata--Ambrosia dumosa--Atriplex polycarpa Association

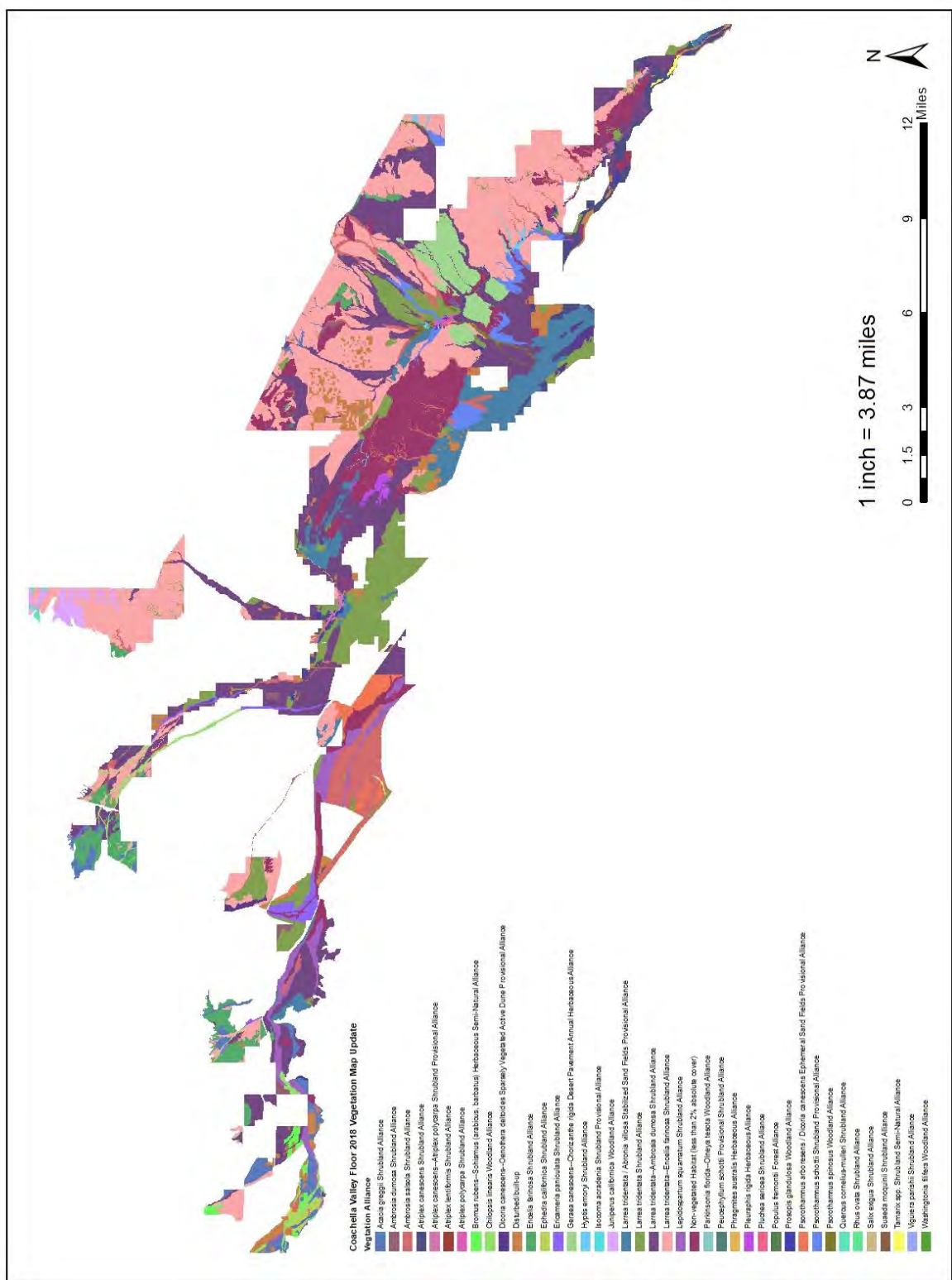
Larrea tridentata--Ambrosia dumosa--Atriplex spp.-- Petalonyx thurberii Association
Larrea tridentata--Ambrosia dumosa--Encelia farinosa Association
Larrea tridentata--Ambrosia dumosa--Encelia farinosa--Psorothamnus arborescens Association
Larrea tridentata--Ambrosia dumosa--Ephedra californica--Psorothamnus arborescens Association
Larrea tridentata--Ambrosia dumosa--Ephedra nevadensis --Encelia farinosa Association
Larrea tridentata--Ambrosia dumosa--Ericameria paniculata--Ambrosia salsola Association
Larrea tridentata--Ambrosia dumosa--Hyptis emorii Association
Larrea tridentata--Ambrosia dumosa--Krameria grayi Association
Larrea tridentata--Ambrosia dumosa--Psorothamnus arborescens Association
Larrea tridentata--Ambrosia dumosa--Psorothamnus schottii--Encelia farinosa Association
Larrea tridentata--Ambrosia salsola Association
Larrea tridentata--Ambrosia salsola--Psorothamnus schottii Association
Larrea tridentata--Atriplex canescens Association
Larrea tridentata--Atriplex polycarpa Association
Larrea tridentata--Encelia farinosa Association
Larrea tridentata--Encelia farinosa--Ambrosia dumosa Shrubland Association
Larrea tridentata--Encelia farinosa--Ambrosia dumosa--Yucca schidigera Association
Larrea tridentata--Encelia farinosa--Ambrosia salsola Association
Larrea tridentata--Encelia farinosa--Atriplex canescens Association
Larrea tridentata--Encelia farinosa--Ephedra californica Association
Larrea tridentata--Encelia farinosa--Ephedra californica--Psorothamnus arborescens--Ambrosia salsola Association
Larrea tridentata--Encelia farinosa--Psorothamnus schottii Association
Larrea tridentata--Encelia farinosa--Psorothamnus schottii--Association
Larrea tridentata--Krameria grayi Association
Larrea tridentata--Psorothamnus spinosus--Hyptis emoryi--Acacia greggii Association
Lepidospartum squamatum / Chilopsis linearis / Ericameria paniculata--Ambrosia salsola Association
Lepidospartum squamatum--Ambrosia salsola Association
none
Non--vegetated Habitat / Atriplex canescens Association
Non-vegetated Habitat / Larrea tridentata / Pleuraphis rigida Association
Non-vegetated Habitat / Larrea tridentata Association
Non-vegetated Habitat / Larrea tridentata--Ambrosia dumosa Association
Non-vegetated Habitat / Larrea tridentata--Encelia farinosa--Pleurocoronis pluriseta Association
Non-vegetated Habitat / Pleuraphis rigida Association
Pleuraphis rigida / Larrea tridentata--Encelia farinosa--Pleurocoronis pluriseta Association
Prosopis glandulosa / Atriplex canescens Association
Prosopis glandulosa / Atriplex polycarpa Association
Prosopis glandulosa / Atriplex spp--Suaeda moquinii Association
Prosopis glandulosa / Hyptis emoryi--Psorothamnus schottii Association
Prosopis glandulosa / Larrea tridentata Association
Prosopis glandulosa / Larrea tridentata--Atriplex spp. Association
Prosopis glandulosa--Washingtonia filifera Association

Psorotamnus arborescens--Larrea tridentata Association
Psorothamnus arborescens / Dicoria canescens Ephemeral Sand Fields Association
Psorothamnus schottii--Larrea tridentata Association
Psorothamnus spinosus / Ambrosia salsola--Atriplex spp. Association
Tamarix spp.--Atriplex canescens Association
Washingtonia filifera / Phragmites australis Association
Washingtonia filifera / Prosopis glandulosa Association
Washingtonia filifera / Prosopis glandulosa--Atriplex spp--Suaeda moquinii Association

## APPENDIX 3: 2013 COACHELLA VALLEY FLOOR VEGETATION MAP



## APPENDIX 4: 2018 COACHELLA VALLEY FLOOR VEGETATION MAP



Appendix X-  
Dos Palmas Conservation Area  
2013 & 2018 Vegetation Map Report

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**Coachella Valley Conservation Commission**



**September 2019**

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

**Dos Palmas Conservation Area  
2013 & 2018 Vegetation Map Report**



Lynn C. Sweet, Cameron Barrows, James Heintz and Roxann Merizan, Scott Heacox, Melanie Davis and Robert Johnson

Center for Conservation Biology, University of California, Riverside



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## EXECUTIVE SUMMARY

The University of California Riverside's Center for Conservation Biology (CCB) has created fine-scale vegetation maps for a number of Conservation Areas under the jurisdiction of the Coachella Valley Multiple Species Habitat Conservation Plan (CVMSHCP) under contract with the Coachella Valley Conservation Commission (CVCC). The primary purpose for creating these maps is to provide a landscape-scale approach to monitoring changes due to land use, invasive species, recreation, hydrology, and climate. These digital maps, documenting changes and their causes, are then tools for prioritizing future conservation actions. The vegetation classification follows Federal Geographic Data Committee (FGDC) and National Vegetation Classification Standards (NVCS; Federal Geographic Data Committee 2008). The classification is meant to align with previous and concurrent survey and classification work done by California Department of Fish and Wildlife's Vegetation Classification and Mapping Program (VegCAMP) and Aerial Information Systems (AIS) for the Desert Renewable Energy Conservation Plan Area as well as the southeastern Salton Sea Mid-Desert Area, and by the National Park Service for Joshua Tree National Park. This unit was mapped using the California Department of Fish and Wildlife (CDFW) and California Natural Plant Society Combined (CNPS) Vegetation Classification and Mapping Program protocol (CNPS 2014).

This report and the related vegetation maps update those from the 2016 mapping effort (Sweet *et al.* 2016). The primary purpose was to develop an updated vegetation map for the Dos Palmas Conservation Area (Reserve Management Unit 4 under the Plan), so that it may be applied to further conservation efforts and assist with management of the 27 species and 27 natural communities listed within the plan. Map polygons were assessed for vegetation type, percent cover, presence of exotics, anthropogenic disturbance, and roadedness.

The original Dos Palmas Conservation Area 2013 status vegetation map and report were completed in 2016. The report and related map describe a map correction for the 2013 map as well as an updated map for the year 2018 covering the approximately 25,800 acres that comprise the Dos Palmas Conservation Area. Within the study areas, rapid assessment protocol vegetation plots, basic vegetation assessment plots and supplemental reconnaissance observations were obtained within the study at pre-determined points in order to document the plant community, disturbances, and invasive species across space and types. Heads-up photo-interpretation of 2013 local flight true-color imagery, fine-scale National Agriculture Imagery Project (NAIP) imagery (USDA, 2012, 2014, 2016 and 2018), other 2018 imagery and field information were combined to produce delineations of vegetation alliances and associations according to the California Department of Fish and Wildlife classification system, outlined in the Manual of California Vegetation (MCV) Second Edition (Sawyer *et al.* 2009).

The first version of the Dos Palmas map was completed in 2016, however, the map will be referred to as a corrected 2013 map to match the imagery date, and further detail about the

original map is contained in that report (Sweet et al. 2017). For the 2018 map update, additional field data was collected in 2018, which was incorporated into the both the 2013 map correction (as appropriate) and the 2018 map update. The 2018 map delineation was done by photo-interpretation of updated imagery, with a focus on stand changes, mortality, cover and land use changes, and other anthropogenic changes. One hundred ninety-one partial Rapid Assessment plots were conducted in 2015-2016 within the study area, and an additional 222 Rapid Assessments were completed in 2018, plus additional reconnaissance field information that was collected.

To better focus on conservation of particular habitats, there are several alliances where the minimum mapping unit (MMU) is less than an acre; including *Prosopis glandulosa* Woodland Alliance, and *Washingtonia filifera* Shrubland Alliance, as well as wetlands and certain wash types which displayed complexity that would necessitate delineation. In order to better delineate habitat for the aeolian suite of species covered under the CVMSHCP, several provisional alliances were used, including the *Larrea tridentata* / *Abronia villosa* Stabilized Sand Fields Provisional Alliance and the *Cladium californica* Provisional Alliance. The largest amount of land cover for both 2013 and 2018 maps is classified under the Non-vegetated Habitat map type, representing over 2,400 hectares, followed by the *Tamarix* spp. type at 1,600 hectares.

There are several reasons for which the following changes should be interpreted as preliminary findings: the very small detectable changes in vegetation cover and the short time period between maps (5 years); the difficulty in reliably detecting true changes in live cover; and limitations in the availability of matching imagery. The largest mapped declines in area from 2013-2018 type mapped were the *Allenrolfea occidentalis* (-25 ha), the *Prosopis glandulosa* type (-15 ha), and the *Atriplex canescens*-*Atriplex polycarpa* type (-12 ha). The largest increases were in the Non-vegetated Habitat type (+47 ha) and the *Tamarix* spp. types (+21 ha). Shrub cover was characterized by an increase in areas with 1-5% cover, and a decrease overall in areas with 5-50% cover, and an increase in areas with 75-100% cover (the latter due to *Tamarix* spp. being mapped as shrubs in the MCV).

The Dos Palmas Conservation Area contains a Bureau of Land Management designated Area of Critical Environmental Concern, hosting federally endangered species. It is also a land area undergoing environmental change due to several factors, including the spread and removal of exotic plants, as well as changes in water availability. Status of vegetation on the ground in some areas has already indicated change in vegetation cover or identity from the 2013 imagery to the 2018 imagery. Some areas seem to recover due to management actions, showing increases in live cover after water was returned to the area, whereas some stands, especially *Prosopis glandulosa* in the northeast area, continued to decline from 2013 to present.

## INTRODUCTION

### *Conservation Background*

The most direct threat to the biodiversity of the area is habitat loss. From 1996 to 2008, citizens, scientists, land managers, and federal and state agencies of the Valley developed the Coachella Valley Multiple Species Habitat and Natural Community Conservation Plan (CVMSHCP/NCCP), a conservation plan that preserved over 250,000 acres of open space (Figure 1). The CVMSHCP/NCCP identified 27 species and 27 vegetation communities within the Coachella Valley for protection. Reasons for each species/vegetation community being included under the CVMSHCP/NCCP conservation umbrella varied; however, in general they were due to on-going concerns of the species/vegetation communities being vulnerable to the pressures of land development and habitat conversion. Federal and state agencies approved and signed the plan in 2008. This vegetation map is a tool to aid in species monitoring and management in the Dos Palmas Conservation Area of the CVMSHCP/NCCP. This comprehensive land planning essentially protects local ecological drivers and processes to enhance sustainability of community biodiversity. The plan is science-based and investigates hypotheses related to the persistence of species on conservation lands through adapting monitoring and management.

Updated vegetation maps are an essential element of monitoring for covered species and natural communities and provide a baseline to monitor natural communities and landscape-scale vegetation change. These data are key to conservation of biological diversity in the Plan area, especially given the impacts of increasing periods of drought and the effects of climate change. Understanding habitat requirements, extent, and spatial continuity for species will help to guide the development of land management actions that support recovery and sustainability of healthy populations. Data produced under this effort is publicly available and supports concurrent CVMSHCP/NCCP monitoring.

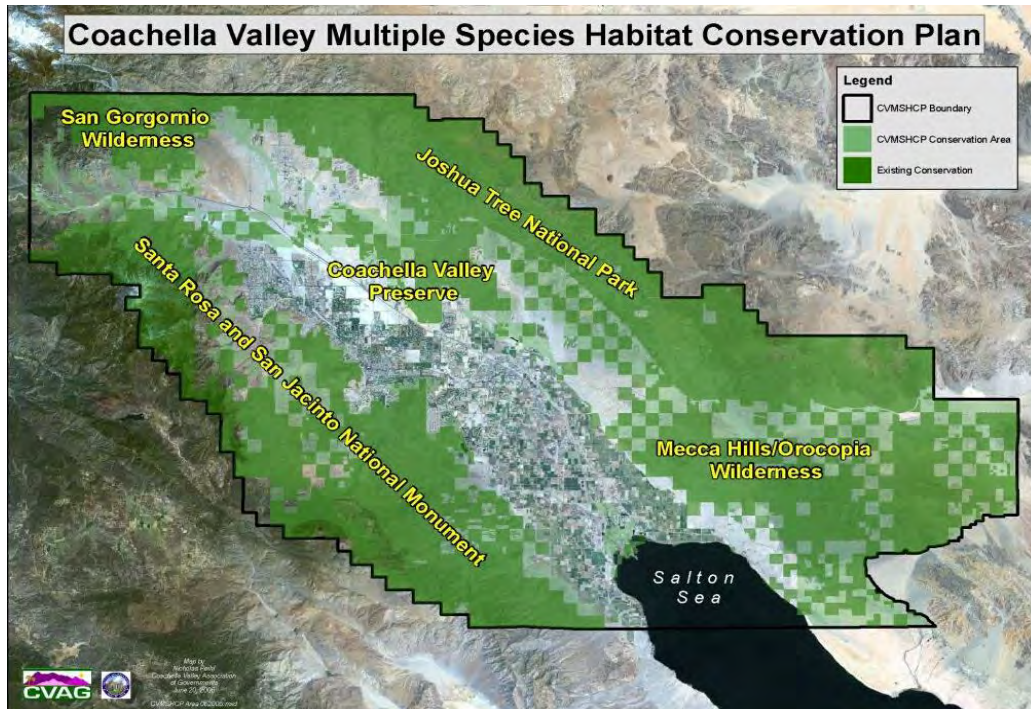


Figure 1: Coachella Valley Multiple Species Habitat Conservation Plan Boundary in relation to Joshua Tree National Park, the Santa Rosa and San Jacinto National Monument, the Coachella Valley USFWS Preserve, Wilderness areas, and the Salton Sea.

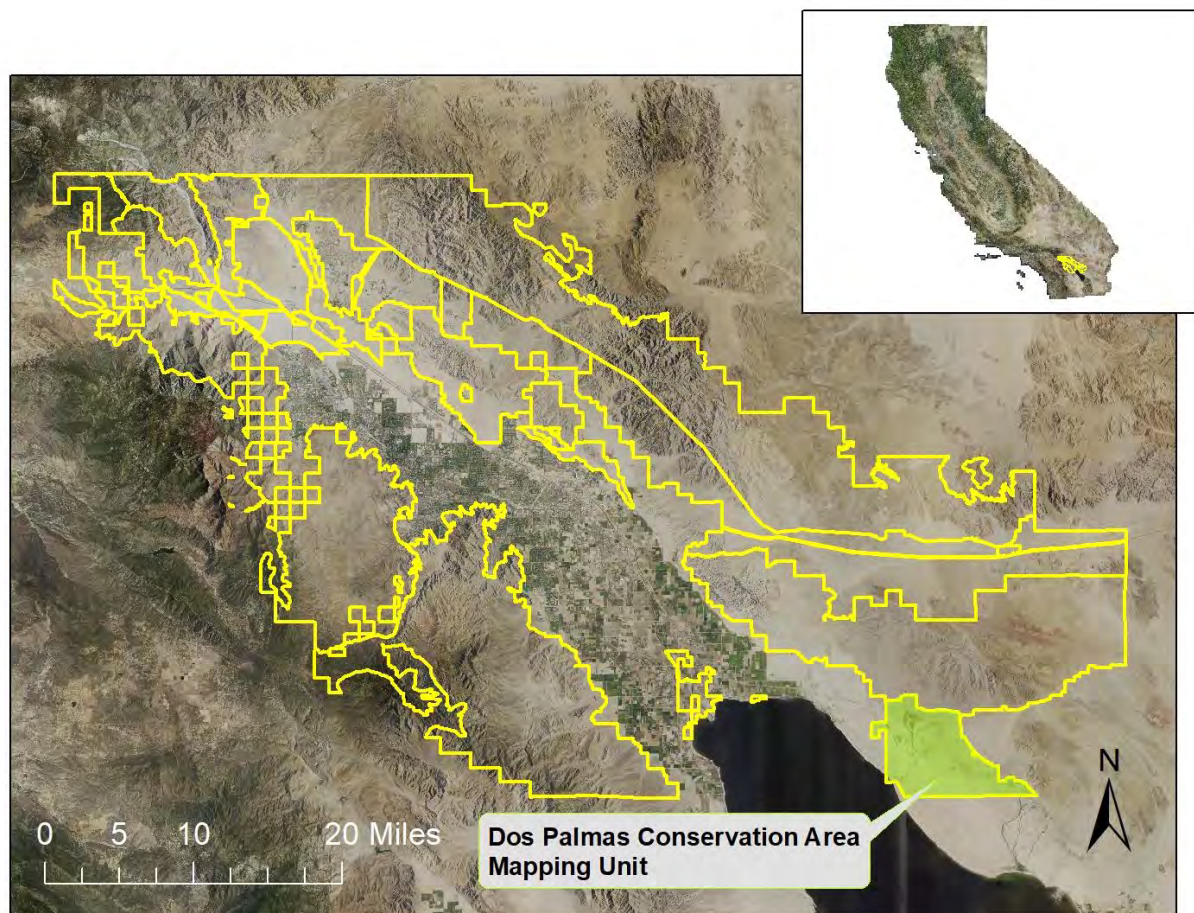
### *Geography and Climate*

The Coachella Valley is situated in the Colorado Desert in the northwest portion of the much larger Sonoran Desert, and consists of a variety of habitats. One hundred miles east of Los Angeles, California, it is bordered on the west by the San Jacinto, San Gorgonio, and Santa Rosa Mountain Ranges. The Valley lies at the northwest end of the Colorado Desert, and to the east of the Valley lies the Salton Sea. The Coachella Valley is an extremely arid desert region that is characterized by aeolian sand communities, fan palm oases, creosote bush scrub, alluvial fan, and salt scrub communities.

Precipitation is the primary driver for vegetation growth in the Coachella Valley, which experiences both summer and winter precipitation events. Rains are highly variable from year to year, but tend to be less frequent in the central and eastern end of the valley, due to the rain shadow of the San Jacinto, Santa Rosa, and San Bernardino mountain ranges. Due to the varying proximity to coastal storms, the rain shadow, and decreasing elevation, there is a gradient of increasing temperature and aridity from west to east. During rare monsoonal events in July to September, weather systems that originate in the Gulf of Mexico bring heavy but isolated thunderstorms to the valley. During average years, the greatest proportion of the annual rainfall



comes from winter rains, which originate to the northwest of the valley and move into the area in October through May.



**Figure 2.** Areas of conservation within the Multiple Species Habitat Conservation Plan Conservation areas (in yellow) that were described in the Dos Palmas Conservation Area Map (in green).

### *Dos Palmas Conservation Area*

Dos Palmas Conservation Area (hereafter, DPCA) (Figure 2) comprises over 27,000 acres as the southernmost in a contiguous chain of conserved lands, from the Joshua Tree Conservation area, the Desert Tortoise Linkage Area, and the Mecca Hills/Orocopia Mountains (Figure 3). To the west it is bounded by non-conserved land and the Salton Sea State Recreation Area, and to the east, the Chocolate Mountains Aerial Gunnery Range. DPCA terminates at the Imperial County line to the south. Within DPCA are two specially-designated areas: the Bureau of Land Management manages the Dos Palmas Area of Critical Environmental Concern (designated in 1980 under the California Desert Conservation Area Plan) and the California Department of Fish and Wildlife manages the Oasis Springs Ecological Reserve (designated in 1993). The remaining lands within DPCA are administered by the federal Bureau of Reclamation, San Diego County

Water Authority, the Coachella Valley Water district, the California Department of Transportation, California State Parks (Salton Sea Recreation Area) and many private conservation land holdings, including the Center for Natural Lands Management, Friends of the Desert Mountains and The Nature Conservancy (Dos Palmas Conservation Area Reserve Management Unit 4 Plan).



Figure 3: Contiguous conserved land areas in the Plan adjacent to Dos Palmas Conservation Area. CVMSHCP conservation boundaries in yellow.

This Conservation Area contains a variety of habitats and sensitive species, including desert pupfish, flat-tailed horned lizard, crissal thrasher, least Bell's vireo (in migration, but occasionally breeding here), southwestern willow flycatcher (in migration), Yuma clapper rail, California black rail, yellow breasted chat, Coachella Valley round-tailed ground squirrel, and southern yellow bat, among others. A general habitat map for DPCA was produced prior, in conjunction with the inception of the Plan, to document the distribution of conserved natural communities according to Holland Type (1986). These habitats were: mesquite hummocks, Sonoran creosote bush scrub, desert sink scrub, arrowweed scrub, cismontane alkali marsh, mesquite bosque, desert dry wash woodland, and desert fan palm oasis woodland in addition to one non-native habitat type, Tamarisk scrub (see (CVCC, *Final Recirculated Coachella Valley MSHCP—September 2007*, Figure 4-24c).



Subsequent mapping by AMEC Foster Wheeler (AMEC) circa 2009 provided vegetation delineation of central marsh areas and areas within DPCA to the north and west. AMEC delineated the natural communities vegetation within the Holland types listed in the Plan, and additionally: alkali seep, desert saltbush scrub and Phragmites (*Phragmites australis*) stands. Additional non-Holland type areas delineated were: open water, developed, and disturbed/built up. The 2013 and the current mapping project encompass the entire Conservation Area, and include many vegetation types not present in the former AMEC map area. In addition, this new effort utilizes the most current CDFW mapping classification system (as above), further refines the map both to a finer spatial scale and with finer taxonomic precision. The new maps also incorporate land and vegetation changes since the earlier Holland-Type map. The correction of the 2013 map and this report is meant to update and replace the prior 2013 vegetation map and report (Sweet *et al.* 2016), while adding 2018 status information.

These new vegetation maps support conservation goals for managing under listed threats to habitats in this management unit: invasive species; threats to hydrological regime/processes; climate change and habitat fragmentation, wildfire management, off-highway vehicle use, and other anthropogenic surface disturbance (CVMSHCP, Section 8). Understanding habitat requirements for species will help to guide the development of land management actions that support recovery and sustainability of healthy populations. Data produced under this effort, as it does not contain location information on state or federally-listed threatened or endangered species, is publicly available and supports concurrent CVMSHCP/NCCP monitoring.

## RECONNAISSANCE

For the original 2013 produced by UCR CCB, 2013 map, initial research on the vegetation communities present in this Conservation Area included a review of existing vegetation maps (CVCC 2007, AMEC, circa 2009) and development of a preliminary database of possible plant species, alliances and associations. To determine the plant communities that might be encountered during field surveys, CCB staff consulted with Bureau of Land Management staff, who provided a plant species list from past survey data. As well, the site was visited for preliminary reconnaissance/plant identification in June 2015, and a preliminary working list of plant species was developed using the Calflora database ([www.calflora.org](http://www.calflora.org), accessed July 2015) during July-August of 2015 for use by the field staff.

Between November 2015 and June 2016, CCB staff conducted surveys throughout the mapping area as a reconnaissance of vegetation types. The purpose of these field visits was to calibrate the photo-interpretation of aerial imagery to existing vegetation types within the area. The CNPS California Native Plant Society/Department of Fish and Game Protocol for Combined Vegetation and Rapid Assessment and Relevé Sampling Field Form was used for Rapid Assessment surveys in the study area (CNPS 2011, 2014). The study area was traversed on foot

and by vehicle, and vegetation was assessed at optimal and accessible points, sited according to relevé plot protocol (see CNPS 2014). The field staff completed 194 plots (hereafter “RA plots”), both opportunistically-located as well as targeted at priority areas according to the photo interpreter’s (Lynn Sweet’s, hereafter, LS) preference and priorities. A significant effort was made to access areas where little was known about the vegetation types from previous visits, or where few reconnaissance points existed. At each point, a RA assessment form was completed, resulting in a database containing perennial vegetation percent cover (and annual cover of key species such as *Abronia villosa*, where it was likely to define the alliance); UTM easting and northing coordinates (NAD 1983 datum, Zone 11N); slope, aspect and elevation; percent surface cover of vegetation, litter and abiotic substrates; and other data (see protocol, CNPS 2014; Appendix A: VAP Plot Database 2016). As well, file numbers for photos at each point in four cardinal directions were recorded (photo database available upon request from CCB). For each RA plot, the field team assessed and assigned an alliance and association.

Because the 2013 vegetation map is tied to aerial imagery acquired by CVCC in 2013 (with the goal of a temporally-uniform snapshot of vegetation across the Plan Area), there is a 3-year gap between the temporal reference period for this map and the state of vegetation as it was recorded on RA plot field surveys. The field team sampled in upland, seasonally-wet and wetland vegetation areas within Dos Palmas. In many cases, dead, dying, or dormant vegetation was encountered. When this occurred, although the field team filled out an assessment form appropriate to the date of the survey (2015 or 2016 as appropriate), the field team also used a visual assessment to decide whether the vegetation was living during the 2013 time period of the map and relayed this information to LS (see additional notes in the following section for information on final assignment of vegetation types in these cases).

In sum, 194 RA plots were used for delineation within this study area, plus an additional 47 modified/basic RA plots that were completed prior, at monitoring points (but not necessarily presence points) for other covered species (*Salvia graetiae*, Orocopia sage; *Toxostoma crissalis*, crissal thrasher; and *Toxostoma lecontei*, Le Conte’s thrasher), all completed in 2014-2015. Additionally, 132 opportunistic rapid observation plots (where only dominant perennial identity was recorded at the point location) were collected as needed, especially for areas identified by the aerial imagery that were problematic for interpretation.

For the 2018 map, 221 Rapid Assessment plots were completed between October 2018 and January 2019. In addition, about 180 locations were visited where basic reconnaissance information was recorded. Plots were located throughout the mapping area and an effort was made to repeat assessments at previous locations, as well as recording information from new areas. The plot data were recorded on tablets (Samsung Galaxy Tab A2 SM-T390, Samsung.com) using a Survey123 App form (versions 3.0-3.2, survey123.arcgis.com, ESRI,

2019) containing the same fields as the CNPS 2016 Combined Vegetation Rapid Assessment and Relevé Field Form (Revised April 28, 2016) (Figure 4).

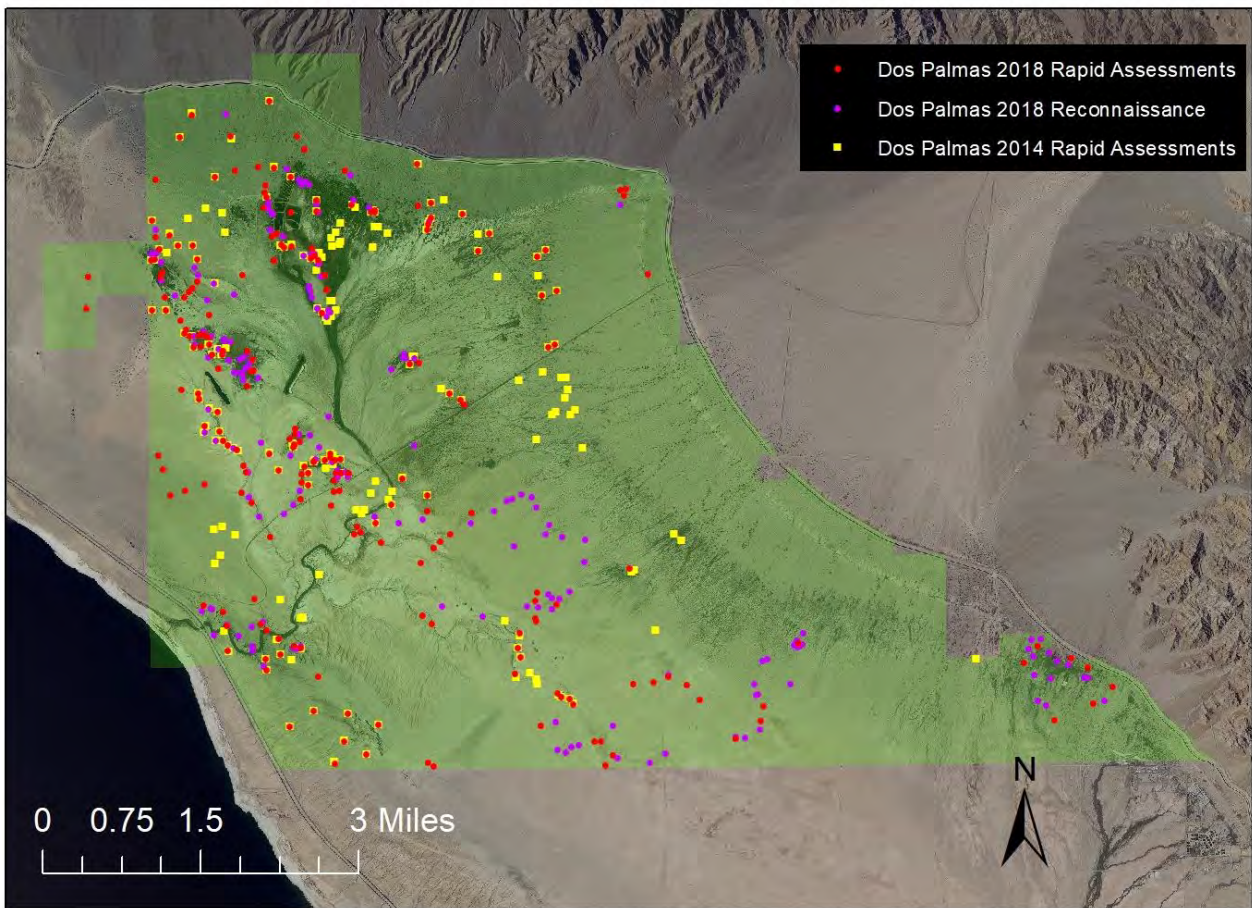


Figure 4: Distribution of 2014 (2013 map) basic Vegetation Assessments, 2018 Rapid Assessments and 2018 basic reconnaissance visits within the vegetation mapping area, in the Coachella Valley, California.

## AERIAL PHOTO INTERPRETATION AND DELINEATION

Photo interpretation of vegetation types employed heads-up digitizing techniques. For the 2013 map, this was accomplished using three-inch resolution true-color (RGB) 2013 aerial imagery provided by the Coachella Valley Conservation Commission from local flights, primarily. This was supplemented with 2014 one-meter imagery from the National Agricultural Imagery Program (NAIP) on the edges of the mapping area that the CVCC imagery did not cover. As well, information was pulled from a variety of other sources to identify phenological stage where CVCC imagery showed dormant vegetation (i.e. the spring-captured imagery showed primarily dormant *Typha*, *Phragmites*). Thus, imagery from sources such as ESRI WorldImagery, while not used as the primary basis for any decision, was useful as supporting information.



For the 2018 map, several sources were used. The primary imagery used to assess vegetation types and boundaries was the 60cm resolution 2018 NAIP imagery. However, since the NAIP imagery was not available until the spring of 2019, earlier procurement of supplemental imagery was required to complete the map. Unfortunately, there was not adequate funding to acquire **for** 2018 true-color imagery at a similar (3 inch resolution) resolution to 2013. In addition, the 2018 NAIP flight data were taken in October of 2018 (according to the metadata), whereas the NAIP program flights are usually flown in the springtime and the data itself was available starting April of 2019. These factors led not only a delay of the mapping effort, but also a problem with interpretation of live % cover using the color-infrared data, because of differences in spring vs. fall phenology. Where indicated, LS used 2016 NAIP data to confirm major changes seen in live % cover. However, the lack of matching and adequate aerial imagery did negatively impact this effort. In the fall of 2018, CVCC purchased ortho-rectified 30cm resolution imagery (aerial acquisition date October 2018) from DigitalGlobe (<https://www.digitalglobe.com/>) and this was used to begin mapping for the north and central areas (Figure 5). These delineations were re-verified once the NAIP imagery was acquired. Unfortunately, there is a phenological difference between the original 2013 CVCC imagery captured in the springtime, and the 2018 NAIP and DigitalGlobe imagery, both acquired in the fall. The color-infrared (CIR) imagery from NAIP 2014, 2016 and 2018 were also used to assess the amount of live cover present.

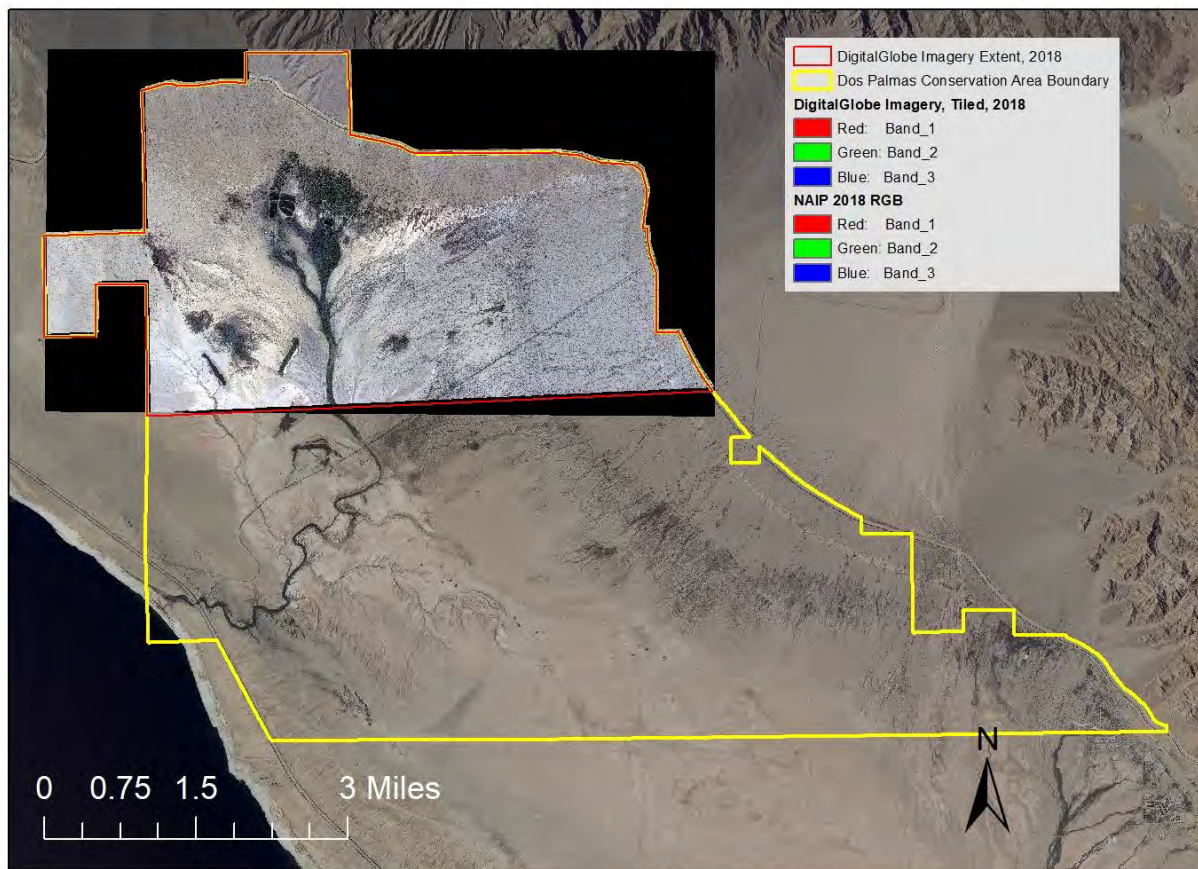


Figure 5: Imagery used for the 2018 vegetation map. Shown is the 30cm DigitalGlobe imagery acquired and the 60cm 2018 NAIP imagery for the Dos Palmas vegetation mapping area, in the Coachella Valley, California.

Vegetation delineation was done using a line feature class, assigned to type using point feature class, and finally, a polygon feature class was created, attributed with alliance and other attributes. Continuous quality control checks were performed using query tools in ArcGIS as well as the utilization of a secondary reviewer from the team (other than the photo-interpreter-LS) to review polygon assignments, identify problematic vegetation assignments errors and discrepancies as monitoring continued, and all were incorporated into the final geodatabase.

Lines are drawn both to distinguish between alliance and association types and to indicate vegetation cover and landscape variables within a type, generally following Menke and others (2013). Due to the fine resolution of the 2013 aerial imagery provided by the Coachella Valley Conservation Commission (three-inch resolution, true-color imagery), LS drafted boundaries separating vegetation types (Alliances) at 1:1500 scale and attributed other categories using field information and relevant datasets. LS used the verified vegetation type locations (vegetation type photo signatures) to identify vegetation across the landscape, additionally using ecological characteristics of vegetation types in relation to landscape characteristics such as topographic features. For example, where imagery alone was unable to resolve the vegetation type in a minor seasonally-flooded non-saline wash area, LS considered vegetation types that were likely to occur in that area, such as *Acacia greggii*, *Ambrosia dumosa*, or *Lycium brevipes*.

Cover was quantified as non-vegetated habitat where it was less than 2%. Some coordinates for plots such as those done specifically for flooded wetland vegetation fall outside of the plot boundaries due to the extremely delicate habitat and accessibility challenges of flooded habitats, as in for *Schoenoplectus americanus*, *Typha domingensis* and occasionally for *Phragmites australis*. For these surveys, the cover estimates, as they currently stand, apply to the projected coordinate locations indicated in the VAP database where applicable.

The 2018 map update was begun using the delineations from 2014. LS used the newer imagery to assess each polygon and determine if the boundary, alliance, association, cover class or any other category (as below) had changed sufficiently (as in changed cover or category classes) to warrant a map change. As necessary, further corrections were made to the 2013 map if prior errors or additional field information was significant enough to warrant a change.

For most alliances occurring in expansive areas, a minimum mapping unit of 2.4 acres (~1 ha) was observed. For the purposes of the CVMSHCP, habitat of sensitive species is of particular concern and therefore to improve the ability of researchers and land managers to target wildlife habitat that is patchily-distributed, there are several alliances where the minimum mapping unit (MMU) is less than an acre. A finer visualization scale was used in some cases to delineate

wetland types occurring in narrow bands and patchy areas. These include *Prosopis glandulosa* Woodland Alliance (habitat for the covered species, *Toxostoma crissalis*, crissal thrasher), *Cladium californica* Provisional Alliance (*Cladium californicum* is a 2B.2 rank rare plant fairly endangered in California (CNPS, 2016)), *Washingtonia filifera* Woodland Alliance (supporting federally endangered *Cyprinodon macularius*, desert pupfish), as well as wetlands types (some support the federally endangered *Rallus longirostris yumanensis*, Yuma clapper rail and other sensitive species), and as well as certain wash types which displayed complexity that necessitated delineation (generally, Groups G531, G533 and G538; see “Classification...” section below). Therefore, for other purposes, such as comparison with other regional vegetation maps, these types may need to be aligned with other protocols.

Percent cover was attributed to each polygon for tree and shrub cover, and as available from field surveys, for the herbaceous cover. For most of the open desert, cover did not exceed 25% except in smaller polygons delineating riparian areas, Mesquite bosques or California fan palm oases. Additionally, percent cover of exotic species (as available), roadedness, anthropogenic alteration and development were quantified (see Menke and others 2013 for cover classes/categories). Generally, polygons were mapped to a 2.5 acre minimum mapping unit (MMU), but specialized and important vegetation, Mesquite bosques and California fan palm oases, were mapped with no minimum MMU with the aim of detecting fine-scale change in stand distribution.

For polygons in which the VA plot data indicated significant mortality of the vegetation or dormant vegetation, LS visually assessed the greenness of the vegetation in the aerial imagery to decide how much of the dominant alliance vegetation was in fact living in 2013. Often, remaining basal sprouts or a small percentage of the vegetation remained alive, with sufficient cover remaining alive to pass the assignment rules for the dominant vegetation type. In very few areas was enough of the dominant vegetation dead, with certainty on the ground and from the aerial imagery, to justify assigning a different alliance, including the non-vegetated assignment where <2% perennial vegetation cover remained. Because of the one-year turnaround time from sampling to map production, and the timing of surveys in early winter for the 2013 map (when much of the central marsh area vegetation was dormant, including *Typha dominguensis*), it was impossible to determine with absolute certainty when and if mortality has occurred in all cases. Where the vegetation could be clearly identified but where it was ambiguous as to whether the dominant vegetation type was sufficiently alive in 2013 after using the decision process described above, LS defaulted to the assumption that the vegetation in question was still alive during the time stamp represented by the map in lieu of assigning a different alliance. For this reason, it should be noted that there are areas depicted in the 2013 map which during 2015 field surveys appeared to contain primarily dead vegetation.

As well, significant management activities are occurring at DPCA. Bureau of Land Management staff are controlling invasive Tamarisk (*Tamarix* spp.), which cover a large portion of DPCA; treatments have included cutting and herbicide application in small areas, as well as removal with large equipment in heavily-infested areas (L. Sweet, *pers. obs.*). Because Tamarisk is so prevalent, and where it occurs, it becomes the dominant (if not sole) species in the local ecosystem, it is recognized as a distinctive vegetation type in California, the *Tamarix* spp. Shrubland Semi-Natural Alliance (Sawyer *et al.* 2009). In most cases, it was straight-forward to identify tamarisk from the aerial imagery and determine when it was removed, so the vegetation type was assigned to either Tamarisk or to the appropriate land cover type present following removal. Occasionally this was Non-Vegetated Habitat type due to low (<2%) cover of any perennial vegetation. Because ecological recovery is slow following perturbation, due to climatic drought, flood, landscape-scale management activities, and changes in hydrologic regime, it will take some time to determine the true distribution of live vegetation and a newer iteration of the map was thus undertaken to represent changes that have happened since 2013. It is recommended, due to ongoing changes within DPCA, that that periodic updates should be published as additional information and newer imagery becomes available.

