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

2021 Annual Report

Coachella Valley Conservation Commission

April 2022

Contents

List of Appendices ii

I. Introduction 1

Plan Background 1

II. Reserve Assembly Progress 2

Land Acquisition to Achieve the Conservation Goals and Objectives 4

III. Status of Conservation Areas 7

Status of Covered Species 7

Covered Activities Outside Conservation Areas 7

IV. Biological Monitoring Program 10

V. Land Management Program 12

Reserve Management Unit Committees 12

Trails Management Subcommittee 12

Land Improvement: Acquisition Cleanups 13

Property Management & Monitoring 13

VI. Unauthorized Activities and Enforcement 16

VII. Significant Issues in Plan Implementation 16

VIII. Compliance Activities of Permittees 16

IX. CVMSHCP Expenditures – 2021/2022 Budget 17

X. Annual Audit 18

Cover photos courtesy of Kathleen Brundige, CVCC

CVCC

List of Appendices

I. Acquisition and Management Credit Allocation

II. Conservation Acquisitions in 2021

III. Conservation Objectives by Conservation Area

IV. Development outside Conservation Areas

V. Aeolian Sand Species Monitoring Report 2021

VI. Triple-ribbed Milkvetch Monitoring Report 2021

VII. Coachella Valley Milkvetch Monitoring Report 2021

VIII. Little San Bernardino Mountains Linanthus Monitoring Report 2021

IX. Peer-reviewed Research: *Forty Years Later: Monitoring and Status of the Coachella Valley Fringe-toed Lizard*

X. Brown-headed Cowbird Management Report 2021

XI. Final Report of Local Assistance Grant: Sand Dune Restoration in the Coachella Valley NCCP

I. Introduction

This Annual Report describes the progress made on implementation of the Coachella Valley Multiple Species Habitat Conservation Plan for the 2021 calendar year. Acquisition of key properties continued, with 2,003 acres added to the reserve system to protect habitat for our desert plants and animals. The CVCC acquired 780 of those acres. We have made significant progress since the Plan's inception, with over 100,000 acres conserved in just 12 years. Authorized disturbance in conservation areas remains infrequent: only 20.5 acres in 2021, and 360 acres in total since baseline planning began in 1996. Development outside the conservation areas, including important road projects and water infrastructure, continued through the streamlined process facilitated by the Plan.

Biological monitoring activities continue to gather important data on covered species, including an expanded study of desert tortoise occupancy and genetics, ongoing monitoring of aeolian sand dune species, revisiting oases to determine occupancy by yellow bats, and expanded studies to understand the location and demographics of Coachella Valley milkvetch, the triple-ribbed milkvetch and the little San Bernardino Mountains linanthus. The information gathered through the biological monitoring program helps us better manage our reserve lands and ensure the survival of the 27 plant and animal species the Plan is charged with protecting. On the land management side, CVCC developed a land management database to better monitor existing fencing and signage and to protect lands from illegal dumping and vehicle trespass. Crews cleared invasive tamarisk from our properties at North Shore Ranch and fountain grass from Cathedral Canyon properties. CVCC also signed an MOU with Riverside County Sheriffs Department and Desert Hot Springs Police Department to increase our enforcement capacity of illegal dumping, shooting, illegal camping, and OHV activity. CVCC also worked with Southern California Mountains Foundation Urban Conservation Corps to remove tires and cleanup refuse from reserve lands. We appreciate the support of the members of the CVCC, our partners, and collaborators for the ongoing success of this visionary Plan.

Plan Background

The Coachella Valley Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan (CVMSHCP) is a multi-agency conservation plan that provides for the long-term conservation of ecological diversity in the Coachella Valley region of southern California. The CVMSHCP includes an area of approximately 1.1 million acres and incorporates the watersheds within the jurisdictional boundaries of the Coachella Valley Association of Governements (CVAG). Tribal lands are not included in the CVMSHCP although coordination and collaboration with tribal governments has been ongoing. State and federal permits were issued in October 2008 and run for a 75-year term, during which the CVMSHCP is expected to be fully implemented and funded.

The Coachella Valley Conservation Commission (CVCC) was established in 2008 to oversee CVMSHCP implementation, and is comprised of elected officials from Riverside County, the cities of Cathedral City, Coachella, Desert Hot Springs, Indian Wells, Indio, La Quinta, Palm Desert, Palm Springs, and Rancho Mirage, as well as the Coachella Valley Water District, Mission Springs Water District, and the Imperial Irrigation District. The Riverside County Flood Control and Water Conservation District, Riverside County Regional Park and Open Space District, and Riverside County Waste Resources Management District are also members, as are the California Department of Parks and Recreation, the Coachella Valley Mountains Conservancy (CVMC), and the California Department of Transportation (Caltrans). Collectively, with the addition of CVAG, these entities constitute the CVMSHCP Permittees.

The CVMSHCP established a Reserve System to ensure the conservation of 27 Covered Species, 23 natural communities, and 3 essential ecological processes in perpetuity. This Reserve System consists of 21 priority Conservation Areas built around existing protected lands managed by local, state, or federal agencies and non-profit conservation organizations. To complete the assembly of the Reserve System, lands are acquired or otherwise conserved (1) by the CVCC directly on behalf of the Permittees, (2) through state and federal agencies to meet their obligations under the CVMSHCP, or (3) through complementary conservation, whereby lands are acquired to consolidate public ownership in areas such as Joshua Tree National Park and the Santa Rosa and San Jacinto Mountains National Monument. Complementary conservation is not a Permittee obligation but does benefit the Plan.

In addition to acquisition, land in the Reserve System may be conserved through dedication, deed restriction, granting of 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.

This Annual Report describes the activities for the calendar year from January 1, 2021 to December 31, 2021. As required by Section 6.4 of the CVMSHCP, this Annual Report will be presented at the CVCC meeting of April 14, 2022, which will serve as a public workshop. The report is also posted and available to the public on the CVMSHCP website, www.cvmshcp.org.

II. Reserve Assembly Progress

As of December 31, 2021, Permittees have conserved 14,292 acres, just over 14% of their conservation goal (Figure 1). State and federal conservation has reached 24,136 acres, or 60% of their required contribution, and complementary conservation has accounted for 61,966 acres, about 89% of the anticipated acreage. Since 1996, 100,394 acres have been conserved under the CVMSHCP, with the assembly of the Reserve System about 48% complete (Table 1, Figure 2). A description of how CVCC allocates acreage credit is included in Appendix I.

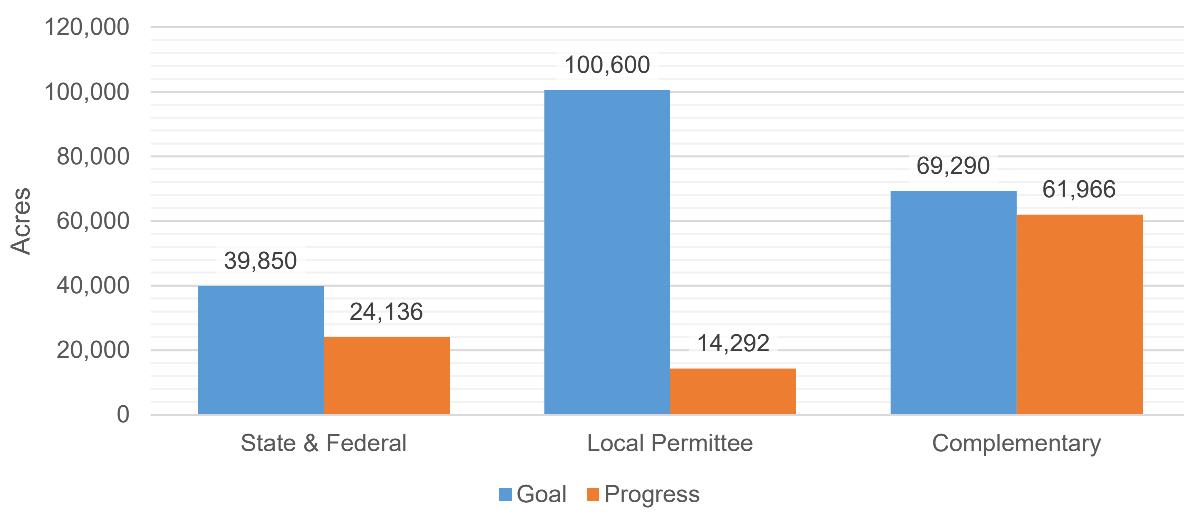

Figure 1: CVMSHCP conservation progress towards conservation goals.

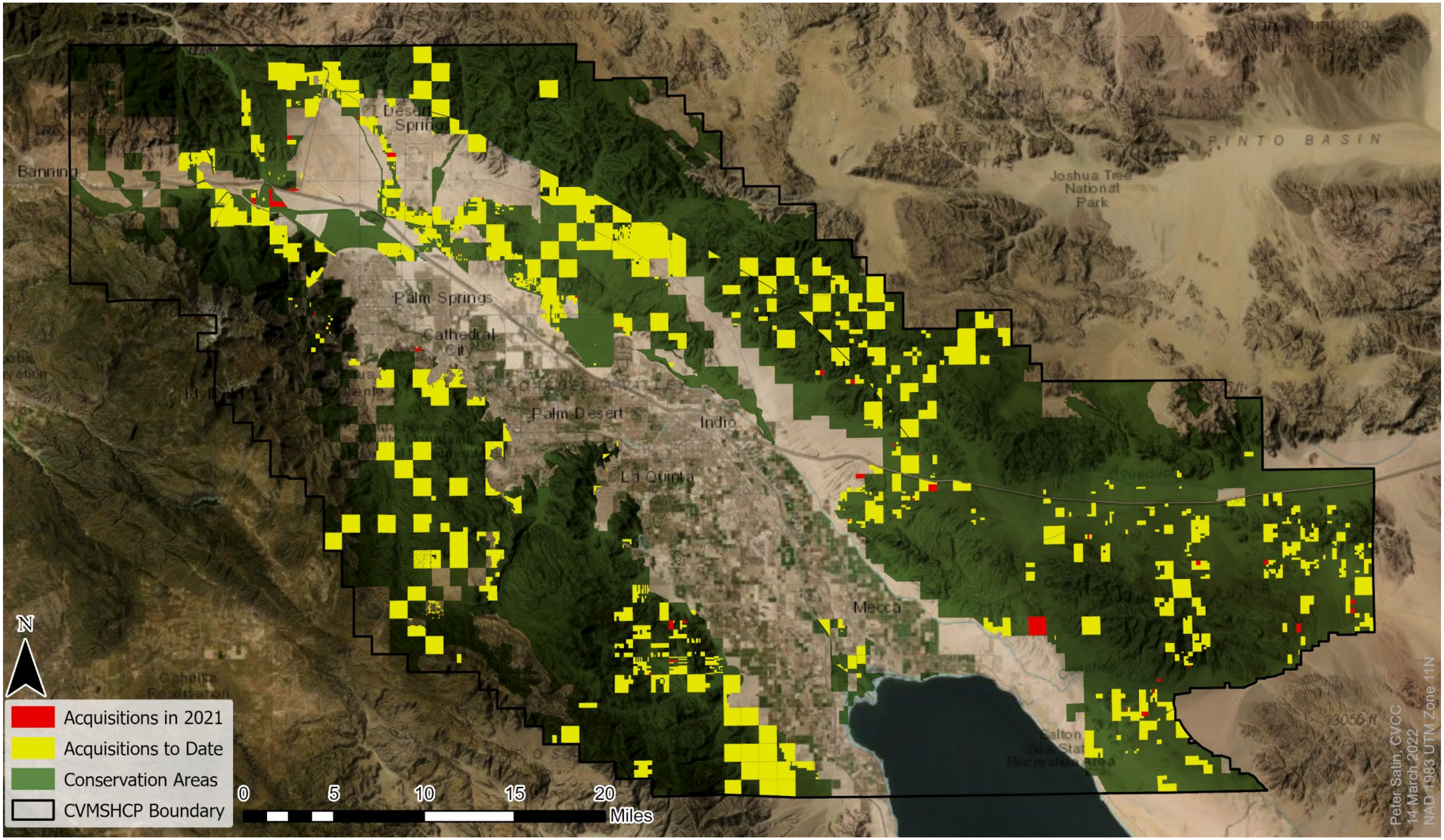

Figure 2: CVMSHCP reserve assembly status, including 2021 acquisitions.

Once acquired, lands within the Reserve System are held in public or private ownership and are managed for habitat conservation and open space values. Land acquired under complementary conservation is often transferred in fee to either a state or federal agency or to a permittee for long term management. Management of these lands contributes to the conservation of the Covered Species and the conserved natural communities included in the Plan.

Table 1: Summary of annual progress on reserve assembly.

Year	State & Federal Credit Acres	Permittee Credit Acres	Complementary Credit Acres	*Yearly Total*
2013	20,048	8,091	54,636	***82,775***
2014	1,681	241	957	***2,880***
2015	296	425	1,445	***2,167***
2016	319	839	612	***1,770***
2017	525	793	1,703	***3,022***
2018	814	578	906	***2,298***
2019	224	421	510	***1,155***
2020	40	2,123	162	***2,325***
2021	189	780	1,035	***2,003***
Category Total	***24,136***	***14,292***	***61,966***	***100,394***
Management Acre Credit	*60,752*	*16,892*	*22,750*	***100,394***

Land Acquisition to Achieve the Conservation Goals and Objectives

In 2021, CVCC completed 13 transactions acquiring 37 parcels totaling 780 acres at a cost of $2,074,747 in CVCC funds, and including one property worth $755,450 donated in accordance with a Joint Project Review requirement (Table 3). CVCC acquisitions on behalf of local Permittees occurred predominantly in the Mecca Hills/Orocopia Mountains Conservation Area, as well as eight other Conservation Areas (Figure 3). Local, state and federal partners acquired an additional 1,223 acres in four Conservation Areas, for a total of 2,003 acres in ten different Conservation Areas (Figure 4). All lands conserved by CVCC and partner organizations during the period from January 1, 2021 to December 31, 2021 are depicted in Figure 2 and listed in Appendix II.

CVCC acquires lands with funding from CVMSHCP development mitigation fees as well as public agency contributions to mitigate for regional roads and other transportation projects. 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 Wildlife Conservation Board and California Department of Fish and Wildlife are both major source of State 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 (Figure 5).

Table 2: Lands acquired by CVCC in 2021.

Project	Conservation Area	Parcel Count	Project Acreage	Acquisition Cost
2018 Tax Default Sale - 4461	Desert Tortoise & Linkage	1	10	$3,246
2019 Tax Default Sale - 4482	Desert Tortoise & Linkage	1	7	$3,043
2019 Tax Default Sale - 4471	Edom Hill	1	5	$7,381
Eisenberger-Perkins	Highway 111/I-10	2	36	$190,000
Winn	Highway 111/I-10	1	10	$48,300
2018 Tax Default Sale - 4483	Mecca Hills/Orocopia Mountains	2	92	$6,013
2019 Tax Default Sale - 4482	Mecca Hills/Orocopia Mountains	1	20	$3,330
Swann Trust	Mecca Hills/Orocopia Mountains	2	80	$21,000
2018 Tax Default Sale - 4461	Santa Rosa & San Jacinto Mountains	1	1	$3,754
2018 Tax Default Sale - 4483	Santa Rosa & San Jacinto Mountains	2	3	$7,478
2019 Tax Default Sale - 4482	Santa Rosa & San Jacinto Mountains	2	2	$5,524
Rimrock	Santa Rosa & San Jacinto Mountains	1	42	$460,000
2017 Tax Default Sale - 4454	Thousand Palms	1	10	$31,607
2018 Tax Default Sale - 4461	Thousand Palms	1	2	$20,595
2019 Tax Default Sale - 4482	Thousand Palms	2	4	$21,968
Mulhearn Trust	Thousand Palms	2	16	$42,459
2017 Tax Default Sale - 4454	Upper Mission Creek/Big Morongo Canyon	1	3	$11,278
Formosa Botanical Gardens	Upper Mission Creek/Big Morongo Canyon	1	39	$215,000
Brookler	Upper Mission Creek/Big Morongo Canyon	1	9	$61,000
DHS Investors, LLC	Upper Mission Creek/Big Morongo Canyon	1	77	$585,000
Willbro Partnership	Upper Mission Creek/Big Morongo Canyon	2	41	$260,000
2017 Tax Default Sale - 4454	Willow Hole	4	12	$19,516
2018 Tax Default Sale - 4461	Willow Hole	1	0	$4,115
2018 Tax Default Sale - 4483	Willow Hole	1	5	$28,923
2019 Tax Default Sale - 4482	Willow Hole	1	5	$14,217
MVPP CVCC 20-005	Whitewater Floodplain	1	248	$755,450
Total		***37***	***780***	***$2,830,197***

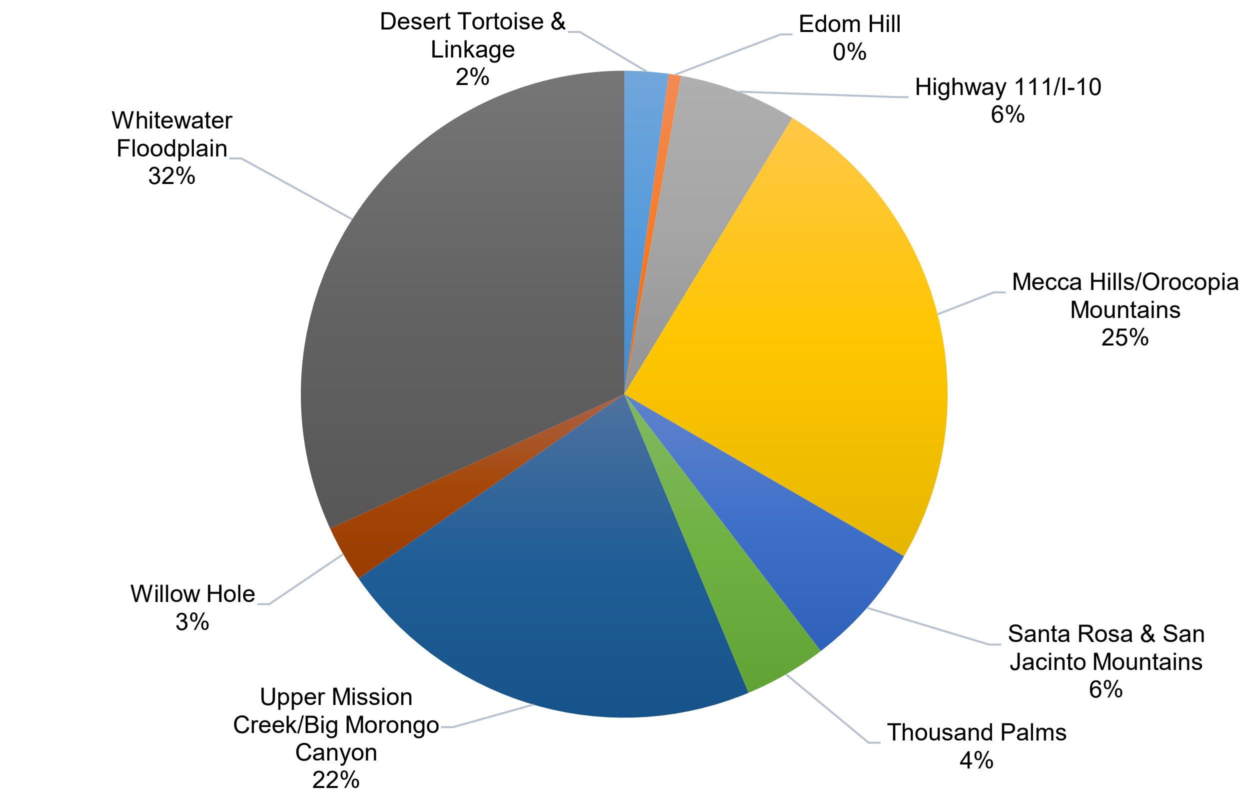

Figure 3: CVCC acquisitions in 2021 by Conservation Area as a proportion of CVCC acreage acquired.