## CLASSIFICATION OF DOS PALMAS CONSERVATION AREA VEGETATION

Classification of the vegetation was done based on prior vegetation Mapping of Anza-Borrego Desert State Park and Environs (Keeler-Wolf *et al.* 1998), the Western Riverside County MSHCP Vegetation Map (2004), Vegetation of Joshua Tree National Park (La Doux *et al.* 2013), and the Vegetation Map in Support of the Desert Renewable Energy Conservation Plan (Menke *et al.*, 2013) and by the UCR Center for Conservation Biology in previous maps (most recently Sweet *et al.* 2017). There were several RA plots for which the existing list of alliances from the Manual of California Vegetation Online (<http://vegetation.cnps.org/>, accessed December 2015-June 28, 2016; July 5, 2019) was not adequate. Thus, we have described several new provisional vegetation alliances that occur in the area. These new alliances are described below in the Provisional Alliance Descriptions section. The provisional alliances identified during this study were based on relevé plot observations and subsequent classification, and these will be proposed to the NVCS upon adequate funded time, including the *Atriplex canescens*--*Atriplex polycarpa* Shrubland Provisional Alliance, the *Larrea tridentata* / *Abronia villosa* Stabilized Sand Fields Provisional alliance, the *Psoralea schottii* Provisional Alliance, and the *Cladium californicum* Provisional Alliance.

The nested hierarchy, including the Macrogroup and Group, was based on the National Vegetation Classification System (Federal Geographic Data Committee 2008); specifically, the recommendations of Evens (2014) to align the NVCS with the Manual of California Vegetation (Sawyer *et al.* 2009).



Class 1. Forest to Open Woodland

Subclass 1.B. Temperate & Boreal Forest

Formation 1.B.3. Temperate Flooded & Swamp Forest

Division 1.B.3.Nd. Southwestern North American Flooded & Swamp Forest

Macrogroup M298. Warm Southwest Semi-natural Flooded & Swamp Forest

Group G510. Southwestern North American Semi-natural Riparian Forest & Scrub

**Tamarix spp. Shrubland Semi-Natural Alliance**

Macrogroup M036. Warm Southwest Riparian Forest

Group G508. Sonoran-Chihuahuan Warm Desert Riparian Woodland

**Populus fremontii Forest Alliance**

**Washingtonia filifera Woodland Alliance**

**Phoenix dactylifera Semi-Natural Woodland Provisional Alliance**

Class 2. Shrubland & Grassland

Subclass 2.B. Temperate & Boreal Grassland & Shrubland

Formation 2.B.6. Temperate & Boreal Freshwater Marsh, Wet Meadow & Shrubland

Division 2.B.6.Nb. Western North American Freshwater Shrubland, Wet Meadow & Marsh

Macrogroup M073. Western North American Temperate Lowland Wet Shrubland, Wet Meadow & Marsh

Group G531. Arid West Interior Freshwater Emergent Marsh

**Schoenoplectus americanus Herbaceous Alliance**

**Typha (angustifolia, domingensis, latifolia) Alliance**

**Phragmites australis Herbaceous Alliance**

Division 2.B.6.Nc. Southwestern North American Warm Desert Freshwater Marsh

Macrogroup M076. Warm Desert Freshwater Shrubland, Meadow & Marsh

Group G533. North American Warm Desert Riparian Low Bosque & Shrubland

**Baccharis sergiloides Shrubland Alliance**

**Prosopis glandulosa Woodland Alliance**

**Cladium californicum Herbaceous Provisional Alliance**

**Pluchea sericea Shrubland Alliance**

**Prosopis pubescens Woodland Alliance**

Formation 2.B.7. Salt Marsh

Division 2.B.7.Nd. North American Western Interior Brackish Marsh

Macrogroup M082. Cool Semi-Desert Alkaline-Saline Wetland

Group G537. North American Desert & Semi-Desert Alkaline-Saline Shrub Wetland

**Suaeda moquinii Shrubland Alliance**

**Allenrolfea occidentalis Shrubland Alliance**

**Atriplex lentiformis Shrubland Alliance**

**Isocoma acradenia Shrubland Provisional Alliance**

Group 538. Western North American Desert & Semi-Desert Alkaline-Saline Herbaceous Wetland & Playa

**Anemopsis californica Herbaceous Alliance**

**Sesuvium verrucosum Herbaceous Alliance**

**Bolboschoenus maritimus Herbaceous Alliance**

**Distichlis spicata Herbaceous Alliance**

**Juncus acutus Herbaceous Provisional Alliance**

**Juncus cooperi Herbaceous Alliance**

Class 3. Desert & Semi-Desert

Subclass 3.A. Warm Desert & Semi-Desert Woodland, Scrub & Grassland

Formation 3.A.2. Warm Desert & Semi-Desert Scrub & Grassland

Division 3.A.2.Na. North American Warm Desert Scrub & Grassland

Macrogroup M088. Mojave-Sonoran Semi-Desert Scrub

Group G295. Mojave-Sonoran Bajada & Valley Desert Scrub

**Ambrosia dumosa Shrubland Alliance**

**Encelia farinosa Shrubland Alliance**

**Larrea tridentata--Ambrosia dumosa Shrubland Alliance**

**Larrea tridentata--Encelia farinosa Shrubland Alliance**

**Larrea tridentata Shrubland Alliance**

**Psoralethamnus schottii Shrubland Provisional Alliance**

**Salvia greatae Shrubland Provisional Alliance**

**Larrea tridentata / Abronia villosa Stabilized Sand Fields Provisional Alliance**

**Psoralethamnus arborescens / Dicoria canescens Ephemeral Sand Fields Provisional Alliance**

Group G675. North American Warm Semi-Desert Dunes & Sand Flats

**Psoralethamnus arborescens / Dicoria canescens Ephemeral Sand Fields Provisional Alliance**

Subclass 3.B. Cool Semi-Desert Scrub & Grassland

Formation 3.B.1. Cool Semi-Desert Scrub & Grassland

Division 3.B.1.Ne. Western North American Cool Semi-Desert Scrub & Grassland

Macrogroup M093. Great Basin Saltbush Scrub

Group G300. Intermountain Shadscale - Saltbush Scrub

**Atriplex canescens--Atriplex polycarpa Shrubland Provisional Alliance**

**Atriplex canescens Shrubland Alliance**

**Atriplex polycarpa Shrubland Alliance**

Class 3. Desert & Semi-Desert

Subclass 3.A. Warm Desert & Semi-Desert Woodland, Scrub & Grassland

Formation 3.A.2. Warm Desert & Semi-Desert Scrub & Grassland

Division 3.A.2.Na. North American Warm Desert Scrub & Grassland

Macrogroup M092. North American Warm-Desert Xero-Riparian Scrub

Group G541. Warm Semi-Desert Shrub & Herb Dry Wash

**Acacia greggii Shrubland Alliance**

**Ambrosia salsola Shrubland Alliance**

**Chilopsis linearis Woodland Alliance**

**Ericameria paniculata Shrubland Alliance**

**Hyptis emoryi Shrubland Alliance**

**Justicia californica Shrubland Alliance**

**Lepidospartum squamatum Shrubland Alliance**

**Parkinsonia florida--Olneya tesota Woodland Alliance**

**Psoralea arguta Woodland Alliance**

**Xylorhiza cognata Shrubland Provisional Alliance**

**Lycium brevipes Shrubland Provisional Alliance**

Class 6. Rock Vegetation

Subclass 6.C. Desert & Semi-Desert Rock Vegetation

Formation 6.C.1. Warm Desert & Semi-Desert Cliff, Scree & Other Rock Vegetation

Division 6.C.1.Na. North American Warm Semi-Desert Cliff, Scree & Rock Vegetation

Macrogroup M117. North American Warm Semi-Desert Cliff, Scree & Rock Vegetation

Group G569. North American Warm Semi-Desert Cliff, Scree & Pavement Sparse Vegetation

**Atriplex hymenelytra Shrubland Alliance**

Non-Vegetated Land Cover Types

**Disturbed/built-up**

**Non-vegetated Habitat (less than 2% absolute cover)**

**Playa**

**Water**

## PROVISIONAL ALLIANCE DESCRIPTIONS

### *Atriplex canescens*—*Atriplex polycarpa* Provisional Alliance

Four-winged saltbush—allscale scrub provisional alliance



The image on the left shows an *Atriplex canescens*—*Atriplex polycarpa* photo signature with Mesquite hummocks to the north and southwest and a non-vegetated playa surrounding the remaining sides. The photo on the right shows a sparse *Atriplex canescens*—*Atriplex polycarpa* stand with *Lycium brevipes* and *Ambrosia dumosa* mixed into the shrub layer in very low density.

**DESCRIPTION:** Polygons mapped as this Provisional Alliance are strongly dominated by *Atriplex canescens* and *Atriplex polycarpa*, with each plant typically comprising at least 2 percent absolute cover in the shrub canopy and no other species having greater or equal cover than their combined totals. *Atriplex canescens*—*Atriplex polycarpa* stands are typically upslope from sparsely- or non-vegetated stands in salt flats on the north eastern shores of the Salton Sea in the DPCA.

### *Isocoma acradenia* Shrubland Provisional Alliance

Alkali goldenbush scrub provisional alliance



The image on the left shows an *Isocoma acradenia* photo signature that is surrounded on three sides by Tamarisk thickets that contain low levels of *Isocoma acradenia* mixed into its understory and small mesquite bosques on the east side. The photo on the right shows an *Isocoma acradenia* stand with a few creosote bushes and the leading edge of a tamarisk thicket coming in from the west.

**DESCRIPTION:** Polygons mapped as this Provisional Alliance are dominated by *Isocoma acradenia*, typically comprising more than 5 percent absolute cover at the DPCA, but requiring at least 2 percent absolute cover in the shrub canopy and no other species having equal or greater cover. At DPCA, these stands are typically found either in sinks or in the upland, upslope from water sources. They surround mesquite bosques, tamarisk thickets and other hydrophilic species.



## ***Cladium californicum* Herbaceous Provisional Alliance**

California sawgrass beds provisional alliance



The image on the left shows a *Cladium californicum* photo signature with *Prosopis pubescens* and *Pluchea sericea* thickets surrounding it. The photo on the right shows a dense *Cladium californicum* area with *Pluchea sericea* in the foreground and *Washingtonia filifera* and *Prosopis pubescens* in the background.

**DESCRIPTION:** Polygons mapped as this Provisional Alliance are dominated by *Cladium californicum*, comprising greater than 50% absolute cover in the tall grass and shrub canopy with no other species having greater or equal cover. *Cladium californicum* areas typically occur at DPCA in areas with high surface water, low overstory cover, and often at springs associated with *Washingtonia filifera* fan palm oases.

## ***Lycium brevipes* Shrubland Provisional Alliance**

Baja desert thorn scrub provisional alliance



The image on the left shows a *Lycium brevipes* photo signature in an upland seasonally-wet wash surrounded by non-vegetated areas. The photo on the right shows a *Lycium brevipes* stand with *Tamarix* spp., and other occasional shrubs including *Ambrosia dumosa*, *Encelia farinosa*, and *Allenrolfea occidentalis*.

**DESCRIPTION:** Polygons mapped as this Provisional Alliance are strongly dominated by *Lycium brevipes*, with each plant typically comprising at least 2 percent absolute cover in the shrub canopy and no other species having greater or equal cover. These areas were typically in the upland, away from the marsh in minor washes that occasionally fill during flood events. Occasional stands were associated with the less-saline upper environments next to wetlands.

## ***Phoenix dactylifera* Semi-Natural Woodland Provisional Alliance**

Date palm naturalized groves provisional alliance

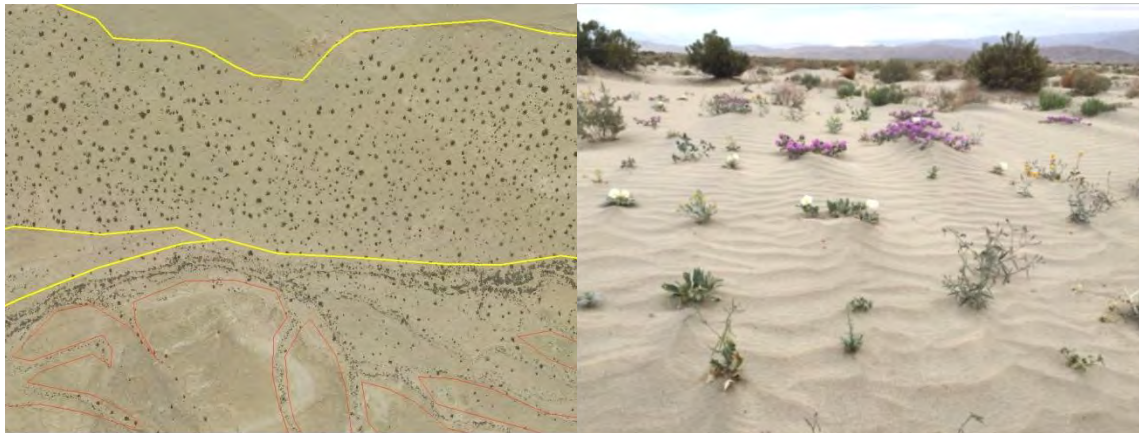


This image on the left shows a *Phoenix dactylifera* photo signature with a *Washingtonia filifera* Woodland surrounding it on the south boundary and an *Isocoma acradenia* Shrubland on the north boundary. The image on the right shows a *Phoenix dactylifera* stand with *Pluchea sericea* in the foreground and *Washingtonia filifera* in the background.

**DESCRIPTION:** Polygons mapped as this Provisional Alliance are strongly dominated by *Phoenix dactylifera* comprising at least 3 percent absolute cover in the tree canopy and at least 60 percent relative cover in the tree canopy with no other species having greater or equal cover. This alliance is typically found near desert seeps and springs, along fault lines where ground water is continuously available to them.

## ***Larrea tridentata* / *Abronia villosa* Stabilized Sand Fields Shrubland Provisional Alliance**

Creosote bush / sand verbena stabilized sand fields provisional alliance



This image shows a *Larrea tridentata* / *Abronia villosa* photo signature with a non-vegetated playa along the north boundary and *Allenrolfea occidentalis* Shrubland to the south. The photo on the right shows a sand field with *Larrea tridentata* in the background and *Abronia villosa* in the center of the photo mixed with other dune annuals.

**DESCRIPTION:** Polygons mapped as this Provisional Alliance are dominated by *Larrea tridentata* and *Abronia villosa*, with a combined absolute cover of each plant of greater than 2 percent and typically comprising at least 2 percent absolute cover in the shrub canopy and at least 2 percent cover in the herbaceous layer, respectively.



## ***Psorothamnus schottii* Shrubland Provisional Alliance**

Schott's indigo bush scrub provisional alliance



The image on the left shows a *Psorothamnus schottii* photo signature with a non-vegetated area to the southeast and a *Parkinsonia florida*—*Olneya tesota* woodland alliance to the north and west. The photo on right shows a *Psorothamnus schottii* stand with *Larrea tridentata* mixed in at very low cover and *Parkinsonia florida* woodland in the background.

**DESCRIPTION:** Polygons mapped as this Provisional Alliance are strongly dominated by *Psorothamnus schottii*, comprising at least 2 percent, but usually 5 percent absolute cover in the shrub canopy with no other species having greater cover in the shrub or tree canopies. They typically occur on rocky alluvial slopes where they receive seasonal runoff.

## **FINDINGS**

The vegetation map for the Dos Palmas Conservation Area Unit of the Coachella Valley Multiple Species Habitat Conservation Plan includes 1248 polygons (2013) and 1271 polygons (2018) with 37 Alliances (2013 and 2018) and 126 Associations (2013 and 2018). Because of the very small changes in vegetation cover and the difficulty reliably detecting true changes in live cover, the following changes should be interpreted as preliminary findings. The changes noted here are changes in the amount of area per category; as the attribute data is categorical (the categories are also uneven and not a proxy for continuous data) analysis showing average changes over space were not possible. Some of the changes found may be artifacts of the mapping process. For instance, for the disturbance categories, these may be affected by changes such as polygons being split or reassigned, and the child polygons containing more or less of the disturbance type assigned to the parent polygon. However, to the degree that multiple indicators agree on the same directionality (increase or decrease), these may be taken as indications of likely changes in the landscape.



Table 1: Vegetation cover alliance designations in the Dos Palmas Conservation Area Mapping Unit. Shown is the amount of area mapped per alliance in the respective maps (2013 Map Correction, 2018 Map Update), and the absolute change in hectares.

Alliance Name	ALLIANCE AREA (ha) 2013	ALLIANCE AREA (ha) 2018	Difference (ha)
<i>Allenrolfea occidentalis</i> Shrubland Alliance	669.9	645.2	-24.7
<i>Ambrosia dumosa</i> Shrubland Alliance	157.9	153.4	-4.5
<i>Ambrosia salsola</i> Shrubland Alliance	75.0	75.0	0.0
<i>Atriplex canescens</i> Shrubland Alliance	383.1	387.7	4.6
<i>Atriplex canescens</i> -- <i>Atriplex polycarpa</i> Shrubland Provisional Alliance	114.8	102.9	-11.9
<i>Atriplex hymenelytra</i> Shrubland Alliance	42.3	43.0	0.7
<i>Atriplex lentiformis</i> Shrubland Alliance	2.1	2.1	0.0
<i>Atriplex polycarpa</i> Shrubland Alliance	113.4	113.4	0.0
<i>Bolboschoenus maritimus</i> Herbaceous Alliance	0.1	0.1	0.0
<i>Chilopsis linearis</i> Woodland Alliance	0.1	0.1	0.0
<i>Cladium californicum</i> Herbaceous Provisional Alliance	6.4	6.5	0.1
<i>Distichlis spicata</i> Herbaceous Alliance	18.3	15.5	-2.8
Disturbed/built-up	222.4	222.5	0.1
<i>Encelia farinosa</i> Shrubland Alliance	9.3	9.3	0.0
<i>Isocoma acradenia</i> Shrubland Provisional Alliance	170.0	169.9	-0.1
<i>Juncus cooperi</i> Herbaceous Alliance	7.4	7.2	-0.2
<i>Larrea tridentata</i> / <i>Abronia villosa</i> Stabilized Sand Fields Provisional Alliance	228.5	228.5	0.0
<i>Larrea tridentata</i> Shrubland Alliance	1183.0	1199.7	16.8
<i>Larrea tridentata</i> -- <i>Ambrosia dumosa</i> Shrubland Alliance	989.2	988.7	-0.5
<i>Larrea tridentata</i> -- <i>Encelia farinosa</i> Shrubland Alliance	12.9	12.9	0.0
<i>Lycium brevipes</i> Shrubland Provisional Alliance	46.6	46.5	-0.1
Non-vegetated Habitat (less than 2% absolute cover)	2413.0	2460.3	47.3
<i>Parkinsonia florida</i> -- <i>Olneya tesota</i> Woodland Alliance	1116.1	1116.1	0.0
<i>Phoenix dactylifera</i> Semi-Natural Woodland Provisional Alliance	0.3	0.3	0.0
<i>Phragmites australis</i> Herbaceous Alliance	38.3	31.0	-7.3
Playa	44.9	44.9	0.0
<i>Pluchea sericea</i> Shrubland Alliance	45.2	40.4	-4.7
<i>Prosopis glandulosa</i> Woodland Alliance	205.5	190.3	-15.2
<i>Prosopis pubescens</i> Woodland Alliance	9.1	8.5	-0.7
<i>Psoralea schottii</i> Shrubland Provisional Alliance	18.1	18.1	0.0
<i>Psoralea spinosa</i> Woodland Alliance	16.8	16.8	0.0
<i>Schoenoplectus americanus</i> Herbaceous Alliance	7.9	7.2	-0.7
<i>Suaeda moquinii</i> Shrubland Alliance	84.2	83.3	-0.9
<i>Tamarix</i> spp. Shrubland Semi-Natural Alliance	1639.1	1660.3	21.3
<i>Typha</i> ( <i>angustifolia</i> , <i>domingensis</i> , <i>latifolia</i> ) Alliance	32.2	27.7	-4.5
<i>Washingtonia filifera</i> Woodland Alliance	106.9	107.0	0.2
Water	47.0	34.9	-12.1

The largest amount of land cover for both 2013 and 2018 maps is classified under the Non-Vegetated Habitat category, representing over 2400 hectares followed by the *Tamarix* spp. Shrubland Semi-natural Alliance at over 1600 hectares. The largest mapped declines in area from 2013-2018 type mapped were the *Allenrolfea occidentalis* Shrubland Alliance (-25 ha) and the *Prosopis glandulosa* Woodland Alliance (-15 ha). The former may be due to conversion to other types, such as the Non-vegetated Habitat (+47 ha) or to *Tamarix* spp. Shrubland Semi-natural Alliance (+21 ha), the two biggest per-alliance gains in acreage. The latter may be due to mortality in this species, notably not throughout the mapping area, but in the northeast area of the mapping unit.

Table 2: Tree and shrub cover categories mapped within the Dos Palmas Conservation Area Mapping Unit and changes, 2013-2018. Shown is the amount of area mapped per category in the respective maps (2013 map correction, 2018 map update), and absolute change in hectares, and the percent change with respect to the category.

	TREE COVER CATEGORY				SHRUB COVER CATEGORY			
	2013 Area (ha)	2018 Area (ha)	Difference (ha)	Difference (%)	2013 Area (ha)	2018 Area (ha)	Difference (ha)	Difference (%)
none	5338.302	5347.042	8.7	0.1	158.0319	147.2973	-10.7	-3.5
>0-1%	3313.542	3314.641	1.1	0.0	2568.874	2594.417	25.5	0.5
>1-5%	876.4861	866.0099	-10.5	-0.6	1605.285	1810.262	205.0	6.0
>5-15%	628.4334	612.9566	-15.5	-1.2	4168.267	4088.595	-79.7	-1.0
>15-25%	76.14905	96.73369	20.6	11.9	1508.778	1416.866	-91.9	-3.1
>25-50%	32.46877	30.041	-2.4	-3.9	206.6583	155.4522	-51.2	-14.1
>50-75%	9.037141	7.407397	-1.6	-9.9	60.19751	62.60779	2.4	2.0
>75-100%	2.830561	2.417881	-0.4	-7.9	1.158412	1.751733	0.6	20.4

Shrub cover was characterized by an increase in areas with 1-5% cover, and a decrease overall in areas with 5-50% cover, and an increase in areas with 75-100% cover (the latter due to *Tamarix* spp. being mapped as shrubs in the MCV). There was a slight increase in the area covered by 1-5% tree cover, and also a decline in the area covered by 25-100% cover. The decline is likely explained by the shrinkage in area and cover class changes for *Prosopis glandulosa*, since the other tree types mapped (*Prosopis pubescens*, *Olneya tesota* and *Parkinsonia florida*) do not generally rise to those higher levels of cover.

## SUMMARY AND RECOMMENDATIONS

Dos Palmas Conservation Area is undergoing environmental change due to several factors, including the spread and removal of exotic plants, as well as changes in water availability. The mapping was limited by available imagery, and in the future, fine-scale imagery that matches the original imagery with respect to resolution and phenology would be ideal to detect true change.

This map reflects a conservative look at changes that may have occurred as the 2013 color-infrared NAIP is particular to a multi-year drought period in spring, and the 2018 NAIP reflects a return to normal precipitation overall, and was taken in the fall. Status of vegetation on the ground in some areas has already indicated change in vegetation cover or identity from the 2013 imagery to the 2018 imagery, with some areas recovering after water was returned to the area, whereas some stands, especially *Prosopis glandulosa* in the northeast area, are continuing to decline from 2013.

In the context of ongoing climate changes, these maps provide a baseline for further monitoring of the status of vegetation. The changes here occurred as Dos Palmas area recovered from the 2011-2015 drought period, and then received additional water inputs during the period between mapping snapshots. Thus, a long-term trajectory for any particular type may be difficult to ascertain with certainty from the changes noted here. Some types saw increases in cover due to the return to a wetter climate period and increased hydrologic input, and others declined, perhaps due to the inability to rebound from these short-term improvements in moisture availability. Vegetation mapping as a tool, especially at scales of 1:1500 is not ideal to detect small, widespread changes. LS was only able to identify broad areas of change, and thus this effort should be repeated at a longer interval for these sparsely-vegetated types.

Overall a decrease in native shrub cover reflects an area that is still subject to pressures of climate change and hydrologic alteration, despite protection under the CVMSCHP. This map should continue to guide land management efforts in several ways. First, as it was intended, this map may be used to target areas of habitat for monitoring of the covered species under the Plan. Secondly, this map may indicate changes to the amount of habitat available, and human pressures/impacts on each specific area of land that may need to be addressed with management. Last, although most of the changes indicated should be investigated further, this map may help guide decisions overall about any broader problems that may indicate the need for new land management or protection that could be afforded.

## REFERENCES

- CNPS. 2011. California Native Plant Society – Vegetation Rapid Assessment Protocol. CNPS Vegetation Committee (*Revised*). Available online at: [http://www.cnps.org/cnps/vegetation/pdf/protocol-rapid\\_assess.pdf](http://www.cnps.org/cnps/vegetation/pdf/protocol-rapid_assess.pdf)
- CNPS. 2016. California Native Plant Society/Department of Fish and Game Protocol for Combined Vegetation and Rapid Assessment and Relevé Sampling Field Form. Available online at: <http://www.cnps.org/cnps/vegetation/pdf/protocol-combined-2016.pdf>
- Evens, Julie M. 2014. Integrating the FGDC National Classification System (NVC) Standard with the CNPS/CDFG *Manual of California Vegetation, second edition*. Agreement Number G12AC20142 Final Report. Available online at: <https://www.fgdc.gov/grants/2012CAP/InterimFinalReports/142-12-5-CA-FinalReport.pdf>
- Federal Geographic Data Committee. 2008. National Vegetation Classification Standard, Version 2. Vegetation Subcommittee, FGDC-STD-005-2008. Available at: [http://usnvc.org/wp-content/uploads/2011/02/NVCS\\_V2\\_FINAL\\_2008-02.pdf](http://usnvc.org/wp-content/uploads/2011/02/NVCS_V2_FINAL_2008-02.pdf)
- Holland, R. 1986. Preliminary descriptions of the terrestrial natural communities of California. Unpublished document, California Department of Fish and Game, Natural Heritage Division. Sacramento, CA.
- Keeler-Wolf, T., K. Lewis, and C. Royce. 1998. Vegetation Mapping of Anza-Borrego Desert State Park and Environs. California Department of Fish and Game, Sacramento, CA. <http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=18246>
- La Doux, T., C. Lea, and E. Babich. 2013. A summary of the Joshua Tree National Park Vegetation Mapping Project: NPS Vegetation Inventory Program. Natural Resource Technical Report NPS/JOTR/NRTR—2013/723. National Park Service, Fort Collins, Colorado.
- Menke, J., E. Reyes, A. Glass, D. Johnson, and J. Reyes. 2013. 2013 California Vegetation Map in Support of the Desert Renewable Energy Conservation Plan. Final Report. Prepared for the California Department of Fish and Wildlife Renewable Energy Program and the California Energy Commission. Aerial Information Systems, Inc., Redlands, CA.
- Sawyer, John O., Todd Keeler-Wolf, and Julie Evens. 2009. Manual of California Vegetation. California Native Plant Society Press.
- Sweet, L.C., C. Barrows, R. Johnson, J. Heintz, R. Merizan. (2016) Coachella Valley Multiple Species Habitat Conservation Plan & Natural Community Conservation Plan: Dos Palmas Conservation Area Vegetation Map Report. Final Report. Prepared for: Coachella Valley Conservation Commission.

USDA Forest Service - Pacific Southwest Region - Remote Sensing Lab. 2014.  
EVEG\_SouthInterior\_2000\_2008\_v1. Remote Sensing Lab, McClellan, CA  
[https://www.fs.fed.us/r5/rsl/projects/gis/data/vegcovs/sinterior/ExistingVegSouthInterior  
2000\\_2008\\_v1.html](https://www.fs.fed.us/r5/rsl/projects/gis/data/vegcovs/sinterior/ExistingVegSouthInterior2000_2008_v1.html)

**APPENDIX TABLE 1: ALLIANCES AND LANDSCAPE ATTRIBUTES IDENTIFIED**

<b>Alliance Name</b>	<b>Common Name</b>
Allenrolfea occidentalis Shrubland Alliance	Iodine bush scrub
Ambrosia dumosa Shrubland Alliance	White bursage scrub
Ambrosia salsola Shrubland Alliance	Cheesebush scrub
Atriplex canescens Shrubland Alliance	Fourwing saltbush scrub
Atriplex canescens--Atriplex polycarpa Shrubland Provisional Alliance	Fourwing saltbush - allscale scrub
Atriplex hymenelytra Shrubland Alliance	Desert holly scrub
Atriplex lentiformis Shrubland Alliance	Quailbush scrub
Atriplex polycarpa Shrubland Alliance	Allscale scrub
Bolboschoenus maritimus Herbaceous Alliance	Salt marsh bulrush marshes
Chilopsis linearis Woodland Alliance	Desert willow woodland
Cladium californicum Herbaceous Provisional Alliance	California sawgrass beds
Distichlis spicata Herbaceous Alliance	Salt grass flats
Disturbed/built-up	Disturbed/built-up
Encelia farinosa Shrubland Alliance	California brittle bush scrub
Isocoma acradenia Shrubland Provisional Alliance	Alkali goldenbush scrub
Juncus cooperi Herbaceous Alliance	Cooper's rush marsh
Larrea tridentata / Abromia villosa Stabilized Sand Fields Provisional Alliance	Creosote bush / sand verbena stabilized sand fields
Larrea tridentata Shrubland Alliance	Creosote bush scrub
Larrea tridentata--Ambrosia dumosa Shrubland Alliance	Creosote bush - white burr sage scrub
Larrea tridentata--Encelia farinosa Shrubland Alliance	Creosote bush - brittle bush scrub
Lycium brevipes Shrubland Provisional Alliance	Baja desert thorn scrub
Non-vegetated Habitat (less than 2% absolute cover)	Non-vegetated habitat
Parkinsonia florida--Olneya tesota Woodland Alliance	Blue palo verde - ironwood woodland
Phoenix dactylifera Semi-Natural Woodland Provisional Alliance	Date palm naturalized groves
Phragmites australis Herbaceous Alliance	Common reed marshes
Playa	Playa (non-vegetated)
Pluchea sericea Shrubland Alliance	Arrow weed thickets
Prosopis glandulosa Woodland Alliance	Mesquite bosque, mesquite thicket
Prosopis pubescens Woodland Alliance	Screwbean mesquite bosques
Psoralea schottii Shrubland Provisional Alliance	Schott's indigobush scrub
Psoralea spinosa Woodland Alliance	Smoke tree woodland
Schoenoplectus americanus Herbaceous Alliance	American bulrush marsh
Suaeda moquinii Shrubland Alliance	Bush seepweed scrub
Tamarix spp. Shrubland Semi-Natural Alliance	Tamarisk thickets
Typha (angustifolia, domingensis, latifolia) Alliance	Cattail marshes
Washingtonia filifera Woodland Alliance	California fan palm oasis
Water	Water

## APPENDIX TABLE 2: ASSOCIATIONS IDENTIFIED

Association
Allenrolfea occidentalis / Distichlis spicata Association
Allenrolfea occidentalis / Juncus cooperi Association
Allenrolfea occidentalis Association
Allenrolfea occidentalis--Atriplex canescens Association
Allenrolfea occidentalis--Isocoma acradenia Association
Allenrolfea occidentalis--Lycium brevipes / Distichlis spicata Association
Allenrolfea occidentalis--Lycium brevipes Association
Allenrolfea occidentalis--Pluchea sericea Association
Allenrolfea occidentalis--Suaeda moquinii Association
Allenrolfea occidentalis--Tamarix spp. / Distichlis spicata Association
Allenrolfea occidentalis--Tamarix spp. Association
Ambrosia dumosa / Atriplex canescens Association
Ambrosia dumosa--Atriplex canescens Association
Ambrosia dumosa--Atriplex hymenelytra Association
Ambrosia dumosa--Larrea tridentata Association
Ambrosia dumosa--Psoralea argemone Association
Ambrosia salsola--Psoralea schottii Association
Atriplex canescens / Prosopis glandulosa Association
Atriplex canescens--Atriplex pycnantha Association
Atriplex canescens--Atriplex polycarpa / Parkinsonia florida Association
Atriplex canescens--Atriplex polycarpa Association
Atriplex canescens--Atriplex polycarpa--Larrea tridentata Association
Atriplex canescens--Atriplex polycarpa--Lycium brevipes Association
Atriplex canescens--Atriplex polycarpa--Psoralea argemone Association
Atriplex canescens--Atriplex polycarpa--Suaeda moquinii Association
Atriplex canescens--Larrea tridentata Association
Atriplex hymenelytra--Isocoma acradenia Association
Atriplex lentiformes / Allenrolfea occidentalis Association
Atriplex polycarpa--Larrea tridentata Association
Bolboschoenus maritimus--Phragmites australis Association
Cladium californicum / Pluchea sericea Association
Distichlis spicata / Allenrolfea occidentalis Association
Distichlis spicata / Bolboschoenus maritimus / Typha domingensis Association
Distichlis spicata / Isocoma acradenia Association
Distichlis spicata--Juncus cooperi Association
Encelia farinosa--Atriplex hymenelytra Association
Isocoma acradenia--Atriplex canescens Association
Isocoma acradenia--Atriplex canescens--Atriplex polycarpa Association
Isocoma acradenia--Atriplex hymenelytra Association
Isocoma acradenia--Lycium brevipes Association

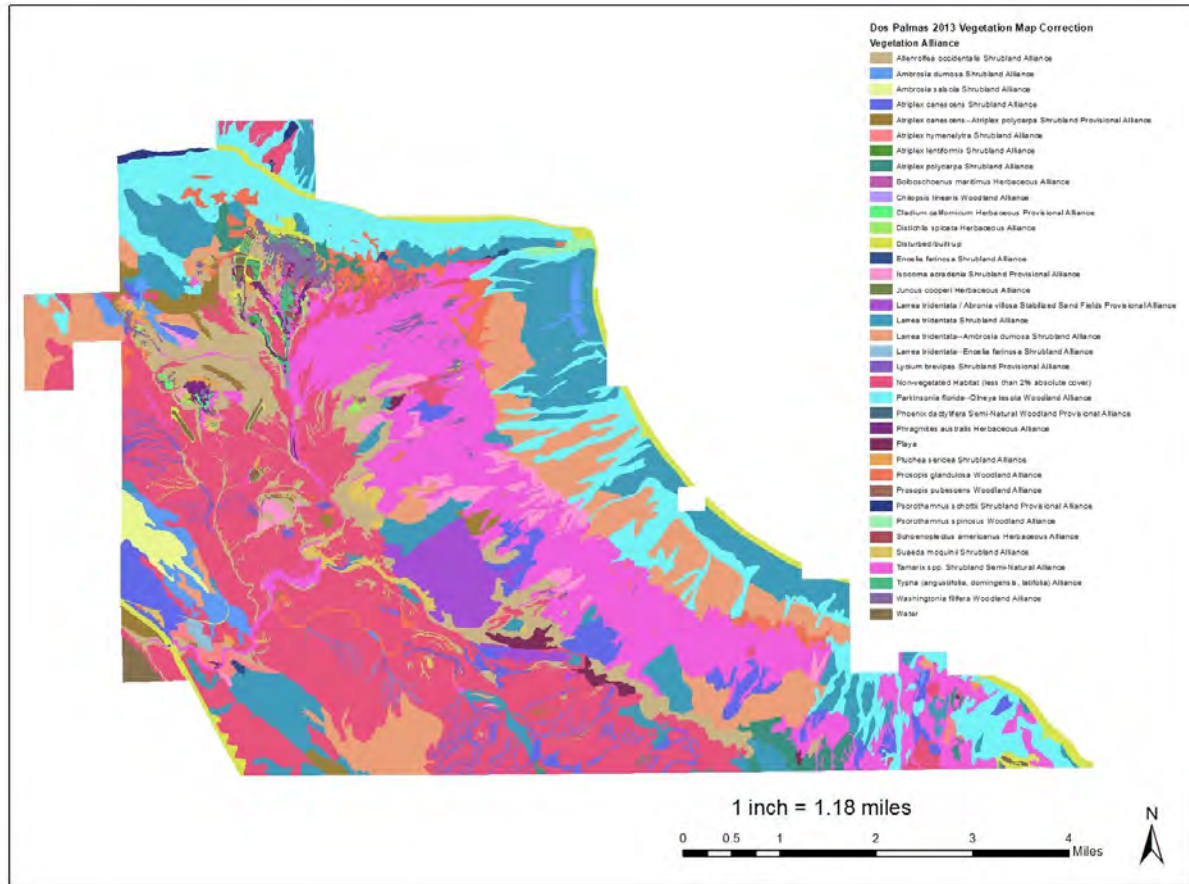


Isocoma acradenia--Pluchea sericea Association
Juncus cooperi / Baccharis sarothroides Association
Juncus cooperi / Phragmites australis Association
Juncus cooperi / Tamarix spp. Association
Larrea tridentata / wash Association
Larrea tridentata Association
Larrea tridentata--Ambrosia dumosa Association
Larrea tridentata--Ambrosia dumosa--Atriplex canescens Association
Larrea tridentata--Ambrosia dumosa--Atriplex hymenelytra Association
Larrea tridentata--Ambrosia dumosa--Encelia farinosa Association
Larrea tridentata--Ambrosia dumosa--Isocoma acradenia Association
Larrea tridentata--Ambrosia salsola--Psoralea schottii Association
Larrea tridentata--Atriplex canescens Association
Larrea tridentata--Atriplex polycarpa Association
Larrea tridentata--Encelia farinosa Association
Larrea tridentata--Encelia farinosa--Psoralea schottii--Association
Larrea tridentata--Lycium brevipes / Olneya tesota Association
Larrea tridentata--Psoralea schottii Association
Larrea tridentata--Tamarix spp. Association
Lycium brevipes--Allenrolfea occidentalis Association
Lycium brevipes--Atriplex canescens Association
Lycium brevipes--Tamarix spp. Association
none
Non-vegetated Habitat (less than 2% absolute cover)
Non--vegetated Habitat / Allenrolfea occidentalis Association
Non--vegetated Habitat / Atriplex canescens Association
Non-vegetated Habitat / Larrea tridentata Association
Non--vegetated Habitat / Psoralea emoryi Association
Non--vegetated Habitat / Tamarix spp Association
Olneya tesota / Larrea tridentata Association
Olneya tesota / Larrea tridentata--Atriplex polycarpa Association
Olneya tesota / Larrea tridentata--Encelia farinosa Association
Parkinsonia florida / Encelia farinosa Association
Parkinsonia florida / Larrea tridentata--Encelia farinosa Association
Parkinsonia florida / Larrea tridentata--Psoralea schottii Association
Parkinsonia florida / Psoralea schottii Association
Parkinsonia florida--Olneya tesota / Acacia greggii Association
Parkinsonia florida--Olneya tesota / Larrea tridentata--Ambrosia dumosa Association
Phoenix dactylifera--Washingtonia filifera / Tamarix spp. Association
Phragmites australis / Allenrolfea occidentalis Association
Phragmites australis Association
Phragmites australis--Schoenoplectus americanus Association

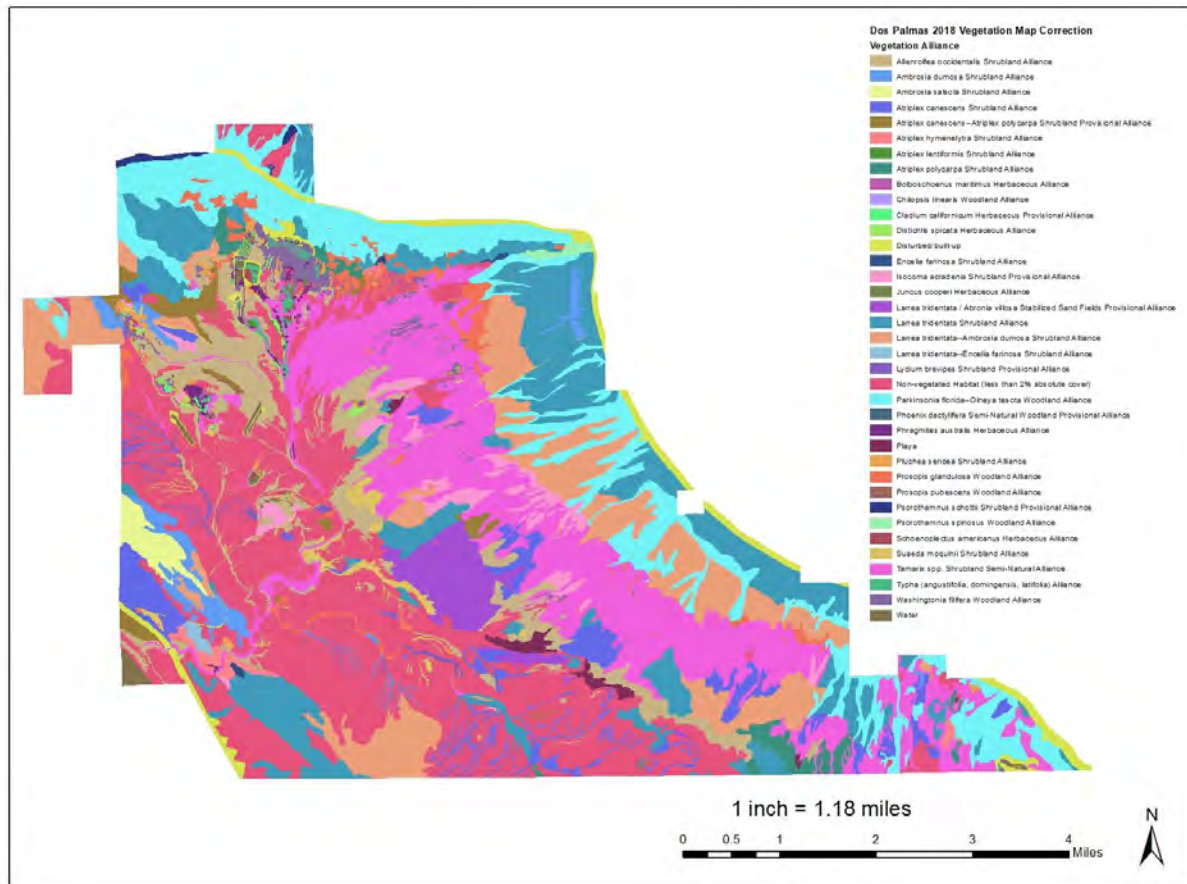
Phragmites australis--Typha domingensis Association
Pluchea sericea / Prosopis glandulosa Association
Pluchea sericea Association
Pluchea sericea--Allenrolfea occidentalis Association
Pluchea sericea--Atriplex polycarpa Association
Pluchea sericea--Tamarix spp. Association
Prosopis glandulosa / Allenrolfea occidentalis Association
Prosopis glandulosa / Atriplex canescens Association
Prosopis glandulosa / Larrea tridentata Association
Prosopis glandulosa / Larrea tridentata--Atriplex spp. Association
Prosopis glandulosa / Lycium brevipes--Atriplex canescens Association
Prosopis glandulosa / Suaeda moquinii Association
Prosopis glandulosa Association
Prosopis glandulosa--Parkinsonia florida Association
Prosopis glandulosa--Tamarix spp. Association
Prosopis glandulosa--Washingtonia filifera Association
Prosopis pubescens / Pluchea sericea / Distichlis spicata Association
Psoralea argemone / Ambrosia salsola--Atriplex spp. Association
Schoenoplectus americanus Association
Schoenoplectus americanus--Phragmites australis Association
Schoenoplectus americanus--Tamarix ramosissima Association
Suaeda moquinii Association
Suaeda moquinii--Allenrolfea occidentalis Association
Suaeda moquinii--Atriplex canescens Association
Tamarix spp. Association
Tamarix spp.--Allenrolfea occidentalis Association
Tamarix spp.--Atriplex canescens Association
Tamarix spp.--Baccharis sarothroides Association
Tamarix spp.--Isocoma acradenia Association
Tamarix spp.--Lycium brevipes Association
Tamarix spp.--Pluchea sericea Association
Tamarix spp.--Prosopis glandulosa Association
Typha domingensis / Tamarix spp. Association
Typha domingensis--Distichlis spicata Association
Typha dominguensis / Juncus cooperi Association
Washingtonia filifera / Phragmites australis Association
Washingtonia filifera / Prosopis glandulosa Association
Washingtonia filifera / Prosopis glandulosa--Atriplex spp--Suaeda moquinii Association
Washingtonia filifera / Prosopis pubescens Association
Washingtonia filifera / spring (Atriplex--Baccharis--Pluchea) Association
Washingtonia filifera / Tamarix spp. Association
Washingtonia filifera / Tamarix spp.--Isocoma acradenia Association

Washingtonia filifera / Typha domingensis / Juncus cooperi Association
Washingtonia filifera--Phoenix dactylifera Association

## APPENDIX 3: 2013 DOS PALMAS CONSERVATION AREA VEGETATION MAP



## APPENDIX 4: 2018 DOS PALMAS CONSERVATION AREA VEGETATION MAP



Appendix XI-  
San Diego Zoo Institute for Conservation  
Research, “Assessing California’s  
Mitigation Guidelines for Burrowing  
Owls: Better Science, Better  
Conservation, Better Economic  
Outcomes.”