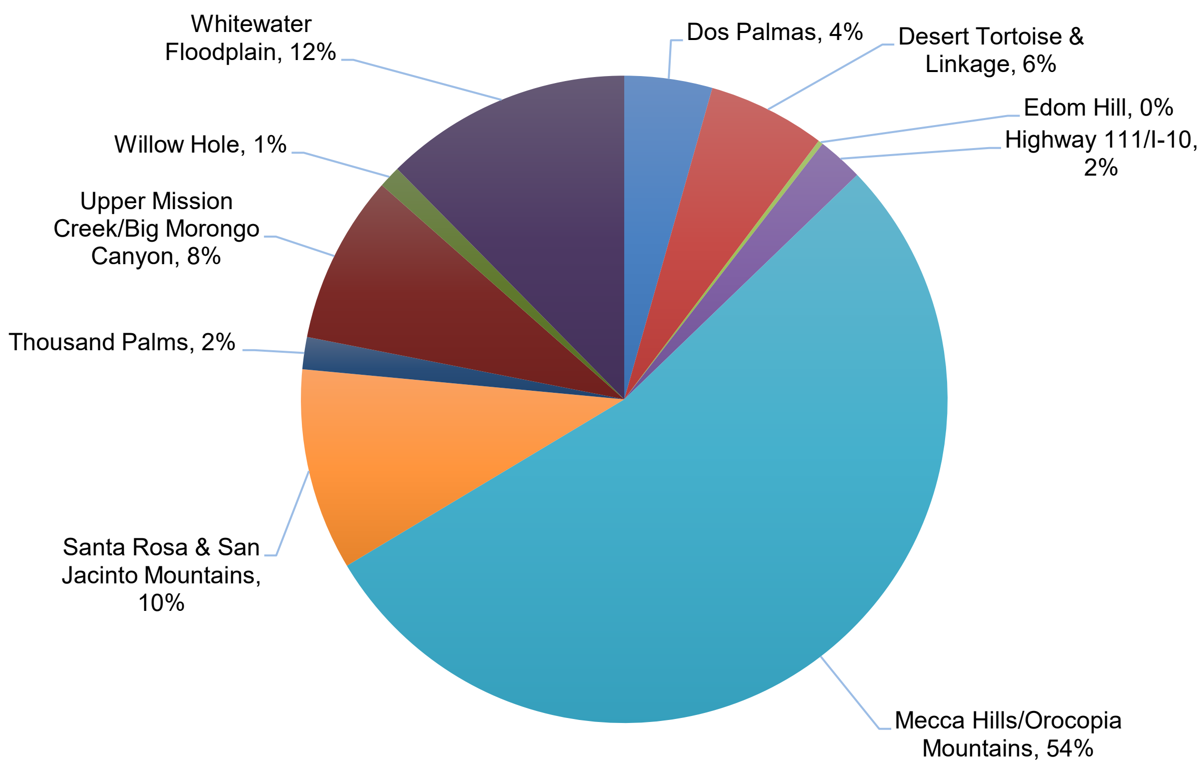

Figure 4: Total acquisitions in 2021 by Conservation Area as a proportion of total acreage acquired.

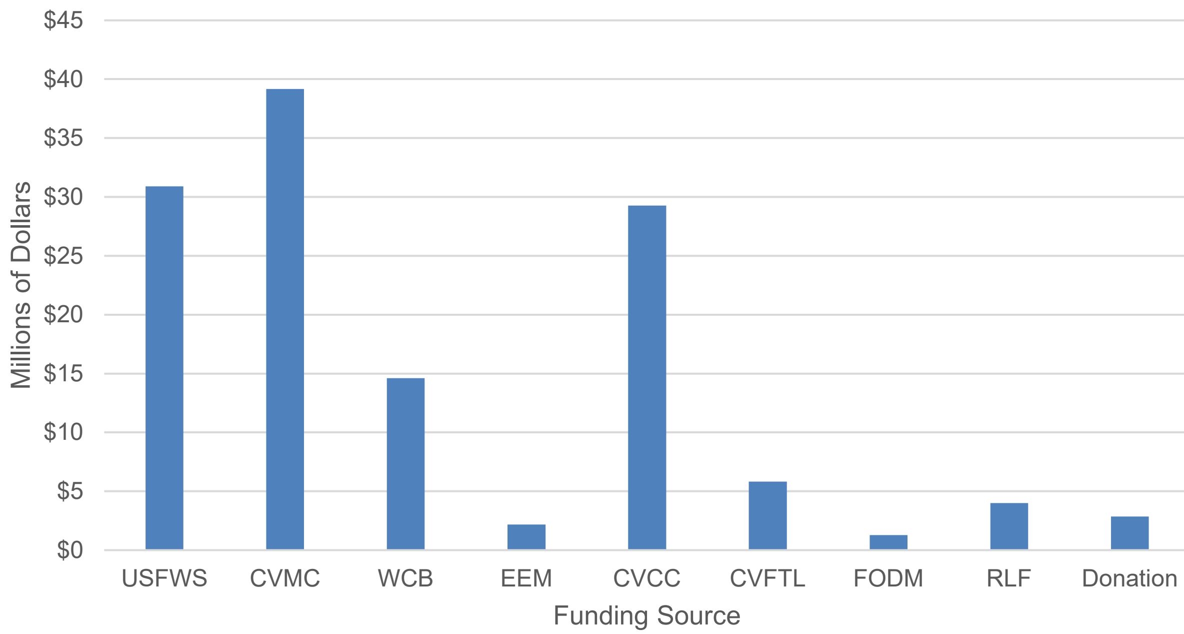

Figure 5: Cumulative acquisition funding per source.

III. Status of Conservation Areas

To ensure the persistence of the Covered Species and natural communities, 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 provide one measure of progress toward meeting the conservation objectives for each Covered Species, natural community, and essential ecological process in the plan. The planning process for the CVMSHCP began on November 11, 1996, and is therefore the baseline date for the authorized disturbance and conservation acreages listed throughout the CVMSHCP document.

This report updates the authorized disturbance and conservation acreages for each of the Conservation Areas through December 31, 2021 (Table 4). Authorized disturbance results from permitted development projects in the Conservation Areas while conservation occurs when land is acquired or otherwise legally protected in perpetuity by a Permittee. In 2021, there were 20.5 acres of authorized disturbance reported, and 2,003 acres of conservation recorded. Appendix III provides a detailed accounting for all the conservation objectives per Conservation Area up through December 31, 2021.

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.

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 IV. 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 2018.

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

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Table 4: Conservation and authorized disturbance within conservation areas.

Conservation Area	Conservation Goal (ac)	Conserved, 2021 (ac)	Conserved to Date (ac)	Disturbed, 2021 (ac)	Disturbed to Date (ac)
Cabazon	2,340	0	0	0	8.86
Coachella Valley Stormwater Channel and Delta	3,870	0	910	0	4.96
Desert Tortoise and Linkage	46,350	118	6,836	0	1.38
Dos Palmas	12,870	88	4,371	0	0.00
East Indio Hills	2,790	0	35	0	0.00
Edom Hill	3,060	5	2,082	0	1.59
Highway 111/I-10	350	46	100	0	0.32
Indio Hills Palms	2,290	0	1,039	0	0.00
Indio Hills/Joshua Tree National Park Linkage	10,530	0	8,995	0	5.73
Joshua Tree National Park	35,600	0	13,326	0	0.00
Mecca Hills/Orocopia Mountains	23,670	1,074	8,293	0	0.00
Santa Rosa and San Jacinto Mountains	55,890	202	33,143	0.25	9.74
Snow Creek/Windy Point	2,340	0	935	0	0.00
Stubbe and Cottonwood Canyons	2,430	0	1,057	0	67.30
Thousand Palms	8,040	32	5,243	0	56.99
Upper Mission Creek/Big Morongo Canyon	10,810	169	7,643	0	107.13
West Deception Canyon	1,063	0	1,833	0.25	0.25
Whitewater Canyon	1,440	0	956	0	28.38
Whitewater Floodplain	4,140	248	1,156	20	62.23
Willow Hole	4,920	22	2,441	0	5.60
Total		***2,003***	***100,394***	***20.5***	***360.46***

IV. 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 years with or following above average rainfall. The CVCC Conservation Program Manager facilitated 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 was notified of two awards from the Natural Community Conservation Planning Local Assistance Grant (LAG) program. The first project entitled, “Creating climate resiliency in the Coachella Valley Natural Communities Conservation Plan: Assessing climate change vulnerability,” was awarded $71,566 to address critical planning initiatives highlighted in the California State Integrated Climate Adaptation and Resiliency Program by modeling current and future habitat suitability for several vulnerable species within the region encompassing the Plan area and determine to what degree the future suitable habitat of these species is and can be protected. The second project entitled,“Using NDVI Data in Models to Determine Habitat Use of Peninsular Bighorn Sheep in Response to Human Presence on Recreational Trails,” was awarded $91,040 to continue critical work on spatial and temporal movement of Peninsular bighorn sheep in relationship to trails in the Santa Rosa and San Jacinto Mountains National Monument, by incorporating data from critical locations found in the Normalized Difference Vegetation Index (NDVI) to estimate vegetation biomass. NDVI is a useful indicator of seasonal diet quality of desert bighorn sheep in the Mojave Desert and has been successfully used to model herbivore-habitat relationships and movements in a number of other systems.

In June 2021, a contract with UC Riverside (UCR) Center for Conservation Biology was approved for monitoring of aeolian sand species, triple-ribbed milkvetch, Coachella Valley milkvetch, and little San Bernardino mountains linanthus. 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 through VIII respectively. Appendix IX is a review of the conservation efforts and status of the Coachella Valley fringe-toed lizard, 40 years after its listing, published in the California Fish and Wildlife Special CESA Issue. The San Deigo Natural History Museum (SDNHM) was contracted to begin monitoring yellow bat locations and continued management of cowbirds in the CV Stormwater Channel and Delta Conservation Area. The yellow bat monitoring will continue through fall of 2022 and the results will be included in the 2022 Annual Report. CVCC also contracted with the United States Geological Survey to assess the distribution, demographics, reproductive output, and genetic linkages of desert tortoises in the foothills surrounding the Coachella Valley, especially in critical linkage areas in the San Jacinto, San Bernardino, Little San Bernardino, and Santa Rosa mountains. By identifying the presence of tortoises within these linkage areas, CVCC can better target management actions to help support the recovery of the species in the Coachella Valley. The final report for this study will be included in the 2022 Annual Report

2021 Biological Monitoring Activities

Photos: 1: CV milkvetch; 2: HOBO weather station installed at Willow Hole; 3: CV giant sand-treader crickets during arthropod surveys; 4. CV fringe-toed lizard 5. Little San Bernardino Mountains linanthus; 6. Triple-ribbed milkvetch in bloom

V. Land Management Program

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

The Reserve Management Oversight Committee held Zoom meetings April 28, July 28 and October 27, 2021. Each RMOC meeting included a report regarding the Monitoring Program and the Land Management Program. The RMOC reviewed the Reserve Management and Monitoring work plans, biological monitoring and management priority activities, and tentative budget remotely at the April meeting. The recommendations from the RMOC were incorporated into the CVCC budget for FY 2021/22 and presented to the CVCC at their June 2021 meeting by Zoom. CVCC staff continues to coordinate with the RMOC and RMUCs to ensure that monitoring and research activities inform and support management of the Reserve Management Units.

Reserve Management Unit Committees

The six Reserve Management Units (RMUs) facilitate coordinated management by local, state and federal agencies to achieve the Conservation Objectives within the MSHCP Reserve System. Because many of the same staff members are involved in both the RMUC and BWG, meetings were combined to reduce demands on staff time and provide for better coordination between management and monitoring teams. The Combined RMUC/BWG met by Zoom on March 9, June 8, September 14, and December 14, 2021. 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. With a focus on invasive species management, members also met with the Low Desert Weed Management Area to better manage invasive species in the Coachella Valley.

Trails Management Subcommittee

The Trails Management Subcommittee (TMS) meetings were held by Zoom on January 20, May 19, September 15, and November 17, 2021. Working groups in 2021 included a focus on Dog Enforcement, Trail Maintenance, the Peninsular Bighorn Sheep and Recreational Use Research, and Bicycles and E-Bike Issues. The TMS working groups report on progress for their tasks and discuss significant issues, management, and funding opportunities at the quarterly TMS meetings. When possible due to the Stay-at-Home order, 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 Oswit Canyon Land Trust, Friends of the Desert Mountains, and other volunteers from the TMS to install "No Dogs On Trails" signs in the City of Palm Springs, and support interpretive rangers at trailheads to increase awareness of why the No Dog ordinance was passed for the protection of bighorn sheep. Finally, CVCC is working with the Coachella Valley Desert and Mountains Recreation and Conservation Authority to better manage trailheads and provide coordinated information and interpretational signage.

Land Improvement: Acquisition Cleanups

In 2021 the CVCC Acquisitions Manager performed pre-acquisition site inspections and job walks on 37 parcels/projects in multiple Conservation Areas. During these inspections the Land Acquisitions Manager identified illegal dumping, hazardous conditions, OHV and equestrian activity, and the existence of listed species, as well as determined property fencing requirements. As per CVCC's standard Purchase and 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 30.12 tons of refuse, including 17 tires, from the Coachella Valley, covering more than 821.48 acres and generating over $46,500 in contractor revenue from sellers' property sales.

Property Management & Monitoring

Monitoring the status of CVCC conservation lands is an essential and ongoing activity. After site visits were minimized in 2020 due to the Stay-at-Home order for COVID-19, CVCC staff and volunteers revisited all of the fencing and signage previously installed to document vandalism and damage, which was extensive. Illegal dumping, OHV use, and shooting continue to be a problem on some of the Reserve lands, and these issues were widely exacerbated by the inability of law enforcement to respond to non-emergency issues during the height of the pandemic. Working in partnership to secure adjacent conservation lands, the Desert Recreation District assisted with maintaining some of the fencing in Thousand Palms. CVCC monitored and logged fencing and signage installed previously within the Willow Hole, Upper Mission Creek, and Big Morongo Canyon, Sky Valley, and Stubbe and Cottonwood Canyon Conservation Areas into our new ArcGIS Online database. By the end of 2021, CVCC still has 16.4 miles of fencing around the perimeter of the Conservation Lands to monitor and maintain. CVCC also hired a Land Management Program Assistant to coordinate volunteer efforts, remove invasive species, schedule cleanups, and monitor conservation parcels.

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. Approximately 8 acres of tamarisk has been removed from the North Shore Ranch properties in 2021 as part of the project for the Proposition 1 Water Bond (Prop 1) entitled, "Wetlands Restoration, Tamarisk Control and Rail Habitat Enhancement Project." Tamarisk removal began in January 2020 on the properties and continued in February 2021 with assistance from the Southern California Mountains Foundation Urban Conservation Corps. CVCC also contracted with GPA Consulting to develop a draft restoration plan for Pond 5 and an analysis of water availability on the property which was completed in July 2021.

CVCC contracted with the San Diego Natural History Museum again in 2021 to continue to control invasive cowbirds in the Coachella Valley Stormwater Channel Conservation Area. The 2021 Cowbird Management Report can be found in Appendix X. Also in June 2021, sand was delivered to the Stebbins Dune site as a result of the project that was funded by the LAG in 2019. The objective of that project was to determine if sand transport could be re-established with clean blow sand collected from roadways and deposited upwind of a sand dune site to enhance the habitat value. Through a partnership with the Coachella Valley Association of Governments (CVAG), which carries out a regional street sweeping program, sand was collected from locations where it otherwise would blow onto roadways. CVAG's regional street sweeping program focuses on control of an air pollutant, PM10 (particulate matter of less than 10 microns). PM10 in the Coachella Valley comes from dust-generating activities, including vehicles traveling over paved or unpaved streets, and construction. In a secondary effect, sand deposits on road surfaces (blow sand) are ground into PM10 by moving vehicles and resuspended in the air as manmade PM10. Street sweeping is one of the primary air quality control measures to reduce PM10. In areas where wind-blown sand is deposited on or adjacent to roadways, street sweepers collect the sand and deliver it to Desert Recycling, a local business that then uses the sand for fill and other purposes. Through this project, the sand was collected from roadways and instead transported to Stebbins Dune where it was deposited upwind of the dune habitat areas, to restore blow sand conditions to the site. Sand was obtained with the assistance of the City of Rancho Mirage, a member of the CVCC. A final report can be found for this project in Appendix XI.

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2021 Land Management Activities

Photos: 1. Cowbird trap in Coachella Valley Stormwater Channel and Delta Conservation Area; 2. Cowbird collected from trap; 3. Fountain grass being removed by volunteers in Cathedral Canyon; 4. Sand delivered to the Stebbins Dune site; 5. Polaris vehicle used by Desert Hot Springs Police 6. Invasive stinknet found next to Worsley Rd. in Desert Hot Springs

VI. Unauthorized Activities and Enforcement

In 2021, areas of vandalism, dumping and OHV use were reported in Stubbe/Cottonwood Canyon, Willow Hole, Upper Mission Creek/Big Morongo Canyon, and Thousand Palms Conservation Areas. Further discussion of the management of these issues is included in section IV. Currently, CVCC forwards reports of OHVs and dumping to the appropriate law enforcement agency. Law enforcement agreements were signed with Riverside County Sheriffs Department and Desert Hot Springs Police Department for up to $60,000 a year to increase patrols and issue citations in conservation lands.

VII. Significant Issues in Plan Implementation

In 2021, progress continued on the La Quinta Peninsular Bighorn Sheep Barrier Project. 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. The CVCC certified the Final Environmental Impact Report for the La Quinta Peninsular Bighorn Sheep Barrier Project, adopting findings and a Mitigation Monitoring and Reporting program, and approving Alternative A2 of the La Quinta Peninsular Bighorn Sheep Barrier Project in April 2019. A competitive sealed-bid process was completed, with four bids being received by the deadline of January 13, 2020. A contract with American Fence Co., Inc. to install the fence was approved by the CVCC at the February 13, 2020 meeting for a not to exceed amount of $2,091,656.58. Since CVCC does not control the land needed for a fence, an ongoing effort has been to work with property owners on access agreements for construction and permanent installation. During September 2021, staff completed agreements for use of property owned or managed by PGA West, a license agreement, and is in the process of completing the license agreement with the Bureau of Reclamation (Reclamation), encroachment permits from Coachella Valley Water District, and use permit from Riverside County Regional Parks and Open Space District (for the Lake Cahuilla Veterans Memorial Park). CVCC also awarded a contract to Wood Environmental in November 2021 for biological monitoring during construction activities.

Progress was made in 2021 on another significant challenge on CVCC lands, control of illegal activities including vandalism, illegal OHV use, and dumping. Since CVCC does not have law enforcement capacity, the intent has been to develop an agreement with one or more of the local agencies that have trained law enforcement personnel. A final MOU was developed for CVCC and Desert Hot Springs and signed in early 2021. An MOU with the Riverside County Sheriff's Department was signed in October 2021. This approach will result in cooperative and coordinated management that will create efficiencies and enhance each entity's management capabilities and effectiveness.

VIII. Compliance Activities of Permittees

All Permittees are in compliance with the requirements of the CVMSHCP. CVCC completed one Joint Project Review for Permittees in 2021. Permitees are also complying with the fee language in their ordinances by reporting their Local Development Mitigation Fee (LDMF) activity and remiting the revenue to CVCC monthly. CVCC reviews all LDMF reports and receipts. The LDMF generated $2,723,559 in Fiscal Year 2020/2021, representing a 1.21 percent increase over the $2,691,023 generated in the previous fiscal year.