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**FINAL REPORT for  
Natural Community Conservation Planning Local Assistance Grant  
Grant Agreement #P1682901**

**Assessing California's Mitigation Guidelines for Burrowing Owls:  
better science, better conservation, better economic outcomes**

Prepared by San Diego Zoo Institute for Conservation Research, San Diego Zoo Global  
for California Department of Fish and Wildlife

March 15, 2019







Photo on preceding page: A burrowing owl from the study with transmitter in front of a natural burrow.

Suggested citation: Hennessy, S., Wisinski, C., Ronan, N., Gregory, C., Swaisgood, R., and Nordstrom, L. 2019. Assessing California's mitigation guidelines for burrowing owls. Final report for CDFW NCCP Local Assistance Grant #P1682901.



## Executive Summary

Once fairly common and widespread throughout the western United States and Canada, the western burrowing owl (*Athene cunicularia hypugaea*; BUOW) has experienced population declines and its breeding range has contracted. Due to locally low numbers and limited distributions, BUOW are covered by both the Western Riverside County Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan (WRCMSHCP) and the Coachella Valley Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan (CVMSHCP). BUOW have adapted to a variety of disturbed and developed sites, but the presence of BUOW in development areas has resulted in a need for effective mitigation methods.

This project is the only study to date to test the consequences of both passive and active relocation methods, and evaluate the relative effectiveness of relocation with and without the addition of conspecific cues. Our primary goal was to improve wildlife mitigation strategies used for BUOW impacted by development, in order to decrease impacts on the species. By conducting a large-scale study on active and passive relocation of owls using a combination of satellite telemetry and field monitoring, we aimed to record and evaluate BUOW dispersal, mortality, and reproductive output in response to passive and active relocations, as compared to control BUOW. We also evaluated whether the addition of conspecific cues (visual and acoustic) improved owl post-translocation settlement, with the goal of making management recommendations for maximizing the effectiveness of BUOW mitigation methods.

This research was conducted as a larger project encompassing four counties in southern California. The Local Assistance Grant (LAG) increased the regional footprint and overall sample size of the study in Western Riverside County and Coachella Valley. Beginning in January 2017, 26 relocated BUOW and control BUOW were enrolled within the LAG study area.

**BUOW settlement and dispersal:** Most BUOW settled within 650 m of the release burrow. Actively-translocated BUOW were 20 times more likely to settle within 650 m when cues were present ( $n=20$ ,  $p=0.02$ ,  $R^2=30$ ). Dispersal distance was examined for differences within the active translocation treatment. The shortest dispersal distances were associated with the use of cues ( $n=19$ ,  $p<0.01$ ,  $R^2=0.35$ ). There was also a secondary effect of translocation distance in addition to the presence of cues, in that higher settlement was associated with translocation distances greater than 17.5 km.

**Reproduction:** No difference in whether breeding was attempted between translocation treatment groups was detected ( $n=32$ ,  $p=0.36$ ,  $R^2=0.13$ ). The negative result is significant in that there does not appear to be a reproductive penalty for translocated BUOW. All explanatory treatment effects on reproductive success and productivity were examined and found to be nonsignificant. This dataset does not yet have the statistical power to detect potential treatment effects on reproduction.

**Survival:** No BUOW died within the first month of enrollment in the study, leading to 100% survival across all treatment groups at the 1-month interval. At the 5-month time interval, survival was significantly lower for active translocation relative to passive relocation and controls ( $n=54$ ,  $\lambda=12.1$ ,  $p<0.01$ ). Survival rates (adjusted for unknown fates) were lower for actively translocated BUOW (60.9%) after 5 months compared to passively relocated BUOW (93.3%) and control BUOW (100%). The mean percentage of unknown fates was 22% after 3 months and 30% after 5 months. The raw survival rates of passively relocated BUOW decreased in the absence of a supply of nearby available burrows, but could not be statistically confirmed due to small sample size.



**Habitat:** When actively-translocated BUOW dispersed from the hack site and selected a new settlement site, they settled in sites with less exotic grass than either origin or hack site ( $n=51$ ,  $p=0.01$ ,  $R^2=0.38$ ). Increasing exotic forb cover was associated with increased probability of dispersal ( $n=14$ ,  $p=0.01$ ,  $R^2=0.34$ ).

These results allow for data-supported recommendations to aid managers in their decision making process when BUOW translocation must be used to mitigate development impacts. This report provides specific management recommendations for both active translocation and passive relocation projects.



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## Permits

Fieldwork was conducted under the California Department of Fish and Wildlife (CDFW) Entity Scientific Collecting Permit SC-11839. BUOW banding, bleeding, and transmitting were conducted under the Federal Bird Banding Permit of Colleen Wisinski (24023) with Susanne Marczak (24023-A) as a subpermittee, and the Federal Bird Banding Permit of Noelle Ronan (23886). BUOW translocations were conducted under SC-11839 and U.S. Fish and Wildlife Service Scientific Collecting Permit MB14619C-4. This project was approved by SDZG's Internal Animal Care and Use Committee (IACUC) and operates in accordance with all IACUC provisions under Project #17-006.



## Introduction

Once fairly common and widespread throughout the western United States and Canada, the western burrowing owl (*Athene cunicularia hypugaea*; BUOW) has experienced population declines and its breeding range has contracted (DeSante et al. 2004, DeSante et al. 2007a, DeSante et al. 2007b, Conway et al. 2010, Wilkerson and Siegel 2010, Wilkerson and Siegel 2011). In response, BUOW have been listed as a Species of Conservation Concern in the United States, federally endangered in Canada, state endangered in Minnesota and Iowa, and threatened in Mexico (Klute et al. 2003, USFWS 2008). In California, BUOW are designated as a Species of Special Concern (Gervais et al. 2008), and may soon be re-evaluated for listing under the California Endangered Species Act (Center for Biological Diversity 2015). BUOW are covered by both the Western Riverside County Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan (WRCMSHCP) and the Coachella Valley Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan (CVMSHCP) due to locally low numbers and limited distributions in addition to the rangewide declines.

Southern California supports one of the last strongholds for BUOW. The largest remaining contiguous population of BUOW in North America occurs in Imperial Valley, which comprises 50 percent of the western North American population and an estimated 70 percent of the California population (DeSante et al. 1996, Bowen 2001, Klute et al. 2003, DeSante et al. 2004, Wilkerson et al. 2011). However, population declines and local extirpations have been documented across southern California (Klute et al. 2003, Gervais et al. 2008), and BUOW population estimates from the Imperial Valley have declined over the last 20 years by nearly 40% (DeSante et al. 2007a, DeSante et al. 2007b, Wilkerson and Siegel 2010, Wilkerson et al. 2011).

BUOW have adapted to a variety of disturbed and developed sites (Klute et al. 2003). However, the presence of BUOW in development areas results in conflicts between conservation and economic activity. Avoidance, minimization, and conservation measures are used when land development displaces and negatively impacts resident species. When avoidance of BUOW impacts is not feasible, the California Department of Fish and Wildlife (CDFW) recommends mitigation (required in compliance with the California Environmental Quality Act) through the use of disturbance buffers (setback distances) and burrow exclusion (passive relocation; CDFG 2012).

Wildlife translocations (or relocation) which involve human-assisted movement of individuals from one area to another are a widely used form of management (IUCN/SSC 2013). Active translocations attempt to reduce animal mortality caused by development by actively relocating individuals away from project sites. The frequency of translocation actions is rising dramatically due to their use as a species recovery tool (Seddon et al. 2007; Ewen et al. 2012), and as mitigation that is required by regulatory agencies to offset development impacts (Germano et al. 2015; Sullivan et al. 2015). Because active translocations are challenging, mitigation strategies have sometimes sought to avoid translocation altogether. In these cases, habitat is impacted and animals relocate themselves (i.e., passive relocation). This strategy may be more effective provided certain assumptions are met, such as nearby suitable habitat.





## Passive relocation and active translocation

Passive relocation and active translocation are two methods used to avoid direct owl take when occupied burrows are within a planned development. Passive relocation involves excluding owls from their burrows, and then collapsing the burrows once owls are absent. Artificial burrows may be installed nearby to encourage rapid resettlement and possibly reduce mortality risks associated with relocation to a completely new area (Trulio 1995). In some circumstances, artificial burrows are not installed nearby and there is no attempt to influence the birds' post-relocation decisions. By contrast, active translocation involves capturing owls at their burrows, moving them offsite, holding owls temporarily in a large field enclosure, and then releasing owls from their enclosures (Trulio 1995, Smith and Belthoff 2001). Active translocation release sites are typically supplemented with artificial burrows to encourage owl retention. In California, passive relocation is the most common mitigation strategy for BUOW affected by the impacts associated with renewable energy (and other) projects, whereas active translocations are more often used elsewhere in North America.

However, the relative effectiveness of passive versus active relocation strategies has never been tested, so their effects on BUOW, compared to non-relocated owls, remains unknown. Although well-implemented passive relocation can be successful (Trulio 1995), the outcomes of too few passive relocations have been rigorously documented to draw general conclusions regarding their success rate across situations. Active translocation of BUOW has been used as a mitigation method in Arizona, Idaho, California, and Canada, with some success (Leupin and Low 2001, Smith and Belthoff 2001, Bloom Biological, Inc. 2009, Mitchell et al. 2011, Wild at Heart 2011). However, the behavioral and demographic consequences of relocation methods have not been comparatively evaluated. Citing a lack of scientific study, active translocation is currently not authorized by the California Department of Fish and Wildlife (CDFW), except within the context of scientific research or a Natural Community Conservation Plan (NCCP; CDFG 2012). Because the WRCMSHCP and CVMSHCP are NCCPs, with long-term conservation mechanisms, active translocation can be authorized by CDFW as a method to compensate for BUOW displacement due to habitat loss from development.

Advantages and disadvantages apply to both methods of BUOW relocation. Passive relocations are less costly in terms of expense and human labor. However, they are strongly limited by the availability of suitable habitat in close proximity of release sites, with relocations of < 100 m producing the best results (Trulio 1995). While short-distance relocations may address highly localized impacts to resident burrows, they do not address long-term risks associated with ongoing activities at development sites, such as the installation of wind turbines. Relocated owls may still be at risk from these continuing threats. An advantage of active translocation is that managers may select sites, such as Multiple Species Conservation Plans (MSCPs), Habitat Conservation Plans (HCPs), and other protected areas, where habitat is believed to be highly suitable and the risk of encountering threatening human activities is greatly reduced. Temporarily holding relocated animals in acclimation enclosures at the release site may encourage them to remain in the vicinity upon release. Thus, active translocations can be more strategically implemented.

There is a large and growing portion of wildlife translocations that largely evade academic scrutiny and common standards (Germano et al. 2015). Mitigation translocations in particular have been recently targeted for several shortcomings, including poor implementation, lack of documentation, failure to



apply scientific principles, and poor outcomes (Dechant et al. 2002; Germano et al. 2015; Sullivan et al. 2015). BUOW relocations (passive and active) are frequently conducted with unknown outcomes, in part due to the lack of or poorly executed monitoring schemes, as well as the low success rate of finding and tracking BUOW outfitted only with leg bands. Reliance on leg bands requires large amounts of effort to re-sight relocated owls, but most birds are not resighted and thus dispersal and mortality events cannot be disentangled. Very High Frequency (VHF) transmitters can yield important data on survival and movement, but only if the owls disperse a short distance and can be located with receiving equipment. These shortcomings must be addressed if mitigation actions are to be cost-effective and produce the desired results of reducing impacts on sensitive, threatened, or endangered species.

However, the field of translocation biology is moving steadily forward through the application of scientific principles (Seddon et al. 2007). A growing body of literature is developing a biologically and ecologically based toolbox that can improve translocation outcomes if considered during design and implementation of the programs (Seddon et al. 2007; Batson et al. 2015). It is critical that the increased application of scientific principles and the theoretical framework developed for translocation biology be incorporated into mitigation-driven translocations in order to increase successful outcomes and enhance cost-effectiveness of environmental mitigation strategies (Germano et al. 2015).

### Dispersal and conspecific cues

Perhaps one of the most significant obstacles facing successful animal relocations is the problem of long-distance movement away from the release site, i.e., dispersal (Stamps and Swaisgood 2007; Batson et al. 2015). Long-distance movements following release have been shown to increase risk exposure and mortality rates of several species (Stamps and Swaisgood 2007; Le Gouar et al. 2011; Shier and Swaisgood 2012). While holding animals in acclimation pens at the release site can reduce post-release dispersal (Bright and Morris 1994; Batson et al. 2015), this method alone does not always yield success (Shier 2006; Shier and Swaisgood 2012). Close attention to the species' behavioral and ecological needs can aid our understanding of factors driving post-release movements (Shier 2006; Stamps and Swaisgood 2007; Shier and Swaisgood 2012). Thus, a major consideration in animal relocation efforts is to find mechanisms to retain or "anchor" animals in suitable habitat at the release site.

A common misconception is that dispersers will find and occupy empty suitable habitat if it is present. However, 'build-it-and-they-will-come' conservation approaches do not always work. Even territorial and less social species often prefer to settle near conspecifics (Stamps 1988). The end result from a conservation perspective is that once a species is extirpated from an area, conspecifics will not re-occupy that area because there are no signs that members of their species inhabit the area. Thus, suitable habitat may remain unoccupied. Using this theoretical framework, conservationists have used bird song playbacks to recruit songbirds to new areas (Ahlering et al. 2010), model decoys to attract terns to new colonies (Kotilar and Burger 1984), white wash (mimicking droppings) to attract vultures (Sarrazin et al. 1996), and rhino dung to encourage settlement in translocated black rhinos (Linklater and Swaisgood 2008). Conspecific attraction as a conservation tool is proving particularly powerful in reintroduction and translocation programs, because, in fact, these conservation actions force a dispersal-like event upon animals whether or not dispersal is biologically appropriate. This may be one explanation for why so many reintroduction programs fail: released animals, following simple behavioral



rules-of-thumb for site settlement, may ultimately vacate otherwise suitable sites because the sites lack conspecific cues.

## Goals and Objectives

This project is the only study to date to test the consequences of both passive and active relocation methods, and evaluate the relative effectiveness of relocation with and without the addition of conspecific cues as a conservation method for BUOW. Our primary goal was to improve wildlife mitigation strategies used for BUOW impacted by development, in order to decrease impacts on the species. By conducting a large-scale study on active and passive relocation of owls using a combination of satellite telemetry and field monitoring, we aimed to:

- Record and evaluate BUOW dispersal, mortality, and reproductive output in response to passive and active relocations, as compared to BUOW not planned for relocation (controls);
- Evaluate whether the addition of experimentally planted conspecific cues (visual and acoustic stimuli) improves owl post-translocation settlement; and
- Determine the most effective mitigation method used for BUOW impacted by development and recommend improvements.

This research was conducted as part of a larger project encompassing four counties in southern California. The Local Assistance Grant (LAG) increased the regional footprint and overall sample size of the study. Full project results are reported with a focus on the LAG study area.

## Methods

### Study area and translocations

Beginning in January 2017, relocated BUOW and control BUOW were enrolled across four regions of Southern California (western San Diego County, western Riverside/San Bernardino Counties, Imperial County, and Coachella Valley). The LAG study area consisted of the WRCMSHCP and CVMSHCP located in Riverside County, California. Climate gradients of increasing temperature and decreasing precipitation stretch from the coastal western boundary of the study area to the desert eastern boundary. Urban development is concentrated in San Diego, western Riverside, and San Bernardino Counties. Sites in Imperial County were influenced by a large existing matrix of subsidized agricultural habitat. Coachella Valley is divided between desert and subsidized areas of urban development, with a smaller proportion of agricultural habitat. While sample sizes were dependent on planned development projects, efforts were made to evenly distribute study owls by region and relocation type. A total of 26 BUOW across the treatment groups were included in the LAG study area (Table 1). A total of 58 BUOW were enrolled in the full study.



**Table 1. Effective sample sizes for each treatment group representing the number of BUOW from the LAG study area that provided data.**

<b>Group</b>	<b>Location</b>	<b>Project</b>	<b>Total</b>
<b>Passive relocation</b>	Western	Meniffee Heights,	2
	Riverside	Renaissance	
	Coachella Valley	29 Palms	3
	<b>Total</b>		<b>5</b>
<b>Active Translocation w/ Cues</b>	Western	Audie Murphy,	4
	Riverside	Renaissance	
	<b>Total</b>		<b>4</b>
<b>Active translocation No Cues</b>	Western		6
	Riverside	Lakeview	
	Coachella Valley	WRP4	5
	<b>Total</b>		<b>11</b>
<b>Resident control</b>	Western		3
	Riverside	ElSol, Morongo	
	Coachella Valley	29Palms, Desert	3
		Hot Springs	
	<b>Total</b>		<b>6</b>
<b>LAG Study Area Total</b>			<b>26</b>

## Translocation

For passive relocations, owls were captured, marked, and fitted with GPS telemetry units (Lotek Pinpoint Argos solar tags) prior to burrow exclusion, with a timing target of 1 week prior to eviction. Relocation included creation of artificial burrows if required by the regulatory agencies, installation of one-way doors at burrow entrances, and plugging or collapsing the burrows after owls had exited. Burrow excavation and collapse remained the responsibility of each development project, and was carried out in accordance with agency requirements.

Active translocation included capturing and marking owls (banding), moving owls to release sites, and an acclimation period (“soft release”). Actively-translocated BUOW were relocated to protected lands within Riverside, Imperial, and San Diego Counties. As part of the soft release, actively-translocated owls were kept in a temporary holding field enclosure (i.e., hacking cage) for 30 days. The hacking cages were 12x12x6 feet in dimension and were removed after the holding period. Water and food, including rodent and invertebrate prey (crickets, mealworms) were provided approximately 2-4 times per week. In one case, supplemental food was provided throughout the breeding season to achieve site-specific conservation goals. GPS telemetry units were attached 7 days before owl release and removal of hacking cages.

Nearby resident owls were identified and enrolled as controls. Control owls were captured and telemetered using the same protocols as those for translocated owls. GPS transmitters were attached using a backpack-style harness and the total weight of all attachments (GPS tag, backpack harness, bands) did not exceed 5% of body weight in accordance with the federal banding permit. An effort was



made to capture owls to remove transmitters at the end of the survey period, and when transmitters failed during the survey period.

Conspecific cue treatments consisted of: 1. natural cues from existing resident owls; 2. artificial visual and auditory conspecific cues near installed artificial burrows; 3. no resident owls present and no artificial cues deployed. Presence of natural cues was recorded as presence/absence of nearby owls. The artificial cues were designed to indicate that other BUOW have settled in the area and found the habitat suitable using both visual and acoustic cues. Artificial visual cues consisted of simulated whitewash (non-toxic latex paint). Acoustic cues consisted of playbacks of pre-recorded vocalizations from multiple individuals, created using online sources with permission or proprietary recordings. The playbacks primarily consisted of territorial “coo-coo” calls. No experimental manipulation of conspecific cues took place at resident control sites or for passively relocated owls.

Relocations occurred across two calendar periods. Several active and passive relocations occurred during the nonbreeding season, September 1 – January 31. However, due to varying timetables of several development projects, four active translocations proceeded in consultation with CDFW between February 1 – April 15 (Table 2). In all, 22 BUOW were actively translocated in the LAG area, with a total number of 46 BUOW actively translocated for the study.



**Table 2. Summary of active translocations conducted between February 2017 and April 2018 for the complete regional study.** Active translocations conducted within the LAG study area are highlighted in tan.

County	Source Site	Capture Dates	Release Site	Cue type	Release Date	BUOW translocated
Riverside	Audie Murphy/Santa Rosa Academy	2/3/17-2/5/17	McElhinney-Stimmel Conservation Area	Artificial	3/7/17	4
Riverside (Coachella Valley)	Spotlight 29 Casino	9/3/17	Coachella Valley Water District Water Reclamation Plant 4	None	10/6/17	6
Imperial	Wistaria Solar	12/20/17	Sonny Bono Salton Sea NWR	Natural	1/22/18	4
San Diego	Brown Field Municipal Airport	2/20/18-3/6/18	Rancho Jamul Ecological Reserve	Artificial	4/3/18	10
Riverside/San Bernardino	Lewis Management sites (Rialto, Ontario)	3/7/18-3/12/18	Lakeview Conservation Area	None	4/11/18	10
Riverside/San Bernardino	Lewis Management sites (Rialto)	3/13/18-3/14/18	McElhinney-Stimmel Conservation Area	Natural	4/12/18	2
San Diego	Border Fence	7/4/18-7/5/18	Johnson Canyon	Natural	8/7/18	4 adults, 6 juveniles

## Owl monitoring

Individuals were tracked remotely through satellite GPS points collected at least 3 times/day. Data were downloaded and processed remotely. For BUOW pairs, we only attached a GPS transmitter to one individual of the pair to maintain data independence. Four telemetry units failed within a month of deployment, preventing the collection of data for these owls. One actively-translocated BUOW was also excluded due to health concerns.

Camera traps and visual surveys were used to monitor owl survival, nesting and productivity, and burrow occupancy. Camera traps were mounted on a 2- to 4-foot-tall stake approximately 1-3 m from the burrow entrance. During the breeding season, cameras were not installed at burrows until after evidence of incubation, to minimize chances of nest abandonment. Field observations were conducted monthly during the non-breeding season (Sept-Feb) and weekly during the breeding season (March-August).



## Habitat data collection

Habitat sampling was designed to characterize habitat surrounding target burrows at two scales: fine-scale habitat within 10 m of the burrow and macro-scale habitat within 100 m of the burrow. Two 50 m transects were anchored at the burrow and oriented to both 0° and 180°. For meters 0-10 along each transect, point intercept readings for substrate, bare ground, functional group, and nativity were collected every 0.5 m. For meters 11-50, point intercept readings were taken every 1.0 m. Two additional 10 m transects were anchored at the burrow in the 90° and 270° directions, with point intercepts read every 0.5 m. The resulting four short transects characterized habitat within 10 m, centered at the burrow (n=80). The two long transects produced a linear measurement of 100 m representing macro-scale habitat (n=100). All functional group types intercepting the point were recorded to accurately reflect multiple layers of vegetation. Vegetation height was also recorded at each point. BUOW burrows in areas with hard edges are identified in the data as an infrastructure category which included areas of transect that crossed features such as concrete canals, other concrete structures, and both dirt and paved roads.

Natural burrow density was measured with a 4-m-wide belt transect centered on each of the two long and two short transects per BUOW burrow (2 m on either side of the tape). The number of burrow entrances attributed to small mammals, defined as burrows with diameter >7 cm, was tallied. Density was calculated as the number of burrow entrances per square meter. In Imperial County, the mammal species present were smaller, so the 7 cm rule was adjusted to include all small mammal burrows, providing a relative measure of burrow suitability. Presence/absence of California ground squirrel (*Otospermophilus beecheyi*) was recorded.

For each relocated owl, the protocol was carried out a minimum of two times. Habitat for actively-translocated BUOW was assessed at the origin burrow, the release burrow, and the settlement burrow. If the BUOW settled at the release burrow, post-translocation habitat was only assessed once. For passively-relocated BUOW, habitat was assessed at origin and settlement burrows. Control BUOW were assessed at origin and any subsequent settlement burrows. Settlement was defined as a minimum of 30 days of occupation.

## Data analysis

All data collected from the period January 25, 2017 to December 31, 2018 were included in the analyses. This research is part of a larger project in southern California, and the data analysis reported here was based on the complete dataset to maximize statistical power for detecting treatment differences. Findings from the LAG areas of Western Riverside County and Coachella Valley are highlighted throughout.

Unless otherwise specified, statistical analyses were conducted as ANOVA or mixed effect models in JMP13 software, with the significance threshold set at  $p=0.05$ . Distance was transformed with a  $\log(n+1)$  transformation. Migratory birds were detected when telemetry revealed long-distance migratory movements away from the study area. Migratory birds were excluded from all analyses because migrants likely use different selection criteria for wintering burrows, and for migrants, chance of dispersal was 100% and did not constitute a rejection of the habitat. Habitat data were analyzed for first year breeding burrows only. BUOW whose status was unknown for specific variables were also excluded from those analyses.

Survival was treated with a "time to event" analysis that defined observed mortality as the event. Right censoring was used for BUOW that disappeared before the end of the specified time interval (due to





transmitter failure or other factors) or were alive at the end of the study. We estimated survival using the Kaplan-Meier nonparametric procedure for staggered entry (Pollock et al. 1989). The interval of interest was defined as 5 months (150 days). This time period was selected as the longest that could be analyzed for the entire dataset, including BUOW that were deployed in mid-2018. Explanatory relationships with translocation type and covariates (settlement within 650 m, dispersal distance, translocation distance, conspecific cues, and available burrows) were tested with the Cox proportional hazards model using the survival package (version 2.43-3) in R 3.5.3.

Whether breeding was attempted ('Breeding Attempted') was defined as breeding/not breeding, and was identified by pairing and behaviors such as territorial vocalization, copulation, and burrow decoration. Reproductive success was defined as whether at least one chick survived to fledgling stage (Yes/No). Two ordinal variables were examined to focus more closely on reproductive output. Maximum number of chicks was defined as the greatest number of post-emergent chicks at a single observation point, either from field observations or camera photos. Productivity was defined as the number of chicks to reach the fledgling stage (21 days post-emergence).

The burrows utilized by actively-translocated BUOW were classified as origin, hack burrows, and settlement burrows. The origin burrow was the pre-translocation burrow, and the hack burrow was the artificial burrow used during acclimation. Subsequent settlement burrows were evaluated if the BUOW dispersed from the hacking location. Habitat statistics at all burrows were calculated at two scales: fine-scale habitat within 10 m of the burrow, and macro-scale habitat within 100 m of the burrow. Areas of transect blocked by impassable barriers were omitted from all calculations.

Settlement status (Y/N) was defined as whether settlement occurred within 650 m, or approximately one BUOW territory. If the BUOW was translocated to a conservation area, settlement within the conservation area was verified. Dispersal distance for passively-relocated BUOW was calculated as the distance between the eviction burrow and the settlement burrow. For actively-translocated BUOW distance was calculated between the hacking cage/release burrow and the settlement burrow. For control BUOW the home burrow was the pre-dispersal location.

Absolute cover values were calculated by functional group and nativity (exotic/native forb, exotic/native grass, crop, shrub). Transect portions covered by roads and/or concrete (i.e. irrigation canals) were reported as "infrastructure" and bare ground cover was also reported. Burrow density was calculated from burrow counts divided by the assessed area ( $m^2$ ): the sum of all assessed transect lengths (120 m maximum length) x 4-m belt transect width. Areas classified as road, canal, or other concrete infrastructure were omitted from calculations of burrow density. Habitat height was evaluated as height mean, height standard deviation, and maximum height (cm).

## Results

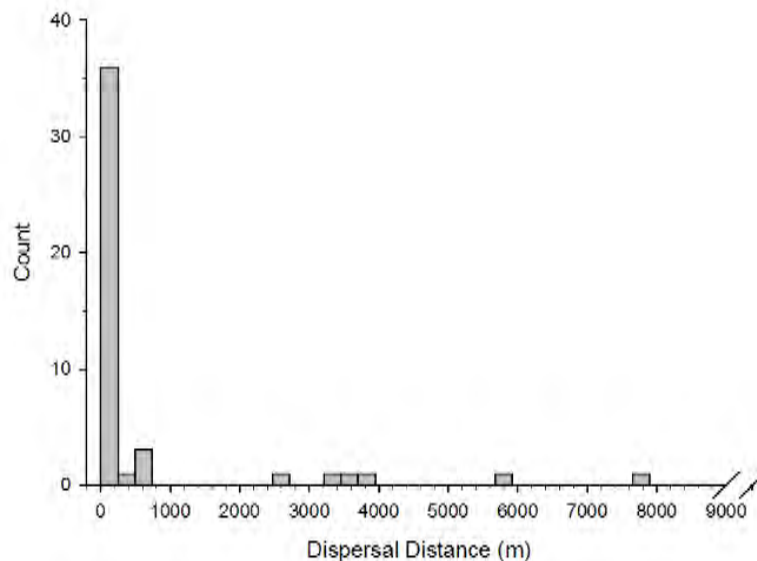
The findings reported here are drawn from the complete regional dataset for this project, in order to maximize statistical power for detecting treatment differences. Specific findings from the LAG areas of Western Riverside County and Coachella Valley are highlighted throughout.

### Settlement and dispersal

We compared settlement status (whether settlement occurred within 650 m) and dispersal distances for actively-translocated BUOW and control BUOW (Table 3). The set limit of 650 m corresponds to a break in the data between shorter and longer dispersal events (Figure 1). Most BUOW dispersal distances

were less than the radius of a BUOW territory (Gervais et al. 2003, Haug and Oliphant 1990, Swaisgood et al. 2015). Eight BUOW undertook dispersal distances greater than 650 m (median dispersal 4846 m) and the maximum recorded dispersal was 40.7 km. The longest dispersal was undertaken by a BUOW that originated at the Rialto airport site, was actively translocated and released to the Lakeview Conservation Area, and subsequently returned to the vicinity of the origin burrow at the Rialto airport.

For both actively- and passively-relocated BUOW the mean settlement rate within 650 m was approximately 65%. Unsurprisingly, mean dispersal distance was much greater for both actively-translocated and passively-relocated BUOW relative to controls ( $n=48$ ,  $p<0.01$ ,  $R^2=0.33$ ; Table 3). Within each relocation group there were significant differences based on burrow availability (passives) or cue treatment (actives). Within the passive relocation group, dispersal distance was greater if burrows were unavailable nearby ( $n=16$ ,  $p=0.02$ ,  $R^2=0.44$ ).



**Figure 1. Histogram of dispersal distances for all BUOW in the study.** Migratory BUOW are excluded ( $n=4$ ). Two long distance outliers are not shown at this scale (distances of 18.3 and 40.7 km).

Within the active-translocation group, exploratory analysis showed no significant differences between artificial cues and natural cues, so the cue treatments were aggregated into a single category representing presence of cues. Actively-translocated BUOW were 20 times more likely to settle within 650 m when cues were present ( $n=20$ ,  $p=0.02$ ,  $R^2=0.30$ ). In addition, the farthest dispersal distances occurred when cues were absent, and the shortest dispersal distances were associated with the use of conspecific cues ( $n=19$ ,  $p<0.01$ ,  $R^2=0.35$ ).

For settlement within the active translocation group, both cues and translocation distance, as a covariate, are strongly significant ( $n=20$ ,  $p<0.01$ ,  $R^2=0.57$ ). Classification and regression tree analysis (CART) shows that the presence of cues is the primary effect (cues present is associated with increased settlement within 650 m). There is also a secondary effect of translocation distance in addition to the presence of cues, in that higher settlement is associated with translocation distances greater than 17.5 km.

**Table 3. Settlement status and dispersal distance across all treatment groups.** BUOW that migrated (n=4) were excluded. BUOW with unknown settlement locations (n=3) are included in the settlement status rate, but excluded from distance calculations.

Treatment	Settled within 650 m		Dispersal distance (m)			
	n		Mean	SD	Min	Max
Control	14	92.9%	41.7	144.3	0	500
Passive	19	68.4%	570.0	1121.1	9	3900
Burrows	16	81.3%	162.0	192.8	9	648
No Burrows	3	0%	3222.0	958.8	2544	3900
Active	20	65.0%	4236.0	9917.0	0	40719
Cues	11	90.9%	392.7	1051.7	0	3540
None	9	33.3%	9520.5	14006.7	0	40719
Total	53	73.6%	1905.0	6533.1	0	40719

Within Riverside County, all BUOW enrolled into the control group remained at their origin burrow through the first breeding season. Five of the seven BUOW actively translocated to McElhinney and Lakeview Conservation Areas settled within 650 m. Several longer dispersal events occurred, however, ranging from 3.3 to 40.7 km (Table 4).

**Table 4. Settlement status and dispersal distance by site in Riverside County.** BUOW that migrated (n=3) were excluded.

Translocation Type	Cues	Site	n	Settled	Dispersal distance (m)				
				within 650 m	Mean	SD	Min	Max	
Control		Total	6	100%	0	0	0	-	0
		Desert Hot Springs	1	100%	0	-	0	-	0
		El Sol	2	100%	0	0	0	-	0
		Morongo	1	100%	0	-	0	-	0
		29 Palms	2	100%	0	0	0	-	0
Passive		Total	2	0%	3222.0	958.8	2544	-	3900
		Meniffee	1	0%	2544.0	-	2544	-	2544
		Renaissance	1	0%	3900.0	-	3900	-	3900
		29Palms	3	0%	Unk				
Active		Total	11	45%	7616.4	12988.6	0	-	40719
	Present	McElhinney	2	100%	0	0	0	-	0
	None	Lakeview	5	60%	11851.8	17965.2	0	-	40719
	None	WRP4	4	0%	5635.0	2218.7	3342	-	7771



## Reproduction

The suite of reproductive variables was examined (Table 5). No difference in whether breeding was attempted was detected between translocation treatment groups ( $n=32$ ,  $p=0.36$ ,  $R^2=0.13$ ). There did not appear to be a reproductive penalty for translocated BUOW. There was a significant effect of settlement within 650 m ( $n=32$ ,  $p<0.01$ ,  $R^2=0.55$ ) on breeding status. The odds ratios are unstable because of unequal group sizes, but the trend can be examined. The group of BUOW that attempted breeding ( $n=29$ ) was much greater than the number that did not attempt breeding ( $n=3$ ). Of the 5 BUOW that dispersed beyond 650 m, a lower percentage (60%) attempted to breed, compared to the percentage that bred after settling (92%). This is not a surprising result, but caution should be used in interpreting this result due to the low sample size.

Of the subset of BUOW that did exhibit breeding behavior, there was no difference in the rates of reproductive success due to translocation treatment group ( $n=30$ ,  $p=0.63$ ,  $R^2=0.03$ ). There were no treatment group differences for either maximum number of chicks ( $n=30$ ,  $p=0.70$ ,  $R^2<0.01$ ) or productivity ( $n=30$ ,  $p=0.70$ ,  $R^2<0.01$ ). All explanatory relationships between effects of cue treatment on reproduction were also examined and found to be nonsignificant. Trends in the data, however, show higher numbers of maximum chicks and fledglings after active translocation relative to either passively-relocated or control BUOW. For passive relocations, burrows available nearby also show higher reproductive levels. However, these results are influenced by small sample sizes and potential site effects. This dataset does not yet have the statistical power to detect potential treatment effects on reproduction.

**Table 5. Measures of reproduction in the first year after translocation for BUOW that were actively translocated or passively relocated, with controls.** BUOW that migrated (n=4) or with unknown breeding status (n=9) were excluded.

Translocation Type	Treatment	Release Site	Breeding Attempted		Reproductive Success		Max Chicks		Fledged		Proportion Fledged	
			n	percent	n	percent	mean	SD	mean	SD	mean	SD
Control		Total	11	100.0%	11	63.6%	3.0	2.9	2.1	2.4	69.0%	34.8%
		29 Palms	2	100.0%	2	100.0%	4.5	0.7	3.5	2.1	75.0%	35.4%
		El Sol	2	100.0%	2	100.0%	4.5	0.7	3.5	0.7	77.5%	3.5%
		Morongo	1	100.0%	1	100.0%	9.0	-	7.0	-	77.8%	-
		Sonny Bono	3	100.0%	3	0.0%	0.0	0.0	0.0	0.0		
		Wistaria	3	100.0%	3	66.7%	2.0	2.0	0.7	1.2	50.0%	70.7%
Passive		Total	7	85.7%	6	83.3%	2.8	1.9	2.3	2.1	80.0%	29.8%
	Burrows	Wistaria	5	100.0%	5	80.0%	3.0	2.1	2.4	2.3	75.0%	31.9%
	No burrows		2	50.0%	1	50.0%	1.0	-	1.0	-	100.0%	-
		Meniffee	1	100.0%	1	100.0%	2.0	-	2.0	-	100.0%	-
		Renaissance	1	0.0%	0	0.0%	-	-				
Active		Total	14	92.9%	13	76.9%	3.5	2.0	2.7	2.2	75.0%	35.6%
	Artificial Cues		5	100.0%	5	80.0%	4.4	2.6	4.2	2.5	95.8%	8.3%
		McElhinney	1	100.0%	1	100.0%	4.0	-	4.0	-	100.0%	-
		Rancho Jamul	4	100.0%	4	75.0%	4.5	3.0	4.3	2.9	94.4%	9.6%
	Natural Cues		4	100.0%	4	75.0%	3.3	0.5	2.3	1.7	66.7%	47.1%
		McElhinney	1	100.0%	1	0.0%	3.0	-	0.0	-	0.0%	-
		Sonny Bono	3	100.0%	3	100.0%	3.3	0.6	3.0	1.0	88.9%	19.2%
	No Cues		5	80.0%	4	75.0%	2.5	1.9	1.3	1.0	58.3%	38.2%
		Lakeview	4	75.0%	3	66.7%	2.7	2.3	1.0	1.0	37.5%	17.7%
		WRP4	1	100.0%	1	100.0%	2.0	-	2.0	-	100.0%	-
Total			32	93.8%	30	73.3%	3.2	2.3	2.4	2.2	74.3%	32.9%



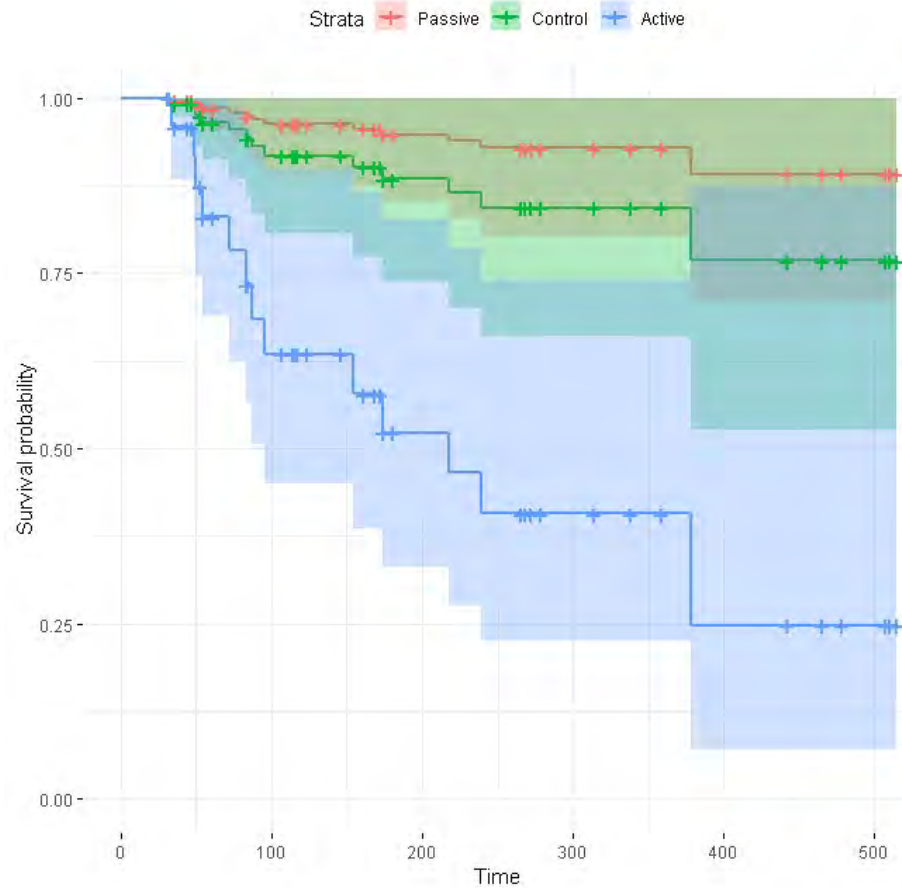
Examining reproduction by county suggests a trend of lower reproductive levels in Imperial County, with a mean reproductive success of 64% (Table 6). By contrast, reproductive success in Western Riverside reached 78%. The small sample sizes for Coachella Valley and San Diego are likely influencing the estimates for those areas.

**Table 6. Reproduction variables grouped by county.** The percentage of BUOW that attempted breeding are reported by group. BUOW that did not attempt to breed are excluded from calculations of reproductive success. All treatment types are included. Migratory BUOW (n=4) and unknowns are excluded.

County	Breeding Attempted		Reproductive Success		Max Chicks		Yr1Productivity	
	n	Percentage	n	Percentage	mean	SD	mean	SD
Western Riverside	10	72.0%	9	77.8%	4.4	2.1	2.9	2.2
Coachella Valley	3	100.0%	3	100.0%	3.7	1.5	3.0	1.7
Imperial	14	100.0%	14	64.3%	2.2	1.9	1.6	1.9
San Diego	4	100.0%	4	75.0%	4.5	3.0	4.3	2.9
Total	32	93.5%	30	73.3%	3.3	2.3	2.5	2.2

## Survival

Survival was significantly lower for active translocation relative to passive relocation (n=54,  $\lambda=12.1$ ,  $p<0.01$ , Figure 2). The Kaplan-Meier procedure provides an adjusted point estimate that excludes individuals with unknown fates from further estimation after their disappearance date. In terms of the adjusted survival rates, survival of actively translocated BUOW was 60.9% (SE= 0.12) after 5-months, compared to 93.3% (SE= 0.06) for passively relocated BUOW and 100% (SE= 0) for control BUOW.



**Figure 2. Survival probability plot adjusted for unknowns and stratified by translocation type (active, passive, control) for the complete study period (515 days).**

Within actively translocated BUOW, the Cox model was fit to test for significant effects of conspecific cues. Survival for BUOW translocated to sites with and without conspecific cues was not significantly different ( $n=20$ ,  $\lambda=1.06$ ,  $p=0.30$ ).

Finally, the same survival model was fit to passively relocated BUOW to test for survival differences due to the presence or absence of available burrows, but the model failed to converge. Although the raw survival rate of BUOW relocated with burrows available nearby was much higher (75%,  $n=16$ ) relative to BUOW with no burrows nearby (33%,  $n=3$ ), the results are negatively impacted by unequal sample sizes.

No BUOW died within the first month of enrollment in the study, leading to 100% survival across all treatment groups at the 1-month interval (Table 7). Unadjusted (raw) levels of mortality were recorded at the 3- and 5- month time intervals. Mean unadjusted survival rate was 65% after 3 months and 55% after 5 months. The mean percentage of unknown fates was 22% after 3 months and 30% after 5 months.



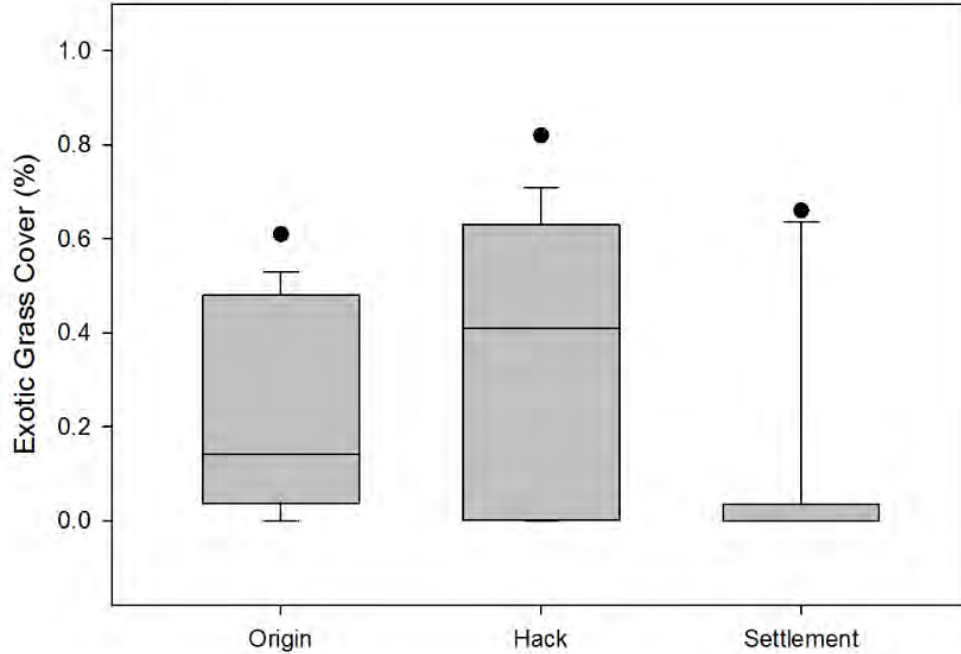
**Table 7. Unadjusted (raw) survival rates for BUOW after 1, 3, and 5 months by treatment group.** Fates were characterized as unknown if the BUOW disappeared with no subsequent telemetry or field observations. Migratory BUOW (n=4) were excluded.

Translocation type	Treatment	n	1 month survival			3 month survival			5 month survival		
			Y	N	Unk	Y	N	Unk	Y	N	Unk
Control		15	100%	0%	0%	73%	0%	27%	53%	0%	47%
Passive		19	100%	0%	0%	79%	0%	21%	68%	5%	26%
	Burrows	16	100%	0%	0%	81%	0%	19%	75%	0%	25%
	No burrows	3	100%	0%	0%	67%	0%	33%	33%	33%	33%
Active		20	100%	0%	0%	50%	35%	15%	45%	35%	20%
	Cues	11	100%	0%	0%	45%	45%	9%	45%	45%	9%
	None	9	100%	0%	0%	56%	22%	22%	44%	22%	33%
Total		54	100%	0%	0%	65%	13%	22%	55%	15%	30%

## Habitat

For the subset of actively-translocated BUOW, functional group cover values were examined for differences among burrow classification (i.e., origin, hack, settlement). Regional effects were accounted for by entering the county ID into the model as a random effect.