IX. CVMSHCP Expenditures – 2021/2022 Budget

	MANAGEMENT AND MONITORING	GENERAL ADMINISTRATION	LAND ACQUISITION	ENDOWMENT	LIZARD ENDOWMENT	TRAVERTINE MANAGEMENT	MANAGEMENT CONTINGENCY	IN-LIEU FEE	TOTAL
BEGINNING FUND BALANCE	$ 510,735.79	$ 661,298.86	$ 9,498,756.42	$ 10,071,742.37	$ 330,930.60	$ 540,449.76	$ 4,629,277.81	$ 1,943,646.29	$ 28,186,837.91
REVENUES:									
Development Mitigation Fees	$ 347,041.64	$ -	$ 1,694,379.76	$ -	$ -	$ -	$ -	$ -	$ 2,041,421.40
Agencies Mitigation Fees	$ -	$ -	$ 2,634,212.00	$ 1,419,878.40	$ -	$ -	$ -	$ 250,000.00	$ 4,304,090.40
Tipping Fees	$ -	$ 440,223.34	$ -	$ -	$ -	$ -	$ -	$ -	$ 440,223.34
Contributions	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Grants	$ 248,522.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 248,522.00
Other Revenue	$ 7,500.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 7,500.00
Investment Income	$ 3,500.00	$ 2,700.00	$ 45,000.00	$ 48,000.00	$ 1,700.00	$ 3,000.00	$ 26,000.00	$ 100.00	$ 130,000.00
Gain (Loss) in Investments	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Revenues	*$ 606,563.64*	*$ 442,923.34*	*$ 4,373,591.76*	*$ 1,467,878.40*	*$ 1,700.00*	*$ 3,000.00*	*$ 26,000.00*	*$ 250,100.00*	*$ 7,171,757.14*
EXPENDITURES:									
Administrative Fees	$ 3,470.42	$ -	$ 16,943.80	$ -	$ -	$ -	$ -	$ -	$ 20,414.21
Accounting / Bank Service Charges	$ -	$ 3,845.80	$ -	$ -	$ -	$ -	$ -	$ 1,500.00	$ 5,345.80
Comprehensive Insurance	$ -	$ 16,408.00	$ -	$ -	$ -	$ -	$ -	$ -	$ 16,408.00
Meeting Attendance Stipends	$ -	$ 11,900.00	$ -	$ -	$ -	$ -	$ -	$ -	$ 11,900.00
Computer Software	$ 6,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 6,000.00
Taxes- Meeting Attend. Stipends	$ -	$ 1,093.00	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,093.00
Office Supplies	$ -	$ 1,500.00	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,500.00
Printing	$ -	$ 1,500.00	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,500.00
Land Improvements	$ 1,812,400.00	$ -	$ 125,000.00	$ -	$ -	$ -	$ -	$ -	$ 1,937,400.00
Legal Services	$ 2,000.00	$ 30,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ 32,000.00
Professional Services	$ 64,000.00	$ 15,750.00	$ 107,303.54	$ -	$ -	$ -	$ -	$ -	$ 187,053.54
Consultants (Regular funds)	$ 798,312.00	$ 283,336.30	$ 341,445.00	$ -	$ -	$ -	$ -	$ 62,911.12	$ 1,486,004.42
Consultants (Grant funds)	$ 248,522.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 248,522.00
Interest	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Miscellaneous	$ 500.00	$ 100.00	$ 500.00	$ -	$ -	$ -	$ -	$ -	$ 1,100.00
Land Acquisitions	$ -	$ -	$ 7,598,881.00	$ -	$ -	$ -	$ -	$ -	$ 7,598,881.00
Furniture and Equipment	$ 3,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 3,000.00
Utilites	$ 15,000.00	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 15,000.00
Payroll Taxes	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sub-Total Expenditures	*$ 2,953,204.42*	*$ 365,433.10*	*$ 8,190,073.34*	*$ -*	*$ -*	*$ -*	*$ -*	*$ 64,411.12*	*$ 11,573,121.98*
OTHER									
Lizard Fee Refund	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Debt Service	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operating Transfers Out	$ -	$ -	$ -	$ 367,077.21	$ -	$ -	$ 1,812,400.00	$ -	$ 2,179,477.21
Operating Transfers In	$ (2,179,477.21)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ (2,179,477.21)
Sub-Total Other	*$ (2,179,477.21)*	*$ -*	*$ -*	*$ 367,077.21*	*$ -*	*$ -*	*$ 1,812,400.00*	*$ -*	*$ -*
Total Expenditures and Other	$ 773,727.21	$ 365,433.10	$ 8,190,073.34	$ 367,077.21	$ -	$ -	$ 1,812,400.00	$ 64,411.12	$ 11,573,121.98
Net Excess (Deficit)	$ (167,163.57)	$ 77,490.24	$ (3,816,481.58)	$ 1,100,801.19	$ 1,700.00	$ 3,000.00	$ (1,786,400.00)	$ 185,688.88	$ (4,401,364.84)
ENDING FUND BALANCE	***$ 343,572.22***	***$ 738,789.10***	***$ 5,682,274.85***	***$ 11,172,544.00***	***$ 332,631.00***	***$ 543,450.00***	***$ 2,842,878.00***	***$ 2,129,335.00***	***$ 23,785,473.00***

Full budget available at: https://www.cvag.org/library/pdf_files/admin/CVCC%20Financials%20Reports%20FY_2021_2022/CVCCBudgetFinal.pdf

X. Annual Audit

CVCC approved their Fiscal Year 2021/2022 budget at the June 10, 2021 meeting.

The audit of the expenditures for the period July 1, 2020 to June 30, 2021 is currently underway and planned for approval by CVCC on May 12, 2022. The financial report is 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.

Appendix I: Acquisition and Management Credit Allocation

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, Snow Creek/Windy and the Mecca Hills and Orocopia Mountains. 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 or if FODM funds are used (e.g., Resources Legacy Fund);
        ii. Donations from landowners.

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

3) For 2021 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. Exceptions to this are TP – Filipone (USFWS letter received) and (WH) Archibald Circle B Ranch (USFWS letter pending).

4) If a grant Section 6 or EEM 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) If joint funds are used to purchase the property, the credit shall be split by using a per acre value calculation. Note this does not include closing costs; only purchase price. Example:
        i. If CVCC and CVMC (State) split the cost of a 10-acre property with a purchase price of $100K; the calculation would be $100/10=$10K per (1) acre. So, in this case CVCC contributed $65K. 10K/65K = CVCC would get credit for 6.5 acres. CVMC contributed $35K. 10K/35K = State/Federal would get credit for 3.5 acres. If either CVCC or CVMC

covered the $2,500 in closing costs; this would not be considered for credit purposes.

6) 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."

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

Management Credit

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

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

Appendix II: Conservation Acquisitions in 2021

Conservation Area & Acquiring entity	Acres
Dos Palmas	**88**
*FODM**	*88*
733060005	17
733150059	10
733160002	61
Desert Tortoise & Linkage	**118**
*CVCC***	*17*
707400005	7
707410005	10
FODM	*101*
697090005	40
707220029	40
713140011	20
Edom Hill	**5**
CVCC	*5*
659090009	5
HWY 111/I-10	**46**
CVCC	46
522070001	10
522070016	24
522070017	12
Mecca Hills / Orocopia Mtns.	**1074**
CVCC	*192*
719090050	10
719110016	20
719280005	40
719280007	40
719290012	82
FODM	*882*
709420019	42
709540004	40
717060003	121
717110023	10
717120008	5
717160001	10
721090001	653
San Jacinto & Santa Rosa Mtns	**202**
CVCC	*49*
636067010	1
636067011	1
636082003	1
636091010	1
636091029	2
681480011	42
FODM	*153*
513050011	10
513240004	5
636075003	1
753190001	79
753190014	20
753260014	10
753280021	10
753280022	19
Thousand Palms	**32**
CVCC	*32*
647290014	2
648170015	2
651040010	10
651050027	2
750200010	5
750200017	11
Upper Mission Creek/Big Morongo Canyon	**169**
CVCC	*169*
522070013	1
664050007	9
665020004	77
665100030	3
667150005	39
668290001	40
Willow Hole	**22**
CVCC	*22*
659220013	5
660020015	3
660020017	5
660091001	0
660110024	5
660110052	1
660200009	3
Whitewater Floodplain	**248**
CVCC	*248*
522070027	248
Grand Total	***2,003***

*Friends of Desert Mountains
**Coachella Valley Conservation Commission

Appendix III: Conservation Objectives by Conservation Area

Conservation Area, Permittee, and Conservation Element	Total Authorized Disturbance	Disturbed 2021	Total Disturbance to Date	Required Conservation	Conserved 2021	Total Conservation to Date	Percent Conserved	Roughstep Value
Cabazon								
Riverside County								
Linkage, Corridor	10	0	0	631	0	0	0%	1
Mesquite hummocks, NC*	1	0	0	12	0	0	0%	0
Sand transport, EEP**	0	0	0		0	0	0%	0
Peninsular Bighorn sheep, Essential Habitat	181	0	0	83	0	0	0%	18
Southern sycamore-alder riparian woodland, NC	1	0	0	9	0	0	0%	0
Sand source, EEP	181	0	0	1,629	0	0	0%	18
Coachella Valley Stormwater Channel and Delta								
Riverside County								
Coastal and valley marsh, NC	6	0	0	51	0	0	0%	1
Crissal thrasher, Core Habitat	87	0	5	781	0	371	48%	41
Desert pupfish, Core Habitat	0	0	0		0	0	0%	0
Desert sink scrub, NC	114	0	0	1,026	0	84	8%	20
Le Conte's thrasher, OCH***	78	0	5	706	0	371	53%	40
Mesquite hummocks, NC	7	0	0	67	0	20	30%	3
California black rail, OCH	6	0	0	52	0	0	0%	1
Yuma Clapper rail, OCH	6	0	0	52	0	0	0%	1
Desert saltbush scrub, NC	79	0	5	713	0	351	49%	38
Dos Palmas								
Riverside County								
Arrowweed scrub, NC	13	0	0	121	0	0	0%	1
Cismontane alkali marsh, NC	23	0	0	205	0	200	98%	22
Crissal thrasher, Core Habitat	38	0	0	343	10	231	67%	27
Desert pupfish, Occurrences	0	0			0	0	0%	0
Desert sink scrub, NC	487	0	0	4,381	47	1,226	28%	171
Le Conte's thrasher, OCH	743	0	0	6,689	34	2,478	37%	322
Mesquite bosque, NC	36	0	0	320	10	221	69%	26
Mesquite hummocks, NC	3	0	0	23	0	12	51%	2
California black rail, OCH	37	0	0	334	1	282	84%	32
Yuma Clapper rail, OCH	42	0	0	374	1	282	75%	33
Flat-tailed Horned lizard, OCH	403	0	0	3,631	0	681	19%	108
Desert dry wash woodland, NC	83	0	0	746	11	256	34%	34
Desert fan palm oasis woodland, NC	6	0	0	50	0	29	59%	4
Desert Tortoise & Linkage								
Coachella								

Conservation Area, Permittee, and Conservation Element	Total Authorized Disturbance	Disturbed 2021	Total Disturbance to Date	Required Conservation	Conserved 2021	Total Conservation to Date	Percent Conserved	Roughstep Value
Desert tortoise, Core Habitat	30	0	0	270	0	0	0%	3
Le Conte's thrasher, OCH	30	0	0	270	0	0	0%	3
Desert dry wash woodland, NC	12	0	0	109	0	0	0%	1
Riverside County								
Desert tortoise, Core Habitat	4,998	0	1	44,977	118	10,257	23%	1,524
Le Conte's thrasher, OCH	2,813	0	1	25,319	37	4,786	19%	758
Linkage, Corridor	1,572	0	0	14,143	17	2,806	20%	438
Mecca aster, Core Habitat	206	0	0	1,855	0	817	44%	102
Orocopia sage, Core Habitat	44	0	0	398	0	222	56%	26
Desert dry wash woodland, NC	752	0	1	6,771	36	1,300	19%	204
Edom Hill								
Cathedral City								
Le Conte's thrasher, OCH	34	0	0	310	0	224	72%	26
Sand source, EEP	35	0	0	310	0	224	72%	26
Coachella Valley milkvetch, OCH	15	0	0	136	0	102	75%	12
Coachella Valley Round-tailed Ground squirrel, OCH	13	0	0	121	0	102	85%	11
Palm Springs Pocket mouse, OCH	11	0	0	103	0	87	84%	9
Riverside County								
Active desert sand fields, NC	4	0	0	37	0	41	100%	4
Fringe-toed lizard, OCH	5	0	0	40	0	43	100%	5
Le Conte's thrasher, OCH	194	0	2	1,745	5	1,339	77%	152
Sand transport, EEP	63	0	1	565	5	381	68%	43
Stabilized desert sand fields, NC	1	0	0	3	0	2	81%	1
Sand source, EEP	197	0	0	1,770	0	1,473	83%	167
Coachella Valley milkvetch, OCH	134	0	0	1,205	1	1,029	85%	116
Coachella Valley Round-tailed Ground squirrel, OCH	145	0	0	1,302	0	1,118	86%	127
Palm Springs Pocket mouse, OCH	104	0	0	935	4	797	85%	90
Coachella Giant Sand treader cricket, OCH	5	0	0	40	0	43	100%	5
East Indio Hills								
Coachella								
Le Conte's thrasher, OCH	6	0	0	56	0	0	0%	1
Flat-tailed Horned lizard, OCH	1	0	0	5	0	0	0%	0
Coachella Valley Round-tailed Ground squirrel, OCH	1	0	0	5	0	0	0%	0
Palm Springs Pocket mouse, OCH	1	0	0	7	0	0	0%	0
Indio								
Le Conte's thrasher, OCH	12	0	0	105	0	0	0%	1

Conservation Area, Permittee, and Conservation Element	Total Authorized Disturbance	Disturbed 2021	Total Disturbance to Date	Required Conservation	Conserved 2021	Total Conservation to Date	Percent Conserved	Roughstep Value
Mesquite hummocks, NC	0	0	0	2	0	0	0%	0
Stabilized desert sand fields, NC	11	0	0	100	0	0	0%	1
Flat-tailed Horned lizard, OCH	11	0	0	100	0	0	0%	1
Coachella Valley Round-tailed Ground squirrel, OCH	11	0	0	103	0	0	0%	1
Palm Springs Pocket mouse, OCH	11	0	0	103	0	0	0%	1
Riverside County								
Active desert dunes, NC	1	0	0	4	0	0	0%	0
Le Conte's thrasher, OCH	139	0	0	1,253	0	35	3%	17
Mecca aster, Core Habitat	116	0	0	1,045	0	0	0%	12
Mesquite hummocks, NC	4	0	0	39	0	0	0%	0
Stabilized desert sand fields, NC	33	0	0	295	0	0	0%	3
Desert saltbush scrub, NC	1	0	0	7	0	0	0%	0
Flat-tailed Horned lizard, OCH	46	0	0	415	0	0	0%	5
Coachella Valley Round-tailed Ground squirrel, OCH	100	0	0	896	0	1	0%	10
Palm Springs Pocket mouse, OCH	105	0	0	944	0	33	3%	14
Highway 111/I-10								
Palm Springs								
Le Conte's thrasher, OCH	39	0	0	350	46	100	29%	14
Coachella Valley milkvetch, OCH	37	0	0	335	46	97	29%	13
Coachella Valley Round-tailed Ground squirrel, OCH	39	0	0	350	0	100	29%	14
Palm Springs Pocket mouse, OCH	39	0	0	350	46	100	29%	14
Coachella Valley Jerusalem cricket, OCH	37	0	0	335	46	97	29%	13
Indio Hills/Joshua Tree National Park Linkage								
Riverside County								
Desert tortoise, Core Habitat	859	0	0	7,735	0	6,561	85%	742
Le Conte's thrasher, OCH	606	0	0	5,457	0	5,469	100%	607
Linkage, Corridor	1,141	0	6	10,267	0	8,991	88%	1,008
Sand transport, EEP	681	0	6	6,132	0	5,791	94%	641
Sand source, EEP	460	0	0	4,135	0	3,199	77%	366
Indio Hills Palms								
Riverside County								
Le Conte's thrasher, OCH	1	0	0	7	0	0	0%	0
Mecca aster, Core Habitat	255	0	0	2,290	0	1,039	45%	130
Mesquite hummocks, NC	1	0	0	1	0	0	0%	0
Desert dry wash woodland, NC	4	0	0	33	0	36	100%	4
Desert fan palm oasis woodland, NC	5	0	0	42	0	7	17%	1

Conservation Area, Permittee, and Conservation Element	Total Authorized Disturbance	Disturbed 2021	Total Disturbance to Date	Required Conservation	Conserved 2021	Total Conservation to Date	Percent Conserved	Roughstep Value
Joshua Tree National Park								
Riverside County								
Desert tortoise, Core Habitat	1,708	0	0	15,367	0	12,687	83%	1,440
Gray vireo, OCH	134	0	0	1,208	0	1,822	100%	195
Le Conte's thrasher, OCH	25	0	0	222	0	104	47%	13
Mojave mixed woody scrub, NC	800	0	0	7,195	0	6,349	88%	715
Desert dry wash woodland, NC	13	0	0	119	0	192	100%	20
Desert fan palm oasis woodland, NC	0	0	0	0	0	0	0%	0
Mojavean pinyon & juniper woodland, NC	134	0	0	1,208	0	1,822	100%	195
Mecca Hills/Orocopia Mountains								
Riverside County								
Desert tortoise, Core Habitat	2,624	0	0	23,617	1,067	10,746	46%	1,337
Le Conte's thrasher, OCH	652	0	0	5,866	107	2,402	41%	306
Mecca aster, Core Habitat	465	0	0	4,181	795	2,016	48%	248
Orocopia sage, Core Habitat	1,803	0	0	16,227	851	6,565	40%	837
Desert dry wash woodland, NC	318	0	0	2,861	103	1,665	58%	198
Desert fan palm oasis woodland, NC	0	0	0	0	0	0	0%	0
Stubbe and Cottonwood Canyons								
Riverside County								
Desert tortoise, Core Habitat	245	0	27	2,276	0	1,000	44%	94
Le Conte's thrasher, OCH	123	0	0	1,111	0	824	74%	94
Linkage, Corridor	117	0	0	1,058	0	877	83%	99
Sand transport, EEP	125	0	0	1,129	0	828	73%	95
Sand source, EEP	138	0	27	1,241	0	228	18%	9
Desert dry wash woodland, NC	26	0	0	229	0	137	60%	17
Sonoran cottonwood-willow riparian forest, NC	3	0	0	25	0	0	0%	0
Snow Creek/Windy Point								
Palm Springs								
Active desert dunes, NC	7	0	0	62	0	40	65%	5
Ephemeral desert sand fields, NC	68	0	0	610	0	136	22%	20
Fringe-toed lizard, Core Habitat	75	0	0	672	0	174	26%	25
Le Conte's thrasher, OCH	86	0	0	775	0	145	19%	23
Linkage, Corridor	27	0	0	247	0	182	74%	21
Sand transport, EEP	93	0	0	838	0	182	22%	27
Peninsular Bighorn sheep, Essential Habitat	16	0	0	144	0	26	18%	4
Coachella Valley milkvetch, Core Habitat	91	0	0	816	0	179	22%	27