At the macro-habitat level, a significant difference was detected for the percentage of exotic grass cover (n=51,  $p=0.01$ ,  $R^2=0.38$ ). Native grasses were either absent or detected at very low cover levels. When BUOW dispersed from the hack site and selected a new settlement site, they settled in sites with less exotic grass than either origin or hack site (Figure 3).



**Figure 3. Box plot showing differences in exotic grass cover between burrow locations.** The origin burrow was the pre-translocation burrow; the hack burrow was the artificial burrow used during hacking. Subsequent settlement burrows were evaluated if the BUOW dispersed from the hacking location.

Within the treatment group of actively-translocated BUOW, dispersal (Y/N) was examined as the response variable relative to the entire suite of habitat characteristics. Only exotic forbs showed a significant effect on dispersal ( $n=14$ ,  $p=0.01$ ,  $R^2=0.34$ ). Increasing exotic forb cover was associated with increased odds of dispersal.

Within the treatment group of passively-relocated BUOW, burrow density was lower in settlement sites relative to origin sites ( $n=31$ ,  $p=0.01$ ,  $R^2=0.20$ ). When BUOW were evicted from a home burrow, they generally settled in sites with a lower supply of available burrows.

**Table 8. Habitat variables for all origin, hack, and settlement burrows.**

Translocation Type	Cues	Burrow Type	<i>n</i>	Bare % cover		Exotic Grass % cover		Exotic Forb % cover		Infrastructure % cover		Height cm		<i>Range</i>	Burrow Density Burrows/m <sup>2</sup>		
				<i>mean</i>	<i>SD</i>	<i>mean</i>	<i>SD</i>	<i>mean</i>	<i>SD</i>	<i>mean</i>	<i>SD</i>	<i>mean</i>	<i>SD</i>		<i>mean</i>	<i>SD</i>	
Active	Artificial Cues	All burrows	51	30.7	24.7	24.0	26.3	14.8	21.6	6.1	13.0	6.2	9.7	0.0 - 177.0	0.0066	0.0139	
		Hack	17	18.9	19.1	40.3	24.1	25.7	24.0	3.2	7.4	5.6	6.1	0.0 - 110.0	0.0067	0.0106	
		Origin	7	10.7	6.1	55.4	17.9	28.3	30.9	0.9	2.3	7.7	7.4	0.0 - 110.0	0.0074	0.0110	
		Settlement	9	26.2	23.9	32.5	22.0	22.0	19.6	5.4	9.6	4.3	5.3	0.0 - 56.0	0.0070	0.0113	
			1	11.0	-	4.0	-	42.0	-	0.0	-	2.7	4.2	0.0 - 35.0	0.0000	-	
	Natural Cues	All Burrows	16	36.7	30.2	26.9	28.5	3.2	2.9	8.9	19.2	5.6	9.6	0.0 - 110.0	0.0049	0.0118	
		Hack	6	24.0	4.2	44.2	27.4	3.7	2.9	4.5	3.6	9.7	14.6	0.0 - 110.0	0.0024	0.0050	
		Origin	5	60.9	39.0	8.1	7.5	3.6	2.9	2.6	5.8	2.3	6.7	0.0 - 72.0	0.0124	0.0196	
		Settlement	5	27.8	28.4	24.8	34.1	2.4	3.6	20.4	32.9	4.1	6.4	0.0 - 99.0	0.0004	0.0009	
	No Cues	All burrows	18	36.5	21.1	6.1	12.4	14.6	24.0	6.2	10.4	7.4	13.2	0.0 - 177.0	0.0079	0.0184	
		Hack	6	47.4	17.0	2.4	4.8	2.3	5.1	1.2	2.5	4.8	10.3	0.0 - 177.0	0.0019	0.0024	
		Origin	6	14.4	13.0	15.7	18.3	41.4	25.4	13.2	15.0	5.9	9.9	0.0 - 111.0	0.0073	0.0049	
		Settlement	6	47.7	13.3	0.3	0.8	0.2	0.4	4.2	6.5	11.4	19.3	0.0 - 150.0	0.0144	0.0320	
Control		All burrows	18	44.6	34.4	3.9	8.1	7.6	14.5	15.4	27.3	6.9	7.8	0.0 - 104.0	0.0115	0.0206	
		Origin	16	45.7	35.4	4.4	8.4	8.4	15.2	16.3	28.8	5.9	7.2	0.0 - 104.0	0.0128	0.0216	
		Settlement	2	35.5	34.6	0.0	0.0	0.5	0.7	8.5	12.0	14.3	11.9	0.0 - 50.0	0.0010	0.0015	
Passive		All burrows	31	33.1	34.1	15.6	14.8	9.4	13.0	7.1	12.0	6.3	10.0	0.0 - 196.0	0.0095	0.0078	
		Origin	14	31.4	32.7	10.9	8.8	11.3	15.7	5.1	6.6	4.4	8.4	0.0 - 135.0	0.0132	0.0085	
		Settlement	17	34.5	36.1	19.5	17.7	7.8	10.6	8.8	15.2	7.8	11.3	0.0 - 196.0	0.0064	0.0056	
Total		All burrows	100	33.9	29.9	17.8	22.0	11.8	18.3	8.1	16.4	6.4	9.4	0.0 - 196.0	0.0084	0.0139	



## Discussion

### Strategies for BUOW settlement

The ability to limit post-translocation dispersal away from release sites is critical to the success of translocations (Batson et al. 2015; Stamps & Swaisgood 2007). Long-distance movements following translocation have been shown across species to increase risk exposure and mortality rates (Le Gouar et al. 2012; Shier and Swaisgood 2012; Stamps & Swaisgood 2007). In this study, dispersal did occur post-translocation, but 65% of actively-translocated BUOW settled at release sites. In contrast, dispersal rates within the control treatment showed resident populations to be quite stable, with only one BUOW (7%) dispersing.

The effects of conspecific cues on settlement were significant, indicating that cues should be a component of active translocations moving forward. Cues at the release site for actively-translocated BUOW were an effective strategy for anchoring owls close to the release site. By contrast, owls that experienced no cues dispersed on average more than 24 times the distance of owls that experienced cues. Passively-relocated BUOW also dispersed much farther than actively-translocated BUOW that experienced cues. Biologically, both artificial and natural cues of conspecifics appear to be powerful attractants for BUOW.

Our dataset for reproduction is smaller than for other measures because we are limited to those owls that establish nesting burrows where we can monitor them. None of our experimental manipulations significantly influenced any of the measures of reproduction. However, examination of trends may be revealing in light of the low statistical power. Mean productivity, measured as the number of chicks fledged per pair, was highest (4.2) for actively-translocated owls receiving artificial cues. Actively-translocated BUOW receiving no cues had the lowest productivity (1.3).

These effects are the mirror image of the dispersal data and suggest that the no-cues experimental treatment group suffered lower reproduction as a result of their high dispersal distances and the artificial-cues treatment group benefitted from shorter dispersal distances. Passively-relocated BUOW had intermediate dispersal distances and productivity. These trends make intuitive sense biologically, as long-distance dispersal entails many costs, including lost foraging opportunities and delayed establishment of breeding (Swaisgood and Ruiz-Miranda In press).

It is also possible that BUOW translocated to protected areas are subsequently able to benefit from the resources and relative safety associated with a landscape intentionally managed for BUOW suitability. Site-specific drivers could be underlying productivity at some of the translocation receiver sites. For example, at Rancho Jamul, supplemental feeding was provided during both the hack period and the subsequent breeding season, in order to support the survival of both chicks and parents through the breeding season. This site received extra management support after translocation to achieve specific conservation goals.

In addition to the significant positive effects of conspecific cues, we found support for the hypothesis that the distance a BUOW is translocated influences settlement. Longer translocation distances appeared to have a secondary additive effect on settlement in combination with cue deployment. The higher settlement associated with translocation distances greater than 17.5 km suggests that BUOW translocated farther from their origin site are less likely to try to return to the origin site. While the



ability to control translocation distance can be limited by the availability of high-quality receiver sites, translocation success may be higher when this guideline can be observed.

## Survival

The survival analysis was based on a 5-month interval to balance the longest interval of available data for all BUOW enrolled in the study against the negative impacts on overall sample size of transmitter failure and unknown fates. BUOW survival at 1- and 3-month intervals were also examined. The assessment of BUOW fates 1 month post-treatment contributed little useful information because all BUOW we tracked survived at least 1 month regardless of treatment or site differences. Likewise, using a single month of post-translocation monitoring to determine whether a particular translocation can be deemed successful or not is likely insufficient. By the end of 5 months, the survival rate for actively translocated BUOW was significantly lower than for passively-relocated BUOW or controls.

The presence of high survival for passive relocations was expected to contrast with lower survival rates in the active translocations. Translocation is a stressor that places animals in novel conditions in which they must learn quickly to survive, and previous animal translocations across many species have established that mortality is highest in the initial weeks following animal translocations (Stamps & Swaisgood 2007). Across species, mortality rates following release can often exceed 50% (Harrington et al. 2013).

However, the long-term value of active translocation may exceed that of passive relocation, even if initial survival is lower. The prospect of increasing future threats and habitat loss may drive the need for translocation of BUOW to protected areas. In many locations in southern California, urban development has been initiated, with more projects planned in the next decade. Many resident BUOW face the prospect of serial passive evictions from home burrows as development infill occurs. A second and related scenario occurs when areas with historic BUOW populations have changed to the degree that they no longer meet the habitat needs of the species, and have become ecological traps (Hale and Swearer 2016). In these locations owls are attracted to settle, but future survival and/or reproduction will be constrained to low levels, with little or no prospect for future population sustainability.

In this study, the selection of owls for treatment (active versus passive) was not randomized or balanced, but was the outcome of developer preference or regulatory constraints. Thus, experimental treatments were geographically clustered, so that individual owls in a treatment were not statistically independent. As a result, treatments were partially confounded by situational conditions specific to a location or project.

For example, most of the owls in the passive treatment group were from a two large relocations. Both sites coincidentally provided relatively ideal conditions for passive relocation. For the Wistaria Solar project in Imperial County, the site was developed much later than planned, so although owls were evicted from their burrows, they were able to establish nearby in readily available and plentiful burrows and did not lose foraging habitat. Likewise, 8 BUOW were passively relocated from burrows affected by the replacement of sections of the U.S.-Mexico border fence in San Diego County. Most of the border BUOW moved less than 650 m north of the fence. Foraging grounds were unaffected at the time, although they will eventually be lost to the development of a new border crossing. Once the fence replacement was completed, squirrels began digging along the fence again, and the passively-relocated



BUOW began utilizing the new burrows. Previous research studies have reported high survival rates for short-distance passive relocation such as these (Trulio 1995).

### Burrow availability in passive relocations

Examination of survival and reproductive trends also provide insights into best practices for passively-relocated BUOW. Survival appeared to be lower when there was no nearby supply of available burrows. Although this dataset did not have the statistical power needed to detect differences in reproduction, trends in the data suggested that a lack of nearby available burrows is also associated with lower reproductive success. The finding that dispersal distance was greater when burrows were unavailable suggests an advantage for BUOW who are able to quickly locate and select a new burrow. This supports the CDFW recommendation to install nearby artificial burrows (or ensure the presence of available natural burrows) for passive relocations conducted to mitigate for development. Passive relocations that occur within an HCP/NCCP are not required to be reported to CDFW and may not require a mitigation plan; this may result in a significant proportion of passive relocations occurring without the provision of nearby burrows which may incur survival and reproductive costs to the affected BUOW.

### BUOW preference for open habitat

The habitat data reveal additional potential drivers of some of the above effects. When BUOW dispersed, they chose to settle in areas with less exotic cover than at their site of origin. This finding suggests that habitat quality at the release site was an important variable governing dispersal decisions, with BUOW moving away from less suitable habitat in search of more suitable habitat characterized by more open vegetation. Since settlement sites had less exotic cover than found at hatch sites when BUOW dispersed, managers should pursue management actions that address the habitat preference for less exotic cover.

### Unknown fates

GPS transmitter issues posed a significant problem, reducing our effective sample size. While we met the target sample size for the study, the effective sample size for statistical analysis is lower due to unknown outcomes for owls with failed GPS transmitters. The cause of the failures was mainly due to antenna breakage and insufficient solar recharge of the Lotek Pinpoint Argos solar tags. Feather coverage along with owl behavior (e.g., occupying burrows or under cover during the day) were the leading culprits for the lack of solar recharge. Reinforced antennae were deployed, and a reduced daily fix rate was adopted to reduce the draw on the battery. We confirmed that the reduced daily fix rate provided sufficient location data for continued monitoring of BUOW locations. We also trimmed back feathers when owls were captured or recaptured to reduce feather coverage of the solar panel. These alterations provided some improvements, but the basic challenge of tracking these small owls that occupy underground burrows remain. Future BUOW studies involving GPS transmitters should take these issues into account.



## Management Recommendations for Mitigating Impacts on BUOW

This research provides the first data evaluating the outcomes and effectiveness of both passive relocation and active translocation, compared to control BUOW not impacted by development. The results of the LAG study will be included in the final report for the larger California Energy Commission project encompassing four counties in southern California.

These results allow for data-supported recommendations to aid managers in their decision making process when BUOW translocation must be used to mitigate development impacts. Decisions regarding the suitability of passive relocation or active translocation should be evaluated depending on each development project's location relative to urbanization, current and future rates of development infill, availability of suitable habitat and burrows, the potential for long-term BUOW security, and their conservation goals. Managers should also weigh the short- and long-term penalties on survival, reproduction, and dispersal tendencies associated with each method, with the following guiding recommendations.

- Protected lands managed for conservation goals are the best receiver sites for translocated BUOW.
- For active translocation, BUOW should be translocated farther than 17.5 km (approximately) from their origin burrow to maximize settlement.
- Presence of conspecifics or, in their absence, application of visual and acoustic conspecific cues reduce dispersal and help anchor translocated BUOW to the release site.
- Supplemental feeding should occur during both the hack period and through the subsequent breeding season. Male BUOW are particularly stressed by the dual challenges of providing for offspring and acclimating to predator pressure at the release site. Regular provisioning can support the survival of both chicks and parents through the breeding season.
- To improve settlement (and possibly survival and reproduction), habitat management to reduce exotic grasses and forbs and promote open ground is recommended.
- For passive relocation, a supply of available nearby burrows within the territory or home range of the impacted owl is needed to support BUOW settlement, reproduction, and survival after burrow eviction.
- Serial passive eviction of the same BUOW should be avoided to minimize cumulative impacts detrimental to BUOW survivorship. If the probability of serial evictions in a specific area is high, active translocation to a protected conservation area should be considered.
- A more reliable mechanism for reporting and monitoring passive relocations to CDFW should be a priority.





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## References

Ahlering, M.A., Arlt, D., Betts, M.G., Fletcher, R.J., Nocera, J.J., Ward, M.P. 2010. Research needs and recommendations for the use of conspecific attraction methods in the conservation of migratory songbirds. *Condor* 112: 252–264.

Batson, W., Gordon, I., Fletcher, D., Manning, A., 2015. Translocation tactics: a framework to support the IUCN guidelines for wildlife translocations and improve the quality of applied methods. *Journal of Applied Ecology*, 1598-1607.

Bloom Biological, Inc. 2009. Report of activities regarding burrowing owl translocations & releases conducted at the El Sol Burrowing Owl Management Area, Riverside County, CA. Prepared for Esther Burkett, California Department of Fish and Game. December 7, 2009.

Bowen, P.J. 2001. Demography and distribution of the burrowing owl in Florida. *Florida Field Naturalist* 29(4):113–142.

Bright, P.W. and Morris, P.A., 1994. Animal translocation for conservation: performance of dormice in relation to release methods, origin and season. *Journal of Applied Ecology* 31(4): 699-708.

(CDFG) California Department of Fish and Game. 2012. Staff report on burrowing owl mitigation. State of California, Natural Resources Agency. Retrieved from: <http://www.dfg.ca.gov/wildlife/nongame/docs/BUOWStaffReport.pdf>.

(CEC) California Energy Commission. 2012. Desert Renewable Energy Conservation Plan (DRECP). Retrieved December 16, 2015, from: <http://www.drecp.org/index.html>.

Center for Biological Diversity. 2015. Excluded from protection: burrowing owls and the California Endangered Species Act. Oral presentation by Jeff Miller, Center for Biological Diversity, Alameda Creek



Alliance. California Burrowing Owl Consortium Conference, San José State University, San Jose, California, October 24, 2015.

Conway, C.J., Macias-Duarte, A., Garcia, V., Finley, C.A. 2010. Migratory linkages of burrowing owls on department of defense installations and adjacent lands, final report. Department of Defense, Legacy Resource Management. Retrieved from: [http://www.denix.osd.mil/nr/upload/DoD-Legacy-final-report\\_09-243\\_ver-2.pdf](http://www.denix.osd.mil/nr/upload/DoD-Legacy-final-report_09-243_ver-2.pdf).

Dechant, J. A., M. L. Sondreal, D. H. Johnson, L. D. Igl, C. M. Goldade, P. A. Rabie, and B. R. Euliss. 1999 (revised 2002). Effects of management practices on grassland birds: Burrowing Owl. Northern Prairie Wildlife Research Center, Jamestown, ND. 33 pages.

DeSante, D.F., Ruhlen, E.D., Rosenberg, D.K. 1996. The distribution and relative abundance of burrowing owls in California during 1991–1993: Evidence for a declining population. The Institute for Bird Populations, Point Reyes Station, California.

DeSante, D.F., E.D. Ruhlen, and D.K. Rosenberg. 2004. Density and abundance of burrowing owls in the agricultural matrix of the Imperial Valley, California. Pages 116–119 in W.D. Shuford and K.C. Molina (eds.). Ecology and Conservation of Birds of the Salton Sink: An Endangered Ecosystem. Studies in Avian Biology 27. University of California Press, Berkeley, California. 169 pp.

DeSante, D.F., E.D. Ruhlen, and D.K. Rosenberg. 2007a. Density and abundance of burrowing owls in the agricultural matrix of the Imperial Valley, California. Pages 103–108 in Barclay, J., K. Hunting, J. Lincer, J. Linthicum, and T. Roberts. Proceedings of the California burrowing owl symposium, November 2003 (Bird Populations Monographs No. 1). The Institute for Bird Populations and Albion Environmental, Inc., Point Reyes Station, California.

DeSante, D.F., Ruhlen, E.D., Scalf, R. 2007b. The distribution and relative abundance of burrowing owls in California during 1991–1993: Evidence for a declining population and thoughts on its conservation. Pages 1–41 in Barclay, J., K. Hunting, J. Lincer, J. Linthicum, and T. Roberts. Proceedings of the California burrowing owl symposium, November 2003 (Bird Populations Monographs No. 1). The Institute for Bird Populations and Albion Environmental, Inc., Point Reyes Station, California.

Ewen, J.G., Armstrong, D.P., Parker, K.A., Seddon, P.J. (Eds.), 2012. Reintroduction Biology: Integrating Science and Management. John Wiley and Sons, West Sussex, UK.

Germano, J.M., Field, K.J., Griffiths, R.A., Clulow, S., Foster, J., Harding, G., Swaisgood, R.R., 2015. Mitigation-driven translocations: are we moving wildlife in the right direction? *Frontiers in Ecology and the Environment* 13:100-105.

Gervais, J.A., Rosenberg D.K., Comrack L.A. 2008. Burrowing owl (*Athene cunicularia*). Pages 218–226 in W.D. Shuford and T. Gardali (editors). California bird species of special concern: A ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Studies of Western Birds 1. Western Field Ornithologists, Camarillo, California, and California Department of Fish and Game, Sacramento, California. 450 pp.

Gervais, J. A., D. K. Rosenberg, and R. G. Anthony. 2003. Space use and pesticide exposure risk of male burrowing owls in an agricultural landscape. *Journal of Wildlife Management* 67:155-164.



Hale, R., Swearer, S.E., 2016. Ecological traps: current evidence and future directions, In Proc. R. Soc. B. p. 20152647. The Royal Society.

Harrington, L.A., Moehrensclager, A., Gelling, M., Atkinson, R.P., Hughes, J., Macdonald, D.W., 2013. Conflicting and complementary ethics of animal welfare considerations in reintroductions. *Conservation Biology* 27, 486-500.

Haug, E. A., and L. W. Oliphant. 1990. Movements, activity patterns, and habitat use of burrowing owls in Saskatchewan. *Journal of Wildlife Management* 54:27-35.

IUCN/SSC, 2013. Guidelines for reintroductions and other conservation translocations, In The reintroduction and invasive species specialist groups' task force on moving plants and animals for conservation purposes. p. 57. IUCN Species Survival Commission, Gland, Switzerland.

Klute, D.S., Ayers, L.W., Green, M.T., Howe, W.H., Jones, S.L., Shaffer, J.A., Sheffield, S.R., Zimmerman, T.S. 2003. Status assessment and conservation plan for the western burrowing owl in the United States. Biological Technical Publication FWS/BTP-R6001-2003. U.S. Department of Interior, Fish and Wildlife Service, Washington, D.C. 120 pp.

Kotilar, N.B., Burger, J. 1984. The use of decoys to attract least terns (*Sterna antillarum*) to abandoned colony sites in New Jersey. *Colonial Waterbirds* 7:134-138.

Le Gouar, P., Mihoub, J.-B., Sarrazin, F., 2012. Dispersal and habitat selection: behavioural and spatial constraints for animal translocations. *Reintroduction biology: integrating science and management*, 138-164.

Leupin, E.E. and Low, D.J. 2001. Burrowing Owl Reintroduction Efforts in the Thompson-Nicola Region of British Columbia. *Journal of Raptor Research* 35(4):392–398.

Linklater, W.L. and Swaisgood, R.R. 2008. Reserve size, conspecific density, and translocation success for black rhinoceros. *The Journal of Wildlife Management* 72(5):1059-1068.

Mitchell, A.M., Wellicome, T.I., Brodie, D.B., Cheng, K.M. 2011. Captive-reared burrowing owls show higher site-affinity, survival, and reproductive performance when reintroduced using a soft release. *Biological Conservation* 144(5):1382–1391.

Pollock, K.H., Winterstein, S.R., Bunck, C.M., Curtis, P.D. 1989. Survival analysis in telemetry studies: the staggered entry design. *Journal of Wildlife Management* 53:7-15.

Sarrazin, F., Bagnolin, C., Pinna, J.L., Danchin, E., 1996. Breeding biology during establishment of a reintroduced Griffon Vulture *Gyps fulvus* population. *Ibis* 138(2):315-325.

Seddon, P.J., Armstrong, D.P., Maloney, R.F. 2007. Developing the Science of Reintroduction Biology. *Conservation Biology* 21(2) 303-312.

Shier, D.M. 2006. Family Support Increases the Success of Translocated Prairie Dogs. *Conservation Biology* 20(6):1780-1790.



Shier, D.M., Swaisgood, R.R., 2012. Fitness costs of neighborhood disruption in translocations of a solitary mammal. *Conservation Biology* 26, 116-123.

Smith, B.W. and Belthoff, J.R. 2001. Burrowing owls and development: Short-distance nest burrow relocation to minimize construction impacts. *Journal of Raptor Research* 35(4):385–391.

Stamps, J.A. 1988. Conspecific attraction and aggregation in territorial species. *American Naturalist* 131:329-347.

Stamps, J.A., Swaisgood, R.R., 2007. Someplace like home: Experience, habitat selection and conservation biology. *Applied Animal Behaviour Science* 102, 392-409.

Swaisgood, R.R., Ruiz-Miranda, C.R., In press. Moving animals in the right direction: making conservation translocation an effective tool, In *International Wildlife: Contemporary Challenges in a Changing World*. eds J. Koprowski, P. Krausman. The Wildlife Society and Johns Hopkins University Press.

Swaisgood R.R., Wisinski C.L., Montagne J.P., Marczak S., Shier D.M., and Nordstrom L.A. 2015. Project Report: An adaptive management approach to recovering burrowing owl populations and restoring a grassland ecosystem in San Diego County, report to San Diego Foundation for the 2014 calendar year, pp. 1-78. San Diego Zoo Institute for Conservation Research, Escondido, California.

Sullivan, B.K., Nowak, E.M., Kwiatkowski, M.A. 2015. Problems with mitigation translocation of herpetofauna. *Conservation Biology* 29, 12-18.

Trulio, L.A. 1995. Passive relocation: A method to preserve burrowing owls on disturbed sites. *Journal of Field Ornithology* 66(1):99–106.

(USFWS) U.S. Fish and Wildlife Service. 2008. Birds of conservation concern 2008. U.S. Department of Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, Virginia. Retrieved from:

<http://www.fws.gov/migratorybirds/NewReportsPublications/SpecialTopics/BCC2008/BCC2008.pdf>.

Wild at Heart. 2011. The burrowing owl project. Retrieved from:

[http://wildatheartowls.org/burrowing\\_owl\\_relocation.html](http://wildatheartowls.org/burrowing_owl_relocation.html).

Wilkerson, R.L. and Siegel, R.B. 2010. Assessing changes in the distribution and abundance of burrowing owls in California, 1993–2007. *Bird Populations* 10(1):1–36.

Wilkerson, R.L. and Siegel, R.B. 2011. Distribution and abundance of western burrowing owls (*Athene cunicularia hypugaea*) in southeastern California. *The Southwestern Naturalist* 56(3):378–384.

Appendix XII-

United States Geological Survey,  
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**Establishing an Effective Agassiz's Desert Tortoise Monitoring Program within the Coachella Valley Multiple Species Habitat Conservation Plan and Natural Community Conservation Plan Area: Final Report to the Coachella Valley Conservation Commission on work performed near the Orocopia Mountains**

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**Summary:** In support of the goals of the Coachella Valley Multiple Species Habitat Conservation Plan and Natural Community Conservation Plan (CVMSHCP/NCCP), a population of Agassiz's desert tortoises (*Gopherus agassizii*) was marked and studied to establish a desert tortoise monitoring program near the Orocopia Mountains beginning in early 2017 and ending in the summer of 2018, following the drought of 2012–2016 which was described as the worst in central and southern California in 1,200 years. This effort compliments a similar effort in the nearby mouth of Cottonwood Canyon in 2015–2016. Surveys were performed to locate tortoises, tortoise burrows, and tortoise remains at the eastern end of the CVMSHCP area north of the Orocopia Mountains and south of Interstate 10 in Riverside County, California. Although the area is considered Critical Habitat for the recovery of tortoise populations, it was heavily impacted by military training activities in the early 1940s and continues to be impacted by off-highway vehicle use. Data were collected from all live and dead tortoise specimens encountered. Only 22 live tortoises were found during transects covering approximately 21 km<sup>2</sup> of habitat surveyed. The sex ratio of live adult tortoises was strongly biased toward males and the sex ratio of recently (4–5 years) dead carcasses during the long drought was strongly biased toward females. High female mortality may have resulted from the interaction of drought (including increased predation) and the reproductive strategy of tortoises. We located only one new live tortoise in the drought year of 2018 when there was no germination of winter annual food plants. A subsample of nine tortoises was outfitted with radio transmitters, and females (n = 4) were X-radiographed at approximately 10-day intervals from April–July. Mean clutch size was about 4 eggs as is typical for tortoises in this region. Additional tortoises were located opportunistically in and around the Santa Rosa Mountains (located in the southern end of the CVMSHCP area), and these tortoises were also marked for future identification. Blood samples were taken from adult tortoises and scute clips were taken from a subset of juveniles for ongoing studies to determine genetic diversity and relationships of desert tortoises within the CVMSHCP/NCCP

area and beyond. The low tortoise density and high adult female mortality observed by us and others in the area may compromise the long-term viability of the population, especially given published predictions of the negative effects of future droughts on tortoises in the region.

## Introduction

Agassiz's desert tortoise (*Gopherus agassizii*) is one of the best-studied turtle species in the world (Lovich and Ennen 2013). The species was listed as federally threatened under the U.S. Endangered Species Act in 1990. However, despite the proliferation of research and conservation efforts, there has been little progress towards the recovery or delisting of the species and populations continue to decline range wide (Allison and McLuckie 2018). The Turtle Conservation Coalition (2018) recently included the species in their list of the world's 25+ most endangered tortoises and freshwater turtles. They also recommended that the status of *G. agassizii* be upgraded to critically endangered due to continued loss of individuals resulting from the effects of climate change, disease, predation, loss of habitat, and other anthropogenic influences. Conservation of this species is dependent on understanding their natural history, how their populations can be sustained in the face of their stressors (both natural and anthropogenic), and the ability of regulatory and management agencies to protect the species and its habitat.

Although commonly known as the Mojave desert tortoise, *G. agassizii* inhabits portions of both the Mojave and Sonoran deserts, with populations occurring from southwestern Utah to near the Mexican border in California (Ernst and Lovich 2009). At its southernmost range in the Sonoran Desert of California, *G. agassizii* population densities vary greatly. In the eastern and western ends of Coachella Valley where *G. agassizii* occurs, it is one of 21 covered species under the Coachella Valley Multiple Species Habitat Conservation Plan and Natural Community Conservation Plan (CVMSHCP/NCCP). Within this approximately 450,000 ha area, the plan specifies that desert tortoise populations be monitored, a task made difficult by low population densities and unpredictable tortoise detection probabilities due to variable annual precipitation patterns and its effect on the availability of tortoise food plants. The highest densities of desert tortoises occur at the western- and easternmost portions of the planning area, with low density populations occurring in some of the alluvial fan communities of the Coachella Valley itself.

The northern Orocopia Mountains lie within the CVMSHCP/NCCP area and just south of Interstate 10. On the northern versant of the mountains is an area predicted to have medium- to low-density tortoise populations using habitat suitability modeling (Barrows 2011; Figure 1). This area, known as Shavers Valley, is drained by Maniobra and Shavers washes. A second study site, Cottonwood, was the focus of investigations from 2015–2016 by the authors (Lovich et al. 2017, Lovich and Puffer 2017). It is drained by Cottonwood Wash, a tributary of Shavers Wash on the north side of the interstate that originates in Joshua Tree National Park. *G. agassizii* have been studied by the principal investigator at the Cottonwood study site since 1997 (Lovich et al. 1999, 2018; Smith et al. 2015, 2016; Henderson et al. 2016), especially in 2015–2016 (Lovich and Puffer 2017, Lovich et al. 2017). The project at the Orocopia study site allows for



comparisons between populations that are in close proximity to one another but feature different terrains.

The project's objectives included investigating tortoise densities and population structure to establish baseline data in the eastern end of the CVMSHCP area. In this part of the Sonoran Desert of California, tortoise populations have been poorly studied (Lovich et al. 2018). We established two monitoring plots in this area, Cottonwood (2015–2016) and the Orocopia study site (2017–2018), where data were collected on reproduction, mortality, habitat utilization, and population genetics. These data will serve as a baseline for longer term monitoring, even if intermittent, of tortoise population health and status. Additionally, genetic data were opportunistically collected in the southern end of the planning area in and around the Santa Rosa Mountains for genetic comparisons among populations. Our overall goal was to facilitate the design and implementation of a monitoring program for *G. agassizii* that will aid in management of the species for its recovery in the CVMSHCP/NCCP area of California. The monitoring program, coupled with determining habitat suitability and developing population estimates, will yield a better understanding of *G. agassizii* population density and demographics. Additionally, studying the population genetics of tortoises in the planning area may give better insights into regional connectivity of tortoise populations, and the natural and anthropogenic barriers that hinder gene flow among populations (Lovich et al. 2017).

## Methods

### *Study site*

The main study site is located on the northern versant of the Orocopia Mountains (hereafter the Orocopia study site), situated south of Interstate 10 and Joshua Tree National Park, and to the west of Chiriaco Summit, California. The area is bounded by the Orocopia Mountains to the south, with a total survey area of greater than 20 km<sup>2</sup> (Figure 2). Most of this land is managed by the Bureau of Land Management (BLM), but there are also interspersed parcels which are privately owned. Wildlands Inc., a company involved in creating “mitigation banks” of wildlife habitat to offset the effects of land development, owns a large portion of these private parcels and gave our team permission to work on their land. This area was heavily impacted by military training activities during the early 1940s associated with Camp Young (Lathrop 1983, Prose 1985, Prose and Metzger 1985, Henley 2000). Tank and jeep tracks are still visible throughout the study site resulting in long-lasting changes to soil conditions and plant growth that are still detectable (Lovich and Bainbridge 1999). The effects of these changes on modern tortoise populations are unknown.

The main study area (where tortoise aggregations have been found) is bisected by a set of powerlines and an associated dirt road that runs east/west. The site also has a network of dirt roads maintained by BLM that both border and run through it. Traffic is generally light, but recreational use of the roads by off-highway vehicles can be significant, especially during holidays and weekends. The site is dominated by gently sloping bajadas and arroyos running northward to Interstate 10 and Maniobra Wash. These bajadas rise to meet the schist-dominated

Orocopia Mountains to the south that generally lack large boulders that could act as shelter sites for tortoises.

Elevations of known tortoise locations at the Orocopia study site ranged from approximately 480 to 620 m with vegetation dominated by creosote bush (*Larrea tridentata*) burro bush (*Ambrosia dumosa*) scrub interspersed with widely-scattered ocotillos (*Fouquieria splendens*) and blue palo verde trees (*Parkinsonia florida*). Winter precipitation in 2016–2017 was adequate to support good germination of winter annual food plants in 2017. However, a single rainfall event during the winter of 2017–2018 led to severe drought conditions in spring 2018, and no winter annual plants germinated at the Orocopia study site for the duration of our study in 2018.

Serendipitous tortoise sampling also occurred in the Santa Rosa Mountains, mainly to obtain tissue for comparative genetic analysis. Jeff Manning at Anza Borrego Desert State Park shared tortoise DNA data with us for regional analysis of tortoise genetic affinities and connectivity. Those data will be presented in another report that is currently under preparation in collaboration with Taylor Edwards at the University of Arizona, Genetics Core.

### *Field techniques*

During 2017–2018, demographic and reproductive studies were conducted at the Orocopia study site. Beginning in February 2017, USGS employees and volunteers performed systematic surveys to locate live tortoises, tortoise burrows, and tortoise carcasses. Transects with 10–25 m spacing between observers were conducted throughout the area until more than 20 km<sup>2</sup> were covered (Figure 3). Tortoises located at the study site were notched with a unique combination of marginal scutes using a triangular file for future identification (Cagle 1939). Biometric data were collected, including mid-line straight-line carapace length (SLCL), plastron length (PL), carapace width (CW), and carapace height (CH) measured using tree calipers ( $\pm 1$  mm), and weight was taken using Pesola spring scales ( $\pm 10$  g). Tortoises were assessed for condition and health, the latter for clinical signs of upper respiratory tract disease (e.g., nasal discharge, swollen eyes, occluded nares). GPS locations were recorded for both live tortoises and carcasses using a Garmin Oregon 550T. If whole shells or shell fragments of dead tortoises were located, notes were recorded on the state of the shell in order to determine approximately when the tortoise died (see subsection below on estimating carcass age). If possible, shell measurements were taken as described above and sex was determined.

A subset of mature male and female tortoises ( $n = 9$ ) was outfitted with radio transmitters (models R1850, R1860: Advanced Telemetry Systems; reptile transmitters with replaceable batteries: Wildlife Materials). Male tortoises are often easier to locate initially and facilitate finding females upon repeated captures (personal observation). During the months of March to July, all transmitted tortoises were located approximately every 10–14 days, and once per month for the remainder of the year. As the conclusion of the study neared in 2018, transmitters were removed from tortoises, with the final radio removed in August 2018.

X-radiography was used to determine the presence of shelled eggs, clutch size, clutch frequency, egg width, and annual egg production. Females ( $n = 4$ ) were X-radiographed from April–July and returned to their capture location, usually within one hour. The period from April to July overlaps known earliest and latest dates of the production of shelled eggs at nearby Joshua Tree National Park (Lovich et al. 1999, 2018). X-radiographs were performed in the field using a digital X-ray generator (model TR80; Min-X-ray) connected to a custom Canon X-radiography system. Exposures were taken using the settings described by Lovich et al. (2015) using doses that are considered to be safe for tortoises (Hinton et al. 1997).

### *Genetic Sampling*

Subcarapacial blood sampling (Hernandez-Divers et al. 2002) was performed to collect DNA for use in genotyping and population assignment of desert tortoises in and around the Coachella Valley. These data will be used to determine linkages and compare with other populations inside and outside of the CVMSHCP area. Blood collection protocols were stringently followed according to guidelines set by the U.S. Fish and Wildlife Service and protocols approved by the Northern Arizona University Institutional Animal Care and Use Committee, with up to 0.5 mL of blood or blood with lymph obtained from individual adult tortoises. Blood collection was attempted on all adult tortoises located at the Orocopia study site with the exception of times when high temperatures, in combination with blood collection, may have caused too much stress on a tortoise. Additionally, *G. agassizii* were opportunistically located in and around the Santa Rosa Mountains near the southern end of the planning area in Coachella Valley (Figure 4). Semi-systematic surveys for tortoises and burrows were performed in Deep Canyon of the Boyd Deep Canyon Desert Research Center. With the help of staff and volunteers at Friends of the Desert Mountains, tortoises were also located via searches and the use of camera traps around the Randall Henderson Trail in the Santa Rosa Mountains. These tortoises were captured, marked, measured, and subcarapacial blood samples were taken from adults when possible.

All blood samples were obtained from tortoises in 2017 and were sent to the University of Arizona Genetics Core (UAGC) for analysis. Scute clips were also obtained from a subset of juvenile tortoises, and the samples were sent to either the University of Southern Mississippi or UAGC for DNA extraction and analysis. Additionally, the intact shell of a juvenile tortoise was salvaged from the Boyd Deep Canyon Desert Research Center, and a DNA sample was obtained for analysis.

### *Estimating Carcass Age*

The time of death in tortoises can be estimated in the first few years post-mortem based on stages of carcass deterioration. However, several factors have to be considered relative to deterioration rates, including the size of the tortoise, the condition of the scutes and bones at time of death, and the amount of predation or scavenging sustained by the carcass. Shell surfaces that are exposed to sunlight or precipitation are likely to disarticulate at faster rates than those that are

not (e.g., those that are shaded by shrubs). Predation or scavenging can remove scutes and separate bones allowing increased exposure to areas that may not be initially exposed (Berry 1984). According to Dodd (1995), the shells of six different turtle species in Florida disintegrate in a predictable pattern. Generally, the keratinized scutes covering the bony shell begin to exhibit dullness and curling, followed by peeling from the larger vertebral scutes down to the marginal scutes around the periphery of the shell. The marginal scutes are usually the last to be exfoliated. Underlying shell bones (post-scute deterioration) also go through stages as they age post-mortem. Skeletal shell bones begin either white to dirty brown in color (if the scutes have recently exfoliated) and have a solid, fresh appearance without cracks, pits, or peeling. As the bones are exposed to the elements, they progress to a cracking, peeling, pitted, or disarticulated state as scavenging and environmental factors cause further deterioration (Berry 1984, Dodd 1995).

All the carcasses located at the Orocopia study site were assessed and placed into one of seven categories of decomposition according to specific criteria (Table 1), which included analyzing the overall articulation of the carcass, scute condition, and bone condition. The categories are derived from a classification system based on a compilation of previous schemes used by Dodd (1995) and Berry (1984: Appendices 6 & 7) (cited in Berry 1986 and used by Lovich et al. [2014a]). Carcasses were examined for recency of death by first looking for the presence of tissue within the shell. Scutes were then assessed for any fading, peeling, shrinkage, and attachment to the underlying bone. Next, shell bones were examined (where exposed) for color, strength, cracking, chalkiness, or separations. Finally, carcasses were assessed for structural rigidity – determining whether the bones were intact (with or without suture separation or minor predation/scavenging damage) or completely or partially disarticulated. Signs of predation or scavenging, particularly tooth marks or breakage that did not correspond to sutures, were also noted since this can influence deterioration rates.

Categories are shown in Table 1. The first category (A) is for a fresh carcass dead up to only a couple of weeks, but we did not find any that met those criteria. The second category (B) includes carcasses that died over a period of up to 2 years prior to discovery, which would include death during the 2012–2016 drought that was classified as the worst drought in central and southern California in 1,200 years according to tree ring data (Griffin and Anchukaitis 2014). This category could also include carcasses that died post-drought, depending on the year of discovery. In this stage, the external surface still has the same fresh appearance of a live tortoise, but internal tissues are dried up and/or have been consumed by predators or scavengers. The scutes have a smooth surface and are not yet peeling or fading. The bone (if exposed) is a solid, non-chalky white or brown color without pits or cracks.

The third category (C) (Table 1) includes carcasses that died during the period 2–4 years prior to discovery. As decomposition progresses, scutes begin to fade causing a dullness on the scute surface, and they may start to peel away from the bone. However, there is still greater than fifty percent area of the shell with scutes attached. The bone begins to show signs of wear (surface cracking or dullness) where it is exposed.

Category D (Table 1) represents the first category encompassing an estimated time since death of greater than four years. Carcasses in this category have less than fifty percent of scutes covering the shell, and the remaining scutes are peeling, shrinking, curling, loose, or brittle. The bone shows signs of aging at this point, including pitting, porous texture, and possible development of suture cracks along the margins. This category is a transitional period for tortoises that died during the recent extended drought period from 2012–2016, or shortly after the drought ended. This is a liberal estimate of tortoises that died during the drought because it would include tortoises that died during the first year of the drought in 2012 before the drought effects increased with time. Category E (Table 1) also includes carcasses that died more than four years prior to discovery, but in this stage, there are few to no scutes remaining on the shell although scutes may still be present on the ground surrounding the carcass. The bone is white and chalky with suture cracks widening, but the carcass is still intact.

Category F (Table 1) is the next stage of decomposition also encompassing an estimated time since death of greater than four years. Sutures are separated, and the carcass is mostly disarticulated with a few large pieces still connected at suture margins. Scutes may or may not be visible on the ground. The bone is brittle and white or pink colored. The final category including carcasses that died greater than four years since discovery is category G, which is also the last stage of decomposition (Table 1). This category includes carcasses that are completely disarticulated into pieces scattered on the ground. Gender may be indiscernible, scutes are rarely present, and bones are bleached white.

All of these categories apply to general time periods since many variables affect rates of decomposition as discussed above, and this makes exact aging nearly impossible. The decomposition study by Berry (1984) was performed in a similar environment to that of our study – both were within deserts of California with relatively similar climates – which makes the Berry (1984) study the best candidate for approximations of time since death. However, age studies were not included in the Berry (1984) study for tortoises thought to have died more than four years prior to discovery.

We considered carcasses both with and without signs of predation that died between 2012–2016 to be victims of the epic drought. This is due to recognition that one of the effects of drought in the California deserts is “prey switching.” For example, during drought, prey species (rodents and rabbits) of coyotes (*Canis latrans*) decline in abundance and coyotes switch to feeding on tortoises and other prey as reviewed recently by Lovich et al. (2014a).

#### *Permits and Approved Protocols*

Research was conducted under permits and approvals from the U.S. Fish and Wildlife Service (Permit #TE-198910-5), Bureau of Land Management, and under a California Endangered Species Act Memorandum of Understanding with the California Department of Fish and Wildlife. The Institutional Animal Care and Use Committee of Northern Arizona University reviewed and approved our research procedures on handling, marking, and obtaining blood samples from tortoises (Approved Protocol #16-002).

## Results

### *Orocopia Study Site*

Our team completed 540 person-km of transects and located 22<sup>a</sup> previously unmarked tortoises (16 males, 5 females, 1 juvenile; Table 2) in an area of approximately 21 km<sup>2</sup> (Figure 2) at the Orocopia study site from 2017–2018. Additionally, three adult tortoises observed in burrows were inaccessible and therefore not marked or captured. All tortoises except for one adult male were located in 2017, despite 266 person-km walked and over 100 person-hours spent searching for tortoises in 2018. The inability to locate tortoises in 2018 can likely be attributed to severe drought conditions and therefore a lack of movement outside burrows over the course of the season (Duda et al. 1999, Freilich et al. 2000). A frequency accumulation curve of the number of unique registered tortoises shows this plateau in 2018 (Figure 5). Of all tortoises located at the Orocopia study site, we were able to obtain a total of 13 blood samples from adults (8 males, 5 females; Table 3) for comparison with DNA from other areas in or near the Coachella Valley, including the Santa Rosa Mountains (7 samples), Cottonwood Canyon (10 samples), the Mesa wind farm (31 samples), and samples collected by Jeff Manning at Anza Borrego Desert State Park.

A subset of nine tortoises was outfitted with radio transmitters (5 males, 4 females) for relocation. Of these radioed tortoises, four males and one female were found to periodically cross the powerline road bisecting the study site (23 total non-direct observations of road crossings, with 9 of the crossings by a single female tortoise). One of these tortoises (a male) was initially located underneath our vehicle during a routine “tortoise check” before driving away. An additional male tortoise that was not outfitted with a radio transmitter was located crossing the Red Canyon Jeep Trail – a dirt road that is popular for recreational vehicle users. A radioed female tortoise overwintered in a pallet burrow less than 8 m from Old Highway 60, an abandoned paved road that runs parallel to Interstate 10 on the south side. One registered tortoise was a juvenile of approximately 3–4 years of age that was located next to a burrow within 50 m of the dirt powerline road.

During the reproductive seasons in 2017–2018, three to four female tortoises were outfitted with radios and X-radiographed upon capture (Table 4). Mean clutch size over both years was  $4.3 \pm 0.8$  eggs/clutch, with mean X-ray egg width across all clutches (XREW)  $38.5 \pm 1.6$  mm, both of which were larger than what was observed at the Cottonwood study site (mean clutch size at Cottonwood over two years was  $3.8 \pm 1.4$  eggs/clutch and mean XREW across all clutches was  $36.5 \pm 1.6$  mm). There was a total of seven known clutches from three individual females, with two individual females producing second clutches only in 2017. In 2017, all three radioed females reproduced, while in the drought year of 2018, only two of four radioed females had visible shelled eggs. No second clutches were observed in 2018. It is possible we missed potential clutches in one female during both 2017 and 2018 as we could not capture her for periods of 28–35 days during the reproductive season. Mean annual egg

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<sup>a</sup> Not including two adult females (carapace lengths 23.7 and 25.4 cm) found on 3 April 2019 after our study ended.

production over both years was  $6.0 \pm 2.8$  eggs/tortoise/year, which was similar to what we observed at Cottonwood where females exhibited a mean AEP of  $6.0 \pm 3.8$  eggs/tortoise/year. First clutches of eggs were not visible on X-ray until 9 May in 2018, 14 days later than when they were first visible in 2017 on 25 April and a month later than when eggs were first visible on X-rays of females at Cottonwood over two years (13 April in 2015 and 6 April in 2016).

A total of 60 carcasses (17 males, 25 females, 2 juveniles, 16 unknowns; Table 5) were located in various stages of deterioration at the Orocopia study site (Table 1, Figure 6). Carcasses that we were unable to identify for sex or age class due to missing bones, disarticulation, or weathering were listed as unknowns. Some carcasses were very old, possibly more than 20 years since death, so the composition of sexes and age classes is spread across time beyond the scope of our study. Twenty-one of the carcasses had intact shells with scutes attached or peeling (4 males, 15 females, 1 juvenile, 1 unknown), suggesting death within the previous 4–5 years during the last extended drought that began in 2012. Even if death occurred as a result of predation during the drought, it is still scored as a drought-induced mortality due to the effect of “prey switching” that occurs during droughts (Figure 7; Lovich et al. 2014a). In total, there were 17 carcasses that showed evidence of predation and/or scavenging. The known adult sex ratio of the potential drought-related deaths was strongly biased toward females, and more of these female carcasses showed signs of predation and/or scavenging than male carcasses. We compared the sex ratios of living and recently deceased adult tortoises using Fisher’s exact test. We rejected the null hypothesis that sex ratios were independent of status (living vs. recently deceased) whether the two females serendipitously found in 2019 were excluded (Fisher’s exact test statistic = 0.0012,  $P < 0.01$ ), or included (Fisher’s exact test statistic = 0.0023,  $P < 0.01$ ).

#### *Additional sites for collection of genetic material*

The final genetics report will include samples provided to us from Anza Borrego Desert State Park, as well as samples we previously collected at Cottonwood Canyon and the Mesa wind farm (Lovich et al. 2017). In addition to the 13 blood samples collected at the Orocopia study site during our 2017–2018 study, seven DNA samples were also collected from the Santa Rosa Mountains, including tortoises that were opportunistically located at the Boyd Deep Canyon Desert Research Center property. Two live adult tortoises were marked and registered (1 male, 1 female; Table 2, Figure 4) in 2017 at the latter location. We were unable to obtain DNA samples from either of the tortoises (despite several attempts), perhaps due to dehydration. The male was re-located in 2018, and at least three other adult tortoises were observed in burrows, but we were unable to extract them. Additionally, five recently hatched juvenile tortoises were located, three of which were marked with nail clippers, and the resulting scute clips were used for DNA extraction (Table 3, Figure 4). The other two were left unmarked and no scute clips were taken because the lead biologist (JEL) was not present upon their capture, although they were temporarily marked with permanent marker on the carapace. At a nearby site in the Santa Rosa Mountains, we marked and registered one adult female tortoise located in a wash next to the Randall Henderson Trail in 2017. This tortoise was located with the help of trail cameras set



up by Colin Barrows of Friends of the Desert Mountains. A blood sample was obtained from this tortoise for DNA analysis (Table 3). Tortoises are often seen in the area by users of the trail, and some of these sightings are reported at the Santa Rosa and San Jacinto Mountains National Monument Visitor Center from where the trail begins. Both adult female tortoises captured at this southern end of the planning area were X-radiographed to assess for the presence of shelled eggs. Clutch sizes of two (Santa Rosas female) and five eggs (Deep Canyon female) were visible on the X-radiographs (Table 4), indicating reproduction was occurring in the tortoise populations in these areas.

In October 2017, our team recorded data on two juvenile tortoises brought in to The Living Desert Zoo and Gardens (Palm Desert, California) by local citizens. Both originated from the area around the Santa Rosa Mountains (a hatchling found crossing the Art Smith Trail and a yearling found in Homme Adams Park), but their exact locations of origin are unknown. Neither juvenile could be returned to the wild after being admitted into The Living Desert's rehab facility due to their policies. We took scute clips from each of these juveniles (Table 3) and sent them to the University of Southern Mississippi for DNA extraction, and the extracted DNA was then sent to UAGC for analysis.

Analyses of population genetics are currently underway. We are working with Taylor Edwards at the University of Arizona and Jeff Manning of Anza-Borrego Desert State Park to analyze the results from DNA samples in and around the Coachella Valley and Salton Trough, and those results will be included in a second final report addressing genetics. Preliminary results suggest that all samples have genetic characteristics that are expected for tortoises in the Sonoran Desert of California.

## Discussion

Tortoise densities in the eastern end of the CVMSHCP/NCCP area appear to be lower than expected according to habitat suitability modeling. Although the area within Shavers Valley is designated as Critical Habitat for *Gopherus agassizii*, aggregations at the Orocopia study site were few and densities were extremely low (22 tortoises located over an approximately 21 km<sup>2</sup> area equates to  $\approx 1$  tortoise per km<sup>2</sup>). It is possible that a density of one tortoise/km<sup>2</sup> is an underestimate of the tortoise density in the area despite ground truthing via transects. This is because of the severe drought conditions during the second year of the study which likely kept tortoise activity low and made tortoises more difficult to locate (Duda et al. 1999, Freilich et al. 2000). Another year of monitoring during conditions of good annual forage may help increase the number of tortoises located in the area since home ranges, above-ground activity, and burrow use all increase during wet years (Duda et al. 1999, Freilich et al. 2000). However, it is unlikely that estimated tortoise densities would greatly increase since multiple groups have found low live-tortoise densities in this area (see below).

In 2017, the U.S. Fish and Wildlife Service monitored tortoises within the much larger Chuckwalla Critical Habitat, including at the Orocopia study site, and located live adult tortoises (39 females, 50 males, 6 unknowns) and carcasses (16 adult females, 12 adult males), with only

one of these located within the bounds of the Orocopia study site. Their numbers also suggest a biased sex ratio of live males to females as well as higher mortality of females. We did not locate any of these previously registered U.S. Fish and Wildlife Service tortoises, but the low numbers found by them over the years support our conclusion of low densities at the Orocopia study site.

Across Interstate 10 at Cottonwood, we estimated tortoise densities at 5.9 tortoises/km<sup>2</sup> in 2015–2016. During this time, Cottonwood annually experienced greater production of food plants for tortoises. A comparable number of tortoises were located during the first year of this study (23 individuals) to the number of tortoises located during the first year of study at the Orocopia study site (21 individuals). However, a second year of good annual forage at Cottonwood led to the location of an additional 10 individual tortoises, whereas in the second year of study at the Orocopia study site when there was no new annual forage available, only one additional tortoise was located within a much larger study footprint. Cottonwood lies within the boundaries of Joshua Tree National Park which provides an additional level of protection for the tortoise population there. However, even the higher population density at Cottonwood was below previous estimates where Cottonwood was listed as a high-density site within the Park with 8–29 tortoises/km<sup>2</sup> (Karl 1988).

Reproduction is occurring at the Orocopia study site, as evidenced by seven clutches of eggs observed on X-radiographs of female tortoises over the two years of study. Shelled eggs were not visible until May in 2018, which was 2 weeks later than in 2017 and 4–5 weeks later than what we observed at the Cottonwood study site. It is possible that this delay was due to the drought conditions experienced in 2018. With no fresh annual forage produced in the spring of 2018, females may have required more time to build the energy reserves needed for producing eggs. However, female *G. agassizii* often enter brumation with enough energy stored for reproduction the following spring (Ennen et al. 2017). Appearance of clutches is also affected by heat-unit accumulation, with shelled eggs appearing later in cooler years relative to warmer years (Lovich et al. 2012). No second clutches were observed in 2018, but drought can limit reproduction in *G. agassizii* (Lovich et al. 1999, 2015; Wallis et al. 1999). Although clutch size and mean XREW were larger at the Orocopia study site than at Cottonwood, mean annual egg production was similar over both years. However, this statistic does include the drought year of 2018 in which annual egg production per tortoise was lower than in previous years. Additional years of study during both good and poor conditions are needed at the Orocopia study site to yield a larger sample size for analysis of reproductive output.

The number of shells located at the Orocopia study site that were attributed to death by drought in the previous five years (21 recent, 60 total shells) had a distinct sex ratio bias (4 males:15 females). The drought beginning in 2012 and lasting until 2016 was described as the worst in central and southern California in 1,200 years according to tree ring data (Griffin and Anchukaitis 2014). The number of tortoises that fit into the recently deceased category (21 shells) is nearly equal to the number of live tortoises located at the site (22 live tortoises).

High mortality was previously reported in the footprint of the proposed Paradise Valley townsite, located less than 10 km to the west of the Orocopia study site. Researchers found a

small number of live tortoises (10) compared to a large number of tortoise carcasses (123) in various stages of deterioration during surveys performed in April and May 2003 over an area of approximately 27 km<sup>2</sup> (Psomas 2003). A classification system using five categories of shell deterioration was used to assess each carcass, but these categories were not associated with estimated times of death (Psomas 2003). Just over 20 km to the north in the Pinto Basin of Joshua Tree National Park, a large number of shells compared to a small number of live tortoises were located during surveys performed in 2012 (Lovich et al. 2014a), and this die-off was attributed to effects of drought and predator prey-switching with low levels of estimated survival being coincident with low three-year moving average precipitation trends. It is likely that prey-switching occurred at the Orocopia study site during the extended drought as some shells were found to have bite/chew marks, but we are unable to determine whether this was due to predation or scavenging, or both. It is possible that declines in these tortoise populations of the Sonoran Desert of California are exacerbated by increasing climatic extremes in a low, hot, and dry area that is already near the southern edge of distribution for the species as predicted by Barrows (2011) and supported by Lovich et al. (2014a).

The strong adult female-biased mortality we observed is of great interest, especially since many appear to have died during the recent epic drought in California (2012–2016). Sex ratios in turtles vary due to the effects of five factors (Lovich and Gibbons 1990, Lovich 1996). First, sampling bias can result in the perception of skewed adult sex ratios. Given the fact that distance sampling transects conducted by the U.S. Fish and Wildlife Service in the Chuckwalla Unit of Critical Habitat (including our Orocopia Plot) observed an adult female carcass bias (see above) like we did, we believe that it is unlikely that our results were biased. Second, tortoises, like many turtles, have environmental sex determination with high incubation temperatures producing more female hatchlings and low incubation temperatures producing more males (Janzen 1994). Given concerns about global warming, some authors have suggested that turtle and tortoise populations may be incapable of producing males in the future (Hulin et al. 2009). However, this would potentially lead to an adult sex ratio opposite of what we observed (i.e., it would be female-biased).

The third possible explanation is differential age of maturity of the sexes, or bimaturism (Lovich et al. 2014b). Simply stated, the sex that matures earlier predominates in adult sex ratios assuming all other factors have little influence. Age of maturity largely determines adult size with little evidence for additional growth (Congdon et al. 2018). Adult male tortoises are larger than females, but sexual dimorphism is not pronounced. Male and female tortoises mature at approximately the same age, so it is unlikely that this would be a significant factor. The fourth reason adult sex ratios can be biased is the possible effect of differential immigration or emigration of one sex or the other. Since desert tortoises are not migratory animals and they typically have relatively small home ranges, it is unlikely that this affected our results.

The fifth, and most likely reason for the female-biased carcass sex ratio we observed is due to differential mortality. For some reason, it appears that females were more likely to die during the drought than males, whether by dehydration and starvation or by predation via “prey

switching” as detailed by Lovich et al. (2014a). If so, the question remains, why? Adult female tortoises are somewhat smaller, on average, than males so it is possible that they are more vulnerable to predation than males. Again, it was not possible for us to determine if carcasses that bore marks from teeth of carnivores were a result of predation, scavenging, or both. It is also possible that females are more susceptible to death by drought and starvation due to their smaller size and thus reduced ability to store water and nutrients. The upright orientation and location of many of the carcasses we found outside of their burrows is consistent with the behavior of tortoises dying from dehydration and starvation (Berry et al. 2002, Lovich et al. 2014a), although alternative explanations are possible (e.g., sex-biased mortality from disease). However, we found no evidence of shell disease, previously reported nearby (Jacobson et al. 1994), or obvious symptoms of upper respiratory tract disease (Jacobson et al. 2014) such as mucus exudate from the nares.

An alternative explanation for the sex-biased mortality we observed as a result of the lengthy drought relates to reproductive strategies. Tortoises have a “bet-hedging” reproductive strategy whereby females make a small reproductive “wager” every year (Ennen et al. 2017). Bet-hedging theory predicts that, if juvenile survival is low and unpredictable, organisms should consistently reduce short-term reproductive output to minimize the risk of reproductive failure in the long-term (Lovich et al. 2015). By producing relatively small single or multiple clutches that are spatially and temporally isolated (Lovich et al. 2014c, 2015), female tortoises reduce the risk of reproductive failure in any one year. Since female tortoises cannot predict the environmental conditions that hatchlings will encounter when they hatch 74–100 days after oviposition (Ennen et al. 2012), females further hedge their bets by rarely skipping even bad years to reproduce. They do that even in drought years, as noted by Ernst and Lovich (2009),

“...by relaxing their control of energy and water homeostasis. Energy does not limit egg production directly, but it is likely that protein and water availability are limiting factors. As expected, females that forgo opportunities to reproduce in dry years store more body nonlipid energy and lose less body water than those that do. In fact, females’ reproductive effort (measured as the amount of energy allocated to reproduction divided by the amount of energy needed for all vital expenditures) is greater during a drought year than during a wet year, because females have the ability to reduce their field metabolic rates 70–90% during a drought. The strategy of sacrificing the condition of their bodies to produce a few eggs is consistent with a life history strategy called bet hedging. Under this strategy, tortoises do not skip opportunities to reproduce under poor conditions but rather continue to try to produce some eggs every year (Henen 1997, 2002).”

Over the long reproductive lifespan of a tortoise, it is likely that their bet hedging strategy will pay off with offspring that survive to reproduce in the next generation. It is possible that bet-

hedging female tortoises continued to “bet” that the next year would yield good forage and precipitation, only to run out of stored resources necessary for their own survival. Given the prolonged severity of the drought, and the fact that it was the worst in over 1,000 years, it would be hard for a tortoise population to adapt to that kind of event. We had at least one tortoise that did not reproduce in 2018, although we only had a single year of data for her, so we cannot definitively say that she was capable of reproducing. There were two females that produced two clutches each in 2017, and then each produced only a single clutch in 2018. It is possible that they ran out of resources to produce a second clutch in 2018. It is also possible that female tortoises experienced greater mortality during the drought than did males because females sacrificed protein and water stores to produce small clutches of eggs almost every year.

Modelling shows that population growth of desert tortoises is most sensitive to the survival of large adult females (Doak et al. 1994). Given the high mortality (especially adult females) and low density of living tortoises we and others (e.g., U.S. Fish and Wildlife Service and Paradise Valley surveyors) observed at or near the study site, the viability of the population is not necessarily assured. The location of a single juvenile (approximately four years old) and one subadult male indicate that some recruitment has occurred in the population during the last several years, but further monitoring would be required to determine if there is enough recruitment occurring to offset mortality in the population.

Continued monitoring, especially during years of good annual forage, would allow for a better assessment of the population and will be necessary to determine whether the tortoise population at the Orocopia study site is stable or declining. With climatic extremes becoming more prevalent, extended periods of drought will continue to affect tortoise survival, reproduction, and recruitment in the area. This study site provides a good comparison to the Cottonwood study site across Interstate 10 as an area that is more impacted by anthropogenic activities (especially off-highway vehicles) than Cottonwood which has additional protections within Joshua Tree National Park. The establishment of study plots at both the Cottonwood and Orocopia sites yielded baseline data that will be a starting point for long-term monitoring of tortoise populations in an area of the Sonoran Desert where tortoise populations have been poorly studied (Lovich et al. 2018). These baseline data are vital to determining how the demography and health of the tortoise populations in the eastern end of CVMSHCP area endure in the face of a changing environment and how the species should be managed for its recovery.

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## **Literature Cited**

- Allison LJ, Mcluckie AM. 2018. Population trends in Mojave desert tortoises (*Gopherus agassizii*). *Herpetological Conservation and Biology* 13:433–452.
- Barrows CW. 2011. Sensitivity to climate change for two reptiles at the Mojave–Sonoran Desert interface. *Journal of Arid Environments* 75:629–635.
- Berry KH. 1984. The status of the desert tortoise (*Gopherus agassizii*) in the United States. Report to U.S. Fish and Wildlife Service, 866 pages.
- Berry KH. 1986. Incidence of gunshot deaths in desert tortoise populations in California. *Wildlife Society Bulletin* 14:127–132.
- Berry KH, Spangenberg EK, Homer BL, Jacobson ER. 2002. Deaths of desert tortoises following periods of drought and research manipulation. *Chelonian Conservation and Biology* 4:436–448.
- Cagle FR. 1939. A system of marking turtles for future identification. *Copeia* 1939:170–173.
- Congdon JD, Nagle RD, Kinney OM. 2018. Front-loading life histories: the enduring influence of juvenile growth on age, size, and reproduction of primiparous female freshwater turtles. *Evolutionary Ecology Research* 19:353–364.
- Doak D, Kareiva P, Klepetka B. 1994. Modeling population viability for the desert tortoise in the western Mojave Desert. *Ecological Applications* 4:446–460.
- Dodd CK. 1995. Disarticulation of turtle shells in north-central Florida: how long does a shell remain in the woods? *The American Midland Naturalist Journal* 134:378–387.
- Duda JJ, Krzysik AJ, Freilich JE. 1999. Effects of drought on desert tortoise movement and activity. *The Journal of Wildlife Management* 63:1181–1192.

- Ennen JR, Lovich JE, Averill-Murray RC, Yackulic C, Agha M, Loughran C, Tennant L, Sinervo B. 2017. The evolution of different maternal investment strategies in two closely related desert vertebrates. *Ecology and Evolution* 7:3177–3189.
- Ennen JR, Lovich JE, Meyer K, Bjurlin C, Arundel TR. 2012. Nesting ecology of a desert tortoise (*Gopherus agassizii*) population at a utility-scale renewable energy facility in southern California. *Copeia* 2012:222–228.
- Ernst CH, Lovich JE. 2009. Turtles of the United States and Canada. Second Edition. Johns Hopkins University Press. Baltimore. 827 pp.
- Freilich JE, Burnham KP, Collins CM, Garry CA. 2000. Factors affecting population assessments of desert tortoises. *Conservation Biology* 14:1479–1489.
- Griffin D, Anchukaitis KJ. 2014. How unusual is the 2012–2014 California drought? *Geophysical Research Letters* 41:9017–9023.
- Henderson RA, Puffer SR, Lovich JE. 2016. *Gopherus agassizii* (Mohave Desert Tortoise). Nest depredation. *Herpetological Review (Natural History Notes)* 47(3):446–447.
- Henen BT. 1997. Seasonal and annual energy budgets of female desert tortoises (*Gopherus agassizii*). *Ecology* 78:283–296.
- Henen BT. 2002. Reproductive effort and reproductive nutrition of female desert tortoises: essential field methods. *Integrative and Comparative Biology* 42:43–50.
- Henley DC. 2000. The Land that God Forgot: The Saga of Gen. George Patton's Desert Training Camps. Western American History Series. Fourth printing and revision. 54 pp.
- Hernandez-Divers SM, Hernandez-Divers SJ, Wyneken J. 2002. Angiographic, anatomic, and clinical technique descriptions of a subcarapacial venipuncture site for chelonians. *Journal of Herpetological Medicine and Surgery* 12:32–37.
- Hinton TG, Fledderman P, Lovich J, Congdon J, Gibbons JW. 1997. Radiographic determination of fecundity: Is the technique safe for developing turtle embryos? *Chelonian Conservation and Biology* 2:409–414.
- Hulin V, Delmas V, Girondot M, Godfrey MH, Guillon JM. 2009. Temperature-dependent sex determination and global change: are some species at greater risk? *Oecologia* 160:493–506.
- Jacobson ER, Brown MB, Wendland LD, Brown DR, Klein PA, Christopher MM, Berry KH. 2014. Mycoplasmosis and upper respiratory tract disease of tortoises: a review and update. *The Veterinary Journal* 201:257–264.



- Jacobson ER, Wronski TJ, Schumacher J, Reggiardo C, Berry KH. 1994. Cutaneous dyskeratosis in free-ranging desert tortoises, *Gopherus agassizii*, in the Colorado Desert of southern California. *Journal of Zoo and Wildlife Medicine* 25:68–81.
- Janzen FJ. 1994. Climate change and temperature-dependent sex determination in reptiles. *Proceedings of the National Academy of Science* 91:7487–7490.
- Karl AE. 1988. Investigations of the status of the desert tortoise, *Gopherus agassizii*, in Joshua Tree National Monument. Cooperative National Park Resources Studies Unit, University of Nevada, Las Vegas. Report number 040/02. pp. 1–61+ Appendices.
- Lathrop EW. 1983. Recovery of perennial vegetation in military maneuver areas. Pages 265–277 *in* Environmental Effects of Off-road Vehicles: Impacts and Management in Arid Regions (RH Webb, HG Wilshire, eds.). Springer-Verlag, New York.
- Lovich JE. 1996. Possible demographic and ecologic consequences of sex ratio manipulation in turtles. *Chelonian Conservation and Biology* 2:114–117.
- Lovich JE, Bainbridge D. 1999. Anthropogenic degradation of the southern California desert ecosystem and prospects for natural recovery and restoration. *Environmental Management* 24:309–326.
- Lovich JE, Ennen JR. 2013. A quantitative analysis of the state of knowledge of turtles of the United States and Canada. *Amphibia-Reptilia* 34:11–23.
- Lovich JE, Gibbons JW. 1990. Age at maturity influences adult sex ratio in the turtle *Malaclemys terrapin*. *Oikos* 59:126–134.
- Lovich JE, Agha M, Meulblok M, Meyer K, Ennen J, Loughran C, Madrak S, Bjurlin C. 2012. Climatic variation affects clutch phenology in Agassiz's desert tortoise *Gopherus agassizii*. *Endangered Species Research* 19:63–74.
- Lovich JE, Agha M, Yackulic CB, Meyer K, Bjurlin C, Ennen JR, Arundel TR, Austin M. 2014c. Nest site characteristics, nesting movements, and lack of long-term nest site fidelity in Agassiz's desert tortoises (*Gopherus agassizii*) at a wind energy facility in southern California. *California Fish and Game* 100:404–416.
- Lovich JE, Edwards TE, Kreiser B, Puffer SR, Agha M. 2017. A preliminary report on genetic affinities and relatedness of Agassiz's desert tortoises (*Gopherus agassizii*) at opposite ends of the Coachella Valley in California. U.S. Geological Survey Cooperators Report (Final report to the Coachella Valley Conservation Commission). 16 pp.
- Lovich JE, Ennen JR, Yackulic CB, Meyer-Wilkins K, Agha M, Loughran C, Bjurlin C, Austin M, Madrak S. 2015. Not putting all their eggs in one basket: bet-hedging despite

- extraordinary annual reproductive output of desert tortoises. *Biological Journal of the Linnean Society* 115:399–410.
- Lovich JE, Gibbons JW, Agha M. 2014b. Does the timing of attainment of maturity influence sexual size dimorphism and adult sex ratio in turtles? *Biological Journal of the Linnean Society* 112:142–149.
- Lovich JE, Medica P, Avery H, Meyer K, Bowser G, Brown A. 1999. Studies of reproductive output of the desert tortoise at Joshua Tree National Park, the Mojave National Preserve, and comparative sites. *Park Science* 19:22–24.
- Lovich JE, Puffer SR. 2017. Developing an effective Agassiz's desert tortoise monitoring program. Final report to the Coachella Valley Conservation Commission. U.S. Geological Survey Cooperators Report. 26 pp.
- Lovich JE, Puffer SR, Agha M, Ennen JR, Meyer-Wilkins K, Tennant LA, Smith AL, Arundel TR, Brundige KD, Vamstad MS. 2018. Reproductive output and clutch phenology of female Agassiz's desert tortoises (*Gopherus agassizii*) in the Sonoran Desert region of Joshua Tree National Park. *Current Herpetology* 37(1):40–57.
- Lovich JE, Yackulic CB, Freilich J, Agha M, Austin M, Meyer KP, Arundel TR, Hansen J, Vamstad MS, Root SA. 2014a. Climatic variation and tortoise survival: has a desert species met its match? *Biological Conservation* 169:214–224.
- Prose DV. 1985. Persisting effects of armored military maneuvers on some soils of the Mojave Desert. *Environmental Geology and Water Sciences* 7:163–170.
- Prose DV, Metzger SK. 1985. Recovery of soils and vegetation in World War II military base camps, Mojave Desert. US Geological Survey. Open File Report 85-234, 114 pp.
- Psomas. 2003. Paradise Valley: Desert tortoise presence/absence and zone of influence surveys, Shavers Valley, Riverside County, California. Final report prepared for Glorious Land Company, California.
- Smith AL, Puffer SR, Lovich JE, Tennant LA, Arundel TR, Vamstad MS, Brundige KD. 2016. A potential predator-prey interaction of an American badger and an Agassiz's desert tortoise with a review of badger predation on turtles. *California Fish and Game* 102(3):131–144.
- Smith AL, Tennant LA, Lovich JE, Arundel TR. 2015. *Gopherus agassizii* (Agassiz's Desert Tortoise). Mechanical Injury. *Herpetological Review (Natural History Notes)* 46(3):423–424.
- Turtle Conservation Coalition [Stanford CB, Rhodin AGJ, van Dijk PP, Horne BD, Blanck T, Goode EV, Hudson R, Mittermeier RA, Currylow A, Eisemberg C, Frankel M, Georges

A, Gibbons PM, Juvik JO, Kuchling G, Luiselli L, Shi H, Singh S, Walde A (eds.)]. 2018. Turtles in Trouble: The World's 25+ Most Endangered Tortoises and Freshwater Turtles–2018. Ojai, CA: IUCN SSC Tortoise and Freshwater Turtle Specialist Group, Turtle Conservancy, Turtle Survival Alliance, Turtle Conservation Fund, Chelonian Research Foundation, Conservation International, Wildlife Conservation Society, and Global Wildlife Conservation, 80 pp.

Wallis IR, Henen BT, Nagy KA. 1999. Egg size and annual egg production by female desert tortoises (*Gopherus agassizii*): the importance of food abundance, body size, and date of shelling. *Journal of Herpetology* 33:394–408.

**Table 1.** Classification system for estimated time since death of *Gopherus agassizii* carcasses, including decomposition descriptions. Table adapted from criteria described by Berry (1984) and Dodd (1995).

Shell decomposition rating	Decomposition description	Estimated time since death
A	Fresh carcass, viscera still attached. All scutes attached with no fading, curling, or seam detachment as would be on live tortoise (unless removed or damaged by predator). Bone shiny, not visibly porous, as would be on live tortoise.	couple weeks
B	Shell intact. Fresh viscera no longer attached but may still have dried skin attached. Scutes are shiny, not faded or curling, minimal separation at seams or from shell, appear as on a live tortoise. No weathering of carapace. Bone appears as on a live tortoise, solid and smooth with a shine and no visible roughness or porousness. May have a brown hue if just separated from scutes.	< 1–2 years
C	Shell intact. More than 50% scutes still on shell (unless disturbed by predator). Scutes fading, lack shine, growth lamina starting to peel away from bone. Bone is dull in color and rough, starting to peel, crack, or chip off.	2–4 years
D	Shell intact but may be developing suture cracks. Less than 50% scutes still on shell. Attached scutes may be curling/peeling, loose, or brittle. Bone is pitted and porous.	> 4 years
E	Shell intact with suture cracks widening. Few or no scutes remaining on shell, although scutes still present on ground. Bone is chalky white.	> 4 years
F	Shell disarticulating but still partially intact. Few or no scutes present on ground. Bone is chalky white, possibly pinkish color. Bone becoming brittle and sometimes crushed between fingers.	> 4 years
G	Shell completely disarticulated, in pieces on ground. Few or no scutes present on ground. Bones bleached.	> 4 years

**Table 2.** Data summary for all tortoises captured and registered within the Coachella Valley Multiple Species Habitat Conservation Plan area in 2017–2018\*. Site abbreviations are as follows: DC = Boyd Deep Canyon Desert Research Center, SR = Santa Rosa Mountains, and OM = Orocopia study site. For ID number, UNM = unmarked, and IMM = immature marked with nail clippers. M = male, F = female, J = juvenile. Straight-line carapace lengths listed indicate the most recent measurement. Weights of tortoises with radio transmitters attached include the weight of a 15 g radio and approximately 10 g of epoxy. All radios were removed by August 2018.

Site	ID no.	Sex	Date of first capture	Date of last capture	No. captures	Straight-line carapace length (cm)	Weight (g)	Radio (Y/N)	Notes
DC	1	F	05/10/17	05/10/17	1	24.5	3350	N	
DC	2	M	10/19/17	04/25/18	1	28.2	4300	N	Gular is broken and worn down to a nub.
DC	UNM 1	J	04/25/18	05/24/18	2	4.9	34	N	Near-yearling. Marked with permanent ink.
DC	IMM 2	J	05/24/18	08/29/18	2	4.6	22	N	Near-yearling. Took scute clips for DNA.
DC	UNM 3	J	05/24/18	05/24/18	1	4.6	31	N	Near-yearling. Marked with permanent ink.
DC	IMM 4	J	08/29/18	08/29/18	1	4.8	25	N	Near-yearling. Took scute clip for DNA.
DC	IMM 5	J	08/29/18	08/29/18	1	4.5	24	N	Near-yearling. Took scute clip for DNA.
SR	3	F	06/22/17	06/22/17	1	23.7	2575	N	Found in wash just off Randall Henderson Trail.
OM	32	M	02/15/17	03/29/17	5	24.6	3100	Y	Initially attached a transmitter but removed it after tortoise made a movement > 1.5 km and became difficult to track.
OM	33	M	02/16/17	06/20/18	30	29.6	3750	Y	
OM	34	F	02/16/17	07/10/18	28	24.5	2900	Y	
OM	35	M	03/01/17	06/20/18	28	30.5	4300	Y	
OM	36	J	03/01/17	03/13/17	2	8.8	168	N	Juvenile with four growth annuli.
OM	37	M	03/13/17	06/05/18	24	23.4	2450	Y	Exfoliation occurring on vertebral scutes.
OM	38	M	03/14/17	03/14/17	1	18.7	1400	N	Subadult male.
OM	39	M	03/14/17	06/05/18	24	28.2	3125	Y	Initially found underneath vehicle while performing a “tortoise check”.
OM	40	F	03/15/17	08/28/18	28	22.7	2300	Y	Initially found copulating with tortoise #35.
OM	41	F	03/29/17	03/29/17	1	23.2	2450	N	
OM	42	M	03/29/17	03/29/17	1	30.5	5300	N	
OM	43	M	03/29/17	05/10/18	20	24.1	2450	Y	Second left marginal scute has a tooth mark that goes to the bone.
OM	44	M	05/09/17	05/09/17	1	26.4	4000	N	
OM	45	F	05/09/17	07/11/18	26	24.5	2375	Y	
OM	46	M	05/09/17	05/09/17	1	22.5	2775	N	Initially found crossing the Red Canyon Jeep Trail.

OM	47	M	05/10/17	08/22/17	2	29.2	5450	N	Posterior carapace is very flared.
OM	48	M	08/22/17	08/22/17	1	29.8	4550	N	
OM	49	M	10/20/17	10/20/17	1	28.2	3600	N	
OM	50	M	10/20/17	04/23/18	3	24.1	2775	N	Initially found cohabitating in a burrow with tortoises #39 and #51.
OM	51	F	10/20/17	07/10/18	15	21.8	1375	Y	Initially found cohabitating in a burrow with tortoises #39 and #50.
OM	52	M	11/16/17	12/18/17	3	27.5	3200	N	Gular curved strongly upward.
OM	53	M	01/18/18	01/18/18	1	25.6	2640	N	Damaged nails on right front foot – only one nail intact.

\*Does not include two adult females (IDs #54 and #55) located on 3 April 2019 after our study ended

**Table 3.** Data summary of blood collection from tortoises captured within the Coachella Valley Multiple Species Habitat Conservation Plan area in 2017–2018. No blood samples were collected in 2018, but scute clips were obtained for DNA extraction. Samples were sent to the University of Arizona Genetics Core for analysis. Site abbreviations are as follows: SR = Santa Rosa Mountains, LDZ = The Living Desert Zoo, DC = Boyd Deep Canyon Desert Research Center, OM = Orocopia study site. Wild juvenile tortoises marked with nail clippers are denoted with “IMM” before the ID number.

Site	ID No.	Date	Sex	Volume (mL)
SR	3	06/22/17	F	0.5
LDZ	036	10/19/17	J	scute clip
LDZ	038	10/19/17	J	scute clip
DC	IMM 2	08/29/18	J	scute clip
DC	IMM 4	08/29/18	J	scute clip
DC	IMM 5	08/29/18	J	scute clip
OM	32	03/29/17	M	0.5
OM	33	03/27/17	M	0.5
OM	34	04/10/17	F	0.4
OM	35	03/27/17	M	0.5
OM	37	03/27/17	M	0.5
OM	39	04/10/17	M	0.5
OM	40	03/27/17	F	0.1
OM	41	03/29/17	F	0.5
OM	43	04/10/17	M	0.5
OM	44	05/09/17	M	0.4
OM	45	05/09/17	F	0.3
OM	50	10/20/17	M	0.5
OM	51	10/20/17	F	0.3



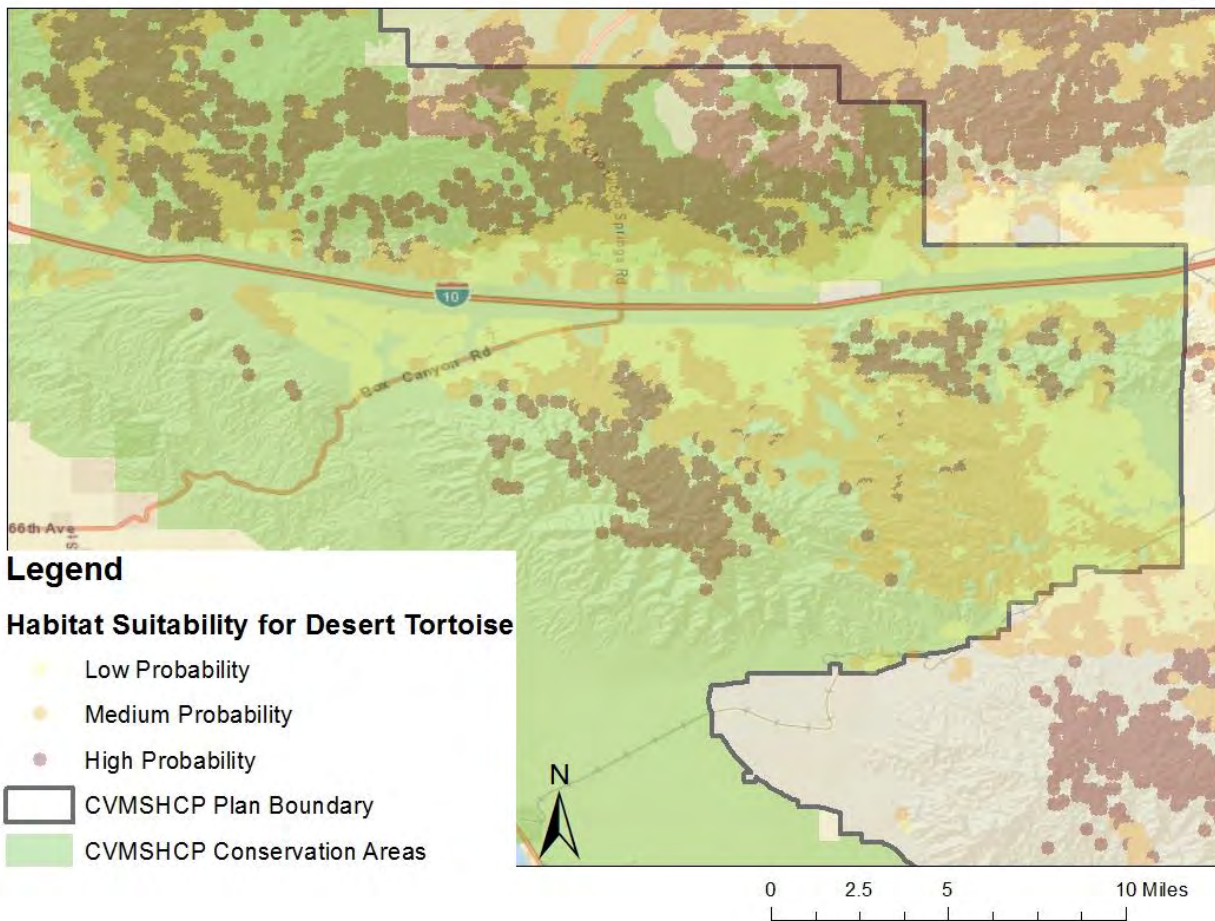
**Table 4.** Clutch sizes for female Agassiz's desert tortoises captured and X-radiographed within the Coachella Valley Multiple Species Habitat Conservation Plan area. Site abbreviations are as follows: SR = Santa Rosa Mountains, DC = Boyd Deep Canyon Desert Research Center, OM = Orocopia study site. Dashes indicate no data available.

Site	ID	Year	Size 1 <sup>st</sup> Clutch	Size 2 <sup>nd</sup> clutch	Notes
DC	1	2017	5	-	X-rayed one time on 05/10/17. Unable to determine if this was a first or second clutch.
SR	3	2017	2	-	X-rayed one time on 06/22/17. Unable to determine if this was a first or second clutch.
OM	34	2017	5	5	
		2018	4	0	No occurrence of second clutch.
OM	40	2017	5	3	
		2018	4	0	No occurrence of second clutch
OM	45	2017	4	-	Unable to extract tortoise from burrow and may have missed the visibility of a second clutch.
		2018	-	-	Unable to extract tortoise from burrow on multiple occasions and may have missed clutch visibility.
OM	51	2018	0	0	No occurrence of any clutches

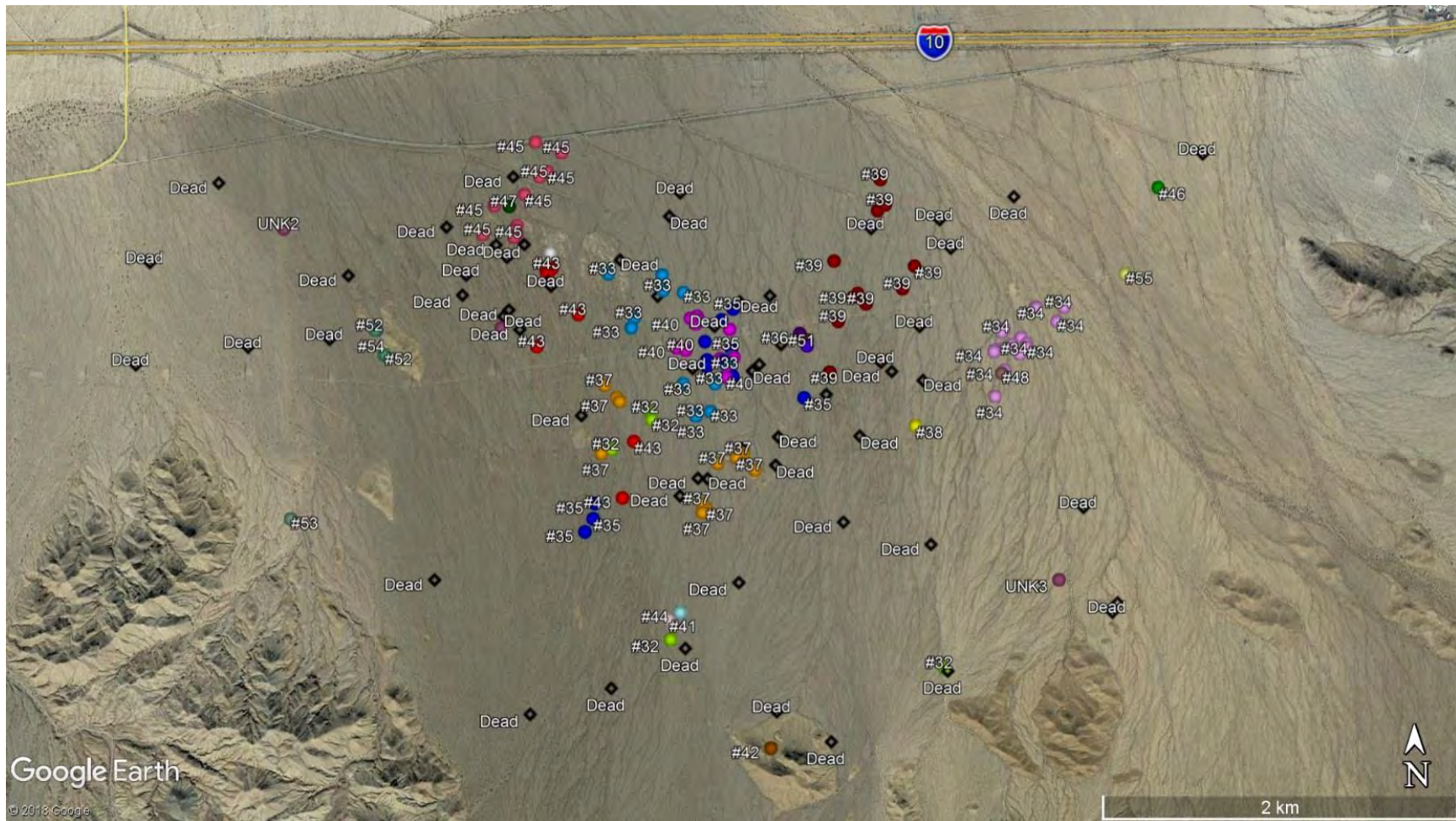
**Table 5.** Summary of all carcasses located during 2017–2018 at the Orocopia study site. Carcasses were assessed for approximate time of death according to their state of decomposition and deterioration (see Table 1 for descriptions of decomposition categories). Shells which were still intact (not yet disarticulating but may be starting to separate at sutures) and had scutes attached were assigned an estimated time of death within the last five years, which would be 2012 at the earliest, the same year in which the epic drought in California began. Carcasses were broken down into two categories: death pre-drought (died prior to the beginning of the 2012 drought) and death during drought (died sometime during the epic drought that began in 2012 and lasted until 2016). No carcasses fit into the category of death post-drought (died after 2016).

<b>Sex</b>	<b>Death pre-drought</b>	<b>Death during drought</b>	<b>Total</b>
Male	13	4	17
Female	10	15	25
Juvenile	1	1	2
Unknown	15	1	16
<b>Total</b>	<b>39</b>	<b>21</b>	<b>60</b>

**Figure 1.** Habitat Suitability Model for desert tortoise in the eastern Coachella Valley Multiple Species Habitat Conservation Plan Desert Tortoise and Linkage Conservation Area (data as used in Barrows 2011).



**Figure 2.** Map depicting the Orocopa study site on the northern versant of the Orocopa Mountains at the east end of the CVMSHCP area. The site is located approximately 80 km to the east of Palm Springs and just southwest of Chiriaco Summit, California. Points on map are labeled with registered tortoise identification numbers (see Table 2 for reference). Each color represents an individual tortoise. Tortoises which were seen in burrows but could not be extracted are labeled as unknowns “UNK”. Black diamonds are labeled “Dead” and represent tortoise carcasses. Some points may overlap. Points include two females found in 2019 (IDs #54 and #55), outside of the time of the main study. Map created using Google Earth.