Conservation Area, Permittee, and Conservation Element	Total Authorized Disturbance	Disturbed 2021	Total Disturbance to Date	Required Conservation	Conserved 2021	Total Conservation to Date	Percent Conserved	Roughstep Value
Coachella Giant Sand treader cricket, Core Habitat	75	0	0	672	0	174	26%	25
Coachella Valley Jerusalem cricket, Core Habitat	90	0	0	815	0	178	22%	27
Coachella Valley Round-tailed Ground squirrel, Core Habitat	93	0	0	838	0	182	22%	27
Palm Springs Pocket mouse, Core Habitat	93	0	0	838	0	182	22%	27
Riverside County								
Ephemeral desert sand fields, NC	45	0	0	409	0	351	86%	39
Fringe-toed lizard, Core Habitat	55	0	0	502	0	346	69%	40
Le Conte's thrasher, OCH	162	0	0	1,453	0	735	51%	90
Linkage, Corridor	46	0	0	415	0	145	35%	19
Sand transport, EEP	165	0	0	1,482	0	698	47%	86
Peninsular Bighorn sheep, Essential Habitat	49	0	0	443	0	66	15%	11
Coachella Valley milkvetch, Core Habitat	134	0	0	1,210	0	592	49%	72
Coachella Giant Sand treader cricket, Core Habitat	56	0	0	501	0	346	69%	40
Coachella Valley Jerusalem cricket, Core Habitat	60	0	0	538	0	360	67%	42
Coachella Valley Round-tailed Ground squirrel, Core Habitat	152	0	0	1,371	0	653	48%	80
Palm Springs Pocket mouse, Core Habitat	148	0	0	1,331	0	698	52%	85
Santa Rosa & San Jacinto Mountains								
Cathedral City								
Desert tortoise, OCH	11	0	0	95	0	35	37%	5
Le Conte's thrasher, OCH	1	0	0	11	0	9	80%	1
Peninsular Bighorn sheep, Essential Habitat	11	0	0	97	0	36	37%	5
Desert dry wash woodland, NC	2	0	0	18	0	19	100%	2
Indian Wells								
Desert tortoise, OCH	111	0	0	999	0	38	4%	15
Le Conte's thrasher, OCH	23	0	0	206	0	1	1%	2
Peninsular Bighorn sheep, Essential Habitat	114	0	0	1,158	0	37	3%	15
Desert dry wash woodland, NC	7	0	0	66	0	0	0%	1
La Quinta								
Desert tortoise, OCH	157	0	0	1,409	0	414	29%	57
Le Conte's thrasher, OCH	43	0	0	387	0	115	30%	16

Conservation Area, Permittee, and Conservation Element	Total Authorized Disturbance	Disturbed 2021	Total Disturbance to Date	Required Conservation	Conserved 2021	Total Conservation to Date	Percent Conserved	Roughstep Value
Peninsular Bighorn sheep, Essential Habitat	159	0	0	2,545	0	429	17%	40
Desert dry wash woodland, NC	8	0	0	76	0	15	20%	2
Palm Desert								
Desert tortoise, OCH	48	0	0	436	0	784	100%	82
Le Conte's thrasher, OCH	4	0	0	33	0	0	0%	0
Peninsular Bighorn sheep, Essential Habitat	14	0	0	130	0	1,524	200%	149
Desert dry wash woodland, NC	3	0	0	29	0	1	2%	0
Palm Springs								
Desert tortoise, OCH	1,317	0	0	8,856	34	5,469	62%	864
Gray vireo, OCH	431	0	0	3,883	0	1,837	47%	227
Le Conte's thrasher, OCH	103	0	0	560	0	865	100%	153
Semi-desert chaparral, NC	51	0	0	571	0	0	0%	5
Southern arroyo willow, NC	0	0	0	0	0	0	0%	0
Peninsular Bighorn sheep, Essential Habitat	1,092	0	0	7,211	82	13,169	200%	1,734
Southern sycamore-alder riparian woodland, NC	2	0	0	24	0	0	0%	0
Desert dry wash woodland, NC	4	0	0	36	0	41	100%	5
Desert fan palm oasis woodland, NC	9	0	0	76	0	52	69%	6
Sonoran cottonwood-willow riparian forest, NC	0	0	0	58	0	4	7%	0
Peninsular juniper woodland & scrub, NC	353	0	0	3,177	0	1,837	58%	219
Rancho Mirage								
Desert tortoise, OCH	147	0	0	1,326	0	1,205	91%	135
Le Conte's thrasher, OCH	2	0	0	17	0	0	0%	0
Peninsular Bighorn sheep, Essential Habitat	42	0	0	450	0	1,209	100%	106
Desert dry wash woodland, NC	1	0	0	9	0	4	45%	1
Riverside County								
Desert tortoise, OCH	2,950	0	7	23,856	142	16,438	69%	2,118
Gray vireo, OCH	881	0	0	7,930	0	6,064	76%	694
Le Conte's thrasher, OCH	911	0	0	5,508	0	5,536	100%	915
Semi-desert chaparral, NC	233	0	0	2,093	0	928	44%	116
Southern arroyo willow, NC	2	0	0	15	0	0	0%	0
Peninsular Bighorn sheep, Essential Habitat	2,418	0	0	19,205	609	69,446	400%	8,123
Southern sycamore-alder riparian woodland, NC	12	0	0	117	0	5	5%	2

Conservation Area, Permittee, and Conservation Element	Total Authorized Disturbance	Disturbed 2021	Total Disturbance to Date	Required Conservation	Conserved 2021	Total Conservation to Date	Percent Conserved	Roughstep Value
Desert dry wash woodland, NC	298	0	0	1,244	0	1,272	100%	304
Desert fan palm oasis woodland, NC	45	0	0	404	0	0	0%	5
Peninsular juniper woodland & scrub, NC	418	0	0	2,899	0	3,319	100%	472
Triple-ribbed milkvetch, Occurences	1	0	0	1	0	0	0%	0
Red shank chaparral, NC	253	0	0	2,274	7	1,821	80%	208
Thousand Palms								
Riverside County								
Active desert dunes, NC	2	0	0	14	0	6	42%	1
Active desert sand fields, NC	91	0	0	820	0	689	84%	78
Desert pupfish, Refugia	0	0	0	0	0	0	0%	0
Fringe-toed lizard, Core Habitat	93	0	0	834	0	693	83%	79
Le Conte's thrasher, OCH	552	0	33	3,879	11	1,996	51%	278
Linkage, Corridor	983	0	57	7,816	14	4,763	61%	580
Mecca aster, Core Habitat	297	0	5	2,676	5	1,997	75%	224
Mesquite hummocks, NC	0	0	0	0	0	0	0%	0
Sand transport, EEP	573	0	51	4,100	15	1,943	47%	250
Sand source, EEP	412	0	6	3,712	2	2,843	77%	319
Desert dry wash woodland, NC	4	0	0	34	5	17	50%	2
Desert fan palm oasis woodland, NC	0	0	0	0	0	0	0%	0
Sonoran cottonwood-willow riparian forest, NC	0	0	0	0	0	0	0%	0
Coachella Valley milkvetch, Core Habitat	111	0	4	1,001	0	835	83%	91
Coachella Giant Sand treader cricket, Core Habitat	93	0	0	834	0	693	83%	79
Coachella Valley Round-tailed Ground squirrel, Core Habitat	468	0	40	2,974	0	1,783	60%	260
Palm Springs Pocket mouse, Core Habitat	518	0	38	3,588	13	1,926	54%	264
Flat-tailed Horned lizard, Core Habitat	97	0	0	877	0	724	83%	82
Upper Mission Creek/Big Morongo Canyon								
Desert Hot Springs								
Desert tortoise, Core Habitat	252	0	2	2,271	0	1,180	52%	141
Le Conte's thrasher, OCH	215	0	2	1,931	0	1,064	55%	126
Linkage, Corridor	10	0	2	88	0	353	100%	35
Sand transport, EEP	217	0	2	1,949	0	1,112	57%	131
Sand source, EEP	16	0	0	141	0	0	0%	2
Desert dry wash woodland, NC	8	0	0	76	0	32	42%	4

Conservation Area, Permittee, and Conservation Element	Total Authorized Disturbance	Disturbed 2021	Total Disturbance to Date	Required Conservation	Conserved 2021	Total Conservation to Date	Percent Conserved	Roughstep Value
Coachella Valley Jerusalem cricket, OCH	10	0	1	90	0	40	45%	4
Palm Springs Pocket mouse, Core Habitat	207	0	2	1,865	0	1,049	56%	123
Little San Bernardino Mountains Linanthus, Core Habitat	107	0	0	966	0	660	68%	76
Palm Springs								
Le Conte's thrasher, OCH	2	0	1	22	0	0	0%	0
Sand transport, EEP	2	0	1	22	0	0	0%	0
Palm Springs Pocket mouse, OCH	2	0	1	22	0	0	0%	0
Riverside County								
Desert tortoise, Core Habitat	882	0	21	7,936	165	5,514	69%	619
Le Conte's thrasher, OCH	119	0	0	1,072	93	725	68%	84
Linkage, Corridor	76	0	0	688	79	356	52%	43
Sand transport, EEP	140	0	0	1,259	128	977	78%	112
Southern sycamore-alder riparian woodland, NC	6	0	0	52	0	60	100%	7
Sand source, EEP	721	0	21	6,488	1	4,742	73%	526
Desert dry wash woodland, NC	8	0	0	76	0	49	64%	5
Coachella Valley Jerusalem cricket, OCH	47	0	10	419	0	51	12%	0
Sonoran cottonwood-willow riparian forest, NC	8	0	0	76	0	78	100%	8
Palm Springs Pocket mouse, Core Habitat	124	0	0	1,112	88	768	69%	89
Little San Bernardino Mountains Linanthus, Core Habitat	117	0	0	1,052	24	701	67%	82
Triple-ribbed milkvetch, Core Habitat	47	0	0	426	0	421	99%	46
West Deception Canyon								
Riverside County								
Sand source, EEP	118	0	0	1,063	0	904	85%	102
Willow Hole								
Cathedral City								
Active desert sand fields, NC	4	0	0	33	0	46	100%	5
Ephemeral desert sand fields, NC	20	0	0	178	0	119	67%	14
Fringe-toed lizard, Core Habitat	24	0	0	211	0	156	74%	18
Le Conte's thrasher, OCH	168	0	0	1,508	0	750	50%	92
Sand transport, EEP	89	0	0	798	0	688	86%	78
Stabilized desert dunes, NC	0	0	0	1	0	0	0%	0
Stabilized desert sand fields, NC	6	0	0	51	0	0	0%	1
Sand source, EEP	79	0	0	710	0	61	9%	14

Conservation Area, Permittee, and Conservation Element	Total Authorized Disturbance	Disturbed 2021	Total Disturbance to Date	Required Conservation	Conserved 2021	Total Conservation to Date	Percent Conserved	Roughstep Value
Coachella Valley milkvetch, Core Habitat	87	0	0	782	0	259	33%	35
Coachella Valley Round-tailed Ground squirrel, Core Habitat	140	0	0	1,256	0	719	57%	86
Palm Springs Pocket mouse, Core Habitat	107	0	0	959	0	707	74%	82
Desert Hot Springs								
Ephemeral desert sand fields, NC	61	0	0	549	0	338	62%	40
Fringe-toed lizard, Core Habitat	0	0	0	3	0	0	0%	0
Le Conte's thrasher, OCH	167	0	0	1,499	0	931	62%	110
Linkage, Corridor	31	0	0	277	0	221	80%	25
Mesquite hummocks, NC	3	0	0	27	0	22	82%	3
Sand transport, EEP	171	0	0	1,542	0	954	62%	112
Stabilized desert dunes, NC	14	0	0	125	0	77	62%	9
Stabilized desert sand fields, NC	5	0	0	49	0	26	53%	3
Coachella Valley milkvetch, Core Habitat	96	0	0	863	0	585	68%	68
Coachella Valley Round-tailed Ground squirrel, Core Habitat	0	0	0	3	0	0	0%	0
Palm Springs Pocket mouse, Core Habitat	171	0	0	1,542	0	954	62%	112
Riverside County								
Ephemeral desert sand fields, NC	20	0	0	179	0	112	63%	13
Fringe-toed lizard, Core Habitat	50	0	6	452	4	351	78%	34
Le Conte's thrasher, OCH	131	0	6	1,178	22	975	83%	105
Linkage, Corridor	13	0	0	120	0	0	0%	1
Mesquite hummocks, NC	8	0	0	71	0	79	100%	9
Sand transport, EEP	133	0	6	1,193	17	961	81%	104
Stabilized desert dunes, NC	21	0	4	194	1	178	92%	16
Stabilized desert sand fields, NC	9	0	2	79	1	69	87%	6
Sand source, EEP	2	0	0	17	5	13	78%	2
Desert saltbush scrub, NC	17	0	0	152	5	142	93%	16
Desert fan palm oasis woodland, NC	0	0	0	0	0	0	0%	0
Coachella Valley milkvetch, Core Habitat	99	0	6	888	16	887	100%	93
Coachella Valley Round-tailed Ground squirrel, Core Habitat	120	0	6	1,078	0	934	87%	100
Palm Springs Pocket mouse, Core Habitat	127	0	6	1,142	13	957	84%	103
Whitewater Canyon								

Desert Hot Springs

Conservation Area, Permittee, and Conservation Element	Total Authorized Disturbance	Disturbed 2021	Total Disturbance to Date	Required Conservation	Conserved 2021	Total Conservation to Date	Percent Conserved	Roughstep Value
Desert tortoise, Core Habitat	0	0	0	0	0	0	0%	0
Sand source, EEP	0	0	0	0	0	0	0%	0
Riverside County								
Arroyo toad, Core Habitat	78	0	0	706	0	717	100%	79
Desert tortoise, Core Habitat	120	0	1	1,084	0	742	68%	85
Linkage, Corridor	22	0	1	201	0	0	0%	1
Sand transport, EEP	48	0	1	435	0	338	78%	37
Sand source, EEP	94	0	0	850	0	618	73%	71
Desert fan palm oasis woodland, NC	0	0	0	0	0	0	0%	0
Sonoran cottonwood-willow riparian forest, NC	11	0	0	107	0	105	99%	11
Triple-ribbed milkvetch, Core Habitat	41	0	0	368	0	277	75%	32
Little San Bernardino Mountains Linanthus, OCH	39	0	0	348	0	277	80%	32
Whitewater Floodplain								
Cathedral City								
Active desert sand fields, NC	5	0	0	43	0	0	0%	1
Fringe-toed lizard, Core Habitat	7	0	0	61	0	0	0%	1
Le Conte's thrasher, OCH	7	0	0	61	0	0	0%	1
Linkage, Corridor	2	0	0	18	0	0	0%	0
Sand transport, EEP	7	0	0	61	0	0	0%	1
Coachella Valley milkvetch, Core Habitat	7	0	0	61	0	0	0%	1
Coachella Giant Sand treader cricket, Core Habitat	7	0	0	61	0	0	0%	1
Coachella Valley Round-tailed Ground squirrel, Core Habitat	7	0	0	59	0	0	0%	1
Palm Springs Pocket mouse, Core Habitat	7	0	0	61	0	0	0%	1
Palm Springs								
Active desert sand fields, NC	44	0	0	392	0	332	85%	38
Ephemeral desert sand fields, NC	123	0	4	1,185	0	520	44%	57
Fringe-toed lizard, Core Habitat	295	0	19	2,659	0	846	32%	95
Le Conte's thrasher, OCH	381	0	32	3,433	0	896	26%	96
Linkage, Corridor	90	0	13	809	0	50	6%	1
Sand transport, EEP	387	0	32	3,484	0	896	26%	96
Stabilized desert sand fields, NC	44	0	0	394	0	0	0%	4
Coachella Valley milkvetch, Core Habitat	297	0	19	2,671	0	846	32%	96
Coachella Giant Sand treader cricket, Core Habitat	295	0	19	2,659	0	846	32%	95

Conservation Area, Permittee, and Conservation Element	Total Authorized Disturbance	Disturbed 2021	Total Disturbance to Date	Required Conservation	Conserved 2021	Total Conservation to Date	Percent Conserved	Roughstep Value
Coachella Valley Round-tailed Ground squirrel, Core Habitat	328	0	23	2,955	0	865	29%	96
Palm Springs Pocket mouse, Core Habitat	347	0	32	3,122	0	882	28%	91
Riverside County								
Ephemeral desert sand fields, NC	6	0	0	52	0	0	0%	1
Fringe-toed lizard, Core Habitat	6	0	0	57	0	0	0%	1
Le Conte's thrasher, OCH	53	20	30	480	247	247	51%	0
Linkage, Corridor	53	20	30	475	247	247	52%	0
Sand transport, EEP	53	20	30	481	247	247	51%	0
Stabilized desert sand fields, NC	1	0	0	4	0	0	0%	0
Coachella Valley milkvetch, Core Habitat	6	0	0	58	0	0	0%	1
Coachella Giant Sand treader cricket, Core Habitat	6	0	0	57	0	0	0%	1
Coachella Valley Round-tailed Ground squirrel, Core Habitat	11	0	0	100	0	0	0%	1
Palm Springs Pocket mouse, Core Habitat	53	20	30	477	245	245	51%	0

*NC: Natural Community
**EEP: Essential Ecological Process
***OCH: OCH

Appendix IV: Development outside Conservation Areas

Conservation Element and Jurisdiction	Acres Disturbed
Active desert dunes	**5**
Palm Springs	0
Riverside County	5
Active sand fields	**407**
Cathedral City	3
Indio	0
Riverside County	404
Arrowweed scrub	**0**
Riverside County	0
Arroyo Toad	**0**
Riverside County	0
California Black Rail	**0**
Coachella	0
Indio	0
Riverside County	0
Chamise chaparral	**0**
Riverside County	0
Cismontane alkali marsh	**0**
Riverside County	0
Coachella Valley Fringe-toed Lizard	**7016**
Cathedral City	581
Coachella	9
Indian Wells	699
Indio	999
La Quinta	556
Palm Desert	1039
Palm Springs	1462
Rancho Mirage	1055
Riverside County	616
Coachella Valley Giant Sand-treader Cricket	**7016**
Cathedral City	581
Coachella	9
Indian Wells	699
Indio	999
La Quinta	556
Palm Desert	1039
Palm Springs	1462
Rancho Mirage	1055
Riverside County	616
Coachella Valley Jerusalem Cricket	**3211**

Cathedral City	591
Desert Hot Springs	10
Palm Desert	6
Palm Springs	1468
Rancho Mirage	1006
Riverside County	130
Coachella Valley Milkvetch	**4584**
Cathedral City	517
Desert Hot Springs	13
Indian Wells	604
La Quinta	1
Palm Desert	1027
Palm Springs	1006
Rancho Mirage	1055
Riverside County	361
Coachella Valley Round-tailed Ground Squirrel	**11860**
Cathedral City	800
Coachella	23
Desert Hot Springs	567
Indian Wells	1028
Indio	1531
La Quinta	1427
Palm Desert	1390
Palm Springs	1444
Rancho Mirage	1207
Riverside County	2443
Coastal and valley freshwater marsh	**0**
Coachella	0
Indio	0
Riverside County	0
Crissal Thrasher	**1248**
Cathedral City	0
Coachella	36
Desert Hot Springs	0
Indian Wells	21
Indio	258
La Quinta	673
Riverside County	260
Desert dry wash woodland	**509**
Cathedral City	5
Coachella	0
Desert Hot Springs	1
Indian Wells	188

Indio	0
La Quinta	61
Palm Desert	201
Palm Springs	7
Rancho Mirage	46
Riverside County	0
Desert fan palm oasis woodland	**0**
Cathedral City	0
Desert Hot Springs	0
Palm Springs	0
Rancho Mirage	0
Riverside County	0
Desert Pupfish	**0**
Indian Wells	0
Desert saltbush scrub	**418**
Coachella	4
Indio	173
La Quinta	0
Riverside County	241
Desert sink scrub	**0**
Riverside County	0
Desert Tortoise	**2513**
Cathedral City	15
Coachella	0
Desert Hot Springs	532
Indian Wells	220
Indio	0
La Quinta	439
Palm Desert	470
Palm Springs	49
Rancho Mirage	179
Riverside County	609
Ephemeral sand fields	**211**
Cathedral City	2
Palm Springs	209
Riverside County	0
Gray Vireo	**29**
Palm Springs	0
Riverside County	29
Interior live oak chaparral	**0**
Palm Springs	0
Riverside County	0

Le Conte's Thrasher	**15164**
Cathedral City	957
Coachella	46
Desert Hot Springs	1156
Indian Wells	1287
Indio	1570
La Quinta	1784
Palm Desert	2000
Palm Springs	1414
Rancho Mirage	1298
Riverside County	3652
Least Bell's Vireo - Breeding Habitat	**189**
Cathedral City	0
Coachella	4
Desert Hot Springs	1
Indian Wells	21
Indio	76
La Quinta	68
Palm Springs	0
Rancho Mirage	0
Riverside County	19
Least Bell's Vireo - Migratory Habitat	**1570**
Cathedral City	5
Coachella	32
Desert Hot Springs	1
Indian Wells	188
Indio	182
La Quinta	667
Palm Desert	201
Palm Springs	7
Rancho Mirage	46
Riverside County	241
Little San Bernardino Mountains Linanthus	**0**
Desert Hot Springs	0
Riverside County	0
Mecca Aster	**0**
Indio	0
Riverside County	0
Mesquite bosque	**0**
Riverside County	0
Mesquite hummocks	**188**
Cathedral City	0

Coachella	4
Desert Hot Springs	0
Indian Wells	21
Indio	76
La Quinta	68
Riverside County	19
Mojave mixed woody scrub	**0**
Desert Hot Springs	0
Riverside County	0
Mojavean pinyon & juniper woodland	**0**
Riverside County	0
Orocopia Sage	**6**
Riverside County	6
Palm Springs Pocket Mouse	**11937**
Cathedral City	805
Coachella	15
Desert Hot Springs	587
Indian Wells	1048
Indio	1419
La Quinta	1285
Palm Desert	1464
Palm Springs	1496
Rancho Mirage	1254
Riverside County	2564
Peninsular Bighorn Sheep	**383**
Cathedral City	4
Indian Wells	2
La Quinta	127
Palm Desert	217
Palm Springs	5
Rancho Mirage	4
Riverside County	24
Peninsular juniper woodland & scrub	**0**
Palm Springs	0
Riverside County	0
Potential Flat-tailed Horned Lizard	**413**
Cathedral City	0
Desert Hot Springs	7
Palm Springs	377
Riverside County	29
Predicted Flat-tailed Horned Lizard	**6997**
Cathedral City	557

Coachella	3
Indian Wells	699
Indio	868
La Quinta	567
Palm Desert	1039
Palm Springs	1083
Rancho Mirage	1042
Riverside County	1139
Red shank chaparral	**0**
Riverside County	0
Semi-desert chaparral	**0**
Palm Springs	0
Riverside County	0
Sonoran cottonwood-willow riparian forest	**0**
Coachella	0
Indio	0
Palm Springs	0
Riverside County	0
Sonoran creosote bush scrub	**2078**
Cathedral City	9
Coachella	1
Desert Hot Springs	46
Indian Wells	32
Indio	320
La Quinta	350
Palm Desert	259
Palm Springs	46
Rancho Mirage	133
Riverside County	882
Sonoran mixed woody & succulent scrub	**1206**
Cathedral City	10
Desert Hot Springs	502
Indian Wells	0
Indio	1
La Quinta	27
Palm Desert	10
Palm Springs	149
Rancho Mirage	0
Riverside County	507
Southern arroyo willow riparian forest	**0**
Palm Springs	0
Riverside County	0

Southern sycamore-alder riparian woodland	**0**
Palm Springs	0
Riverside County	0
Southern Yellow Bat	**1**
Cathedral City	0
Desert Hot Springs	1
Palm Springs	0
Rancho Mirage	0
Riverside County	0
Southwestern Willow Flycatcher - Breeding Habitat	**1**
Cathedral City	0
Coachella	0
Desert Hot Springs	1
Indio	0
Palm Springs	0
Rancho Mirage	0
Riverside County	0
Southwestern Willow Flycatcher - Migratory Habitat	**1758**
Cathedral City	5
Coachella	36
Desert Hot Springs	1
Indian Wells	209
Indio	258
La Quinta	735
Palm Desert	201
Palm Springs	7
Rancho Mirage	46
Riverside County	261
Stabilized desert dunes	**0**
Cathedral City	0
Riverside County	0
Stabilized desert sand fields	**22**
Cathedral City	0
Indio	0
Palm Springs	19
Riverside County	3
Stabilized shielded sand fields	**6276**
Cathedral City	576
Coachella	9
Indian Wells	699
Indio	998
La Quinta	556

Palm Desert	945
Palm Springs	1235
Rancho Mirage	1055
Riverside County	203
Summer Tanager - Breeding Habitat	**1**
Cathedral City	0
Coachella	0
Desert Hot Springs	1
Indio	0
Palm Springs	0
Rancho Mirage	0
Riverside County	0
Summer Tanager - Migratory Habitat	**1758**
Cathedral City	5
Coachella	36
Desert Hot Springs	1
Indian Wells	209
Indio	258
La Quinta	735
Palm Desert	201
Palm Springs	7
Rancho Mirage	46
Riverside County	261
Triple-ribbed Milkvetch	**0**
Cathedral City	0
Coachella	0
Desert Hot Springs	0
Indio	0
Palm Springs	0
Rancho Mirage	0
Riverside County	0
Yellow Warbler - Breeding Habitat	
Yellow Warbler - Migratory Habitat	**1759**
Cathedral City	5
Coachella	36
Desert Hot Springs	2
Indian Wells	209
Indio	258
La Quinta	735
Palm Desert	201
Palm Springs	7
Rancho Mirage	46
Riverside County	261

Yellow-breasted Chat - Breeding Habitat	**1**
Cathedral City	0
Coachella	0
Desert Hot Springs	1
Indio	0
Palm Springs	0
Rancho Mirage	0
Riverside County	0
Yellow-breasted Chat - Migratory Habitat	**1758**
Cathedral City	5
Coachella	36
Desert Hot Springs	1
Indian Wells	209
Indio	258
La Quinta	735
Palm Desert	201
Palm Springs	7
Rancho Mirage	46
Riverside County	261
Yuma Clapper Rail	**0**
Coachella	0
Indio	0
Riverside County	0

Appendix V. Aeolian Sand Species Monitoring Report 2021

Report begins on following page.

Coachella Valley Conservation Commission

Coachella Valley Multiple Species Habitat Conservation Plan

Aeolian Sand Species Trends

2021

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

Contents

Introduction 3

Coachella Valley Fringe-toed Lizards 11

Flat-tailed Horned Lizards 16

Coachella Valley Milkvetch 23

Coachella Valley Giant Sand-Treader Cricket 24

Annual Plant Monitoring 29

Arthropod Monitoring 30

Round-tailed Ground Squirrel 40

Palm Springs Pocket Mouse 41

ACKNOWLEDGEMENTS 42

LITERATURE 42

Introduction

No other landscape type, habitat for at least six of the species and four natural community types, covered under the CVMSHCP-NCCP, has been reduced in extent (95% reduction) and has been so extensively fragmented, as has the Coachella Valley sand dunes and aeolian sand fields. Monitoring the covered species restricted to this landscape is an essential task for ensuring those species continue to support sustainable populations.

Monitoring environmentally sensitive species to assess populations trends, when done right, is an essential tool for protecting and managing biodiversity. "Doing it right" includes appropriate survey methods that provide an index of population trajectories and sample sizes that provide the statistical power to detect real change across remaining aeolian sand patches. Another essential component of "doing it right" is to put the survey data into a context of environmental variables that might effect change (Barrows et al. 2005). Healthy populations are rarely stable, rather they fluctuate from year to year as key resources rise and fall. Occupancy or abundance data alone do not inform landowners and managers why changes are happening, if intervention is appropriate, and what if any management prescriptions might support population persistence. We have developed a different monitoring approach in parallel with the design and development of the CVMSHCP-NCCP (Barrows et al. 2005; Barrows and Allen 2007a; Barrows and Allen 2007b). That approach considers monitoring as a series of hypotheses using the varying intensity of drivers and stressors over time and space as independent variables. Changes in species' abundance are then the dependent, or response variable. Without context, distinguishing natural oscillations of healthy populations from those requiring management actions may not be impossible. Precipitation is the primary driver of population growth in arid environments (Noy-Meir 1973; Kearney *et al*. 2018). Still, the relationship between population growth and rainfall is not linear; the seasonality, intensity, and amount of rainfall all have differential effects (Barrows et al. 2009). Monitoring in arid habitats must be able to partition the complex effects of rainfall from other anthropogenic effects to identify if management actions are warranted to reverse population declines.

Habitat conservation efforts for the CVMSHCP-NCCP are coordinated by the Coachella Valley Conservation Commission (CVCC). Current conservation landownership protected aeolian sand habitats includes the U.S. Fish and Wildlife Service National Wildlife Refuges, California Department of Fish and Wildlife Ecological Reserves, U.S. Bureau of Land

Management, Coachella Valley Water District, Coachella Valley Association of Governments (CVAG), Coachella Valley Mountains Conservancy, and Friends of the Desert Mountains. Individual conservation landowners are responsible for land management, while biological monitoring is funded and coordinated by the CVCC. Monitoring protocols are therefore applied evenly across the remaining habitat, independent of land ownership.

Sand dune habitats are dynamic; aeolian driven sands are continuously shifting in response to the wind, while new upwind sand additions are dependent on stochastic flood events bringing sediments out of the surrounding mountains (Barrows 1996). The aeolian sand habitat of the Coachella Valley includes four different natural community types that comprise the remnants of the valley's original aeolian sand landscape; they are defined by unique wind, sand, and vegetation characteristics (Table 1). Protection goals included maintaining sustaining populations of the Coachella Valley fringe-toed lizard within each of these community types. Flat-tailed horned lizards, while once much more wide spread, are now restricted to the stabilized sand fields and (less) active dunes of the Coachella Valley National Wildlife Refuge and California State Ecological Reserve. Monitoring goals focused on quantifying lizard densities in response to precipitation, the variation in habitat quality due to aeolian and fluvial sand dynamics, and anthropogenic stressors (Table 2) across each of the four natural communities.

We tested and rejected multiple approaches for visual counts of the lizards. Fisher et al. (2020) monitored fringe-toed lizards via a mark/recapture approach on a single 2.25 ha plot for +31 years, marking each resident lizard with a unique combination of three colored beads attached to the base of their tails (Fisher and Muth 1989). They were able to acquire both accurate annual population estimates and delineation of home ranges for resident lizards. Still, their method was time and effort intensive, typically requiring dozens of surveys per year, and so was impractical to apply to more than one or two plots; we needed a monitoring method that allowed us assess the lizard's populations on dozens of plots across the variation in habitat types spread over multiple conservation areas.

Our ultimate solution was to not count the lizards directly, but to quantify lizard densities using their tracks left in the fine aeolian sand. By using tracks, we eliminated the problem of the lizard's variable, inconsistent activity patterns – if any individual was active on a plot during or prior to the survey we could detect it by the diagnostic tracks it left behind. However, using tracks created challenges: what species had left those tracks and how many individuals were present? To determine how many lizards were represented by the tracks observed on each transect we used four criteria. First, we only surveyed on mornings after a night with strong enough winds to clear all tracks from the previous day. Second, we followed each set of tracks to determine if it connected with tracks seen previously, and so whether a set of tracks were from a previously counted lizard or a new one. Third, we looked for interactions between lizards to again know if we were looking at one or multiple individuals. Fourth, there are considerable size differences between male and female lizards and between juveniles and adults, and those differences are mirrored in the track widths. Ensuring that the species-track identification was accurate was resolved with adequate training, and when in doubt following the tracks to the lizard that created them. Much like learning to count birds by their calls and songs, accurately identifying tracks is a learnable skill. A benefit of the tracking method was that we could detect many more lizards, and so could reduce plot size to just 0.1 ha and still have adequate numbers of lizard sightings for robust statistical analyses. With smaller plots and smaller time and effort per plot we were able to survey 68 core plots (plots resurveyed every year) across the entire range of the lizards, with 4-6 repeated surveys per plot within a six-week survey window.

Methods

We configured the 0.1 ha plots as 10m × 100m rectangles. Those plots were then clustered (3-7 plots) within separate dunes or habitats within the same natural community type, with plot clusters > 500 m apart, (with the exception two clusters that were < 500 m apart as a result of a random placement) from an adjacent plot cluster. Placement of the initial plot within a cluster was random. Thereafter additional plots were either placed randomly or regularly to answer specific questions (such as edge effects). Non-random plot placements occurred within three clusters where we wanted to measure the effect of distance from a road/powerline that formed a habitat edge. Within a cluster we placed plots ≥ 50 m apart to avoid individual lizards overlapping adjacent plots. Fisher et al. (2020) identified home range sizes for CV fringe-toed lizard females ($\overline{X} =$ 505 m^2) and males ($\overline{X} =$ 662 m^2), which, assuming roughly circular home ranges, equate to home range diameters of 25-29 m, well below the 50 m separation between plots.

Table 1: Characteristics that distinguish the four aeolian sand natural communities found in the Coachella Valley, and that provide habitat for the Coachella Valley fringe-toed lizard.

Aeolian Community Characteristics	Active Dunes	Stabilized Sand Fields	Ephemeral Sand Fields	Honey Mesquite Dunes
Habitat Area / Number of Habitat Fragments	1370 ha / 2	400 ha / 1	1700 ha / 4	200 ha / 1
Sand	Deep, continuous, well-sorted fine sand with low silt or finer particle content	Well-sorted fine sands form discontinuous layers over layers with higher silt content.	Discontinuous patches of well-sorted fine sands, coarse sands, gravel, rocks, and boulders	Deep, well-sorted fine sand with low silt or finer particle content
Sand Movement	High mobility shifting dunes	Low mobility	Extremely high mobility	Low mobility
Perennial and annual Plant Composition	Sparse perennial and annual cover: *Larrea* and *Atriplex*	Moderate cover of *Larrea* and *Atriplex*	Moderate cover of *Larrea, Psorothamnus, Croton*, and *Petalonyx*	High cover of mesquite, moderate cover of other shrubs: *Prosopis, Larrea, Atriplex*, and *Isocoma*
Invasive Plant Species	Low to moderate cover of *Brassica*	Moderate to high cover of *Brassica* and *Schismus*	Low to zero cover of invasive species	Moderate cover of *Brassica* and *Schismus*
Plot numbers/ Names	AD2 1-6 (6) AD4 1-6 (6) MH 11-12 (2) J 100-250 (3) KN 1-3 (3)	H 0-250 (7) L 0-250 (7) MH 7-10 (4) J 0-50 (3) FF 1-3 (3)	GA 7-12 (6) MA 13-18 (6) T 19-24 (6) Stebbins 2-6 (5)	MH19-24 (6) MH 25-29 (5)

Table 2. Primary stressors impacting the Coachella Valley fringe-toed lizard, their effects, and management responses for reducing those impacts

STRESSOR	SCALE	EFFECT	MANAGEMENT RESPONSE
CLIMATE CHANGE	Broad, but most severe at the eastern, hotter/drier conserved habitats	Reduced surface activity for the lizards, more severe droughts, reduced vegetation cover. Higher mortality and lower recruitment rates	Reduce impacts from other stressors
INVASIVE PLANT SPECIES	Localized, varies between sites, and between species. Most severe where there are lower sand transport rates	Sand stabilization, out-competes native annuals, reducing both plant and insect food resources for the lizards. Notably, insect abundance and diversity are reduced as Sahara mustard increases	Hand removal is the safest, but the scale of the infestations easily overwhelms staff or volunteers for large scale removal efforts. Removal efforts then need to be strategically targeted to the habitats with the greatest benefits
EDGE EFFECTS	Localized	Increased predation from greater roadrunners, American kestrels, and common ravens	Remove anthropogenic nesting sites and power lines used by the predators to hunt from.
LOSS OF GENETIC HETEROGENEITY	Broad, but most severe on the smallest habitat patches	Potential reduced adaptability to climate change and other stressors, as well as reduced. Otherwise unexplained population declines	Translocation of gravid females and/or hatchlings to increase heterogeneity. Adults do not appear to translocate as successfully.
LOSS OF ECOSYSTEM PROCESSES	Localized	Increased sand stabilization, reduced active, loose sand habitats	Keep sand corridors open. Recycle fugitive sand (sand on roads or otherwise unwanted areas) to sand corridors
OFF-ROAD VEHICLE TRESPASS	Localized	Reduced perennial vegetation cover. Increased debris dumping	Maintain fencing, increased law enforcement patrols

Population densities can vary as habitat characteristics vary, and responses to those shifting habitat qualities can become apparent at different scales (Morris 1987; Smith and Ballinger 2001). By collecting lizard densities at a plot scale (0.1 ha) that can be combined and analyzed as plot clusters provides analytic flexibility at multiple scales; these plot clusters then can be combined at the natural community or landscape scale. Our 68 core plots included replicates within the four natural communities as follows (plot clusters / total # of plots): 1) active dunes (4 / 18); 2) mesquite dunes (1 / 11); 3) ephemeral sand fields (3 / 18); and 4) stabilized sand fields (3 / 21).

Two to three people surveyed each plot, a professional biologist plus 1-2 volunteer community scientists. Surveyors slowly walked equidistant from each other along the length of the plot, noting and identifying all vertebrate tracks, which were then verified and recorded by the biologist. The addition of the community scientists significantly increased detection rates for lizards and their tracks (Barrows et al. 2016).

While population density is a useful metric, it is dependent on long-term habitat conditions. Due to a finite number of breeding adults, it can take multiple years for a population to shift from lower to higher densities, or due to multiple-year lifespans, to go from higher to lower densities. Population growth rate (γ) can prove to be a more sensitive response variable to shorter term changes in independent variables. Here population growth was calculated as $\gamma = \ln(N_{i+1}/N_i)$, where N_i is the population density in year $_i$, and N_{i+1} is the population density the following year.

Independent variables

Although this region receives occasional isolated summer rain that can result in localized flooding, primary productivity and breeding success of the lizards are catalyzed by cool season rains (Noy-Meir 1973; Kearney *et al*. 2018). To illustrate the relationship between rainfall and the lizards' population dynamics we compared annual November-April rainfall totals from the eastern-most protected habitat, the Coachella Valley National Wildlife Refuge and California State Ecological Reserve. Rainfall data were collected on site and were found to be nearly identical to a nearby, internet accessible weather station in the city of Indio (https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca4259). Rainfall levels do vary across the Coachella Valley, with an increase toward the western edge of the valley at the western limits of the lizards' remaining habitat; however, the relative trajectories (drought, average rainfall, or relatively wet conditions) are consistent throughout the region. Using this rainfall metric to illustrate relationships between rainfall and lizard population dynamics throughout the lizards' range, while not precise for specific locations, provides the opportunity to assess how drought or wetter conditions influence the lizards' population densities. Rainfall levels provide a coarse-scale expectation of population growth rate trajectories.