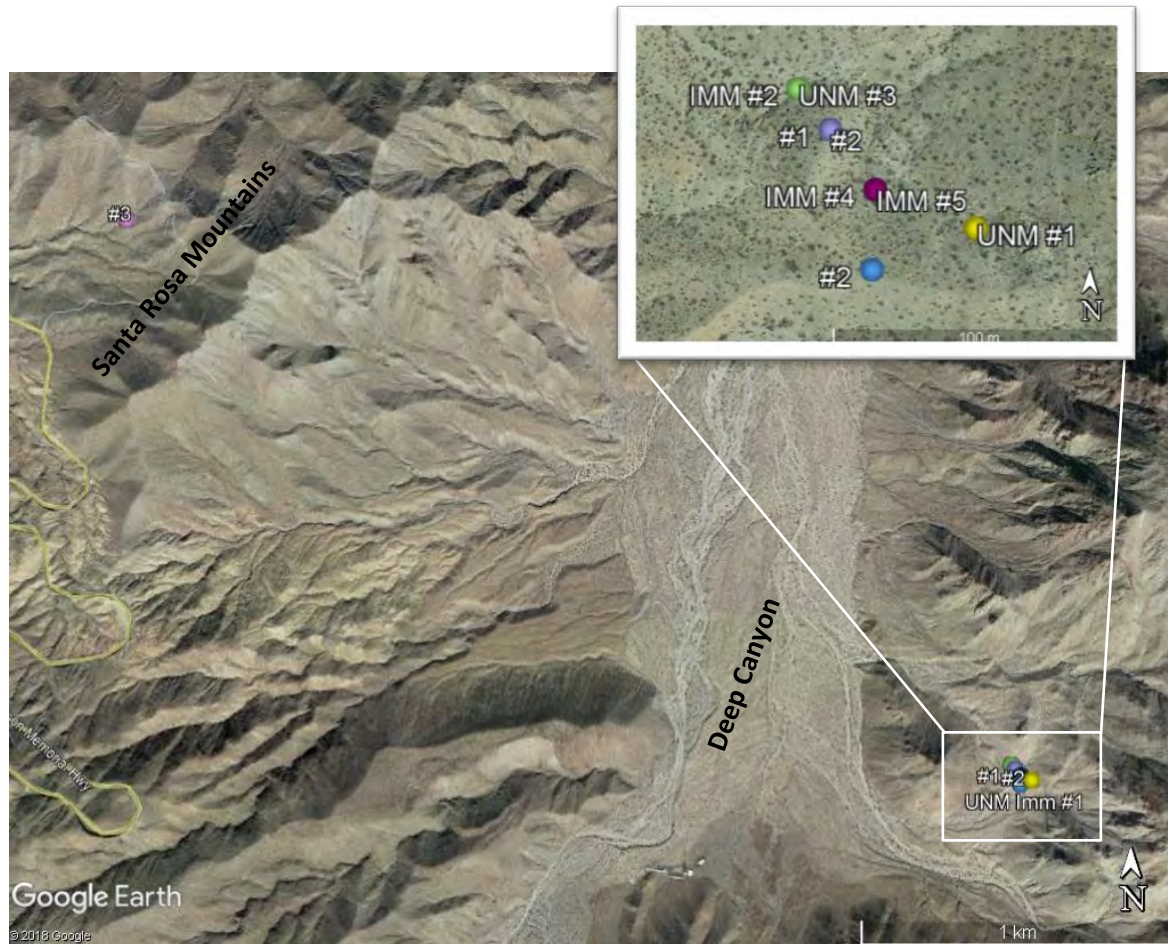




**Figure 3.** Map depicting locations of systematic transects performed at the Orocopia study site approximately 80 km to the east of Palm Springs and just southwest of Chiriaco Summit, California. Map created using Google Earth.

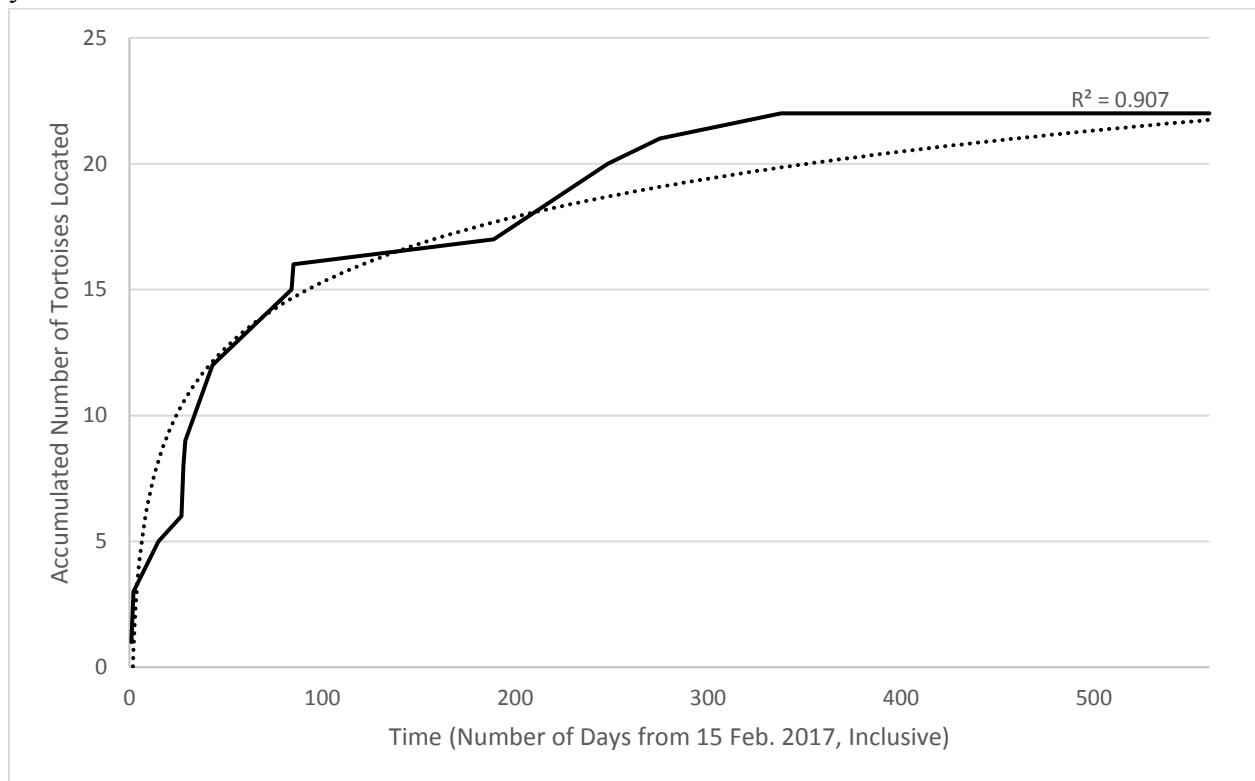


**Figure 4.** Map depicting the study sites located in and around the Santa Rosa Mountains near the southern end of the CVMSHCP area, near Palm Desert, California. Points on map are labeled with registered tortoise identification numbers (see Table 2 for reference). Each color represents an individual tortoise. Some points may overlap. Map created using Google Earth.





**Figure 5.** Frequency accumulation curve of the number of tortoises located over time at the Orocopia study site. Time is measured in days from the first day spent surveying for desert tortoises at the site (15 February 2017, inclusive) to the last day when the final radio was removed from a tortoise (28 August 2018), a span of 560 days. The logarithmic curve (trendline of best fit applied to the data) indicates that the number of new tortoises located over time tapered off significantly following the first year of study. This would normally suggest that more time spent at the study site would not continue to yield additional new tortoises. However, 2018 was not a good year to locate tortoises due to drought conditions. Following below average winter precipitation, no annual plant germination occurred at the study site, and it remained dry throughout the tortoise activity season. Tortoises appeared to be less active than during the prior year.





**Figure 6.** Photographs of carcasses exemplifying assigned categories of decomposition and disintegration based on combined criteria for aging tortoise remains as given in Dodd (1995) and Berry (1984) (see Table 1 for decomposition category descriptions). Photos are assigned to categories as follows: (6a) Category B: dead < 1–2 years, shell intact, scutes attached; (6b) Category C: dead 2–4 years, shell intact, more than 50% scutes still attached; (6c) Category D: dead > 4 years, bone developing suture separation; (6d) Category E: dead > 4 years, suture separations widening; (6e) Category F: dead > 4 years, shell is disarticulating, partially intact; (6f) Category G: dead > 4 years, shell is completely disarticulated and bone is weathered.

6a



6b



6c



6d



6e



6f





**Figure 7.** Example of a carcass that was assigned to the “death during drought” category that had evidence of biting and chewing from predation and/or scavenging. Even if death occurred as a result of predation during the drought, it is still scored as a drought-induced mortality due to the effect of “prey switching” that occurs during droughts (Lovich et al. 2014a).



Appendix XIII-  
Crissal Thrasher Surveys in the Coachella  
Valley  
2019

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Crissal Thrasher, One Hundred Palms, Coachella Valley, 2015. Photo credit Matt Grube.

## Crissal Thrasher Surveys in Coachella Valley 2019

November 1, 2019

*Prepared for:*

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## Introduction

The Crissal Thrasher (*Toxostoma crissale*) is a California Species of Special Concern (Fitton 2008), and is a covered species in the Coachella Valley Multiple Species Habitat Conservation Plan/Natural Communities Conservation Plan. This species historically occurred throughout the Coachella Valley from Mecca up to Palm Springs (Gilman 1902, Grinnell 1904), but is now thought to be extirpated from latter locale. Gilman (1902) stated that “great numbers of them can be found in the dense thickets of mesquite and screw-bean in the depressed portion of the desert near the Salton Sink... towns- Indio, Thermal and Walters [Mecca]... Toros, Martinez, and Agua Dulce- near all these places the mesquite and screw-bean make great thickets and the crissal thrasher is at home.” However, the thrasher has declined in these areas due to conversion of the habitat into agriculture (Patten et al. 2003). Crissal Thrashers utilize vegetation composed of mesquite (*Prosopis glandulosa*), arrow weed (*Pluchea sericea*), saltbush (*Atriplex* spp.), and other dense undergrowth (Cody 1999), including shrubby Joshua Tree woodland in the Mojave desert (SDNHM unpublished). Crissal Thrashers have also been known to occupy tamarisk (*Tamarix* spp.) thickets in some locations (Hunter et al. 1988). The species typically nests low in mesquite thickets (Gilman 1902, Hanna 1933). In Arizona Crissal Thrashers inhabit foothill and montane chaparral and juniper habitats (Corman and Wise-Gervais 2015), but in California, probably due to the presence of California Thrashers (*Toxostoma redivivum*) in these habitats, Crissal Thrashers are restricted to desert locales. This species is notoriously cryptic and shy, which makes detection difficult. Multiple visits to occupied habitat are often required to confirm presence.

Surveys for the Crissal Thrasher were conducted in 2014 by the Coachella Valley Conservation Commission (CVCC 2014). Surveys were restricted to Dos Palmas and the southern Whitewater Channel. Sixty points were visited three times, and Crissal Thrashers were detected at eight points. Habitats used by Crissal Thrashers at Dos Palmas were found to be consistent with those previously identified, including mesquite, arrow weed, and saltbush alliances, but also California fan palm (*Washingtonia filifera*), blue palo verde (*Parkinsonia florida*), and catclaw acacia (*Acacia greggii*) alliances at some sites. At the Whitewater Channel, tamarisk was present, and mesquite lacking, at all sites where Crissal Thrashers were detected. This reflects a lack of mesquite in the disturbed channel, and some flexibility in Crissal Thrasher’s ability to utilize fast growing tamarisk in disturbed habitats.

The focus of the 2019 survey effort was to further document Crissal Thrasher presence and habitat usage throughout a wider portion of the Coachella Valley (Figure 1), in conjunction with concurrent surveys for the LeConte’s Thrasher throughout the valley (Hargrove et al. 2019). Priorities for the 2019 surveys included:

1. Survey of the Crissal Thrasher at a broader scale in than in 2014, to encompass a wider area at the price of fewer repetitions. Surveys include area searches of the Dos Palmas Conservation Area, Coachella Valley Stormwater Channel and Delta Conservation Area, and native scrub remaining between Mecca and Indio.
2. Description of vegetation at the sites of Crissal Thrasher detections if the number is sufficient for quantitative analysis of differences between points of detection and points of nondetection.
3. Compare use of conserved and of nonconserved habitat.
4. On the basis of survey results, recommend further improvements for future surveys of the Crissal Thrasher in the Coachella Valley.
5. Identify and prioritize sites suitable for habitat restoration likely to benefit the Crissal Thrasher.



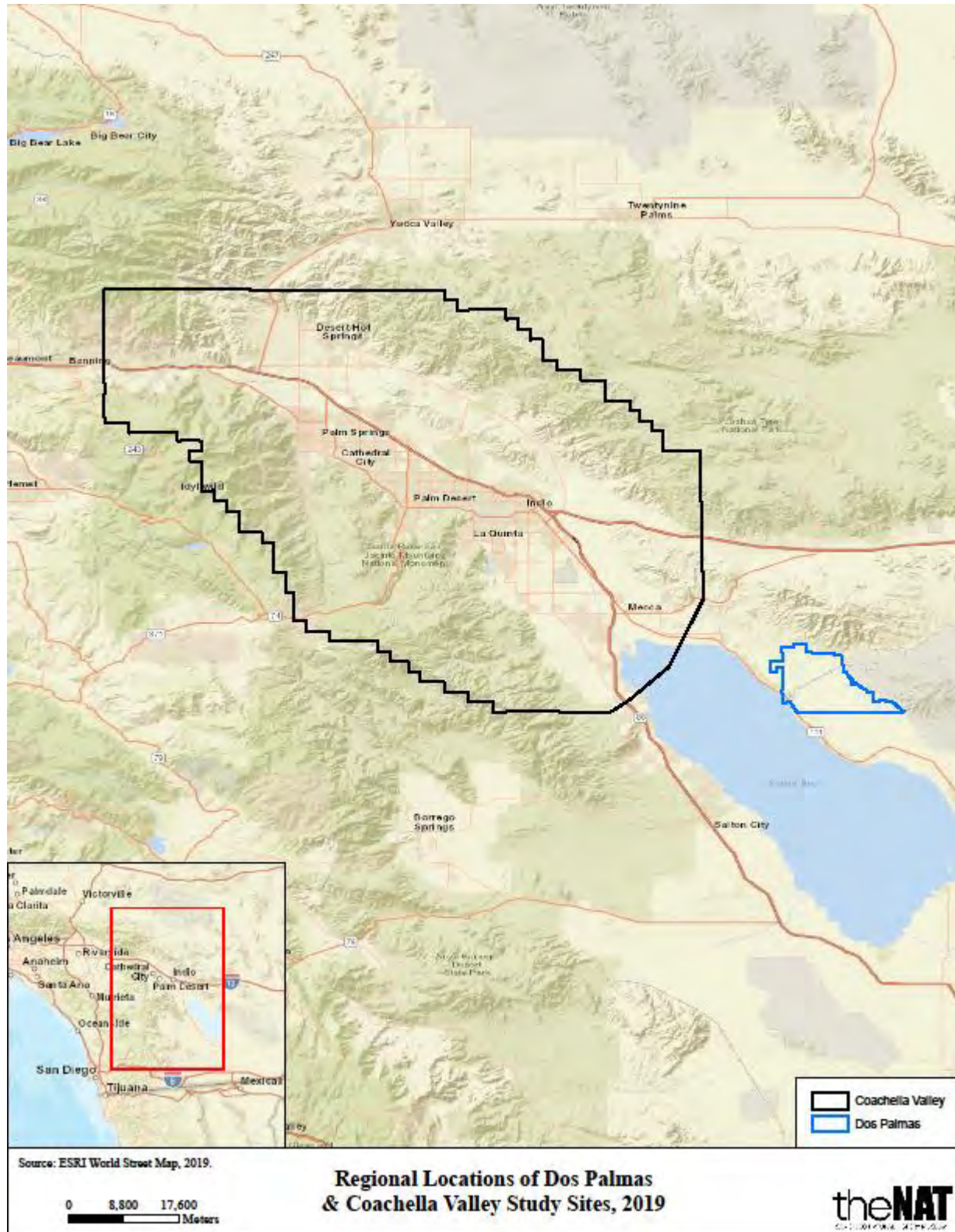


Figure 1. Regional location of Coachella Valley MSHCP boundary and Dos Palmas Preserve.



## Methods

Surveys were conducted concurrently with ongoing surveys for LeConte's Thrashers in the Coachella Valley in 2019 (Hargrove et al. 2019). Methods followed the protocol established for Crissal Thrashers in the valley (Coachella Valley Conservation Commission 2014). Survey sites were selected based upon past reports of occupancy (e.g. eBird, iNaturalist), or the presence of suitable habitat such as mesquite or other dense undergrowth as described above. A total of twelve sites were surveyed in 2019 (Table 1). Survey methods included point counts using song playback at approximately 250 m intervals. At most sites the small extent of the habitat patch restricted the survey to a single point. Smaller sites were also surveyed by walking the perimeter of the habitat patch while utilizing song playback on various edges of the patch. Sites were visited up to three times, though access and other restrictions resulted in some sites being visited fewer times. Sites lacking suitable habitat were not visited again.

Surveys were conducted by Kimberly Ferree, Lea Squires, Kevin Clark, Lori Hargrove, Philip Unitt, and Marco Combs.

Table 1. Sites surveyed for Crissal Thrasher in 2019.

Site	Survey Dates	Lat/Long
Willow Hole	1/15, 2/18, 3/12	33.890764, -116.470815
Merganzer Road	1/15, 3/12, 7/16	33.903664, -116.441603
Dos Palmas	2/13, 3/27, 7/14, 7/19	33.504206, -115.837839
Terra Lago	2/25	33.7405, -116.1984
Wild Bird Center	2/25	33.711667, -116.195784
Thousand Palms	3/5, 3/12, 4/2	33.847696, -116.312593
Mecca	3/29	33.5873, -116.0787
Hundred Palms	3/29	33.5702, -116.1690
World Mark	5/4	33.746944, -116.185556
Whitewater north of 52 <sup>nd</sup> Ave	5/13	33.675592, -116.152109
Whitewater south of 52 <sup>nd</sup> Ave	5/13, 7/16	33.66669, -116.14424
Whitewater West of Lincoln	4/29-7/24	33.531222, -116.087619

## Results

A total of twelve sites were surveyed at least once in 2019, and Crissal Thrashers were confirmed at five sites: Willow Hole, Merganzer Road, World Mark, Whitewater Channel at 52<sup>nd</sup> Avenue, and Dos Palmas (Table 2, Figure 2). These sites will be further discussed individually below.



Figure 2. Survey sites and Crissal Thrasher detections, 2019.

Table 2. Survey dates, locations, and surveyors for Crissal Thrasher surveys in 2019.

Date	Obs	Site	Findings
1/15/2019	LDS	Willow Hole	1 CRTH seen at Willow Hole
1/15/2019	LH, PU, LDS	Merganzer Road	1 probable CRTH brief song at Merganser Road
2/13/2019	LDS	Dos Palmas	0 CRTH
2/18/2019	LDS	Willow Hole	CRTH not refound at Willow Hole
2/25/2019	KC, LDS	Terra Lago	0 CRTH
2/25/2019	KC, LDS	Wild Bird Center	0 CRTH
3/5/2019	LH, LDS	Thousand Palms	0 CRTH
3/12/2019	KC	Thousand Palms	0 CRTH
3/12/2019	KC	Willow Hole	CRTH not refound at Willow Hole
3/12/2019	LH	Merganzer Road	pair CRTH seen same spot as 1/15/19
3/27/2019	LH	Dos Palmas	0 CRTH
3/29/2019	KF	Mecca	0 CRTH
3/29/2019	KF	Hundred Palms	0 CRTH
4/2/2019	PU	Thousand Palms	0 CRTH
5/4/2019	MC	World Mark, Indio	1 CRTH
5/13/2019	KC	East of Whitewater Channel North of Ave 52	0 CRTH
5/13/2019	KC	East of Whitewater Channel South of Ave 52	1 CRTH singing
7/16/2019	KC	East of Whitewater Channel South of Ave 52	1 CRTH singing within 50 m of observation on 5/13
7/16/2019	KC	Merganzer Road	1 CATH singing
7/14/2019	MC	Dos Palmas	1 CRTH
7/19/2019	MC	Dos Palmas	1 CRTH
4/29-7/24	MC/KC	North of Whitewater Channel west of Lincoln	0 CRTH

Surveyors: LDS=Lea Squires, KC=Kevin Clark, LH=Lori Hargrove, KF=Kimberly Ferree, PU=Philip Unitt, MC=Marco Combs. Abbreviations: CRTH=Crissal Thrasher, CATH=California Thrasher

### Willow Hole

This site supports large patches of dense mesquite surrounded by open sand dunes. On January 15 a Crissal Thrasher was observed foraging among mesquite at this site. Subsequent visits on February 18 and March 12 did not detect the species.

### Merganzer Road

This site is located approximately 3 km northeast of Willow Hole at 20<sup>th</sup> Street and Merganzer Road. This site consists of ponds and flowing water with riparian vegetation. On January 15 a probable Crissal Thrasher was heard singing at this site. On March 12 a pair of Crissal Thrashers was well-seen foraging under the riparian vegetation. A subsequent visit on July 16 found a California Thrasher singing at this location (see further discussion below). Approximately 1 km to the northeast a California Thrasher was also seen on February 18 at Langlois Road and 19<sup>th</sup> Avenue.

### World Mark

This site consists of a resort and golf course with irrigated landscaping where a Crissal Thrasher was found and photographed on May 4 2019 (Figure 3). The extensive area of irrigated landscaping at this site makes it difficult to estimate the number of pairs that may be present. Previous observers have documented and photographed Crissal Thrashers at this site in the past (eBird reports).



Figure 3. Crissal Thrasher observed and photographed at World Mark in Indio, May 4, 2019.



Whitewater Channel south of 52<sup>nd</sup> Ave.

This site consists of a dense mesquite woodland extending for approximately 2 kilometers south of Avenue 52 and just west of Highway 86. On May 13 a Crissal Thrasher was observed singing at the top of a mesquite in response to song playback (Figure 4). On July 16 a Crissal Thrasher was briefly seen approximately 50 meters south of the previous sighting.



Figure 4. Crissal Thrasher observed May 14, 2019 east of the Whitewater Channel and south of 52<sup>nd</sup> Avenue in Indio.

Dos Palmas

A Crissal Thrasher was found and photographed on July 14 in dense arrow weed near the administrative building on the west side of the preserve (Figure 5). A Crissal Thrasher was refound approximately 100 meters away on July 19 (Figure 6). This site has had repeated sightings in the past (CVCC 2014, eBird reports).

Cumulative sightings from this survey effort are plotted in Figure 7. Recent reports of Crissal Thrasher in Coachella Valley supported by photo or other documentation from 2014-2018 are also plotted, and listed in Appendix 1. Historical Coachella Valley specimens of Crissal Thrasher in museum and university collections are also included in the figure for reference and are listed in Appendix 2. Specimen information was retrieved from VertNet ([www.vertnet.org](http://www.vertnet.org)).



Figure 5. Crissal Thrasher photographed July 14, 2019 at Dos Palmas.



Figure 6. Crissal Thrasher photographed July 19, 2019 at Dos Palmas.



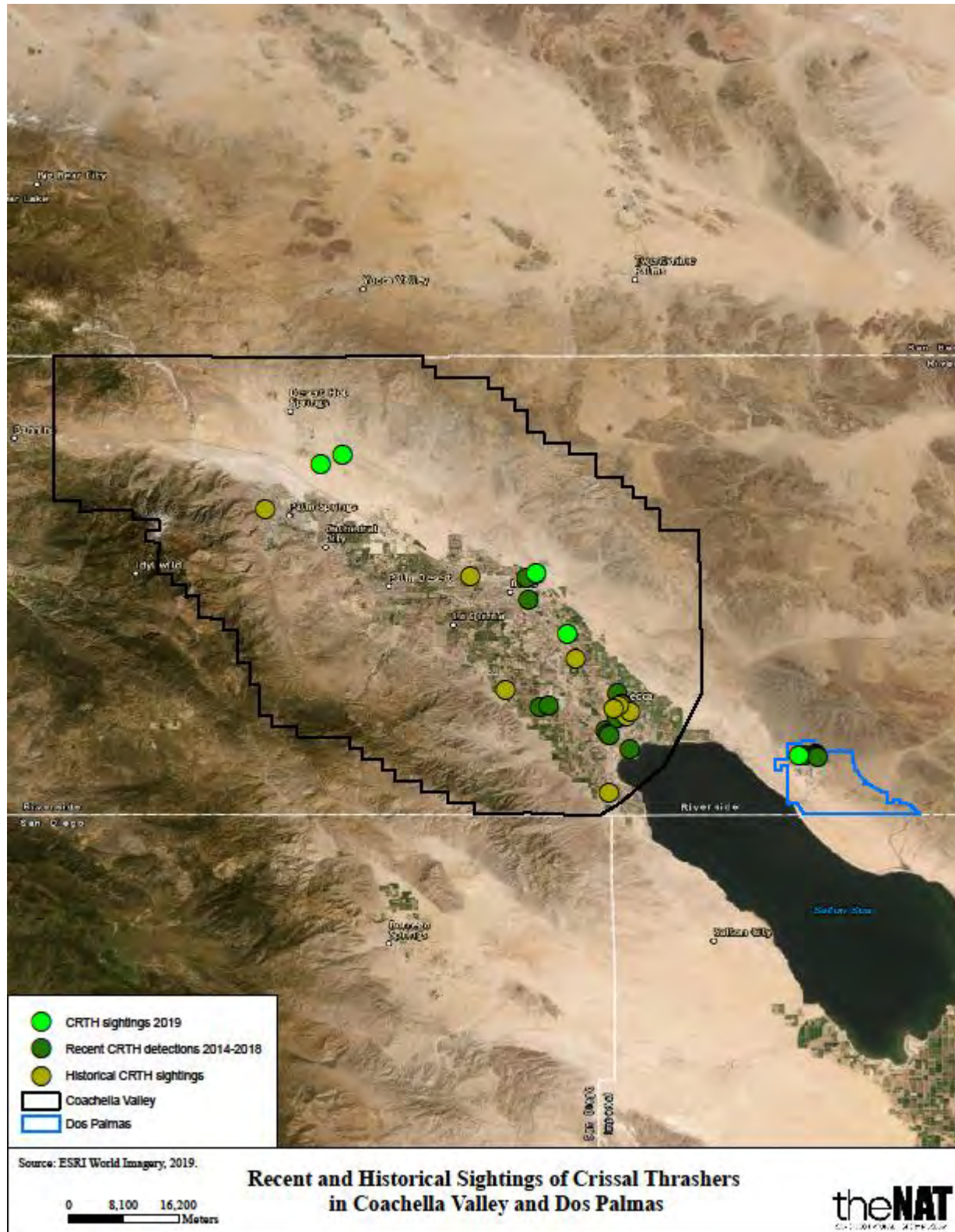


Figure 7. Recent and Historical Sightings of Crissal Thrashers. For locations included in this map, see Appendices 1 and 2.



### Replacement of Crissal Thrasher by California Thrasher

As discussed above, a pair of Crissal Thrasher was observed foraging at Merganzer Road on March 12, 2019. A subsequent visit on July 16, 2019 found a California Thrasher respond to a Crissal Thrasher song playback and sing for several minutes (Figure 8). Elsewhere in California Crissal and California Thrashers do not co-occur (Cody 1999). In San Diego County, numerous riparian and mesquite thicket habitats occur along the east base of the peninsular ranges that appear suitable for Crissal Thrasher, however all of these sites are occupied by California Thrasher. The only site to support Crissal Thrasher is Borrego Sink far out onto the desert floor (Unitt 1984). Surveys for LeConte's Thrasher in the Coachella Valley in 2019 found California Thrasher at several sites at the north end of the valley where they were not known historically (Hargrove et al. 2019), and online reports with photographs confirm California Thrasher at various desert riparian sites in the northern valley (eBird reports).



Figure 8. A California Thrasher observed at Merganzer Road July 16, 2019. This site was occupied by a pair of Crissal Thrashers on January 15 and March 12, 2019.

### Habitat Use

We plotted confirmed Crissal Thrasher locations over vegetation maps produced for Coachella Valley and Dos Palmas and provided by the Coachella Valley Conservation Commission. Vegetation supporting Crissal Thrashers included Arrowweed Thickets (*Pluchea sericea* Shrubland Alliance), California Fan Palm

Oasis (*Washingtonia filifera* Woodland Alliance), Fourwing saltbush scrub (*Atriplex canescens* Shrubland Alliance), and Mesquite bosque-mesquite thicket (*Prosopis glandulosa* Woodland Alliance). Several sites with recent sightings were mapped as urban or agricultural, though the sites utilized by thrashers were clearly smaller inholdings of mesquite thickets. These four vegetation alliances likely form the core of Crissal Thrasher habitat in the region.

## Conclusions and Recommendations

Despite limited survey effort for Crissal Thrasher in the Coachella Valley in 2019 in deference to an intensive LeConte's Thrasher survey and nest monitoring effort, several conclusions can be drawn. The first is that the long-term persistence of Crissal Thrashers in the Coachella Valley at sites in close proximity to known California Thrasher locations at the northern end of the valley is in doubt. This would include Willow Hole, Merganser Road, and possibly the World Mark site in Indio. The observed replacement of Crissal Thrasher by California Thrasher at Merganser Road in 2019 only confirms a trend of California Thrasher invasion of riparian and shrubland sites throughout the northern Coachella Valley over the recent past. Conservation of Crissal Thrasher habitats should focus on sites at Indio and to the south.

The imprecise vegetation maps available for agricultural districts in the southern Coachella Valley prevented a more detailed analysis of the amount of available habitat for Crissal Thrashers in this area. Further effort to map natural vegetation communities in this area, especially the four vegetation alliances identified as Crissal Thrasher habitat, would allow for the identification of additional potentially occupied sites in the valley. Though there is no data on adult or juvenile dispersal, banding and behavioral studies imply that Crissal Thrashers are extremely sedentary and unlikely to disperse far from their natal sites (Cody 1999). Therefore the increasingly fragmented remaining habitats for this species in the southern Coachella Valley may represent isolated islands which are not demographically or genetically connected. Further efforts to map habitat and identify the largest remaining habitat islands would identify sites of conservation importance for this species.

Cody (1999) lists territory sizes for Crissal Thrasher as averaging 12 acres in the Granite Mountains of California, with a range from 9.4-17.1 acres. This corresponds well to the pair regularly seen near the administrative building at Dos Palmas, that occurs in an isolated patch of California fan palm, arrow weed, and mesquite thicket that totals approximately 16 acres. Conducting a GIS analysis of available habitat patches in the southern Coachella Valley of at least 20 acres would provide a useful metric of available habitat in the area.

The results of the recent survey efforts as well as recently documented sightings of Crissal Thrasher in the Coachella Valley show that the regional population is low and highly fragmented among widely separated habitat patches. Given that the species exhibits high site fidelity and low dispersal rates, the remaining occupied sites are subject to extirpation. The species' requirement for dense undergrowth means that even modest disturbance to the vegetation may be detrimental to long-term persistence at a site. Habitat restoration efforts, including clearing of exotic vegetation such as tamarisk may potentially harm this species unless it is done at a small scale and in conjunction with mesquite or other native habitat restoration.

## References

- Barbour, M., T. Keeler-Wolf, and A.A. Schoenherr, eds. 2007. *Terrestrial Vegetation of California*. 3<sup>rd</sup> edition. University of California Press.
- Coachella Valley Conservation Commission. 2014. Results of 2013-2014 protocol surveys for Crissal Thrasher (*Toxostoma crissale*) within the Coachella Valley. Pp 28-39 in *Biological Monitoring Program 2013-2014 Year-End Report*. Prepared by the University of California Riverside Center for Conservation Biology for the Coachella Valley Conservation Commission. 102 pp.
- Coachella Valley Conservation Commission. 2014. *Biological Monitoring Protocol for Toxostoma crissale* (Crissal Thrasher). Prepared by the University of California Riverside Center for Conservation Biology and CVCC Biologist Working Group. 10 pp.
- Cody, M.L. 1999. Crissal Thrasher (*Toxostoma crissale*). In *The Birds of North America*, No. 419 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
- Corman, T.E. and C. Wise-Gervais, eds. 2005. *The Arizona Breeding Bird Atlas*. University of New Mexico Press.
- Fitton, S. D. 2008. Crissal Thrasher (*Toxostoma crissale*) in *California Bird Species of Special Concern* (W. D. Shuford and T. Gardali, eds.), pp. 316–320. *Studies of Western Birds* 1. W. Field Ornithol., Camarillo, CA, and Calif. Dept. of Fish and Game, Sacramento.
- Gilman, M.F. 1902. The Crissal Thrasher in California. *Condor* 4(1): 15-16.
- Grinnell, J. 1904. Midwinter Birds at Palm Springs, California. *Condor* 6(2): 40-45.
- Hanna, W.C. 1933. Nesting of the Crissal Thrasher in Coachella Valley, California. *Condor* 35(2): 79-79.
- Hargrove, L., P. Unitt, K. Ferree, K. Clark, L. Squires. 2019. *LeConte's Thrasher (Toxostoma lecontei) Status and Nest Site Requirements in the Coachella Valley*. Report prepared for the Coachella Valley Conservation Commission. San Diego Natural History Museum, San Diego.
- Hunter, W.C., R.D. Ohmart, and B.W. Anderson. 1988. Use of exotic saltcedar (*Tamarix chinensis*) by birds in arid riparian systems. *Condor* 90(1): 113-123.
- Laudenslayer, W.F., A.S. England, S. Fitton, and L. Saslaw. 1992. The *Toxostoma* Thrashers of California: Species at Risk? *Transactions of the Western Section of The Wildlife Society* 28: 22-29.
- Patten, M.A., G. McCaskie, and P. Unitt. 2003. *Birds of the Salton Sea: status, biogeography, and ecology*. Univ of California Press.
- Sibley, D.A. 2000. *The Sibley Guide to Birds*. National Audubon Society. Alfred A. Knopf, New York. 545 pp.
- Unitt, P. 2004. *San Diego County Bird Atlas*. Proceedings of the San Diego Society of Natural History, No 39, 31 Oct. 2004. Ibis Publishing Co. 645 pp.

## Appendices

Appendix 1. Recent reports of Crissal Thrasher in Coachella Valley supported by photo or other documentation 2014-2018.

Locality	Date	Latitude	Longitude	Source	Comments
Dos Palmas	5/8/2014	33.50506	-115.83162	CVCC 2014	CRTH observed during 2014 surveys
Dos Palmas	6/2/2014	33.50506	-115.83162	CVCC 2014	CRTH observed during 2014 surveys
Dos Palmas	6/3/2014	33.50668	-115.81586	CVCC 2014	CRTH observed during 2014 surveys
Dos Palmas	5/15/2014	33.50454	-115.81516	CVCC 2014	CRTH observed during 2014 surveys
Dos Palmas	6/3/2014	33.50321	-115.81298	CVCC 2014	CRTH observed during 2014 surveys
CV Stormwater Channel Delta	5/21/2014	33.53708	-116.09376	CVCC 2014	CRTH observed during 2014 surveys
CV Stormwater Channel Delta	5/21/2014	33.53331	-116.09118	CVCC 2014	CRTH observed during 2014 surveys
CV Stormwater Channel Delta	5/21/2014	33.53194	-116.08905	CVCC 2014	CRTH observed during 2014 surveys
CV Stormwater Channel Delta	6/10/2014	33.51216	-116.06169	CVCC 2014	CRTH observed during 2014 surveys
Coachella Valley Wild Bird Center, Indio	4/3/2018	33.71167	-116.19578	ebird	Multiple observations, photos, recent sightings; Revisited 7/2019- cleared, no habitat
WorldMark, Indio	10/2/2018	33.74483	-116.18799	ebird	Multiple observations, photos, recent sightings
Terra Lago Pkwy, Indio	8/22/2017	33.74047	-116.19840	ebird	photo, recent sighting
Lincoln St.--mesquite islands, Indio	2/26/2010	33.58727	-116.07869	ebird	Multiple observations, photos, recent sightings
NESS CBC - West Area, 100 Palms	12/30/2016	33.56872	-116.18128	ebird	Multiple observations, photos, recent sightings
66th Ave./Tyler Street, 100 Palms	5/13/2015	33.57017	-116.16905	ebird, iNaturalist	Multiple observations, photos, recent sightings
69th St and Lincoln. Mecca	12/30/2016	33.55474	-116.07869	ebird	Photo

Appendix 2. Historical Coachella Valley specimens of Crissal Thrasher in museum and university collections. Retrieved from VertNet ([www.vertnet.org](http://www.vertnet.org)).

Institution	Date	Locality	Latitude	Longitude
MVZ	29-Apr-1908	Mecca	33.5719174	-116.072719
MVZ	6-Feb-1913	Mecca	33.5719174	-116.072719
MVZ	15-Apr-1908	Torres	33.5920129	-116.22599
MVZ	28-Mar-1921	Palm Springs	33.83	-116.544
MVZ	18-Apr-1908	Mecca	33.5719174	-116.072719
MVZ	3-Apr-1892	Agua Dulce, Coachella Valley, Colorado Desert	33.455107	-116.089381
MVZ	23-Apr-1937	1 mi S Mecca	33.5573954	-116.066424
PSM	11-Apr-1926	Mecca	33.5724258	-116.073547
SDNHM	29-Sep-1985	1 mi. SE Mecca	33.5621659	-116.061291
UMMZ	11-Jan-1937	Thermal, .5 Mi W	33.6333351	-116.133331
YPM	2-Mar-1930		33.5717	-116.0764
SDNHM	8-Jan-1890	Indio	33.7423273	-116.27243
UMMZ	9-Jan-1937	Mecca, 1 Mi SE	33.5666656	-116.083336
USNM	4-Apr-1937	Mecca	N/A	
USNM	30-Mar-1934	Mecca	N/A	
HSU	3-Apr-1924	Mecca	N/A	
HSU	5-Mar-1933	Thermal	N/A	

Institutions: MVZ=Museum of Vertebrate Zoology, UC Berkeley; PSM=Slater Museum of Natural History, University of Puget Sound; SDNHM=San Diego Natural History Museum; UMMZ=University of Michigan Museum of Zoology; YPM=Yale Peabody Museum; USNM=U.S. National Museum, Smithsonian Institution; HSU=Humboldt State University.

# Appendix XIV- Monitoring Results for LeConte's Thrasher

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## LeConte's Thrasher (*Toxostoma lecontei*) Status and Nest Site Requirements in the Coachella Valley



*Final Report October 31, 2019 (Revised January 15, 2020)*

*Prepared for:*

Coachella Valley Conservation Commission

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Cover photo: LeConte's Thrasher nest with four eggs, near Fried Liver Wash, Joshua Tree National Park, 12 February 2019. Photo by Kimberly Ferree.

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## Executive Summary

Our team from the San Diego Natural History Museum has undertaken a study of the LeConte's Thrasher in support of the Coachella Valley Multiple Species and Habitat Conservation Plan. In the early 20th century the Coachella Valley was among the areas where LeConte's Thrasher was best known, but numbers have dwindled. Much of the valley has been converted to agriculture and communities, but even where apparently suitable habitat remains, numbers have dropped sharply since baseline surveys in 2004-2005. Desert bird populations are clearly depressed after years of drought, but there may be other factors at play. To investigate the current status of the LeConte's Thrasher in the Coachella Valley, we surveyed after a wet winter in 2019 with three objectives: (1) determine the current distribution of the thrasher in the Coachella Valley by locating and mapping any territories, (2) gain a better understanding of territory and nest-site requirements in this region, and (3) identify likely causes of decline. Anticipating low sample sizes, we surveyed intensively in the Coachella Valley by means of three different protocols, but we also expanded the study areas to include neighboring areas of the Colorado Desert, Joshua Tree National Park (higher elevations) and Anza-Borrego Desert State Park (lower elevations), where populations are known to persist. From January to July 2019 we located a total of 26 LeConte's Thrasher nests, confirmed at least 23 territories, and tallied 229 observations, but none of these were in the Coachella Valley. In Joshua Tree we detected LeConte's Thrasher at 11 of 12 sites, in Anza-Borrego at 9 of 20 sites, and in the Coachella Valley we had no detections at 40 sites surveyed. We measured habitat features of nest plots and compared them to unoccupied plots, finding that lack of nest substrates, especially the scarcity of large cholla, is a key factor contributing to reduced quality of Coachella Valley plots. Cholla die-off from recent droughts has been documented in the region, and fires, facilitated by invasive grasses and mustards, have virtually eliminated chollas in some areas. Increases in nest predators and competitors, especially the Common Raven and Northern Mockingbird, make the quality and quantity of nest substrates all the more critical. We used multiple criteria to rank 20 sites in the Coachella Valley for their potential to sustain LeConte's Thrasher populations in the future and recommend that future survey efforts be concentrated on just a few highest quality "sentinel" sites. Despite our extensive efforts, we can't be sure of complete extirpation, which would represent a substantial contraction of the range, and a few recent sightings have been reported ([www.ebird.org](http://www.ebird.org)). However, some or most of the sightings of LeConte's Thrasher in the Coachella Valley in the past few years may be of unmated birds displaced from territories rendered unsuitable. Furthermore, no recent reports have been supported by photographs, and follow-up of some has revealed they were misidentifications of the California Thrasher, which has recently been spreading on the valley floor, perhaps aided by vegetation planted around communities and golf courses. The LeConte's Thrasher is one of very few avian desert specialists of the southwest and was formerly emblematic of the Coachella Valley. Its habitat needs overlap with those of many other species of interest, such as the Desert Tortoise, Burrowing Owl, and Round-tailed ground squirrel, all documented during our surveys. Future research could consider comparisons of the ground arthropod community in nest plots vs. unoccupied plots, improved predictive modeling, and efforts to restore cholla.

## Background

The LeConte's Thrasher (*Toxostoma lecontei*; LCTH) is not only a xerophile, but an extremophile, occurring in the driest, hottest, most barren parts of the desert southwest, including Death Valley. It occurs along relatively flat dry washes, sinks, or alluvial fans, wherever there are pockets of at least a few shrubs other than creosote. It spends most of its time running on the ground and digging for arthropods in soft sand with its sickle-shaped bill. The thrasher avoids steep terrain (Fletcher 2009) and gravelly areas (Blackman et al. 2012). It is an enigma—infamously cryptic (invisibly sand-colored), shy, and scarce—it has eluded and frustrated biologists and bird-watchers alike. Our limited knowledge about its biology has been summarized by Jay Sheppard, who in the late 1960s banded and studied the birds near Maricopa, Kern County (Sheppard 1970). He also compiled natural history data on the species from throughout its range (Sheppard 1996, 2018). The species is sedentary (non-migratory), and aridity appears to define its limits, because it occurs over a wide range of temperatures and desert or sage scrub habitat within its range as long as annual rainfall is not much more than 16-17 cm and snowfall is minimal. Two exceptional localities where it has been recorded despite average precipitation >20 cm/yr are Cabazon and Palmdale, both in extremely windy passes where desiccation is apparently sufficient to keep the vegetation open. Otherwise, too much vegetation cover or too much snow inhibits its specialized foraging, which requires ample runways of open sand. This species has declined in at least parts of California, including the San Joaquin Valley and Coachella Valley, even in areas of apparently suitable habitat. Data from the Breeding Bird Survey ([www.mbr-pwrc.usgs.gov/bbs.html](http://www.mbr-pwrc.usgs.gov/bbs.html)) are not robust but suggest a significant decline statewide over the entire length of the survey (1966–2017). The Coachella Valley Multiple Species and Habitat Conservation Plan (CVMSHCP 2007) identified this thrasher as a focal species for monitoring and conservation efforts.

## History in the Coachella Valley

Though historical records and collections were concentrated around train stops, they confirm that LeConte's Thrasher once ranged over the entire length of the Coachella Valley, from the San Geronio Pass, including Banning and Cabazon, to the north end at Whitewater (along the current Tipton Road) and Desert Hot Springs, down to Indio, Thermal, and Mecca (Figure 1). However, the majority of historic collections were from the Palm Springs area, where more specimens were collected than anywhere in the species' range (123 specimens, including egg clutches, listed at [www.vnet.net](http://www.vnet.net), covering each decade from 1884 to 1938), but where no suitable habitat remains today because of extensive development. Though Palm Springs was a popular collecting locality, the take from the area represents only 2.2 specimens per year and is of the same order of magnitude as many other bird species that remain common in the area today. Much of the southern part of the valley, only lightly collected (Figure 1), was converted into agriculture. Some possibly suitable habitat remains in a few areas, but LeConte's Thrasher has not been found there for many decades (Patten et al. 2003; [www.ebird.org](http://www.ebird.org)). There are still

many areas with possibly suitable habitat at the north end of the Coachella Valley where LeConte's Thrasher has been found regularly, as at Desert Hot Springs in the 1970s (Sheppard 2018).