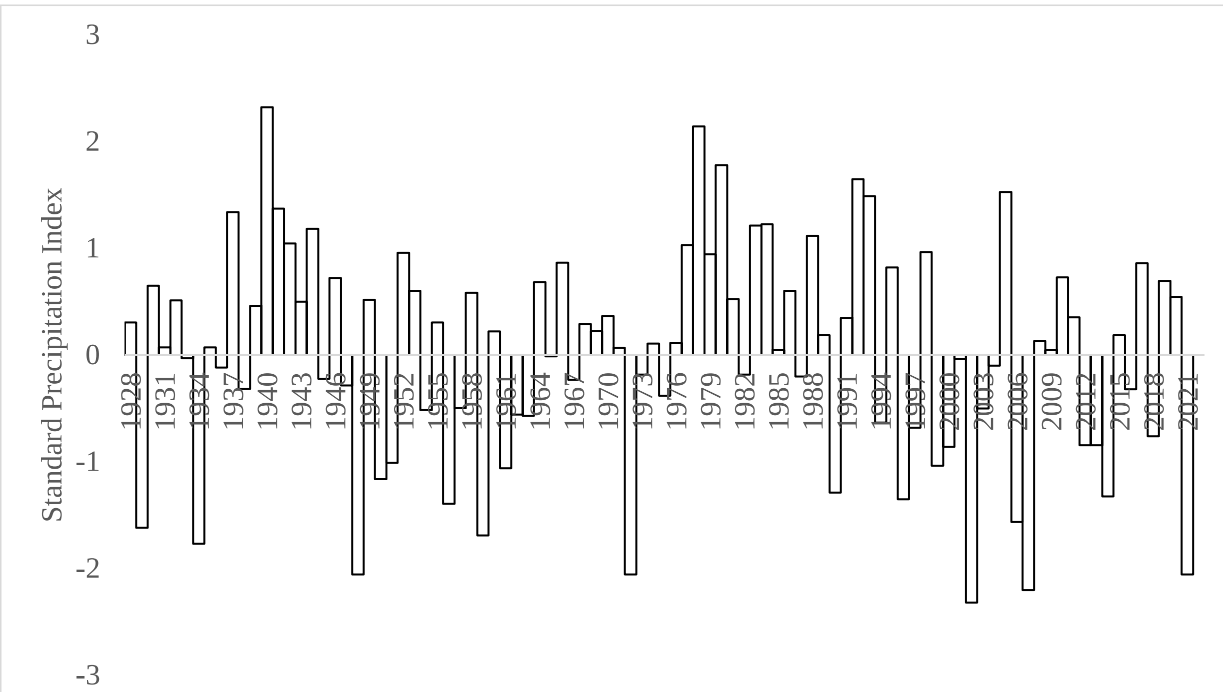

Figure 1. Historical drought patterns impacting the Coachella Valley region from 1928 to the present. Standard Precipitation Index (Livada, I., and V.D. Assimakopoulos, V.D. 2007) values of < -1 indicate dry conditions, and those ≤ -2 indicate severe drought (two standard deviations below the long term mean annual rainfall totals). While there was a mid-century drought period (1949-1961), the more recent drought (2002-present) is both longer and more severe. Rainfall data used to calculate the Index were from the Indio reporting station, Western Regional Climate Center, www.wrcc.edu.

Figure 1 illustrates the patterns of wet, dry, and drought conditions that the Coachella Valley has experienced over the past 93 years. Severe drought (SPI values ≤ -2.0) years occurred just twice between 1928 and 2001, averaging 1.4 severe droughts/50 years. Since 2001 there have been 3 severe droughts; if that pattern continued there would be an average of 7.5 severe droughts/50 years. Between 1928 and 2001 there were 11 “wet years”, SPI values of ≥ 1.0, or an average of 7.5 wet years/50 years. Since 2001 there has been just one wet year (2005), giving an average of just 2.5 wet years/50 years. These data, plus the overall increases in mean temperatures, increasing evaporation of what little rain occurs, indicate the potential impacts of modern climate change, and the increasing levels of aridity this region is experiencing. Predominantly drier than average conditions will have a potentially negative impact on lizard populations, especially on the eastern-drier end of the Coachella Valley (Coachella Valley National Wildlife Refuge and State of California Ecological Reserve).

Additional independent data that we collected annually on each 0.1 ha plot included: 1) annual and perennial plant abundance and density by species, including both native and non-native species; 2) arthropod abundance and species diversity, 3) sand compaction, and 4) associated vertebrates, using track counts collected at the same time that the lizards were surveyed. These metrics provided fine-scale, plot-specific indicators of habitat characteristics. For annual vegetation cover we measured both and density and % cover, by species, on 12, 1m^2 sub-plots, four at each end and in the center of each 0.1 ha plot. We measured arthropods using three pitfall traps placed overnight, one at each end and one in the center of each 0.1 ha plot. One of those arthropods, the beetle *Asbolus* (previously *Cryptoglossa*) *laevis*, (Tenebrionidae) proved to be a useful indicator of sand compaction, only occurring on the less compacted sands of active dunes (Barrows 2000). Sand compaction was measured using a Pocket Penetrometer (AMS Inc.). Twenty-five compaction measurements, each separated by roughly 4 m, were made along the mid-line of each plot. Associated vertebrates were measured using the same track protocol used to measure the lizard densities. Some of the associated vertebrates are predators and so could influence fringe-toed lizard abundance. Potential predators include leopard lizards (*Gambelia wislenzenii*), sidewinders (*Crotalus cerastes*), coachwhips (*Masticophis flagellum*), glossy snakes (*Arizona elegans*), greater roadrunners (*Geococcyx californianus*), loggerheaded shrikes (*Lanius ludovicianus*), common ravens (*Corvus corax*), American kestrels (*Falco sparverius*), coyotes (*Canis latrans*), and potentially some species of rodents (Timberlake and Washburne 1989). Roadrunner, kestrel, and raven densities increased with proximity to human development; both the roadrunner (except on the mesquite dune natural community) and kestrel were dependent on planted non-native trees and shrubs for nesting sites. Others are possible competitors such as zebra-tailed lizards (*Callisaurus draconoides*) and flat-tailed horned lizards

(*Phrynosoma mcallii*), but none are as habitat specific to active aeolian sand as are fringe-toed lizards.

Coachella Valley Fringe-toed Lizards

Figure 2 illustrates the between-cluster differences in fringe-toed lizard densities as well as temporal asynchrony across the range of this species. Along with the Kim Nicol plot cluster in the western Indio Hills, the Ephemeral Sand Fields and the Active Dune clusters consistently have the highest fringe-toed lizard densities. During 2016-2018 the Active Dunes had higher densities than the Ephemeral Sand Fields (t-test: two-way analysis, mean 6.15 versus 2.56 lizards /0.1 ha plot; d.f. = 19, $P = 0.0000034$). Then, during 2019-2021 the Active Dune populations declined (t-test: two-way analysis, mean 6.15 versus 3.75 lizards /0.1 ha plot; d.f. = 17, $P = 0.00017$), and the Ephemeral Sand Field lizards increased (t-test: two-way analysis, mean 2.56 versus 4.98 lizards /0.1 ha plot; d.f. = 11, $P = 0.015$). The result was that during 2019-2021 there was no longer a statistical difference between Active Dunes and Ephemeral San Fields (t-test: two-way analysis, mean 3.75 versus 4.98 lizards /0.1 ha plot; d.f. = 10, $P = 0.\ 15$). The population increases on the Ephemeral San Fields were expected as 2019 and 2020 were above average in rainfall. However, the declines on the Active Dunes were not expected. Large population swings are a regular occurrence and should not catalyze management responses if they are synchronized in direction and amplitude with shifting rainfall levels. The question then is when does asynchrony between precipitation and lizard densities indicate a need for management intervention?

The regression of 2020 lizard density versus sand compaction was significant for both active dunes ($R^2 = 0.5939$; $P < 0.00001$) and stabilized sand fields ($R^2 = 0.2101$; $P < 0.003$); less compacted sand is correlated with higher densities of fringe-toed lizards (Figure 2). There appears to be a sand compaction level of approximately 0.125 kg / cm^2 that distinguishes most active dunes from stabilized sand fields. Of the AD2 and ADM plots designated *a priori* as active dunes, 75% had sand compaction levels fitting to that natural community. However, for the AD4 and ADJ active dune plots, just 30% had sand compaction levels ≤ 0.125 kg / cm^2. The occurrence of plots previously identified as active dunes, but now with sand compaction and lizard densities well within the stabilized sand field range, identified a need to initiate remedial management. We did not find any support for other additional explanations, such as edge effects which are manifested by increases in potentially anthropogenically augmented predator densities (i.e. roadrunners, ravens, or kestrels). Our data identified that management intervention to remove mustard as well as remove any other barriers to aeolian sand movement was warranted on the AD4 and ADJ dunes. The lack of synchrony between lizard density and coarse scale precipitation data identified that a potential problem existed; finer scale invasive species densities and sand compaction data identified a cause and management solutions.

Another possible contributing factor is the hyper aridity of this eastern site compared to the less arid western Ephemeral Sand Fields. Modern climate change could be eroding habitat quality (cover and food abundance) at a higher rate than on the more western sites. However, similar declines occurred on the Willow Hole Mesquite dunes, a site which is also compromised by insufficient sand source connectivity. The mesquite dunes have ample cover/shade and are similarly more western, so giving additional credence for the need for additional sand inputs as a hypothesis explaining the lizard declines on the Active Dunes. Additionally, the flat-tailed horned lizards occupying the stabilized sand fields that surround the active dunes on the CV National Wildlife Refuge and Ecological Reserve, increased during 2020-2021, at the same time as the fringe-toed lizards were decreasing. This also supports need for additional sand inputs as a hypothesis explaining the lizard declines on the Active Dunes.

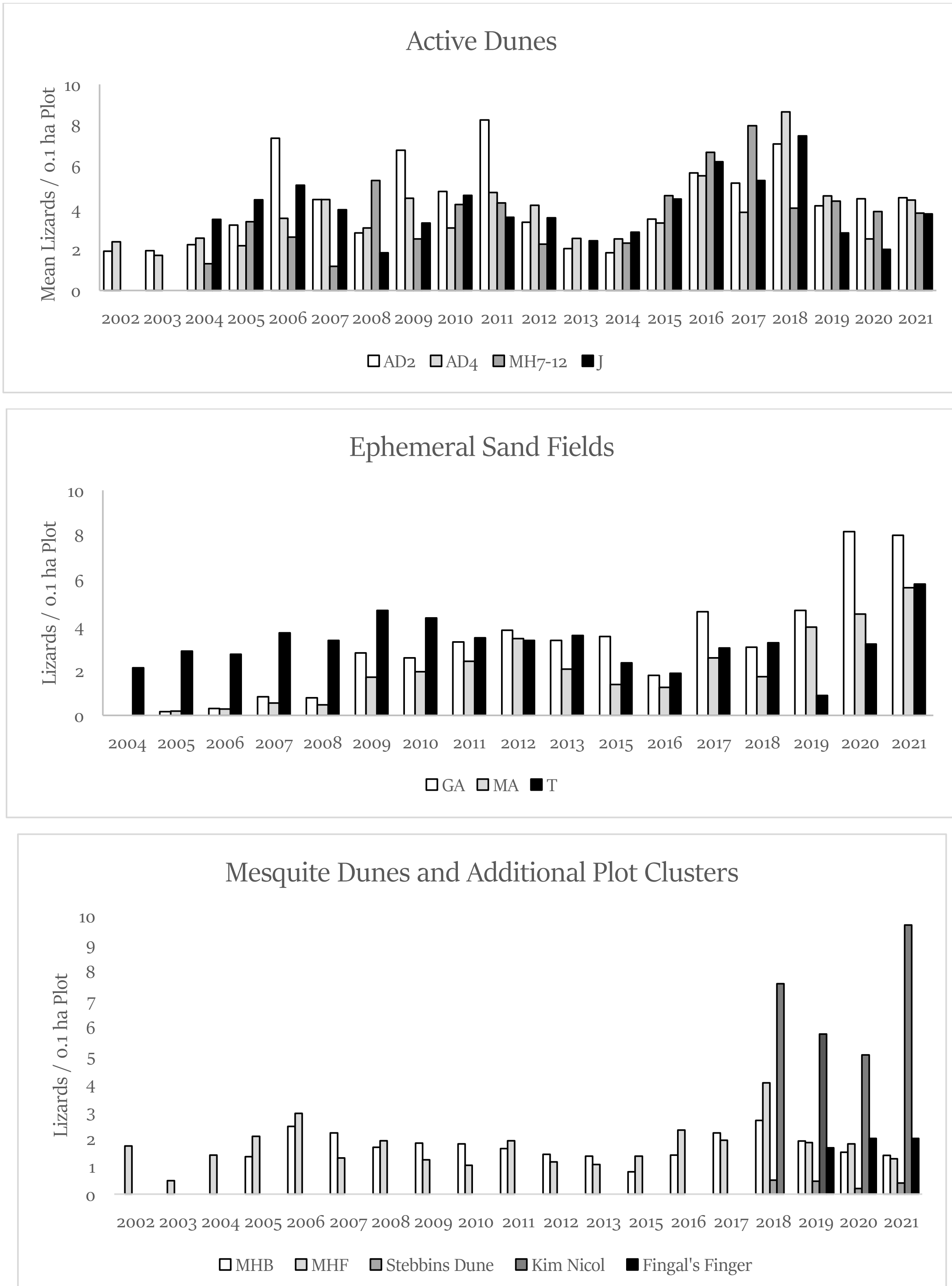

Figure 2. Annual changes in lizard density within plot clusters across the range of Coachella Valley. Letters refer to plot names within each of the broad aeolian sand community types (Table 1)

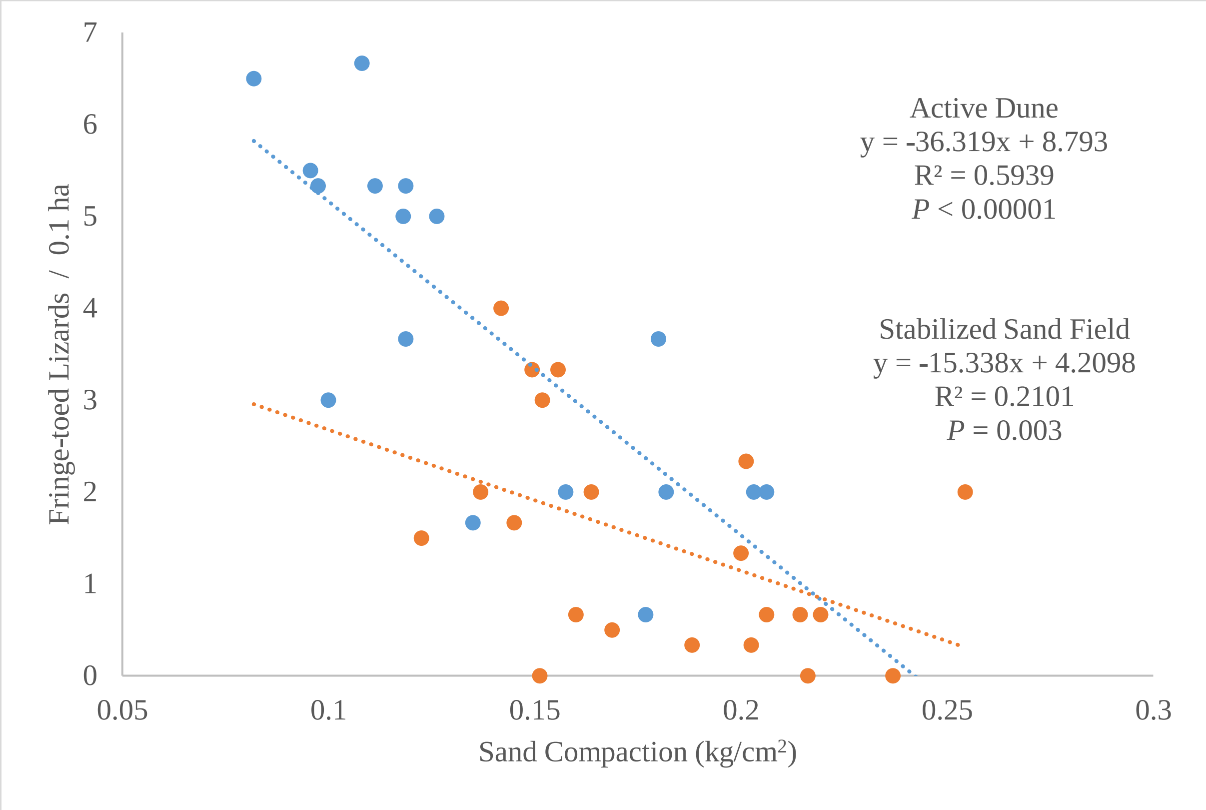

Figure 3. Patterns of Fringe-toed lizard densities in relationship to sand compaction in 2020. Active dunes (each plot indicated by a blue circle) generally have less compacted sand and higher lizard densities, whereas stabilized sand field plots (orange circles) have more compacted sand and fewer lizards. The regression of lizard density versus sand compaction for each habitat type show statistically significant correlations. The plots identified as active dunes, but that have values that are well within those for stabilized sand fields are not receiving new sand and are being invaded by Sahara mustard.

Flat-tailed Horned Lizards

Flat-tailed horned lizards reach highest densities on the “stabilized sand field” community type within the CVMSHCP-NCCP. Flat-tails were also found occupying the more stabilized portions of the active dunes, but their occurrence there was irregular, so the following analyses only pertain to the stabilized sand fields.

In 2006 we documented an “edge effect” that was keeping flat-tailed horned lizards from being able to occupy the full extent of the habitat that has been set aside for them on the Coachella Valley National Wildlife Refuge and California State Ecological Reserve (Barrows et. al. 2006). What we found was that lizard predators, subsidized by the nesting structures unwittingly being provided for them on adjacent, non-conservation lands, had created a resident population of those predators (American kestrels and greater roadrunners) that were then utilizing the flat-tails as food to feed their chicks. Flat-tailed horned lizards typically occupy treeless aeolian sand and silty habitats where, due to the lack of nesting habitat, such avian lizard predators are absent. The lizard’s survival adaptations do not include mechanisms for avoiding such predators, especially when predators such as the kestrels can scan their hunting grounds from power lines, and then swoop down to capture the horned lizards.

While no management efforts have been employed to reduce the impact of subsidized predators on the flat-tailed horned lizards, now 15 years later, we want to document whether that predation-based edge effect was still occurring. Figure 3 clearly shows that it is. What we found was that yes, the edge effect still exists. However, there has been an incremental, statistically significant increase in flat-tail densities on the 25 and 50 m from the habitat edge plots (ANOVA, d.f. = 1, F = 7.9526, $P = 0.0078$). There was also an increase in horned lizard density on the 200 and 250 m plots (ANOVA, d.f. = 1, F = 5.1954, $P = 0.02867$), perhaps reflecting an overall increase in the flat-tail populations.

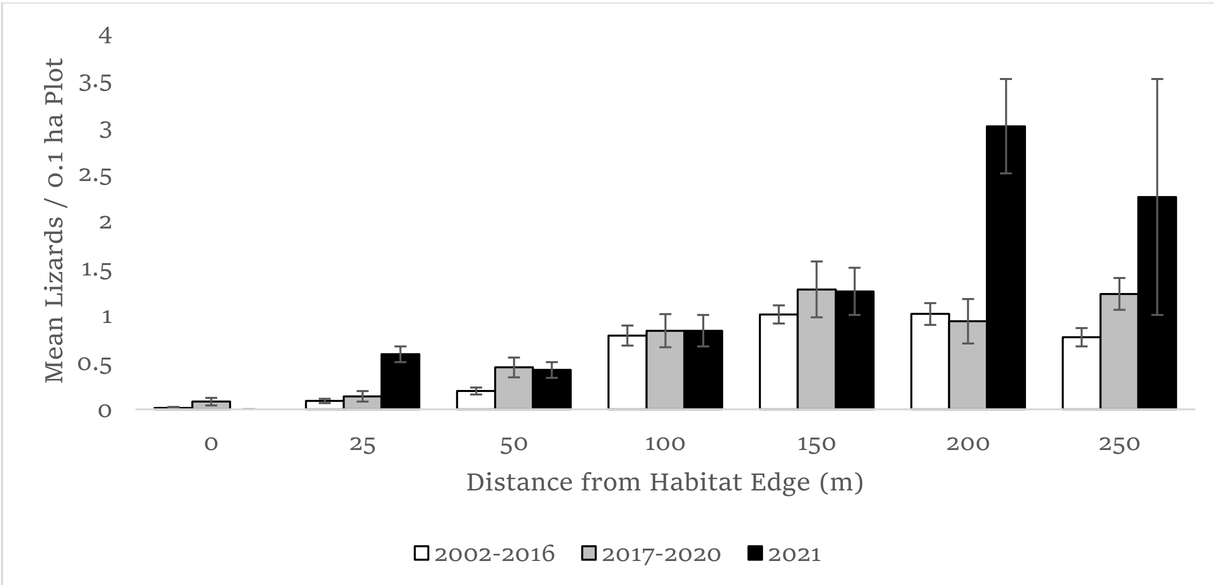

Figure 4. Densities of flat-tailed horned lizard as a function of distance from the habitat edge. Data are based on the L & H plot clusters; the temporal categories are arbitrary, aiming only to separate recent versus older population densities and to have sufficient data in each category to allow for statistical testing. Error bars indicate one standard error.

As with the fringe-toed lizards, one of our aims is to identify metrics that then indicate expected temporal and spatial population fluctuations, and so when the lizard densities deviate from those expectations, management actions may be warranted. Since there is a clear edge effect impacting flat-tailed horned lizards, for understanding what those additional habitat metrics are, we have excluded data collected from plots < 100 m from habitat edges from analyses of those broader habitat constraints. Although sand compaction is an important spatial metric for identifying expected densities of fringe-toed lizards, within the range of compaction values these horned lizards have available to them within the stabilized sand field community, that metric has no explanatory value for flat-tailed horned lizards.

Annual densities of flat-tailed horned lizards are shown on Figure 5. Temporal patterns of annual rainfall are negatively correlated with annual differences in flat-tailed horned lizard densities (Table 3). This strong negative relationship may be explained by the abundance of Sahara mustard, *Brassica tournefortii*, which can become extremely dense across the flat-tail's habitat in years with high early winter rainfall. This mustard outcompetes and greatly reduces annual plant abundance and species richness during the years when it is present in high densities (Barrows et al. 2009). The impact on the flat-tailed horned lizards could include limiting mobility through their habitat, potentially impairing foraging, and their ability to find mates. By reducing overall plant diversity and abundance there may also be a negative impact on the lizards' primary food, harvester ants.

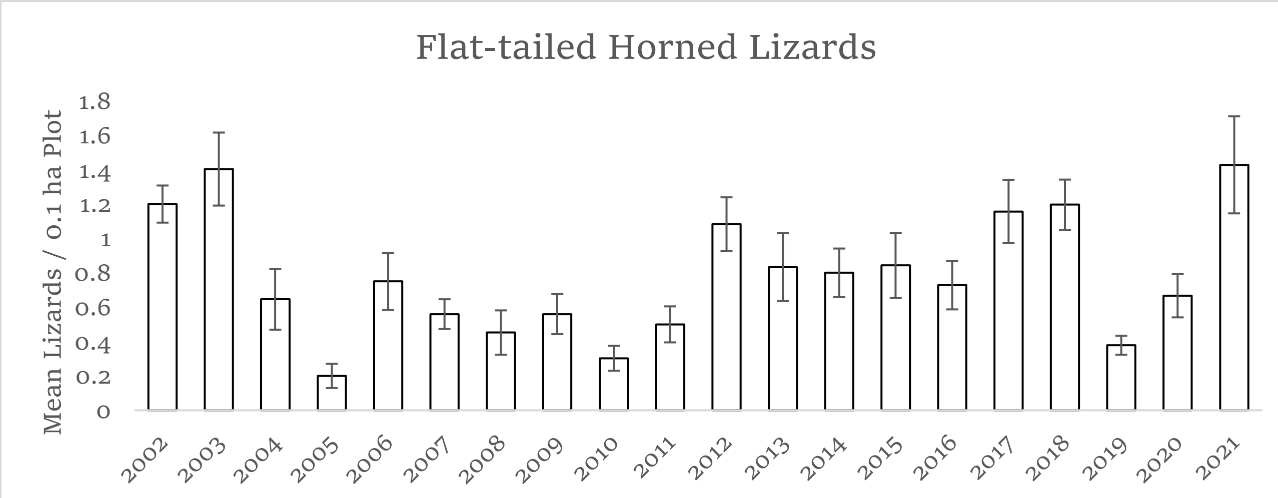

Figure 5. The relationship between annual rainfall and flat-tailed horned lizard densities on the Coachella Valley National Wildlife Refuge and State Ecological Reserve. Plots within 50 of the habitat edge were excluded. Error bars indicate one standard error.

Table 3. Relationships between flat-tailed horned lizard densities and habitat characteristics.

	Correlation (r)	Regression (R^2)	*P*
Annual Rainfall	-0.579	0.336	0.007
Sahara Mustard (*Brassica tournefortii*)	-0.645	0.416	0.003
Harvester/Honeypot Ants *Pogonomyrmex/Myrmecocystus*	-0.018	0.0003	0.946
Shovel-nosed Snake *Chionactis occipitalis*	0.672	0.452	0.006

The primary food for flat-tails, like all horned lizards, is ants, primarily species of harvester and honeypot ants. As such we would expect to see a relationship between those ants' abundance and the abundance of flat-tails. As Table 3 shows, we found no relationship between these ants and flat-tailed horned lizards. The reason for this lack of a relationship could be that these ants are never a limiting resource for the horned lizards, or that our sampling design aimed at quantifying ant abundance and availability is inadequate. We have previously tried to determine the impact and mechanism of the mustard on harvester ants by rearing ant queens on diets of just mustard seeds or just a mix of native annual seeds. Beginning April of 2019, we collected five California harvester ant (*Pogonomyrmex californicus*) queens shortly after the first nuptial flight of the spring. We collected these queens after they had mated (evidenced by loss of wings), but before they had founded colonies. In order to investigate the effects of a *Brassica*-dominated diet, we provided three queens with only *Brassica* seeds, in excess, as a food source, while the remaining two queens received a mixture of seeds from three abundant native plants, narrow-leaved forget-me-not (*Cryptantha angustifolia*), brown-eyed primrose (*Chylismia claviformis*), and brittlebush (*Encelia farinosa*), in excess. By the end of May, all *Brassica*-fed queens had perished without producing workers. These queens mostly ignored the *Brassica* seeds, indicating that they may not recognize them as a viable food source. On the other hand, the two queens fed with native seeds survived approximately eight months and produced viable brood, with one colony achieving a maximum of four simultaneous mature workers, and the other having three workers. This brief, informal experiment will require fine-tuning in the future (updated formicaria design, improved variable control, increased sample size), but it nonetheless offers intriguing evidence that an environment saturated with *Brassica* may be detrimental to harvester ant survival.

Although known insectivores, though not ant specialists, annual fluctuations in shovel-nosed snakes, *Chionactis occipitalis*, paralleled those for flat-tailed horned lizards. This indicates that both species are either responding to the same environmental drivers and constraints, or that their drivers and constraints are responding to the same environmental stimuli.

DISCUSSION

Wild populations fluctuate naturally in size from year to year. The challenge for managing endangered species that are facing multiple stressors is distinguishing natural population oscillations from population shifts that are anthropogenic-driven and that, if not managed, could result in population declines leading to extinction. Here we provided examples of how the hypothesis-driven monitoring approach employed for the Coachella Valley fringe-toed lizard and flat-tailed horned lizard has clarified those distinctions and identified site-specific management recommendations. Using two abiotic metrics, precipitation (coarse scale) and sand compaction (fine scale), plus a biotic metric (invasive plant densities), we identified site-specific priorities for managing an invasive weed, Sahara mustard, to promote more sustainable lizard populations. Without management intervention, some active dune communities, habitats that where fringe-toed lizard populations are consistently the densest throughout its range, appear to be transitioning to stabilized sand fields, a natural community with consistently the lowest lizard densities. Similarly, flat-tailed horned lizards are consistently at low densities when and where the mustard is densest.

We continue to find that the mustard decreases native plant abundance (Barrows et al. 2009), decreases arthropod abundance (Hulton et al. 2013), and increases sand compaction. The result was that as Sahara mustard increased the lizards became increasingly scarce, and ultimately absent. Our findings indicate that the mustard continues to be a significant threat to the sustainability of the lizard populations, especially on stabilized sand fields and active dunes. This is in contrast to our findings that another invasive weed, Russian thistle, *Salsola tragus,* had a benign to positive impact on the lizards (Barrows 1997).

The density of the mustard is tied to both the amount of rainfall and sand transport rates, the more rainfall and the more stable the sand, the denser the mustard. It is not just the amount of rainfall, but also the timing. Heavy early December rains guarantee a dense growth of mustard, but if the rains do not start until late February or March, little mustard germinates. If there is a sequence of storms beginning in December and continuing through February, a new cohort of mustard germinates after each storm. These patterns complicate control efforts. Herbicides that kill mustard will also kill native annual plant species; following an herbicide treatment, if more storms occur, then more mustard will still germinate. That leaves “surgical” hand pulling, focusing on areas where mustard removal will yield the greatest benefits, as the primary control method. Unless a safe, species-specific biological control for the mustard is identified, hand pulling will be an ongoing management task. Stabilized sand fields have the highest levels of Sahara mustard infestation as well as the highest sand compaction levels of any of the aeolian sand communities. The beetle *Asbolis laevis* does not occur there, and the dominance of the mustard has so far overwhelmed any effort to control it there.

Ephemeral sand fields also did not have significant correlations with precipitation; this community occurs in a region of the Coachella Valley where wind and sand transport are so strong as to continue to blow deposited sand downwind and scour rocks into ventifacts (Table 1).

Within the ephemeral sand fields, due to these strong winds, sand residence time is relatively short compared to the other aeolian sand-based natural communities. These scouring winds also inhibit annual plant growth (including non-native invasive species), so higher annual rainfall that supports annual plant growth and arthropod prey for the lizards elsewhere has less of an impact on the lizard's population dynamics here. A close correlation between annual precipitation and the lizard's population growth should not be expected. Rather, when sand delivery is sufficient to build sand hummocks, and when that coincides with sequential years of average or greater rainfall to maintain high soil moisture to support leaf and flower production of perennial shrubs, the lizard population there does grow, as it did in 2020. Understanding site-specific interactions between abiotic inputs and biotic responses is critical for developing models from which the need for management interventions can be determined. For this natural community there are up-wind sand corridor challenges, such as sand and gravel mining, channelization for aquifer re-charging, and conflicts associated with roadways that cross the sand corridor. Each of these could restrict sand delivery to this habitat, and each needs to be watched to ensure sand delivery is not constrained.

We have previously addressed questions that included whether the high degree of habitat fragmentation had resulted in a loss of genetic diversity in the lizards. Based on tissue samples collected in the mid-1990s, Hedtke et al. (2007) found no genetic structure associated with the lizard populations occupying the different fragments; their genetic profile reflected the pre-fragmentation, panmictic condition. A follow-up study analyzing tissues collected in 2008, (Vandergast et al. 2016) found a different result; lizard populations occupying each habitat fragment had a unique genetic signature, and each population had lost genetic diversity relative to that 1990s baseline. Climate change also looms as a threat to the lizards. Barrows et al. (2010) modeled the response of the fringe-toed lizards to expected levels of climate change if no significant reductions in anthropogenic greenhouse gases occur and found that only the westernmost habitat areas will likely continue to provide the climate envelope currently preferred by the lizards. Of course, models are just hypotheses in need of empirical testing, and so far, on all the remaining protected habitats the lizards are sustaining populations as expected with respect to annual rainfall and Sahara mustard densities. Given that land managers do not have the capacity to alter the course of climate change, it is imperative that they address those threats that they can affect. These include controlling invasive plants and keeping sand corridors unobstructed, and reducing other stressors that might, together with climate change, result in local extirpations.

Forty years after the listing of the Coachella Valley fringe-toed lizard as endangered, this species continues to thrive across much of the same landscape they occupied in 1980. Land protection efforts, purchasing essential private parcels and so taking them out of a trajectory toward future development, has been extremely successful. However, long-term success, defined as maintaining sustaining fringe-toed lizard populations across those protected lands, will depend on effective management informed by hypothesis-based monitoring.

Coachella Valley Milkvetch

Coachella Valley milkvetch (*Astragalus lentiginosus* var *coachellae*), is federally endangered and endemic to the Coachella Valley. It is found only in areas with abundant loose sand, as it is thought that its seeds require sand scarification to germinate. It is found at its highest density on the ephemeral sand fields of the Whitewater Floodplain Preserve, but can also be found as far east as the Coachella Valley National Wildlife Refuge and as far west as our Tipton Road plots near Windy Point. This plant is normally an annual, but with sufficient conditions it can survive multiple years; one robust specimen in Desert Hot Springs has survived for at least three years. Our surveys of this plant consist of a simple count of all individuals present at each of our aeolian community plots. Due to the hyper-arid condition s of 2021, no milkvetch were found on any plot.

Coachella Valley Giant Sand-Treader Cricket

Coachella Valley Giant Sand-Treader Cricket (*Macrobaenetes valgum*)

Introduction

The Coachella Valley Giant Sand-Treader Cricket (*Macrobaenetes valgum*, or CVGST) is a large, wingless camel cricket of the family Rhaphidophoridae. Its protected status under the CVMSHCP is due to its restriction to areas with large amounts of fine, active sand which have drastically declined in area because of development and blocking/alteration of sand sources. However, at areas with remaining healthy dunes, such as the CVNWR, these crickets can be exceptionally abundant. Little is known of their biology, but their lifecycles appear to be closely linked to winter rains (Tinkham 1962, Barrows 2012). Nymphs (juveniles) are present in large numbers in the autumn months, but are too small to be easily detectable. However, the crickets grow rapidly throughout winter, and by late winter or early spring the surviving CVGST are large enough to survey. CVGST are important nocturnal generalist detritivores that likely feed opportunistically on plant and animal matter (Polis 1991). They are sensitive to high heat, so each morning, before the heat of the day arrives, they excavate a new burrow into the sand presumably to a depth where conditions are comfortably cool and moist (Tinkham 1962). Their method of excavation leaves behind a characteristic triangle-shaped pile of sand tailings at the mouth of each burrow. By July or August, when summer temperatures are at their maximum, adult CVGST have mostly disappeared.

Methods

Our surveys of CVGST take place in late winter to early spring, when the crickets are large enough and abundant enough to detect. We conduct surveys across all of our 0.1ha aeolian community plots. This year, we conducted surveys from 2 February to 25 May. Each plot is surveyed once during the monitoring season. CVGST are recorded by counting the diagnostic triangle-shaped sand piles at the mouths of their burrows. This method is useful for a variety of reasons. These sand piles are almost always distinctive enough as to be rarely confused with a burrow from another species, even to a novice observer. Secondly, counting burrows is an activity that can be conducted by our team during daylight hours. Otherwise, we would either have to monitor the crickets at night when they are above-ground and detectable, or we would have to excavate them from the ground during the day, which would seriously risk the health of the animal. Only burrows that are "closed" (the entrance is blocked with sand) are recorded, as this indicates that a CVGST is actually occupying the burrow. Additionally, because crickets may burrow into similar areas each morning, only one cricket is counted per square meter in order to avoid duplicate records, unless the tailings are of notably different size which indicates two separate crickets are occupying the same area.

We created graphs using R 4.1.0 (R Foundation for Statistical Computing, Vienna, Austria) with the ggplot2 package for R (Wickham 2016). We ran correlation analyses (two-tailed Pearson's correlation coefficient tests) using Base-R.

Results

CVGST abundance can vary widely year-to-year, as seen in Figures 6 and 7. It appears that winter precipitation influenced CVGST abundance during our sampling efforts from 2004 to

2009 (fig. ###). This correlation was statistically significant at our stabilized sand field and mesquite hummock plots. While not statistically significant, the trends of cricket abundance and rainfall at the active dunes and ephemeral sand fields still appear to follow in many cases. However, our more recent monitoring efforts, from 2017 to 2021 (fig.7), do not indicate the same relationship between CVGST abundance and rainfall. The reason for this is unknown, but may be influenced by post-drought period changes in environmental factors such as invasive plant cover, predation, and sand stabilization.

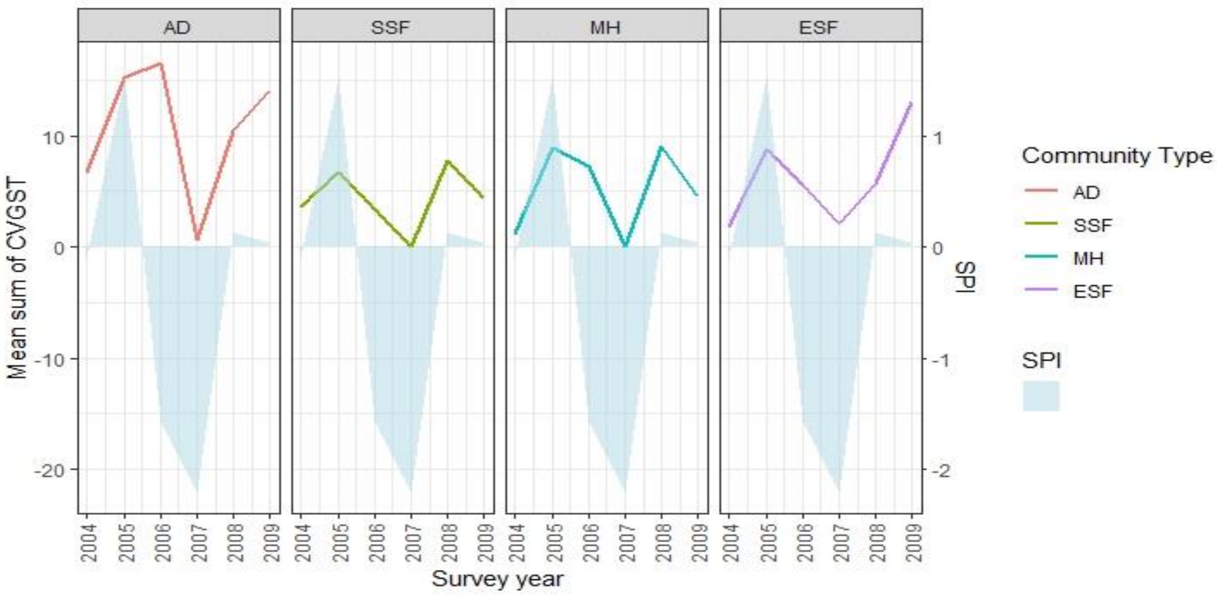

Figure 6. CVGST population trends (mean abundance per plot) and winter SPI during our sampling effort from 2004 to 2005 by aeolian community type. AD = active dune, SSF = stabilized sand field, MH = mesquite hummock, ESF = ephemeral sand field.

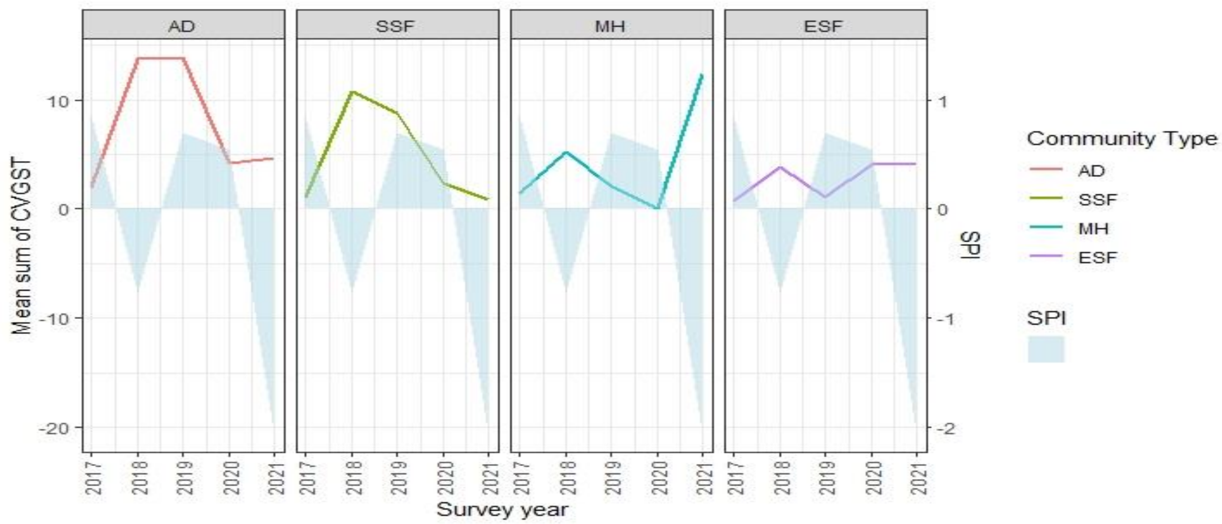

Figure 7. CVGST population trends (mean abundance per plot) and winter SPI during our sampling effort from 2017 to 2021 by aeolian community type. AD = active dune, SSF = stabilized sand field, MH = mesquite hummock, ESF = ephemeral sand field.