**Figure 1. Specimens of LeConte's Thrasher collected in the Coachella Valley since the 1880s, including individual birds and egg sets (from [www.vertnet.org](http://www.vertnet.org)).**

The Coachella Valley Multiple Species and Habitat Conservation Plan considered the species “to occur at low densities in suitable habitat throughout the Plan Area,” on the basis of 33 records widely scattered in the Coachella Valley. Ten of these are more recent than 1990. The plan identified three objectives toward the general goals of conserving the species and its habitat: (1a) conserve habitat within 20 Conservation Areas that have habitat potentially suitable for the species, (1b) conserve nest sites, and (2) implement actions to ensure self-sustaining populations within each Core Habitat area. During baseline surveys by the University of California at Riverside's Center for Conservation Biology, LeConte's Thrasher was detected on 4 of 20 transects in 2004 and on 4 of 8 transects in 2005 with a grand total of 40 detections (Hutchinson 2005). Occupied areas included Mission Creek east of Highway 62, Willow Hole Preserve, and Thousand Palms Preserve, where at least one of two pairs nested successfully (Hutchinson 2005). These baseline surveys found that use of song broadcast increased detections approximately 3x that of transect surveys without. The Biological Working Group thus adopted broadcast survey into their monitoring protocol and identified 30 survey sites for monitoring (CCB 2013).



In 2014, however, thorough surveys at 16 high-priority sites yielded only one possible pair near Stubbe Canyon (CCB 2015). Recent Grinnell Resurveys by SDNHM (Hargrove et al. 2014) have found the species to be missing from Banning, Cabazon, Palm Springs, and Mecca. We found only a single bird at Whitewater (Tipton Road) in 2010, implying numbers greatly reduced from 100 years ago. Most recently, only a few scattered sightings have been reported from these areas via [www.ebird.org](http://www.ebird.org). None of these, however, is supported by photograph, while recent photographs of the California Thrasher from these sites, historically unknown from the floor of the Coachella Valley, abound. Therefore we believe that recent reports of LeConte's from the upper Coachella Valley, into which the California Thrasher has apparently spread in the 21st century, must be regarded with caution. Observers' expectations based on past history are evidently not keeping pace with the two species' changes in status. For example, after a resident of Desert Hot Springs reported a LeConte's Thrasher to us, she later sent a photo that showed the bird to be a California Thrasher.

### Possible causes of decline

Although drought is expected to depress population sizes, there may be other factors impairing the suitability of remaining habitat. The LeConte's Thrasher has three basic habitat requirements: (1) large contiguous areas of relatively flat, open, arid scrub, especially alluvial fans, washes, or sinks; (2) open stretches of sand for foraging with a healthy ground arthropod community, and (3) at least a few large chollas, shrubs, or trees for nesting and shelter. Gilman (1904) commented on this thrasher's frequent nesting in cholla (*Cylindropuntia* spp.) in the Coachella Valley, and Hanna (1933), who also collected in the Coachella Valley, stated that "probably 99% of the large deep nests of LeConte's Thrasher which I have observed have been in cacti." Nesting in cholla was also noted by Stephens near Palm Springs (Stephens 1884), and Pemberton (1916) published photographs of LeConte's Thrasher nests in Cabazon and Whitewater—two were in chollas; one was in a yucca (*Yucca schidigera*). Fieldwork in support of the San Diego County Bird Atlas (Unitt 2004) found nests in a broader variety of plants equipped with thorns and/or stiff dense twigs, including, besides cholla, desert thorn (*Lycium* sp.), saltbush (*Atriplex* sp.), mesquite (*Prosopis* sp.), ocotillo (*Fouquieria splendens*), smoketree (*Psoralea spinosa*), mistletoe (*Phoradendron californicum*), and palo verde (*Parkinsonia florida*). Sheppard (2018) emphasized that lack of nesting substrate can be a limiting factor in regions that appear to be otherwise suitable, and also noted that nests can sometimes be placed in manmade structures.

### Monitoring challenges

Study of LeConte's Thrasher is challenging because the species is so sparsely distributed and difficult to detect. While a defended territory around a nest can be as little as 4 ha, the pair moves around within a much larger home range, which over a year can be 30 ha (Sheppard 2018). For example, Sheppard (2018) documented a banded pair that built successive nests over 1 km apart. LeConte's can also be confused with other species such as the Crissal and California Thrasher (Table 1), which overlap in the Coachella Valley. Each species' song and call are distinctive, but LeConte's is often quiet, and it can be mimicked by other species of the

**Table 1. Contrasting morphology of three sickle-billed thrashers in the Coachella Valley. Each also has distinctive calls and songs, but mimicry can occur.**

Character	LeConte's	Crissal	California
Upperparts	Pale sand color	Medium gray	Dark brown
Breast and belly	Uniform cream color	Uniform gray	Breast brownish gray, belly tawny
Throat	White, bordered by very narrow dark mustache stripe	White, bordered by distinct black and white mustache stripes that contrast boldly with gray head	Buff, bordered by dark mustache stripe that contrasts weakly with brown head
Crissum	Tawny, contrast muted	Rufous, contrast bold	Tawny, same as belly
Tail	Gray, contrastingly darker than upperparts	Nearly the same as rest of upperparts	Nearly the same as rest of upperparts
Bill	Gently curved, 30-35 mm	Strongly curved, 32-39 mm	Strongly curved, 32-40 mm
Iris color	Dark	Medium olive-greenish	Dark

family Mimidae. Other clues of its presence are old nests, dig marks, and tracks. These alone may not prove occupancy, but their absence helps to confirm that an area is not within an active territory.

After the disappointing surveys in 2014, the CCB (2015) suggested repeat surveys after a wet winter, and developed a habitat model to identify highest-priority sites. One possibility is that the birds could be easier to detect in a wetter year when actively nesting, and another is that some could recolonize.

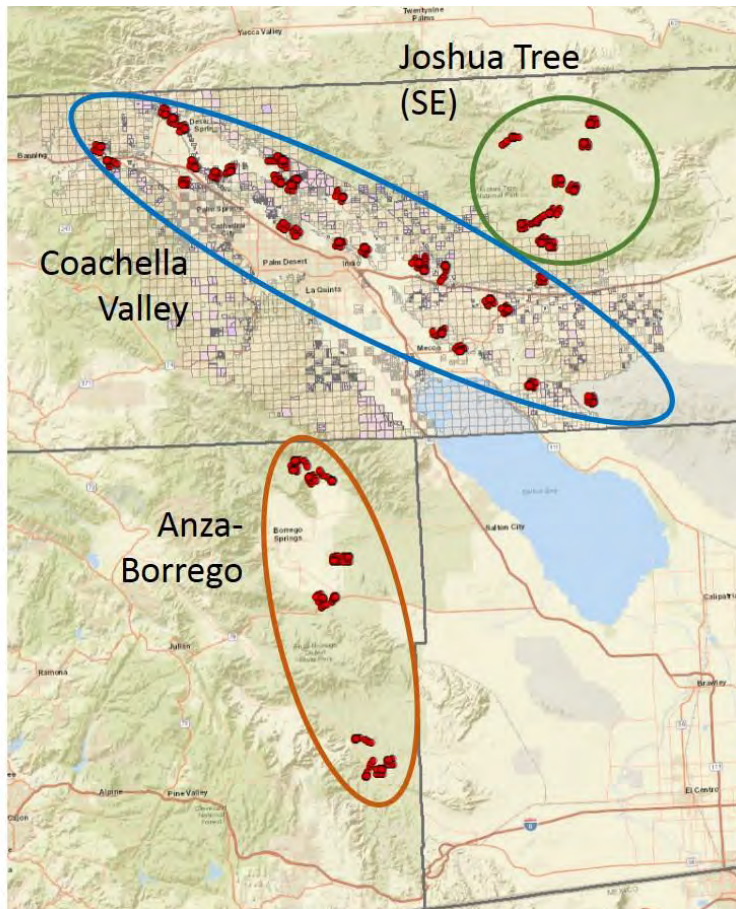
The Desert Thrasher Working Group (DTWG 2018) adopted a monitoring protocol for Bendire's Thrasher (*T. bendirei*) that covers LeConte's as well. Its survey protocol is based on 300-m<sup>2</sup> plots with no broadcast. Using a habitat model, it has instituted stratified random sampling across the thrashers' range, but this sampling is focused mostly on the Mojave Desert. Neither the CCB's nor the DTWG's models appear to have good predictive power in the parts of Riverside and San Diego counties where LeConte's Thrasher is known currently, based on the CCB's records (Figure 5 in CCB 2015) and Unitt (2004). However, for a rare species with depressed population sizes, the utility of predictive modeling is limited because even high quality habitat may be unoccupied.

## Objectives and strategy for study in 2019

To investigate the current status of the LeConte's Thrasher in the Coachella Valley, the San Diego Natural History Museum (SDNHM) undertook surveys after a wet winter in 2019 with three objectives: (1) determine the current distribution of the thrasher in the Coachella Valley by locating and mapping any territories, (2) gain a better understanding of territory and nest-site requirements in this region, and (3) identify likely causes of decline. Anticipating low sample sizes, we surveyed the Coachella Valley extensively, using both the BWG and DTWG



protocols, and we also expanded the study areas to include neighboring areas of the Colorado Desert, Joshua Tree National Park (higher elevations) and Anza-Borrego Desert State Park (lower elevations), where populations are known to persist (Figure 2). Through a better understanding of the bird's nesting ecology in this region, we hope to identify sites that have the best potential of sustaining LeConte's Thrashers in the Coachella Valley.



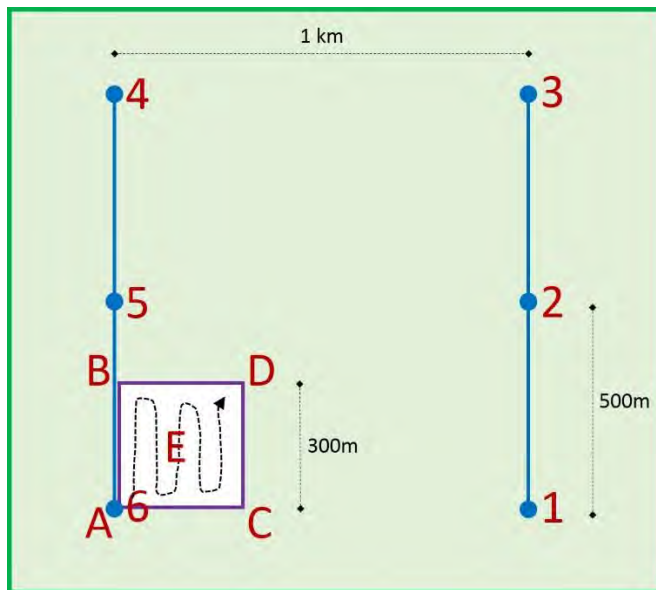
**Figure 2.** Three study areas (south-east Joshua Tree, Coachella Valley, and Anza-Borrego), and sites with combined standardized surveys (red dots), 2019.

## Methods

During winter-spring 2019, we surveyed for LeConte's Thrashers in the three study areas according to standardized protocols adapted from both the CCB (2013) and the DTWG (2018).

We established survey sites with a goal of at least 20 sites in the Coachella Valley and 10 each in Joshua Tree National Park and the Anza-Borrego Desert, but augmented this number as needed to obtain a minimum total sample size of 20 territories. First, we identified general areas of possibly suitable habitat in or near areas of historic or recent records. Then within these areas we delineated by map any types of sandy desert scrub, avoiding only steep rugged terrain and

private property. In the Coachella Valley, wherever possible we used existing survey transects established previously (CCB 2013, 2015). These consisted of a pair of transects each 1 km long and separated by 1 km. Each transect had two end points and one middle point for broadcast. In new areas without existing transects, we overlaid a 500-m<sup>2</sup> grid to place transects in a similar fashion, orienting them however they best fit within the delineated areas. Finally, we added a single 300-m<sup>2</sup> plot to a randomized point at the end of a transect. Thus each survey site consisted of a pair of 1-km transects and one 300-m<sup>2</sup> plot (Figure 3).



**Figure 3.** Diagram of one survey site, consisting of a pair of 1-km transects (6 points) and one 300-m<sup>2</sup> plot.

In summary, we used three survey methods to locate thrashers:

- (1) transect survey: 1-km transect, with broadcast of song and calls at each of 3 points after first pass if no thrashers were detected, and recording perpendicular distance to all vertebrate species detected along the transect. Two per site.
- (2) plot survey: limited to 40 minutes within a 300-m<sup>2</sup> area, and no broadcast.
- (3) area search: unconstrained searching within and adjacent to site, before and/or after transect and plot surveys.

Surveys took place during morning or afternoon hours during fair weather, and were usually done by a single observer per site, or by two observers split up. We recorded all vertebrate species detected during each survey method, the method of detection (visual, call, song), and any evidence of nesting activity (survey form, Appendix 1). To search for thrasher nests we looked inside all large dense shrubs, trees, and cacti that might support and shelter a thrasher nest. If a LeConte's Thrasher was detected, or any possible thrasher was detected, we paused the survey to confirm the identification and observe its behavior for any evidence of nesting. Impressions of size and color can be deceptive in the field, so multiple criteria are essential (Table 1). Whenever possible, we also obtained photographs and/or recordings for documentation.

We attempted to visit all sites during a first round of surveys from mid-January to mid-February. For sites without detections, we prioritized them for second and third rounds of surveys on the basis of any suggestive evidence (tracks, dig marks) and dropped sites with the most obviously unsuitable habitat (e.g., gravelly, absence of any suitable nest shrubs).

For sites with detections, we mapped territories, observed behavior, searched for nests, and returned approximately weekly to check any active nests (nest-monitoring form, Appendix 2). We limited disturbance by avoiding use of broadcast in occupied areas, by observing a thrasher less than one hour per visit, and by not forcing birds to flush off nests.

To increase sample sizes of territories and nests, we opportunistically added other sites with area searching only, including any with recent sightings or reports from the Coachella Valley.

From May to July we returned to measure each nest, and measured habitat features around each nest by defining a 300-m<sup>2</sup> plot with the nest as the centroid, for comparison to unoccupied plots. During habitat measurements at nest plots and unoccupied plots, we also recorded vertebrate species detected as during plot surveys but did not constrain the survey to 40 minutes (habitat form and instructions, Appendix 3).

For the whole 300-m<sup>2</sup> plot, we estimated the relative cover and average height of each dominant non-herbaceous plant species, the overall percentage of the plot that was open vs. covered by non-herbaceous vegetation, herbaceous vegetation, rock (>25 cm diameter), and other (e.g., road), the overall percentage of the plot that was covered by wash, sink, drift sand, desert pavement, any other flat terrain, and steep terrain, and we described the herbaceous cover, any disturbance, and the surrounding terrain. We counted and rated prospective nest substrates as of moderate (rank 2) or high quality (rank 3) by species (Table 2).

At each of 5 plot points (4 corners and centroid), we located the nearest potential nest substrate (i.e., shrub, tree, yucca, or cholla) within the plot with quality rank of at least 1, and recorded the species, quality rank, and measured its height and width. If no truly suitable substrate was within 50 m, we selected the best we could find. We used a penetrometer to measure soil compaction at five positions within 5 m of each point, and we used a laser rangefinder to measure the distance to the nearest plant (>0.5 m tall) in each of four quarters by compass. We used a sifting kit to measure the composition of silt (<.06 mm diameter), fine sand (0.06–0.25 mm), coarse sand (0.25–2.0 mm), fine gravel (2–4 mm), and large gravel (4–250 mm) in any friable substrate within 2 m of the plant substrate, and we took photographs in each cardinal direction.

**Table 2. Ranking system for categorizing potential nest substrates.**

Rank	Description
0	Unsuitable (inadequate support and concealment)
1	Possibly suitable, low quality (minimal support and concealment)
2	Probably suitable, moderate quality (sufficient support but concealment poor)
3	Definitely suitable, high quality (good support and concealment)

## Results

From January to July 2019, we completed a total of 332 site surveys for LeConte's Thrasher (Appendix 4), with 169 transect surveys, 104 plot surveys, and 54 habitat surveys. Surveys encompassed a total of 72 sites (Table 3, Appendix 5), 40 in Coachella Valley, 12 in Joshua Tree, and 20 in Anza-Borrego, with some combination of standardized plot-transect surveys at 51 sites (Appendix 6). Excluding time spent returning to occupied sites, we logged almost 400 hours of field time searching for LeConte's Thrashers, more than half of which was spent at Coachella Valley sites (Table 3).

**Table 3. Summary of LeConte's Thrasher survey results at three study areas, 2019.**

Survey summary	Coachella Valley	Joshua Tree	Anza-Borrego	Grand Total
Study sites	40	12	20	72
Study sites with plot/transect surveys	29	10	12	51
Total time (hours)	220	60	115	395
Area search time	150	33	74	257
Plot survey time	26	10	16	52
Transect survey time	45	18	25	88
Sites with LCTH detected	0	11	9	20
LCTH territories minimum	0	15	8	23
LCTH nests	0	17	9	26

We located at least 23 LeConte's Thrasher territories, where we detected birds on multiple visits, but this is a conservative minimum estimate since no birds were banded. We detected the birds at 20 sites and we located 26 nests. In the Coachella Valley, we detected LeConte's Thrasher at 0 of 40 sites (Figure 4), in Joshua Tree we detected LeConte's Thrasher at 11 of 12 sites (Figure 5), and at Anza-Borrego at 9 of 20 sites (Figure 6).

In the Coachella Valley study area we surveyed 29 sites with some combination of standardized transects or plots (Stubbe Canyon, Snow Creek west, Desert Hot Springs west, middle, and east, Whitewater River, Seven Palms Valley west and east, Willow Hole, Sky Valley west and east, Thousand Palms west, north, and south, Coachella Valley National Wildlife Refuge west and east, Pushawalla Canyon, Indio west and east, Double Canyon west and east, Thermal Canyon, Painted Canyon, Box Canyon, Shaver's Valley west, east, and north, and Dos Palmas Preserve west and east). Also, we searched on a less standardized basis at an additional 11 sites (Snow Creek east, Tipton Rd., Mission Creek Preserve, Seven Palms Valley north and south-east, Thousand Palms Preserve north and south, Coachella Valley National Wildlife Refuge north, Willis Palms, Biskra Palms, and Shaver's Valley BLM south of aqueduct).



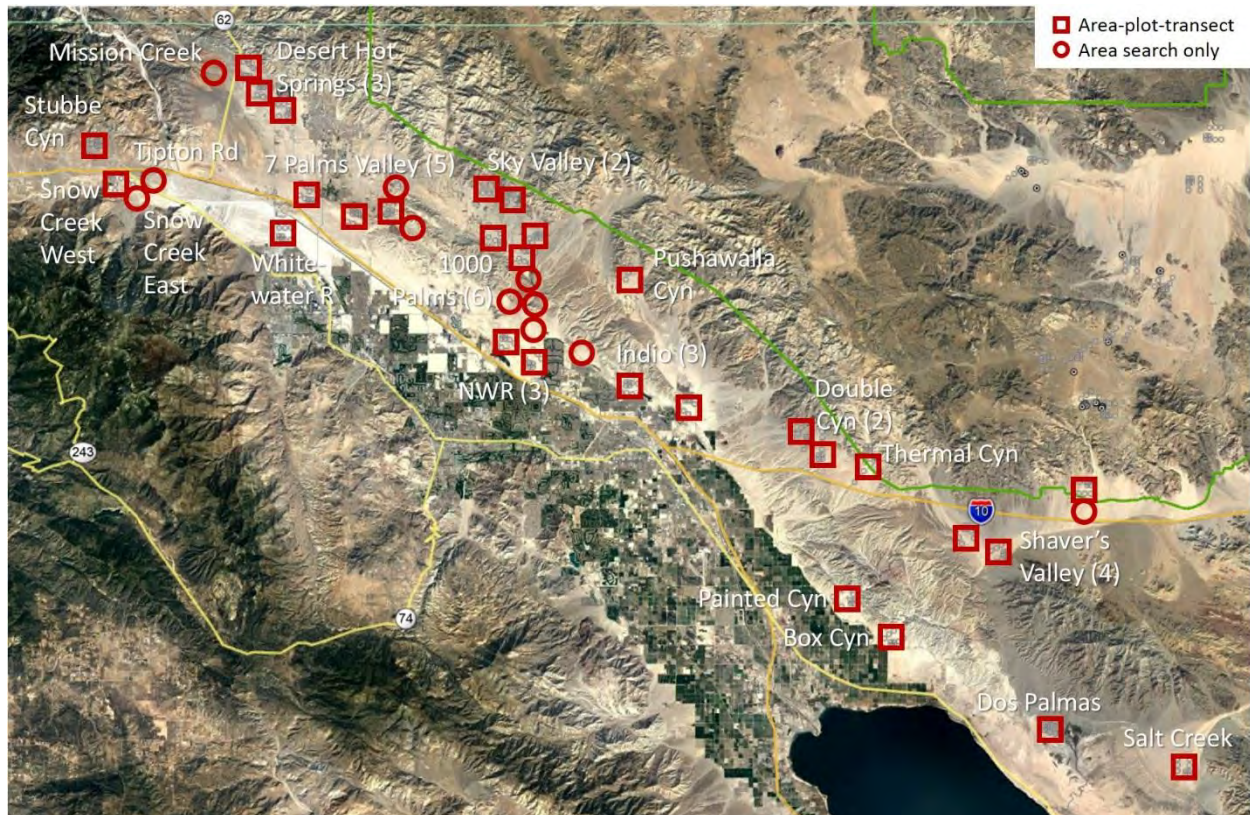


Figure 4. Coachella Valley study sites: no occupancy detected (squares encompass 1-km<sup>2</sup> area).

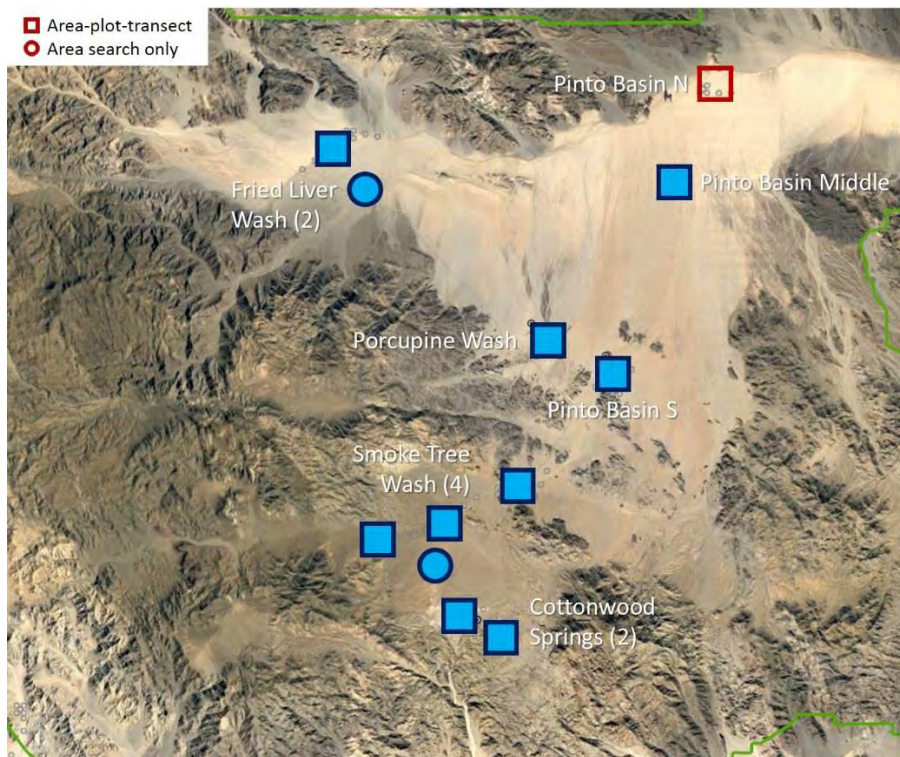


Figure 5. Joshua Tree study sites: blue indicates occupancy (squares encompass 1-km<sup>2</sup> area).





Figure 6. Anza-Borrego study sites: blue indicates occupancy (squares encompass 1-km<sup>2</sup> area).

In Joshua Tree National Park we surveyed 10 sites with some combination of standardized transects or plots (Cottonwood Springs campground northwest and northeast, Pinkham Canyon, Smoketree Wash west and east, Black Eagle Mine Road, Pinto Basin north and middle, Porcupine Wash, and Fried Liver Wash). For greater comparability, all sites were in the southern “Sonoran” part of the park. Because we found territories relatively easily in Joshua Tree NP, we added only two sites with incidental searching, one south-east of the Fried Liver Wash site, and another near Smoke Tree Wash along a service road. In Anza-Borrego Desert we surveyed 12 sites with some combination of standardized transects or plots (Clark Valley west, north, east, and south, Borrego Sink Wash west and east, Cactus Valley, San Felipe Wash at Borrego Valley Road, Bow Willow, Palm Spring, Carrizo Wash west and east), and an additional 8 sites with incidental searching (Clark Dry Lake, Font’s Wash, 4 sites in Borrego Sink, east San Felipe Wash north of Borrego Mountain, and Ocotillo Wells).

Most nests were very well concealed in nooks of large chollas or within other dense shrubs. The majority were in chollas (16), most often silver (or golden) cholla (*Cylindropuntia echinocarpa*) but also pencil (or diamond) cholla (*C. ramosissima*). Five nests were in honey mesquite (*Prosopis glandulosa*), always below a “roof” of mistletoe, and other shrubs used were desert almond (*Prunus fasciculata*), desert lavender (*Hyptis emoryi*), jojoba (*Simmondsia chinensis*), and smoke tree (*Psoralea arguta*) (Figure 7).

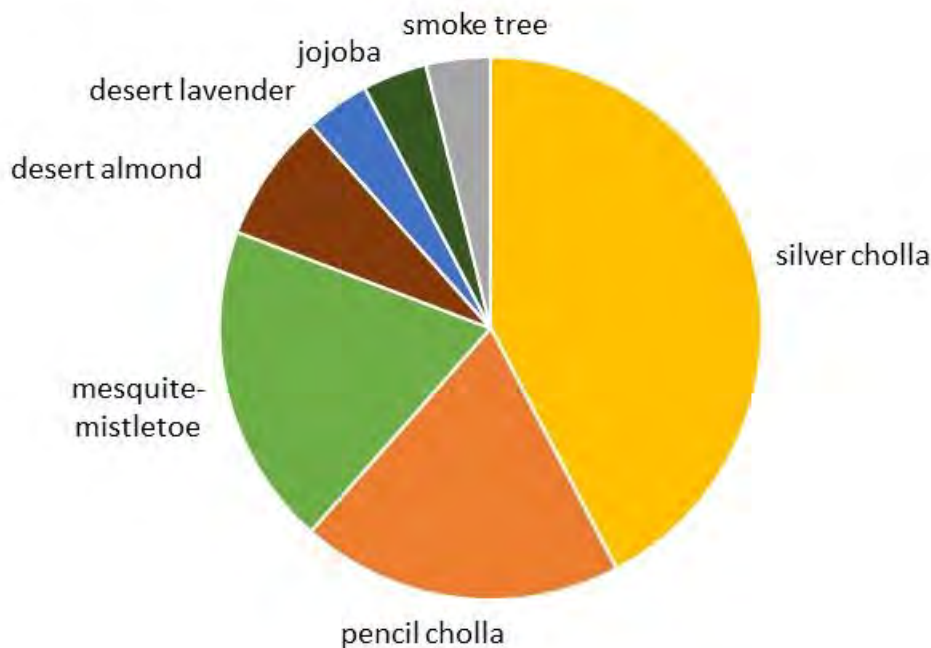


Figure 7. Proportion of substrates used for nests, 2019 (N=26).



All nests were wide bowls of a similar build (average 23 cm wide and 14 cm tall, Table 4), always composed of small twigs (2-4 mm in diameter) and often shredded bark, and always lined with a distinctive thick, soft pad (Figure 8). Their average height (from ground to base of nest) was 0.8 m (range 0.5–1.6 m), and the average height of the supporting shrub was 1.8 m (range 1.0–4.1 m). The tallest nest substrate was a smoke tree (Figure 9); the shortest were chollas. Across nests, an average of 85% of the nest was hidden from view from the sides at a distance of 3 m, and 84% was hidden if viewed from above (estimated), providing protection from both sun and predators (Figures 10-14).

**Table 4. Summary of LeConte's Thrasher nest measurements, 2019.**

Nest measurements	Min	Max	Avg	SD	N
% concealment sides	66%	100%	85.1%	10.2%	26
% concealment above	30%	100%	83.8%	20.5%	25
% concealment below	10%	90%	46.4%	26.0%	25
substrate height (m)	1.0	4.1	1.82	0.89	26
substrate width (m)	1.0	7.6	3.02	2.29	26
nest height (m)	0.5	1.6	0.83	0.34	26
outer nest height (cm)	8	19	13.5	2.7	25
outer nest width (cm)	15	35	22.7	4.4	25
inner cup height (cm)	5	12	7.1	1.8	24
inner cup width (cm)	9	15	11.7	1.7	24
clutch size	3	5	4	0.7	18

In the 18 nests whose final clutch size we could determine, the average clutch size was 4 eggs, higher than reported in the literature (mean 3.3, Sheppard 2018). Four of the 18 nests had 3 eggs, 8 had 4, and 4 had 5. One of the eggs in a clutch, however, often failed to hatch, and in none of the 5-egg clutches did all 5 eggs hatch. None of the birds were banded, but it was clear that most if not all pairs attempted multiple successive nests. Evidently, some pairs had three successful nests within the season. Successive nests we suspected were built by the same pair were up to 350 m apart but were sometimes located within the same shrub (Figure 14). Sheppard (2018) documented a banded pair that built successive nests 1 km apart.



Figure 8. LeConte's Thrasher nest with four eggs. Note densely padded lining within bowl of sticks and bark (near Fried Liver Wash, Joshua Tree National Park, 12 February 2019).



Figure 9. Smoke Tree in which LeConte's Thrasher nested, Joshua Tree National Park (same nest as above). Note size and density sufficient to both support and conceal a large stick nest.





Figure 10. Typical chollas in which LeConte's Thrashers nested (*Cylindropuntia ramosissima*, upper left; remainder *C. echinocarpa*). Each contains a well-concealed nest.



Figure 11. Relatively exposed nests in golden cholla (upper left) and jojoba (lower left) vs. completely concealed nests in a pencil cholla shrouded by desert star vine (*Brandegea bigelovii*, upper right) and desert almond (taller shrub behind *Tetracoccus hallii*, lower right).





Figure 12. Five-egg clutch in nest of LeConte's Thrasher near Cottonwood Springs campground, Joshua Tree National Park, 7 May 2019. Nearly 100% of the nest was concealed within the cholla.



Figure 13. LeConte's Thrasher nestlings shielded from predators and sun inside nook of cholla, San Felipe Wash, Anza-Borrego Desert State Park, 31 March 2019.



**Figure 14. Mesquite supporting three successive LeConte's Thrasher nests, each placed below a mistletoe roof, Borrego Sink, 2019.**

We could not be certain of every nest's outcome, but we confirmed that from 11 nests the young successfully fledged (Table 5), often observing fledglings at or near the nest (Figures 15–16). In only two cases did the nest clearly fail. We observed fledglings or young juveniles at some point in almost all territories, in most cases repeatedly.

**Table 5. Summary of LeConte's Thrasher nest outcomes, 2019.**

Nest outcomes	#
Successfully fledged	11
Probably fledged	4
Unknown (at least to nestling stage)	2
Unknown (eggs unconfirmed, fresh nest near fledglings)	5
Unknown (eggs unconfirmed, fresh nest near pair)	2
Failed	2
Total	26





Figure 15. Young LeConte's Thrasher fledgling, probably within 1 day of fledging, hiding inside agave within 20 m of nest, San Felipe Wash, Anza-Borrego Desert State Park, 28 May 2019.



Figure 16. Older fledgling LeConte's Thrasher, three weeks out of nest (nest in Figures 8–9), 26 March 2019. Note the bill only slightly decurved and the wing and tail feathers not quite full length. Its 3 siblings were also seen in the same large *Chilopsis*, which had not yet begun to leaf out. Even with fledglings so young, the parents were evidently working on their second nest, in which the eggs hatched approximately 2 weeks later.



Figure 17. Adult LeConte's Thrasher for comparison, with more strongly decurved bill, Joshua Tree National Park, 11 April 2019.

## Detectability

As expected, detectability was low, and we sometimes did not detect any LeConte's Thrashers until the third visit to a site. At one site we had already spent 9 hours until we had our first detection (Figure 18). However, over half of our sites with confirmed territories had detections on the first visit, and almost half of our first detections were within the first hour of visiting a site (Figure 18). Unoccupied sites were visited up to four times (including a final visit to measure habitat), but the number of visits per site varied.

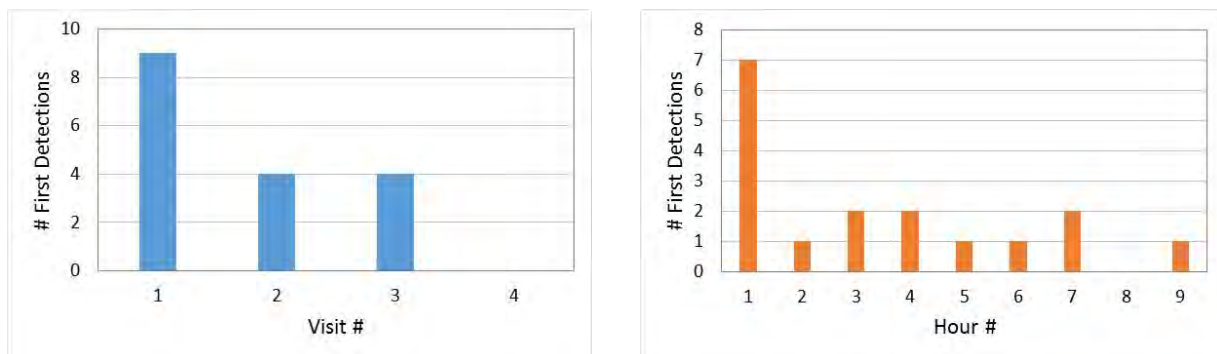


Figure 18. Of sites with confirmed territories, in more than half we detected a LeConte's Thrasher during the first visit (left) and in many cases within the first hour of survey (right, all visits combined).



Although about half of all first detections resulted from area searching, after division by the time spent on each method prior to the first detection, plot surveys appeared to be the most efficient. However, we did not randomize the order of the methods used at a site. Also, we often found clues first: tracks, dig marks, or old nests, so at these sites we spent more time area searching where we might have missed the birds had we only used the standardized methods.

Almost half of nests were discovered by searching for the nests in any potential substrates in the general areas where adults had previously been seen or heard, but almost as many were found by directly observing or following an adult (Figure 19, left). Some nests were found incidentally because of their proximity to the previous nest, including one that was found during measurement of the habitat. Only one nest was located prior to detection of any adults, during a plot survey (Figure 19, left). No nests were located during transect surveys. Almost half of nests were at the egg stage when first found (Figure 19, right). We also counted fresh, complete, intact nests that were found immediately adjacent to a pair and/or fledglings, but we could not be certain if these nests were used or of their outcome.

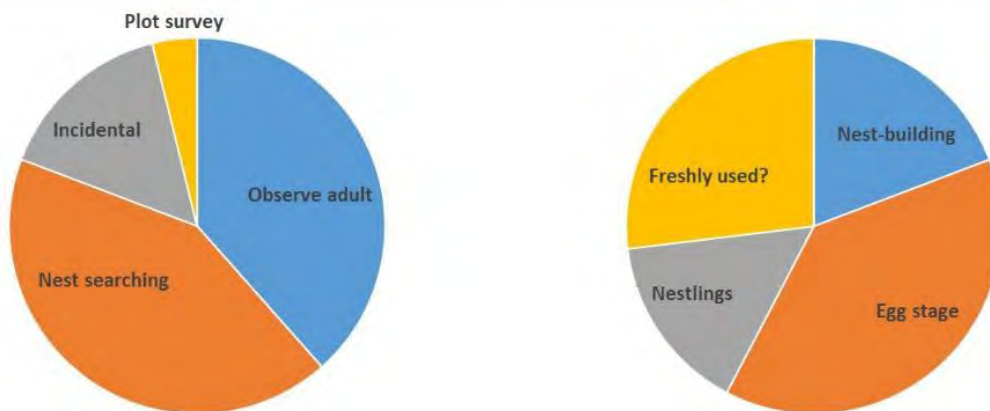


Figure 19. Method of nest discovery (left) and stage when first found (right).

## Habitat Survey Results

We had one last chance to detect LeConte's Thrashers when we returned to plots to measure habitat from May to July. Our habitat-survey protocol included covering the whole 300-m<sup>2</sup> plot and noting all vertebrate species detected. For plots centered around a nest, we completed 22 habitat surveys. Of those, we detected LeConte's Thrashers at 13 plots, for a repeat detection rate of over 50%, (Table 6). We found that juveniles were highly detectable, often perched out in the open and calling very frequently, even in July.

Even though we detected LeConte's Thrashers at almost all of the Joshua Tree sites, territories did not always appear to overlap with the smaller 300-m<sup>2</sup> plots, so we were able to consider 6

plots in Joshua Tree unoccupied, as well as 6 in Anza-Borrego. For comparison, we measured 20 unoccupied plots in the Coachella Valley, favoring those that seemed more potentially suitable. Of all 32 “unoccupied” plots, we detected LeConte's Thrashers in two plots (Table 6), but in both cases we believe the birds to have been dispersing juveniles, away from any known territories. One of these cases was a juvenile found dead, tangled in a desert star-vine in Pinto Basin (Figure 20).

**Table 6. Summary of habitat surveys at three study areas, 2019.**

Study Area	Nest plots	Nest plots with LCTH detections	Unoccupied plots	“Unoccupied” plots with LCTH detections
Joshua Tree	15	10	6	2
Anza-Borrego	7	3	6	0
Coachella Valley	0	0	20	0
Total	22	13	32	2



**Figure 20. Juvenile found dead, tangled in desert star-vine (Pinto Basin, 22 May 2019).**

At unoccupied sites, vegetation density, as measured by distance to nearest “shrub” (shrub, tree, yucca, or cholla > 0.5 m tall) within each quarter, tended to be lower (Figure 21, left). Thus open sand alone is not adequate habitat; LeConte's Thrasher likely requires some minimum and maximum spacing of shrubs. Cover of cholla was particularly low in the Coachella Valley (Figure 21, right). The number of potential nest substrates tended to be greater at nest plots than at unoccupied plots, both for shrubs ranked as moderate quality (Figure 22, left) and high quality (Figure 22, right).

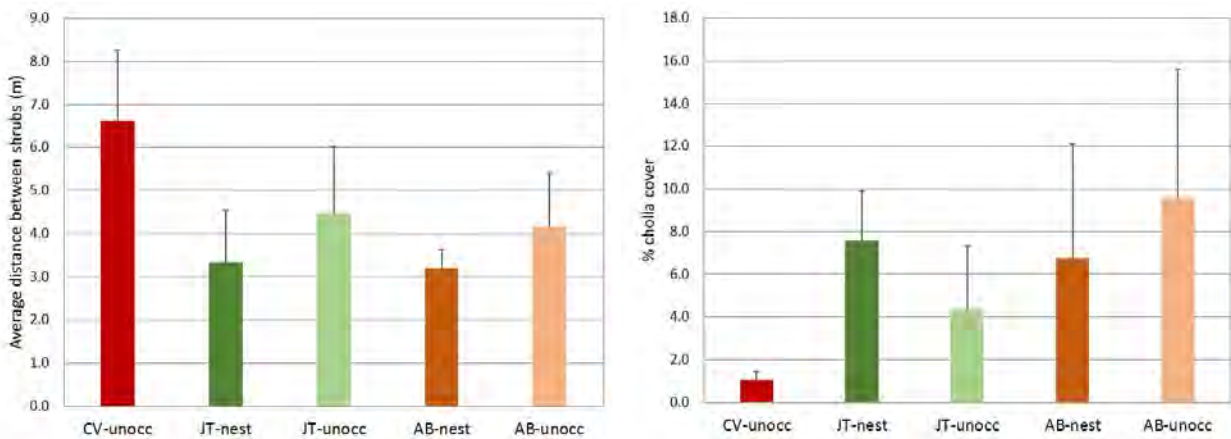


Figure 21. Average spacing of “shrubs” (any non-herbaceous vegetation >0.5 m in height, left) and relative cover of cholla (right), by study area and plot occupancy. Lines above bars, 95% confidence intervals.

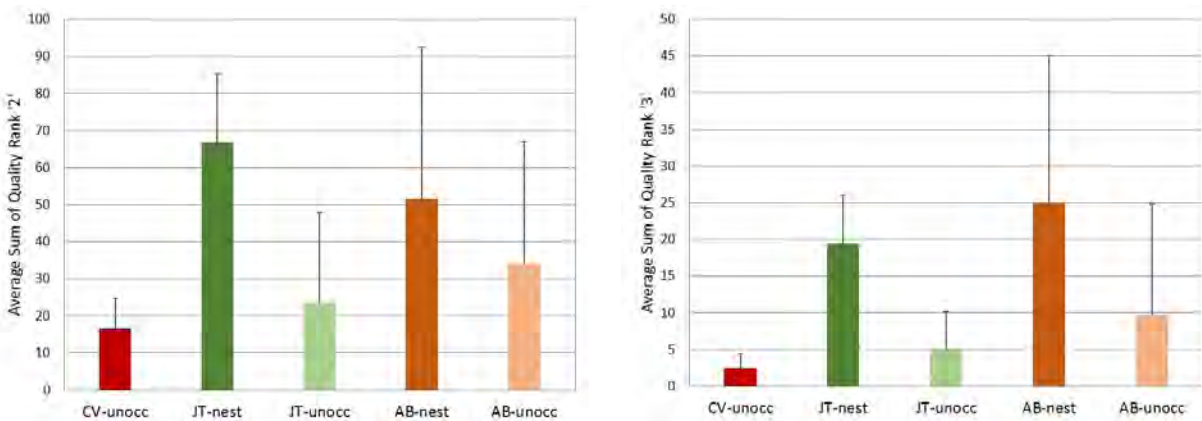
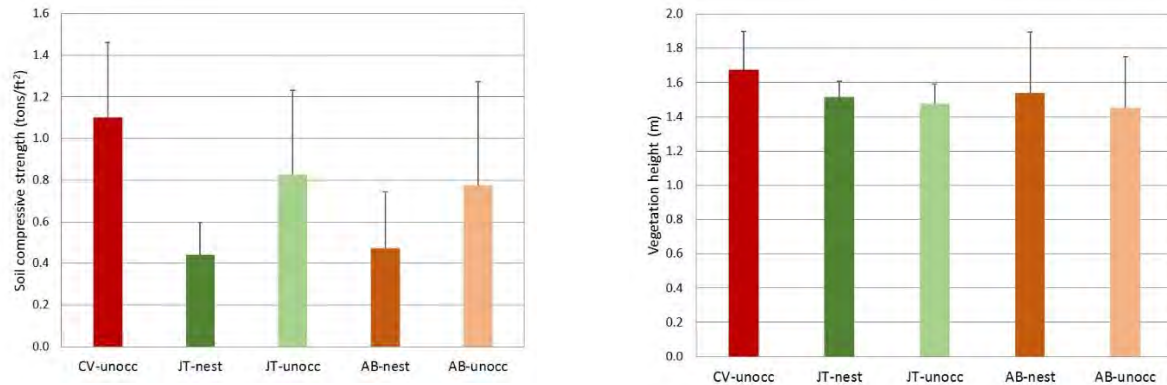
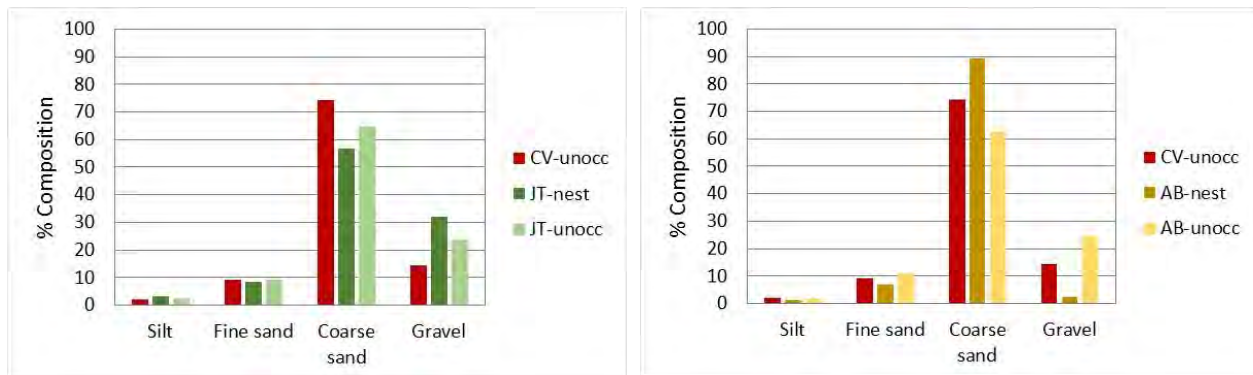


Figure 22. Average number of possible nest substrates of moderate rank (left) and high rank (right), by study area and plot occupancy. Lines above bars, 95% confidence intervals.

Sand tended to be looser or more friable in nest plots than in unoccupied plots, as measured by compression with a penetrometer (Figure 23, left), and there was little difference in average vegetation height (Figure 23, right). Coarse sand was dominant at all plots, but Joshua Tree plots tended to have slightly more gravel (Figure 24, left), Anza-Borrego nest plots less (Figure 24, right).



**Figure 23. Soil compression (left), and vegetation height (right), by study area and plot occupancy. Lines above bars, 95% confidence interval.**



**Figure 24. Soil composition, by study area and plot occupancy.**

When relative cover by plant species was averaged across plots, coverage of creosote ranked highest (33% average on nest plots, 44% on unoccupied plots), followed by ambrosia (12% average on nest plots, 6% on unoccupied plots), desert indigo (3% average on nest plots, 10% on unoccupied plots), honey mesquite (7% average on nest plots, 3% on unoccupied plots), and saltbush (1% average on nest plots, 7% on unoccupied plots).

To quantify vegetation composition, we performed a detrended correspondence analysis (unconstrained) using PC-ORD version 5.33. Unconstrained ordination of 38 plant species' cover (Appendix 7) showed a tendency toward separation of a higher-elevation community with juniper at Joshua Tree and two lower-elevation communities: palo verde–desert ironwood and mesquite–tamarisk. However, there was a zone of overlap within which the vegetation composition of some Coachella Valley plots was similar to nest plots.



To identify which Coachella Valley sites were most similar to occupied nest plots, we used 10 habitat measures: sum of weighted nest-substrate rankings, soil compaction, composition of rock and gravel, cholla cover, vegetation spacing, vegetation height, road density within 3-km radius, and vegetation composition (first two axes of ordination). We scored each measure for each site as 0 if it fell outside the range of values for nest plots, and 1 if it fell within the range (Appendix 8). On the basis of these measures, only Indio #23 had the highest score possible with 10 out of 10 points. It was followed by Snow Creek #3, Thousand Palms #17, Desert Hot Springs #7, and Seven Palms Valley #13, each with 9 out of 10 possible points. Snow Creek lost one point only because of the nearby road density exceeding the value of any nest plots, while the other three plots lost one point because they lacked nest substrates of adequate quality. Six plots scored 8 points: National Wildlife Refuge #15 and #18 (both with widely spaced vegetation and no cholla), Desert Hot Springs #6 and #8 (high adjacent road density, and differences in vegetation), and Thousand Palms Preserve #14 and #16 (both with compacted soil and lack of adequate nest substrates). Of course, the location of a single 300-m<sup>2</sup> plot is not necessarily representative of the broader surrounding habitat, so additional measures at various scales could improve the analysis. For example, Dos Palmas Preserve #28 scored relatively poorly by these criteria, but we noticed pockets of potentially more suitable habitat within the broader landscape.

## Discussion

The LeConte's Thrasher appears to be extirpated or nearly extirpated from the Coachella Valley. Despite our extensive coverage, there is still the possibility that a few birds could be at least wandering through, and there could be territories at sites that we did not visit. An extensive cholla patch near Cabazon is one potential area that we did not survey. However, this is relatively isolated, and there are evidently no nesting populations at the 40 sites that we surveyed in the Coachella Valley. Population decline in the Coachella Valley has been dramatic in comparison to historic (<1940) records, and has evidently continued since the baseline surveys in 2004-2005. Use of the same survey methods concurrently at nearby Joshua Tree National Park (higher elevations) and Anza-Borrego Desert State Park (lower elevations) confirmed the persistence of populations in these areas and also helped to both validate and inform our findings in the Coachella Valley.

Cholla was not the only nest substrate used and was not always present within the LeConte's Thrasher territories that we measured. Abundance of cholla is not necessarily a good territory predictor but rather some moderate amount of shrub spacing combined with high-quality nest substrates is likely key, as Figures 21-22 illustrate. However, cholla was a preferred nest substrate and there is evidence that it has declined in the Coachella Valley. The historic distribution of cholla in the Coachella Valley is not known in detail, but it was clearly more common historically in at least some areas. In 1904 Grinnell wrote: "In the vicinity of Palm Springs the desert floor is more or less closely dotted with several peculiar species of cacti" (Grinnell 1904). The Palm Springs area was where more LeConte's Thrashers were collected

historically than anywhere else in its range, and several biologists noted the use of cholla for nesting. Smeaton Chase (1919) described how difficult it was to pass through “the Devil’s Garden, a great cactus thicket between the Whitewater Wash and Seven Palms.” Walking near this area at Tipton Road, we noted hundreds of dead cholla trunks. Cholla occurred historically even at lower elevations, such as near Mecca, but not below the shoreline of ancient Lake Cahuilla as noted by Taylor in 1908: “There is even a markt difference in the vegetation as one crosses the shore-line. Below it there is no species of *Opuntia* whatever, while above it there are several” (field notes archived at Museum of Vertebrate Zoology, University of California, Berkeley; available at <http://ecoreader.berkeley.edu/>). Here the 1908 team of biologists noted LeConte’s Thrashers using the extensive thickets of mesquite, along with many other birds and even Cactus Wrens. Occurrence records ([www.calflora.org](http://www.calflora.org)) suggest that cholla is much more common along the rocky foothills, but we documented presence of cholla at 75% of plots we measured in the Coachella Valley, so it is still widespread away from the foothills, but mostly small in stature and in very low numbers.

After the record dry year of 2002, massive die-offs of cholla were documented in both Deep Canyon (Bobich et al. 2014) and Joshua Tree National Park (Miriti et al. 2007). And these studies preceded the most recent cycle of drought. After the wet winter of 2018–2019 we saw exuberant fresh growth of most individual chollas, but many areas had only dead chollas. Photos taken by Jay Sheppard near Desert Hot Springs in 1970 depict typical LeConte’s Thrasher habitat in the Coachella Valley at that time. Retakes of the same views 49 years later illustrate how the habitat has changed. Housing has replaced former LeConte’s Thrasher habitat (Figures 25–26), and in areas without houses chollas are far fewer, whereas the creosote bush and exotic mustard have increased (Figures 27–28). Even in areas not urbanized, we estimate from these photos that 49 years ago there was at least 40 times more cholla than in those same areas today. Besides drought and development, cholla is also threatened by the increased risk of fire due to invasive grasses and mustard—plants prevalent in 2019. Fires are at least partly responsible for reduced cholla and shrub cover in some areas, facilitated by invasive grasses and mustard. Historic photographs and accounts suggest that other shrubs that the thrasher can use for nesting have been greatly reduced in the Coachella Valley as well, including mesquite, yucca, saltbush, and smoke tree. We noted extensive areas with dieback of mesquite, including in the Seven Palms Valley area, where water levels are being monitored at Willow Hole. In some areas, lowered ground water levels may be contributing to dieback, which can be exacerbated by ground-water pumping, such as has been suggested for Cabazon (<https://www.desertsun.com/story/news/2014/07/22/nestle-arrowhead-bottling-plant-responds-aquifer-story/13019397/>) and for Borrego Springs (<https://www.desertsun.com/story/news/environment/2019/01/11/california-farmer-borrego-springs-groundwater-pumping-cuts/2169848002/>).





Figure 25. Former LeConte's Thrasher habitat in Desert Hot Springs (top, photo by Jay Sheppard, May 1970) vs. today (bottom), view to northwest.





Figure 26. Former LeConte's Thrasher habitat in Desert Hot Springs (top, photo by Jay Sheppard, May 1970) vs. today (bottom), view to northeast.



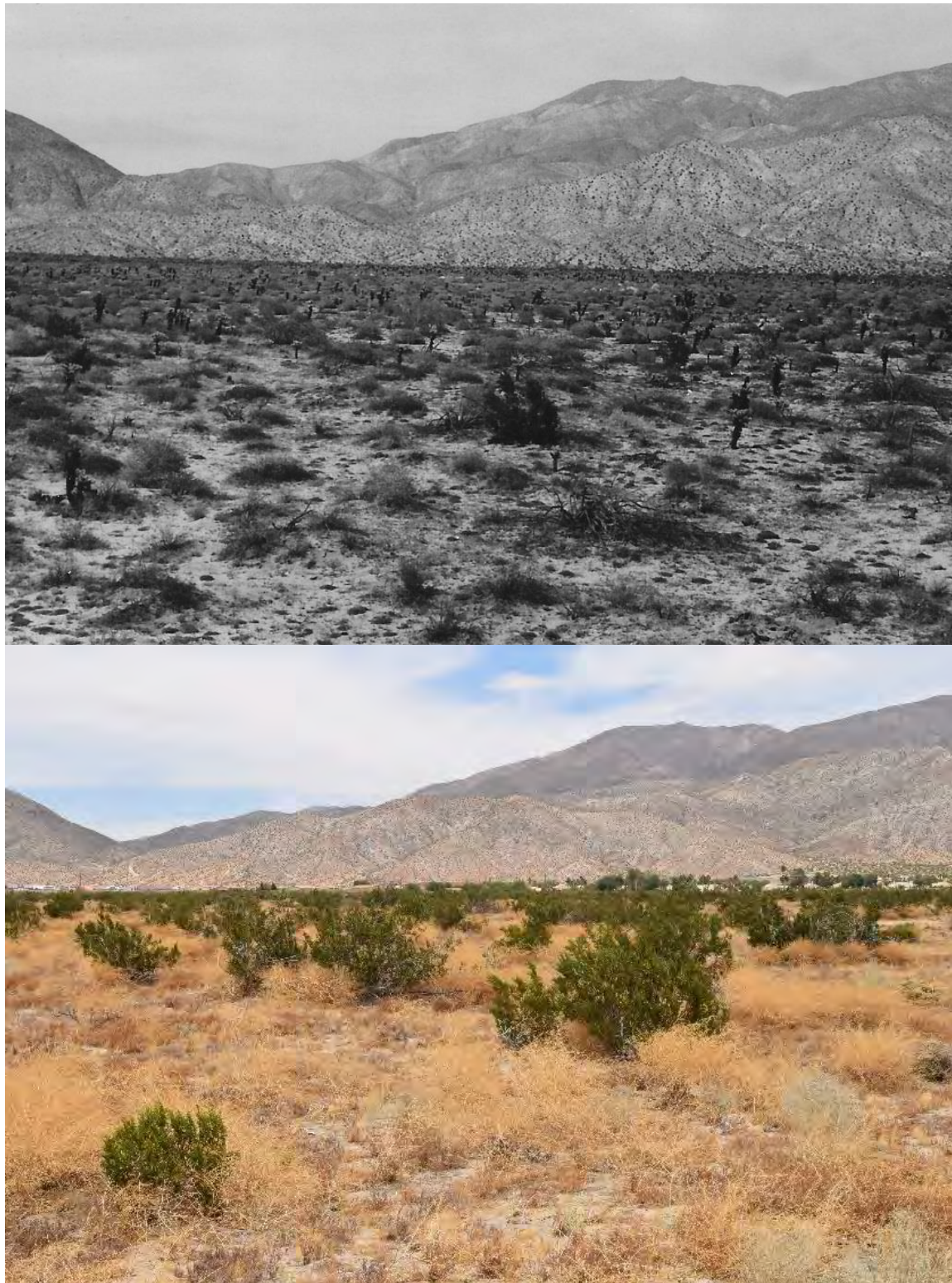


Figure 27. Former LeConte's Thrasher habitat in Desert Hot Springs (top, photo by Jay Sheppard, May 1970) vs. today (bottom), view to north, from a point south of previous photos. Note increase of creosote and mustard.





Figure 28. Former LeConte's Thrasher habitat in Desert Hot Springs (top, photo by Jay Sheppard, May 1970) vs. today (bottom), view to south. Note remains of dead cholla in foreground.

At most of our Coachella Valley sites we measured at least a few shrubs with at least a moderate quality ranking for nest substrate potential, and several sites scored very highly suggesting possible suitability, but other quality indicators often fell short (Appendix 8). Besides presence of dead chollas (Figure 29), many sites had varying degrees of disturbance, or poor foraging substrate (choked with mustard, rocky, too hard-packed/impenetrable, or recently flood scoured). While other large thorny/stiff shrubs, or even manmade structures, could substitute for cholla as a nest substrate, extensive sand with some minimum penetrability and open runways are required for suitable foraging substrate for this thrasher that specializes on probing for ground arthropods.



**Figure 29. Dead cholla, impenetrable ground, and/or thick mustard (top left, Stubbe Canyon, top middle and right, Mission Creek); flood scouring (lower right, National Wildlife Refuge); good foraging substrate but lack of nest substrates (lower left and middle, Seven Palms Valley).**

Of the key requirements, lack of suitable nest substrates appears to be the strongest factor distinguishing Coachella Valley sites from nest plots measured in nearby Joshua Tree and Anza-Borrego. However, multiple factors have likely contributed to the decline of the LeConte's Thrasher in the Coachella Valley (Table 7). Reduced and fragmented habitat is an especially important factor for LeConte's because it is a year-round resident bird with a large home range, a weak flyer prone to vehicle strikes, and not known for long-distance dispersal (Sheppard 2018). Although recent droughts have likely taken a toll throughout its range, other less drought-tolerant species are faring better in the Coachella Valley.



**Table 7. Multiple causes have likely contributed to the decline of the LeConte's Thrasher in the Coachella Valley.**

Possible causes of decline	Effects
--die-off of cholla and other large shrubs	--lack of suitable nest substrates, shelter
--reduced, fragmented habitat	--area insufficient to support populations, high mortality during dispersal, edge effects
--recent droughts	--suppresses nesting attempts, increases mortality, contributes to cholla die-off, leads to arthropod community collapse
--nest predators, competitors	--makes quality and quantity of nest substrates more critical
--invasive grasses, mustard	--blocks open runways for foraging, facilitates fire, depresses arthropod community
--past disturbance (e.g., off-road vehicles)	--may have contributed to decline of nest substrates, arthropod community
--floods scouring washes	--local, temporary decline of nest substrates, arthropod community

An increase of nest predators makes the quality of the nest substrate all the more important, and competitors make the number of nest substrates all the more important. A predator, the Common Raven, detected at 64 of 72 sites, was the species noted most widely (Table 8), and is also one of the species most increased over historic numbers in this region (Hargrove et al. 2014).

Increased competition for nest sites with the Northern Mockingbird and possibly the California Thrasher or even the Crissal Thrasher is likely. The mockingbird was our second most widespread species, detected at 60 sites (Table 8), and is another human-commensal species that has increased dramatically over historic numbers in this region (Patten et al. 2003). In natural desert habitat, the mockingbird is notably nomadic, invading in large numbers after wet winters like 2018-2019, then disappearing after nesting. Other thrasher species tended to be rare and localized—although we counted up to 7 California Thrashers per day at Stubbe Canyon. The apparent recent spread of the California Thrasher into the upper Coachella Valley represents a possibly increasing threat of competition.

Our focus was on LeConte's Thrashers and these numbers do not control for differences in level of effort, but, strikingly, of all predators and competitors, only in LeConte's did occupancy (% sites with detections) in the Coachella Valley differ appreciably from the proportion of all study sites combined (Table 8). The wide distribution of nest predators and competitors suggests that they alone are not the cause of LeConte's Thrasher decline in the Coachella Valley, but are likely an important factor in conjunction with limited availability of high-quality nest substrates.



**Table 8. Total numbers observed and % of sites with records for potential nest predators and competitors relative to LCTH, 2019. (See Appendix 9 for complete list of species by study area.)**

Species	Total Obs	Total % Sites	CV Obs	CV % Sites
Common Raven	1137	89%	595	90%
Greater Roadrunner	53	32%	20	28%
Loggerhead Shrike	345	81%	125	78%
Northern Mockingbird	517	83%	187	83%
California Thrasher	23	6%	17	8%
Crissal Thrasher	9	7%	3	5%
Bendire's Thrasher	4	3%	0	0%
Cactus Wren	209	46%	83	45%
LeConte's Thrasher	229	28%	0	0%

An average creosote is not sufficient to support or conceal a thrasher nest, but use of creosote has been documented (Sheppard 2018) and should be possible if the shrub is very large and tangled, especially if it is overgrown with vines. Shrikes and mockingbirds have slightly smaller, softer nests and are a bit more flexible in what they are capable of nesting in. We documented 14 shrike nests, including one in a large tangled creosote, but none in cholla. Cactus Wrens nest almost exclusively in cholla, but can perch their roofed nests in more exposed areas, such as on teddy-bear cholla (*C. bigelovii*), which often grows taller but less branched than the other local species of cholla. We found no LeConte's Thrasher nests in teddy-bear cholla.

LeConte's Thrasher nests all had distinctive soft padding inside a similarly sized inner bowl. Other thrashers and mockingbirds tend to use much more grassy material in the lining. Thrasher surveys should always include checking any potential nest substrates for nests. We noted that the LeConte's Thrasher nests were very sturdy, deteriorating little if at all over several months, while the mockingbird and shrike nests deteriorated rapidly.



**Figure 30. California Thrasher photographed near Willow Hole, Merganser Road, 16 July 2019. Photo by Kevin Clark.**

Large dense shrubs and cholla are critical not only for nest sites but also provide shelter during the hottest summer months and protection from storms, wind, and predators. Cholla and other large thorny shrubs can still be found in some parts of the Coachella Valley, but they have become rare remnants, patches isolated in a fragmented landscape (Figure 31). However, the persistence of very large cholla at sites such as Palm Springs shows that it is capable of withstanding severe droughts, and these survivors all had exuberant fresh growth after the wet winter. Conservation and restoration of cholla and other potential nest shrubs such as mesquite-mistletoe, smoke tree, saltbush, and jojoba would improve habitat suitability for LeConte's Thrashers in the Coachella Valley and would likely benefit many other species as well.



**Figure 31.** A few remnant cholla patches in Palm Springs (left) and Snow Creek (right), both sites that LeConte's Thrasher formerly occupied.

### Future Survey Efforts

Reproductive success of LeConte's Thrashers in the neighboring areas of Joshua Tree National Park and Anza-Borrego Desert was very high this year, so although we found no evidence of dispersal into the Coachella Valley this spring-summer, it is possible that the species could recolonize after a series of wet winters. We suggest that resurveys occur only after a series of wet winters, that they be focused on the highest-quality sites, and that they include nest searching. Additional potential sites may be identified through assessing the presence of any high-quality potential nest substrates combined with open friable sand.

Although our standardized surveys revealed no LeConte's Thrashers in the Coachella Valley, they will provide a solid baseline for future comparisons if the population should ever rebound. And a better understanding of LeConte's Thrasher's nest-site requirements will reveal the degree to which the reduction in the supply of suitable nest sites or declines in other aspects of habitat quality are contributing to the thrasher's decline in this region.

We used a ranking system based on multiple habitat criteria to identify sites in the Coachella Valley with the most potential of supporting LeConte's Thrasher populations. This tool can be expanded by measurements of additional plots and by adding more GIS layers that quantify the

habitat at a variety of scales. Finally, a predictive model can be constructed with each variable weighted. LeConte's Thrasher's requirement for sandy soil and relatively flat desert terrain is already well established. Because all our surveys were in such habitat our data do not clearly demonstrate this relationship, but it should be included in any predictive habitat modeling that is used to map suitable habitat across the wider region.

Additional analysis and larger sample sizes across the region will likely shed more light on territory and nest-site requirements, and enable the building of an accurate predictive model that can be used as a tool to identify highest-quality sites for conservation and monitoring. Standardized survey methods allow for analysis of abundance and occupancy while controlling for covariates that affect probability of detection, while nest-centered measurements are useful for revealing habitat features most directly related to quality thresholds or limitations. Many additional analyses are possible, such as testing use versus availability of different nest substrates.

The LeConte's Thrasher is one of very few avian desert specialists of the southwest and was formerly emblematic of the Coachella Valley. Its habitat needs overlap with those of many other species of interest that we documented during these surveys, including the Desert Tortoise (3 sites, Figure 32), Burrowing Owl (6 sites, Figure 33), and Round-tailed ground squirrel (18 sites). We documented a total of 142 species, including 112 in the Coachella Valley (Appendix 9). Our database includes confirmations of nesting of 20 species, including 75 nests of species other than LeConte's Thrasher. Most frequent among these was the Loggerhead Shrike (14 nests). We had 88 records of fledglings and/or feeding young by species other than LeConte's Thrasher, most commonly the Loggerhead Shrike (29). Conservation and restoration of LeConte's Thrasher habitat will benefit many other desert species.



**Figure 32. Desert Tortoise within a LeConte's Thrasher territory near Cottonwood Springs, one of several species of conservation concern with overlapping habitat requirements.**





**Figure 33.** More examples of species documented during this project include a fledgling Long-eared Owl (left, Carrizo Wash in Anza-Borrego Desert State Park), and adult Burrowing Owl near nest burrow (right, Pushawalla Canyon near Dillon Road).

## Recommendations

(1) Limit future LeConte's Thrasher survey efforts to a few sites with highest quality rankings, which can be refined with additional quality measures and modeling. Refined predictive modeling may identify additional high-quality sites. Selected "sentinel" sites should be searched more intensively with multiple visits during the season, preferably after a series of wet winters, including searching for nests in plots and in adjacent areas. Only after reoccupancy has been documented should a broader-scale resurvey be considered. On the basis of our habitat measures, the sites that should be given highest priority for more intensive surveys should include:

- South sentinel site: Indio #23
- North sentinel site: Snow Creek #3
- Middle sentinel site: Thousand Palms #17

Additional sites to consider:

- National Wildlife Refuge #15
- Seven Palms Valley #12 (Willow Hole)
- Desert Hot Springs #7
- Dos Palmas Preserve #28: although this site did not rank highly, expanding the number of plots to include more areas could reveal pockets of higher-quality habitat

(2) Experiment with restoration of cholla, which has been effective for recovery of the Cactus Wren on the coastal slope (The Nature Conservancy 2015 Appendix D). Remnant cholla patches in Palm Springs, Snow Creek, and next to houses in many areas including Cabazon and Desert Hot Springs, especially from any areas to be developed, could be used for propagation. High-priority sites to consider for cholla restoration should demonstrate past cholla or individuals

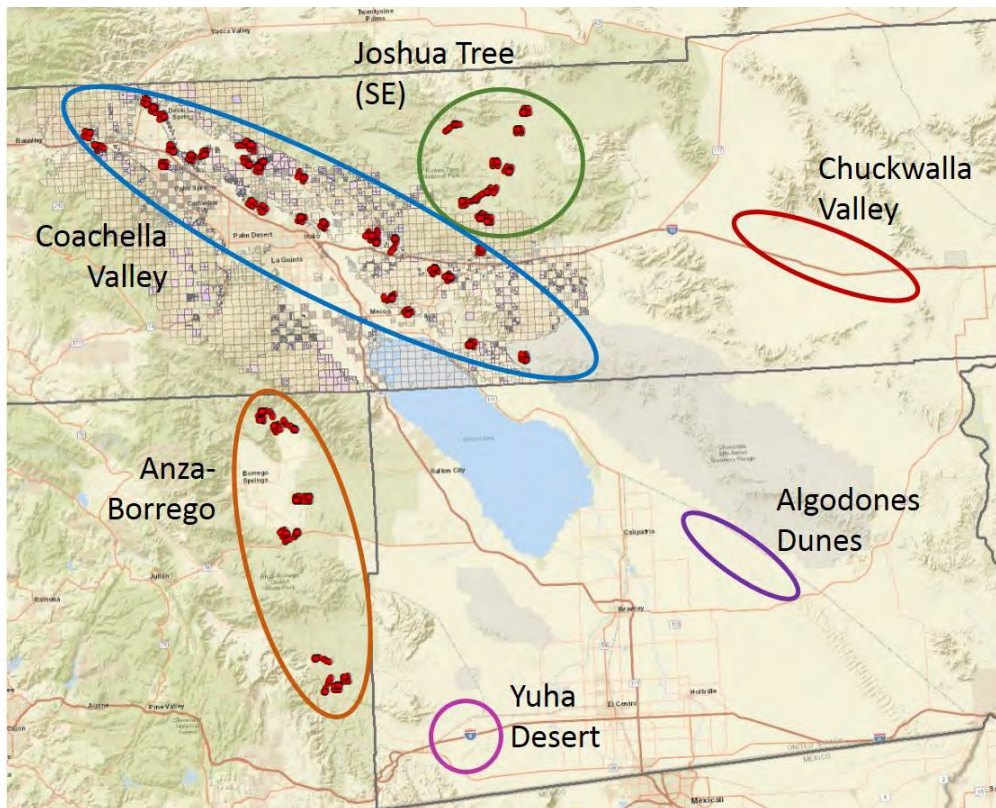
nearby, show evidence of past disturbance that may have contributed to their decline, and have high quality rankings in all areas except that they are lacking in nest substrates, such as:

- Seven Palms Valley #13
- Thousand Palms #14
- Desert Hot Springs #7

(3) Consider experimentation with artificial wooden nest structures (Sheppard 2018, page 63), as a temporary measure in areas selected for cholla restoration. These can be partially hidden within creosote bushes.

(4) Consider comparisons of ground arthropod community in regional nest plots vs. Coachella Valley plots, as the food supply could be a critical factor contributing to habitat suitability.

(5) Future research could be expanded to other study areas to increase sample sizes and obtain representative sampling across the Colorado Desert region for better predictive modeling, and especially to include low-elevation areas for better comparisons with the Coachella Valley. Three other major areas with recent sightings of LeConte's Thrasher are the Chuckwalla Valley, Algodones Dunes, and Yuha Desert (Figure 34). Other possibilities with recent records include Chuckwalla Bench and Ocotillo Wells.



**Figure 34. Prospective areas for expanding the study to broaden its perspective and improve understanding of territory and nest-site requirements for the LeConte's Thrasher in the Colorado Desert region.**

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## Literature Cited

- Blackman, S. T. and J. Diamond. 2015. Meta-population dynamics of LeConte's Thrasher (*Toxostoma lecontei*): a species at risk on three southwestern military installations. Year 3 report. Wildlife Contracts Branch, Arizona Game and Fish Department.
- Bobich, E. G., N. L. Wallace, and K. L. Sartori. 2014. Cholla mortality and extreme drought in the Sonoran Desert. *Madrono* 61:126-136.
- Center for Conservation Biology (CCB), University of California, Riverside. 2013. Biological Monitoring Protocol for *Toxostoma lecontei* (LeConte's Thrasher). Prepared for the Coachella Valley Conservation Commission, 23 pp.
- Center for Conservation Biology (CCB), University of California, Riverside. 2015. Biological Monitoring Program 2013–2014 year-end report, in Coachella Valley Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan: 2014 annual report; <http://www.cvmshcp.org/pdf%20files/2014%20BioMonitoring%20FINAL%20REPORT-UCR.pdf>.
- Coachella Valley Multiple Species and Habitat Conservation Plan (CVMSCHP). 2007. <http://www.cvmshcp.org/index.htm>. Accessed December 15<sup>th</sup>, 2014.
- Desert Thrasher Working Group Survey Protocol: LeConte's (*Toxostoma lecontei*) and Bendire's (*Toxostoma bendirei*) Thrasher Surveys. 2018.
- Fletcher, D. M. 2009. Distribution and site selection of LeConte's and Crissal thrashers in the Mojave Desert: A multi-model approach. UNLV Theses/Dissertations/Professional Papers/Capstones. 1122.
- Gilman, M. F. 1904. The Leconte thrasher. *Condor* 6(4): 95-98.
- Grinnell, J. 1904. Midwinter birds at Palm Springs, California. *Condor* 6(2): 40-45.



- Hanna, W. C. 1933. Nesting of the Crissal Thrasher in Coachella Valley, California. Condor 35:79.
- Hargrove, L., P. Unitt, S. Tremor, D. Stokes, B. Hollingsworth, M. Stepek, G. Fleming, and J. Berrian. 2014. Implementation of the Centennial Resurvey of the San Jacinto Mountains Project towards Development of a Landscape-scale, Long-term Monitoring Strategy. Report prepared for California Department of Fish and Wildlife. San Diego Natural History Museum, San Diego.
- Hutchinson, D. 2005. LeConte's Thrasher, *Toxostoma lecontei*. pp. 70-76 In Allen, M. F., J. T. Rotenberry, C. W. Barrows, V. M. Rorive, R. D. Cox, L. Hargrove, D. Hutchinson, and K. Fleming. 2005. Coachella Valley Multiple Species Habitat Conservation Plan Monitoring: 2002-2005 Report. Center for Conservation Biology.  
<http://repositories.cdlib.org/ccb/CCB2005b>.
- Miriti, M. N., S. Rodriguez-Buritica, S. J. Wright, and H. F. Howe. 2007. Episodic death across species of desert shrubs. Ecology 88:32-36.
- Patten, M. A., McCaskie, G. and Unitt, P., 2003. Birds of the Salton Sea: status, biogeography, and ecology. Univ of California Press.
- Pemberton, J. R. 1916. Nesting of the Leconte thrasher. Condor 18: 219-221.
- Sheppard, J. M. 1970. A study of LeConte's Thrasher. Calif. Birds 1:85-95.
- Sheppard, J. M. 1996. LeConte's Thrasher (*Toxostoma lecontei*), version 2.0. In The Birds of North America (A. F. Poole and F. B. Gill, Editors). Cornell Lab of Ornithology, Ithaca, NY, USA. <https://doi.org/10.2173/bna.23>.
- Sheppard, J. M. 2018. The Biology of a Desert Apparition: LeConte's Thrasher (*Toxostoma lecontei*). Studies of Western Birds No. 2. Western Field Ornithologists. Camarillo, CA.
- Smeaton Chase, J. 1919. California Desert Trails. Houghton Mifflin, Boston.
- Stephens, F. 1884. Collecting in the Colorado Desert – LeConte's Thrasher. The Auk 1:353-358.
- The Nature Conservancy. 2015. South San Diego County Coastal Cactus Wren (*Campylorhynchus brunneicapillus*) Habitat Conservation and Management Plan. Report prepared by The Nature Conservancy in collaboration with San Diego Management and Monitoring Program for San Diego Association of Governments, June 18, 2015.
- Unitt, P. 2004. San Diego County Bird Atlas. Proceedings of the San Diego Society of Natural History, No. 39. 645 pp.

# Appendix XV- Cowbird Management in the Coachella Valley

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# Cowbird Management in the Coachella Valley

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## INTRODUCTION

The Coachella Valley Multiple Species Habitat Conservation Plan (CVMSHCP 2007) identified five species of riparian birds as targets for conservation, the Willow Flycatcher, Least Bell's Vireo, Yellow-breasted Chat, Yellow Warbler, and Summer Tanager, and one species as a potential threat with management concern, the Brown-headed Cowbird (Table 1).

**Table 1.** Riparian bird species identified by the CVMSHCP for conservation monitoring.

Common name	Code	Scientific name	Status
Willow Flycatcher, incl. ssp. Southwestern Willow Flycatcher	WIFL	<i>Empidonax traillii</i> ( <i>Empidonax traillii extimus</i> )	State Endangered (Federally Endangered)
Least Bell's Vireo	LBVI	<i>Vireo bellii pusillus</i>	State Endangered/ Federally Endangered
Yellow Warbler	YEWA	<i>Setophaga petechia</i>	State Species of Special Concern
Yellow-breasted Chat	YBCH	<i>Icteria virens</i>	State Species of Special Concern
Summer Tanager	SUTA	<i>Piranga rubra</i>	State Species of Special Concern
Brown-headed Cowbird	BHCO	<i>Molothrus ater</i>	None (potential threat)

From 2002 to 2004, the Center for Conservation Biology conducted baseline surveys for these six riparian bird species and established standardized monitoring survey protocols (Allen et al. 2005). The baseline surveys covered 18 riparian sites in the Coachella Valley with a total of 116 count points.

In 2014, the San Diego Natural History Museum (SDNHM) performed resurveys at seven of these sites that were identified as higher priority on the basis of presence of target species from 2002-2004 and lack of recent surveys. The 2014 resurvey found low numbers of target riparian bird species compared to historic levels and neighbouring regions, and high numbers of Brown-headed Cowbirds, with 100% nest parasitism of the Least Bell's Vireo at Chino Canyon (Hargrove et al. 2014). However, successful nesting of the Least Bell's Vireo was documented at upper Whitewater Canyon, where no Brown-headed Cowbirds were observed. Three sites, Chino Canyon, Dos Palmas Preserve, and Whitewater Channel, were identified as having the most potential for riparian bird habitat where cowbirds were likely depressing riparian bird populations below a sustainable level, thereby creating a population "sink." Therefore, initiation of cowbird control was planned for 2017 at these three sites in addition to continued nest monitoring. At least three years of cowbird control was recommended in conjunction with nest monitoring. Broader-scale monitoring of population trends that includes additional riparian sites was recommended at a five-year interval.

In 2017, Cowbird control was implemented at the two sites where access was granted, Whitewater Channel, and Dos Palmas Preserve (San Diego Natural History Museum 2017). A



total of 84 Brown-headed Cowbirds were trapped during 2017, 75 at Whitewater Storm Channel and nine at Dos Palmas Preserve, using modified Australian Crow traps (Griffith and Griffith 2004). Of the 84 total trapped, 23 males were banded and released, to determine recapture rate, and 60 were collected. Only nine cowbirds were captured at Dos Palmas Preserve, and alternative methods of cowbird capture were recommended, namely targeted mistnetting.

In 2018, 55 Brown-headed Cowbirds were trapped in the two Whitewater Channel traps, including 22 males, 15 females, and 18 juveniles.

This report summarizes trapping efforts in the Coachella Valley in 2019. Cowbird removals at Dos Palmas Preserve have been discontinued due to low capture rates, and four traps were placed in the vicinity of the Whitewater Channel.

## METHODS

Four cowbird traps were installed and opened on 29-30 April 2019, all in the general vicinity of Mecca and near the Whitewater Channel (Table 2, Figure 1). The first cowbird was captured on 30 April. The traps were shut down and removed on 23-24 July 2019. All traps were checked and maintained on a daily basis, and were labelled with signage (Figures 2-4).

**Table 2.** Locations of four cowbird traps in the Coachella Valley, 2019.

Trap	Latitude	Longitude
Whitewater Delta Trap #1 (WW1)	33.512734	-116.063309
Whitewater Delta Trap #2 (WW2)	33.568267	-116.106378
Whitewater Delta Trap #3 (WW3)	33.53151	-116.08763
Whitewater Delta Trap #4 (WW4)	33.53837	-116.06584



**Figure 1.** Locations of four cowbird traps in the Coachella Valley in 2019. All four traps were south or west of Mecca, and north of the Salton Sea.



Figure 2. WW3 was located adjacent to the Whitewater River Channel levee.





Figure 3. WW1 was placed directly adjacent to riparian vegetation along the Whitewater River Channel.





Figure 4. WW4 was placed in a heterogeneous landscape of tamarisk and mesquite north and east of the Whitewater River Channel.

## RESULTS

### *Cowbird Trapping:*

A total of 79 cowbirds were trapped at the four Whitewater Channel traps (Table 3). This includes 45 males, 10 females, and 24 juveniles (Figures 5-6). This compares to 17 males, 5 females, and 53 juveniles trapped in 2017, and 22 males, 15 females, and 18 juveniles in 2018.

**Table 3.** Summary of cowbird trapping data, Whitewater Channel, 2019. Numbers do not include recaptures.

Totals	Males	Females	Juveniles	Totals	Bycatch	Dates
<u>WW 1</u>						
collected	0	4	9	13		
Trap Total	4	4	10	18	1 ABTO; 2 LOSH; 1 BEWR	29 April - 23 July
<u>WW 2</u>						

collected	0	3	9	12		
Trap Total	19	3	9	31	1 ABTO	28 April - 24 July
WW 3						
collected	0	2	1	3		
Trap Total	15	2	1	18	2 ABTO; 1 LOSH; 1 NOMO	29 April - 24 July
WW 4						
collected	1	1	2	4		
Trap Total	7	1	4	12	2 GAQU; 1 LOSH; 2 ABTO	28 April - 23 July
All Traps						
collected	1	10	21	32		
total	45	10	24	79		



Figure 5. Juvenile male cowbird captured 23 July 2019, showing post-juvenile molt with black feathers growing in.





Figure 6. The first fledgling in 2019 was captured at WW1 on 24 June.

Non-target species captured and released included Abert's Towhee (*Melospiza aberti*), Gambel's Quail (*Callipepla gambelii*), Loggerhead Shrike (*Lanius ludovicianus*), Bewick's Wren (*Thryomanes bewickii*), and Northern Mockingbird (*Mimus polyglottos*). Abert's Towhees were regularly found in traps throughout the season and released (Figure 7). Loggerhead Shrikes were also found in traps on multiple occasions and released. The Gambel's Quail were juveniles that had entered the trap for food and were released. The single Bewick's Wren likely wandered into the trap while foraging and was released unharmed. The Northern Mockingbird was a juvenile that was also safely released.



Figure 7. Abert's Towhee captured at WW3 on 15 July 2019.

A total of five non-target birds were found dead in the traps. On one occasion two Loggerhead Shrikes had entered a trap, and subsequently one of the shrikes, a juvenile, and two cowbirds were found dead before the remaining shrike was set free (Figure 8). On another occasion another juvenile Loggerhead Shrike was found dead in a trap for unknown reasons. Three Abert's Towhees were found dead in traps through the course of the season. Additionally one adult Gambel's Quail was found dead near a trap for unknown reasons. All non-target birds found dead in or near traps were collected and prepared as specimens for accession into the San Diego Natural History Museum collection (Table 4, Figures 9-10).





Figure 8. Loggerhead Shrike released from WW1 on 4 June 2019. This shrike killed two cowbirds and one juvenile shrike in the trap before it was captured and released.

***Specimens:***

Twenty three cowbirds and the six non-target birds found dead have been prepared as specimens and accessioned into the research collections of the SDNHM (Table 4, Figure 9-10).

Table 4. 29 specimens were accessioned into the research collection of the SDNHM.

CATALOG_NO	GENUS	SPECIES	SEX	Date	AGE
56334	Callipepla	gambelii	m	13 Jun 2019	
56304	Lanius	ludovicianus	f	03 Jun 2019	juv.
56305	Lanius	ludovicianus	?	17 Jun 2019	juv.
56295	Melospiza	aberti	m	13 May 2019	
56301	Melospiza	aberti	m	29 May 2019	
56312	Melospiza	aberti	m	11 May 2019	
56308	Molothrus	ater	f	18 Jun 2019	
56309	Molothrus	ater	m	18 Jun 2019	
56320	Molothrus	ater	f	15 Jul 2019	juv.
56321	Molothrus	ater	m	15 Jul 2019	juv.
56322	Molothrus	ater		15 Jul 2019	juv.
56327	Molothrus	ater	f	23 Jul 2019	
56328	Molothrus	ater	f	23 Jul 2019	
56329	Molothrus	ater	f	23 Jul 2019	
56330	Molothrus	ater	f	23 Jul 2019	juv.
56331	Molothrus	ater	f	23 Jul 2019	juv.
56332	Molothrus	ater	f	23 Jul 2019	
56336	Molothrus	ater	f	23 Jul 2019	
56337	Molothrus	ater		15 Jul 2019	juv.
56338	Molothrus	ater		15 Jul 2019	juv.
56339	Molothrus	ater	m	15 Jul 2019	juv.
56340	Molothrus	ater	m	15 Jul 2019	juv.
56341	Molothrus	ater	m	15 Jul 2019	juv.
56342	Molothrus	ater	?	15 Jul 2019	juv.
56352	Molothrus	ater	f	15 Jul 2019	
56360	Molothrus	ater	f	24 Jul 2019	
56361	Molothrus	ater	f	24 Jul 2019	
56369	Molothrus	ater	m	15 Jul 2019	
56372	Molothrus	ater	f	15 Jul 2019	



Figure 9. Brown-headed Cowbird specimens prepared for accession into the SDNHM research collection.





Figure 10. Abert's Towhee specimens prepared for accession into the research collection.

#### ***Recaptured Banded Cowbirds:***

Three male Brown-headed cowbirds that had been banded in 2017 were routinely trapped and released throughout the 2019 season (Table 5). The first (#1751-48124; Figure 11) was recaptured on 14 May at WW1 and continuously re-captured and released at this trap and WW4 through 16 July. This bird had been originally banded at Dos Palmas Preserve on 13 July 2017, and thus had moved the 14 miles between the two sites. The second (#1891-29110) was first recaptured 5 May at WW1 and continuously re-trapped and released until 18 June. This bird had been banded from trap WW1 on 21 July 2017. A third bird first banded at Dos Palmas in 2017 (1891-29106) was captured several times over four days at WW2. All other captures in 2019 were of birds banded in 2019 (Table 5).



Table 5. Banded male cowbirds captured and released during 2019.

Band number	trap	First capture	Last release	Notes
1751-48124	WW1	14 May	9 July	First banded at Dos Palmas Preserve on 13 July 2017; recaptured WW4 26 June-16 July;
1891-29110	WW1	5 May	18 June	First banded at WW1 on 21 July 2017
1891-29106	WW2	18 June	21 June	First banded at Dos Palmas Preserve on 13 July 2017
2891-14007	WW2	18 June	21 June	First banded at WW2 on 18 June 2019
2891-14013	WW2	18 June	21 June	First banded at WW3 on 18 June 2019
2891-14010	WW3	18 June	24 July	First banded at WW3 on 18 June 2019
2891-14012	WW3	18 June	20 June	First banded at WW3 on 18 June 2019
2891-14017	WW4	18 June	11 July	First banded at WW4 on 18 June 2019; recaptured at WW2 on 25 June; recaptured WW4 1-11 July
2891-14011	WW3	18 June	21 June	First banded at WW3 on 18 June 2019
2891-14006	WW2	18 June	11 July	First banded at WW2 on 18 June 2019
2891-14014	WW3	18 June	7 July	First banded at WW3 on 18 June 2019



Figure 11. Banded male cowbird (1751-48124) captured and released at Whitewater trap WW1. The male, first banded in 2017 at Dos Palmas Preserve, was captured and released nearly daily throughout the duration of the 2018 and 2019 trapping season.

One unexpected event was the occurrence of a severe thunderstorm and windstorm on 23 July. This storm turned over trap WW3 (Figure 12). However no cowbirds escaped, and the trap was not damaged.



Figure 12. A strong windstorm on the evening of 23 July tipped over trap WW3. No cowbirds were injured or escaped however.

## DISCUSSION AND RECOMMENDATIONS

The cowbird trapping at Whitewater Delta removed 34 cowbirds from the population, including ten breeding females. As the last survey of breeding birds in this area was accomplished in 2014, it is unclear if the three years of trapping are having the desired effect of increased breeding productivity and population sizes of target bird species. This area support numerous Yellow-breasted Chat territories, and is suitable breeding habitat for other focal riparian bird species including Yellow Warbler and Least Bell's Vireo. Therefore targeted surveys of breeding birds in this area is advisable.

Survey work in 2014 documented Yellow-breasted Chat breeding in only two sites in the Coachella Valley: Chino Canyon with one territory, and the Whitewater Delta with 7-10 territories from Lincoln St. to the Salton Sea (Hargrove et al. 2014). No survey work was conducted north of Lincoln St. in 2014, and the total size of the Chat population in the

Whitewater Channel is therefore unknown. With over 17 miles of riparian habitat in the Whitewater Channel from the water source at the Valley Sanitary District Treatment Plant in Indio down to the Salton Sea, there is significant potentially suitable habitat for target riparian species in this portion of the Coachella Valley. The potential occurrence of other target riparian bird species such as Least Bell's Vireo or Yellow Warbler within this portion of the Whitewater Channel is also unknown. Should these species be found, specific areas of the Channel can be identified for focused management.



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## LITERATURE CITED

- Coachella Valley Multiple Species Habitat Conservation Plan (CVMSHCP). 2007. Available from <http://www.cvmshcp.org/index.htm>. Accessed December 15, 2014.
- Griffith, J.T. and J.C. Griffith. 1992 (updated 2004). Brown-headed Cowbird Trapping Protocol. Unpublished document prepared for internal and agency use by John T. Griffith and Jane C. Griffith, Griffith Wildlife Biology, Calumet, Michigan.
- Hargrove, L., P. Unitt, K. Clark, and L. Squires. 2014. Status of Riparian Bird Species in the Coachella Valley. Final Report Prepared for University of California, Riverside and the Coachella Valley Multiple Species Habitat Conservation Plan Biological Monitoring Program. Prepared by the San Diego Natural History Museum. December 31, 2014.
- Kus, B., S. L. Hopp, R. R. Johnson and B. T. Brown. 2010. Bell's Vireo (*Vireo bellii*), version 2.0. In The Birds of North America (A. F. Poole, Editor). Cornell Lab of Ornithology, Ithaca, NY, USA. <https://doi.org/10.2173/bna.35>.
- Morrison, M. L. and A. Averill-Murray. 2002. Evaluating the efficacy of manipulating cowbird parasitism on host nesting success. 2002. The Southwestern Naturalist 47: 236-243.
- Patten, M. A., G. McCaskie, and P. Unitt. 2003. Birds of the Salton Sea: Status, Biogeography, and Ecology. University of California Press, Berkeley.
- San Diego Natural History Museum. 2017. Riparian Bird Nest Monitoring and Cowbird Management in the Coachella Valley. Annual Progress Report 2017. Prepared for Coachella Valley Conservation Commission. March 23, 2018. 51 pp.
- San Diego Natural History Museum. 2018. Riparian Bird Nest Monitoring and Cowbird Management in the Coachella Valley. Annual Progress Report 2018. Prepared for Coachella Valley Conservation Commission. December 21, 2018. 15 pp.
- Siegle, R., and D. Ahlers. 2004. Brown-headed Cowbird Management Techniques Manual. Prepared by U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Ecological Planning and Assessment. Denver, Colorado. 78 pp.
- Sogge, M. K., D. Ahlers, and S. J. Sferra. 2010. A natural history summary and survey protocol for the Southwestern Willow Flycatcher: U.S. Geological Survey Techniques and Methods 2A-10, 38 pp.