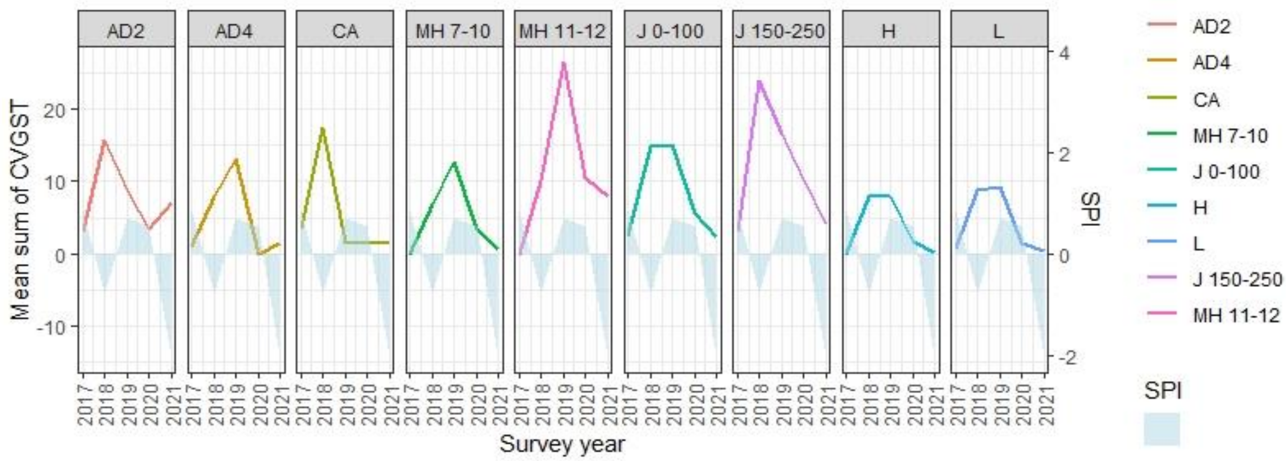

Figure 8. CVGST population trends (mean abundance per plot) and winter SPI during our sampling effort from 2017 to 2021 at our Coachella Valley National Wildlife Refuge plots.

To investigate CVGST population trends at a finer scale, Figure 8 shows the mean CVGST abundance across all our plots at the Coachella Valley National Wildlife Refuge (CVNWR). These plots are comprised of active dune and stabilized sand field community types, and generally follow a similar trajectory since 2017. We chose to split the "J" and "MH 7-12" plot clusters here to account for increased sand deposition at the J 150-250 and MH 11-12 plots, giving them sand characteristics closer to those of active dunes. The remaining plots in these clusters are still categorized as stabilized sand fields. The separation of these plots into differing community types is supported by the much higher mean CVGST abundance present on the plot clusters now designated as active dunes, since it is presumed that CVGST prefer fine, loose, active sand.

While the trends of these plots superficially appear to be of similar shape, some sites reached their maximum CVGST abundance at different times than others. For instance, the CVGST abundance at our AD2 site peaked in 2018, then began a sharp decline, while CVGST at AD4 peaked a year later, in 2019, before declining. This may indicate that there are, on occasion, other drivers of CVGST populations are in effect besides precipitation. Environmental process such as patterns of sand deposition, dune stabilization, and soil moisture retention may play an important role in CVGST population trends, along with local variation in predation, parasitization, and disease.

Our newly established plot clusters (Stebbins' Dune, Fingal's Finger, and Kim Nicol) showed slight changes in CVGST abundance from 2020 to 2021 (Figure 9) CVGST abundance slightly increased at Fingal's Finger and Kim Nicol, while abundance slightly decreased at Stebbins' Dune. This is not unexpected, since the sand at Fingal's Finger and Kim Nicol much more closely matches CVGSTs' preference (loose, fine, deep, retains moisture longer), while Stebbins' Dune possesses only small patches of coarse, shallow sand.

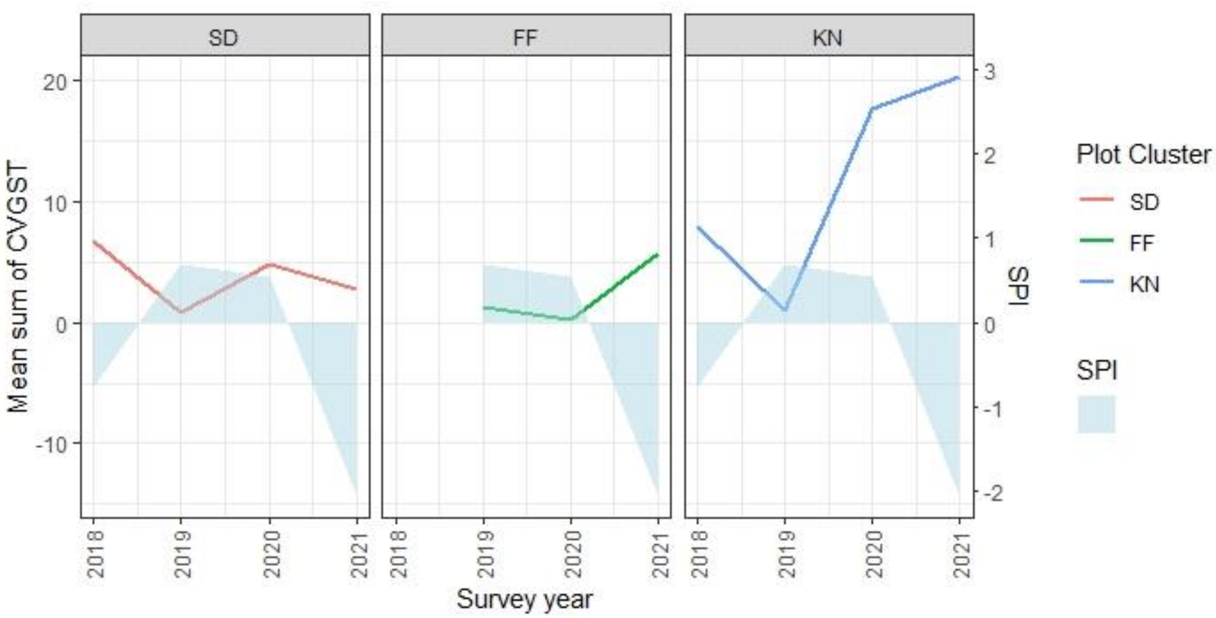

Figure 9. CVGST population trends (mean abundance per plot) and winter SPI during our sampling effort from 2018 to 2021 at our newly established plot clusters. SD = Stebbins' Dune, FF = Fingal's Finger, KN = Kim Nicol.

Annual Plant Monitoring

Due to hyper-arid conditions during the 2020-2021 winter, no annuals germinated on the aeolian dunes and sand fields in 2021.

Arthropod Monitoring

Introduction

Pitfall traps have been widely used by entomologists since the late 1800s (Brown and Matthews 2016). Pitfall traps are a passive trap design (do not require constant monitoring) used to sample ground-dwelling arthropods. Extensive variation exists in pitfall trap design (see Brown and Matthews 2016), but the basic blueprint involves setting a collecting container, which can be anything from a small glass vial to a large bucket, into the ground so that wandering arthropods will fall into the collecting container where a researcher can later collect them. The exact pitfall trapping methodology is often dictated by the specific project's needs and limitations. Pitfall traps are invaluable research tools because they require minimal effort to install and maintain and they allow for the study of an otherwise largely undetectable yet extremely important animal assemblage.

Our primary objectives are to 1.) document how species' abundance changes over time and correlate this to changing landscapes, such as loss of sand and increase in invasive plant cover, 2.) identify arthropod species or species assemblages that we can use to help characterize habitat types, 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*).

California harvester ants (*Pogonomyrmex californicus*) removing seeds from narrow-leaved forget-me-not (*Cryptantha angustifolia*).

Commonly sampled ants include California harvester ants (*Pogonomyrmex californicus*), big-eye harvester ants (*Pogonomyrmex magnacanthus*), black harvester ants (*Veromessor pergandei*), Kennedy's honeypot ant (*Myrmecocystus kennedyi*), *Myrmecocystus tenuinodis*, *Dorymyrmex* ca. *insanus*., and *Forelius pruinosus*. Harvester ants are often considered keystone species due to their capacity to harvest large quantities of seeds, which serve as their primary food source, therefore affecting plant abundance and distribution, and for providing aeration and nutrient transport for the soil they inhabit (McMahon et al. 2000). Importantly, harvester ants are also a primary or important food source for flat-tailed horned lizards and Coachella Valley fringe-toed lizards (Barrows 2006, Barrows and Allen 2009). It was found in our 2019 assessment of dune ant communities that different aeolian habitat types can be distinguished by the species of ants present. This is likely due in part to certain ants' tolerance of particular substrate types (e.g. *Veromessor* and *Dorymyrmex* preferring course sand/gravel).

Darkling Beetles

Darkling beetles are diverse both in their species richness and their morphology, particularly in the Coachella Valley which may host the highest darkling beetle diversity of any California desert areas (Barrows 2000). Some species, such as the armored stink beetle (*Eleodes armata*), are among the largest insects present at up to 3.5 centimeters in length, while species such as *Batulius setosus* are only about 4 millimeters in length. Most species are nocturnal foragers, but others, such as *Araeoschizus hardyi*, may be at least partially associated with ants and feed on their food stores (Papp 1981). Two of the larger species, the blue death-feigning beetle (*Asbolus verrucosus*) and the smooth death-feigning beetle (*Asbolus laevis*) are very common in their respective habitats. *A. verrucosus* are found in more stabilized areas, such as creosote scrub surrounding dunes and basins dominated by herbaceous plants. *A. laevis* appear to prefer exclusively habitat characterized by loose, deep, active sand, such as active dunes and mesquite dunes (Aalbu 1985, Barrows 2000). This difference in substrate preference makes them potentially useful for identifying changes in sand compaction and stabilization, with less *A. laevis* being detected at a site with increasing stabilization (Barrows 2000, Barrows and Heacox 2021).

Blue death-feigning beetle (*Asbolus verrucosus*).

Methods

Every spring, we measure ground-dwelling arthropod species richness and abundance across our aeolian community plots using non-lethal pitfall traps. Each trap consists of a single plastic 1-liter plastic cup, funnel, and shade cover (Figure 10). We sink the cup into the ground so that the top of the cup is flush with ground level, and then we place a funnel into the top of the cup, preventing escape of captured arthropods. We use a small Masonite board elevated above the trap by wooden pegs to provide shade for captured insects and camouflage from animals that might tamper with the traps, such as ravens. Wandering arthropods encounter the trap and fall into the cup where they remain until we arrive the next day to collect the pitfalls. To record the contents of the traps, we remove the cups from the ground and dump the contents onto a light-colored surface such as a pillowcase or white fiberboard. We then record the sampled species and abundance with the assistance of magnifying loupes and aspirators. We release captured nocturnal arthropods into a shady spot so they are not harmed by the temperatures experienced in direct sun.

Each plot hosts 3 pitfall traps – one trap per 0m, 50m, and 100m mark. We set traps for an approximately 24-hour period and intentionally select sampling periods which have low wind to minimize the risk of traps being filled by blowing sand. To further minimize the risk of blowing sand, we often place traps on the downwind side of shrubs which provide some protection. We conducted trapping from April 7 to May 12. Due to an unusually windy spring, we were unable to set traps at Stebbin's Dune, Kim Nicol, and Fingal's Finger.

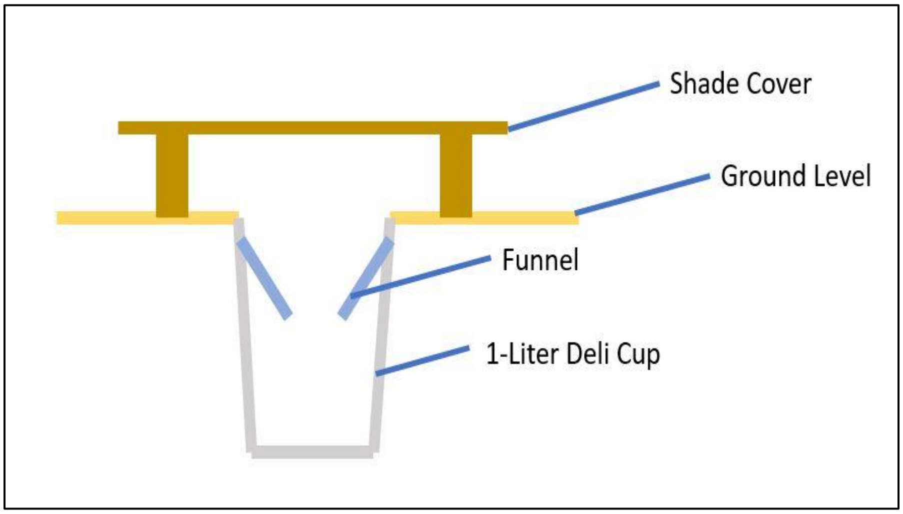

Figure 10. diagram of the pitfall traps used in our study.

We used R 4.1.0 (R Foundation for Statistical Computing, Vienna, Austria) to analyze the arthropod data. We determined correlation via two-tailed Pearson's correlation coefficient tests. We used the vegan package for R (Oksenen et al. 2020) to calculate principal component analyses (PCA). Data for PCA was transformed using "method = 'hellinger'" and standardized using "scale = TRUE". We used the ggplot2 package for R (Wickham 2016) to create graphics to display the year-to-year arthropod abundance variation and to create biplots for our PCA output.

Arthropod Diversity

Beetles (order Coleoptera) are the most species-rich group sampled with our pitfalls, with most of the richness owing to darkling beetle (family Tenebrionidae) diversity. Ants, bees, and wasps (order Hymenoptera) are another important group sampled with our pitfalls. Ants (family Formicidae), on the other hand, show lower species richness but high abundance, and are therefore treated as one of the most ecologically important insects present. As such, we have selected ants and darkling beetles to serve as focal indicator species for habitat type and health across our aeolian plots.

Yearly Variation of Abundance

Figure 11 demonstrates how the mean abundance of three important harvester ants, (*P. californicus* (POGCAL), *P. magnacanthus* (POGMAG), and *V. pergandei* (VERPER), has varied yearly since surveys began in 2003. POGCAL is clearly the most abundant harvester ant species within the active dune (AD) and stabilized sand field (SSF) aeolian community types. However, it is much rarer within mesquite hummocks (MH) and ephemeral sand field (ESF) communities. POGMAG and VERPER are relatively less abundant across all community types, but VERPER is typically the most abundant harvester ant within ephemeral sand fields.

The density of these three harvester ants was not correlated to winter standardized precipitation index (SPI). However, somewhat counterintuitively, the density of POGCAL (except at mesquite hummocks) and POGMAG (except at ephemeral sand fields) exhibit a statistically significant negative correlation to SPI when we replaced each year's SPI with that of the previous year. Shifting the SPI values ahead can more accurately accounts for the lag-time some desert species may exhibit in response to varying winter precipitation, but one would typically expect abundance to be positively correlated to precipitation due to associated increase of resources available. The cause for this negative correlation is unknown, but may be influenced by several factors: decreased above-ground activity due to an abundance of food and, therefore, less need to forage (and subsequently less likely to encounter a pitfall trap); less food availability due to Sahara mustard (*Brassica tournefortii*) out-competing native plants with more palatable seeds; and/or unknown pathogens/competition/predation that depress ant populations when conditions are unusually wet.

Figure 12 shows the mean annual abundance of three of the most abundant darkling beetles (*A. laevis* (ASBLAE), *A. verrucosus* (ASBVER), *and Edrotes* sp.) at our aeolian plots. We have found that ASBLAE is strongly linked to areas of abundant loose, active sand, such as our active dune plots. As with most previous years, ASBLAE were the most abundant large darkling found at our active dune plots. Due to this beetle's preference for active sands, we believe it has the potential to act as an indicator species for dune health. One would expect that as a dune stabilizes and plant cover increases, ASBLAE populations will decline, and the overall beetle assemblage will begin to follow the trends seen at our stabilized sand field plots.

Like ants, the abundance of these beetles can vary significantly from year to year. However, they generally do not appear to respond predictably to changes in winter SPI, even when the SPI is offset by one year. The exceptions to this are ASBVER at mesquite hummocks, and *Edrotes* sp. at active dunes and stabilized sand fields, which both exhibited a statistically significant negative correlation to offset SPI.

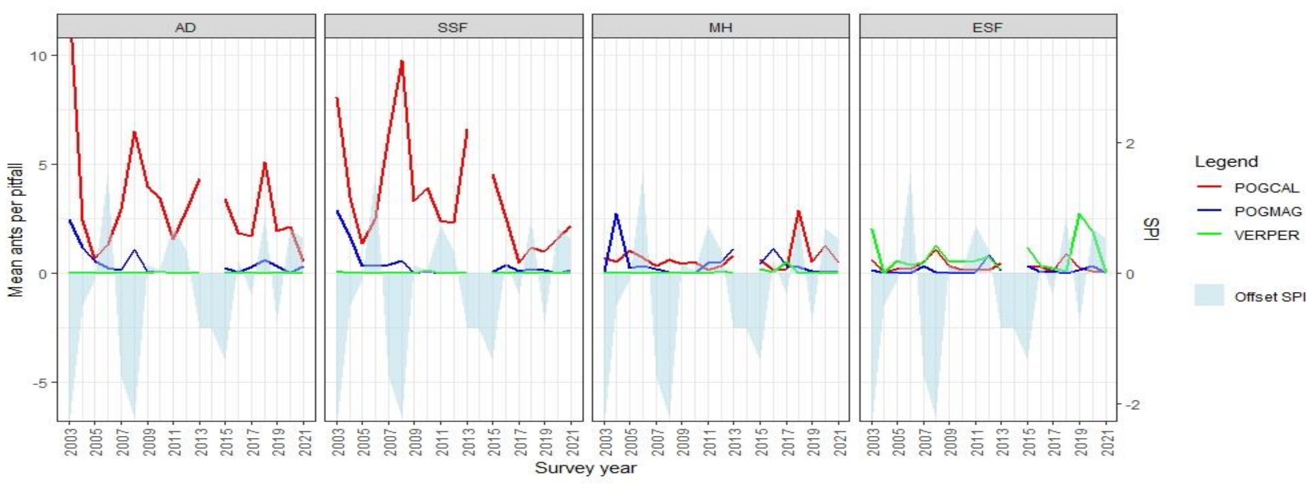

Figure 11. Pitfall survey results for harvester ants *Pogonomyrmex californicus* (POGCAL), *P. magnacanthus* (POGMAG), and *Veromessor pergandei*) (VERPER) since 2003, by aeolian community type. AD = active dune, SSF = stabilized sand field, MH = mesquite hummock, ESF = ephemeral sand field. SPI is offset forward by one year.

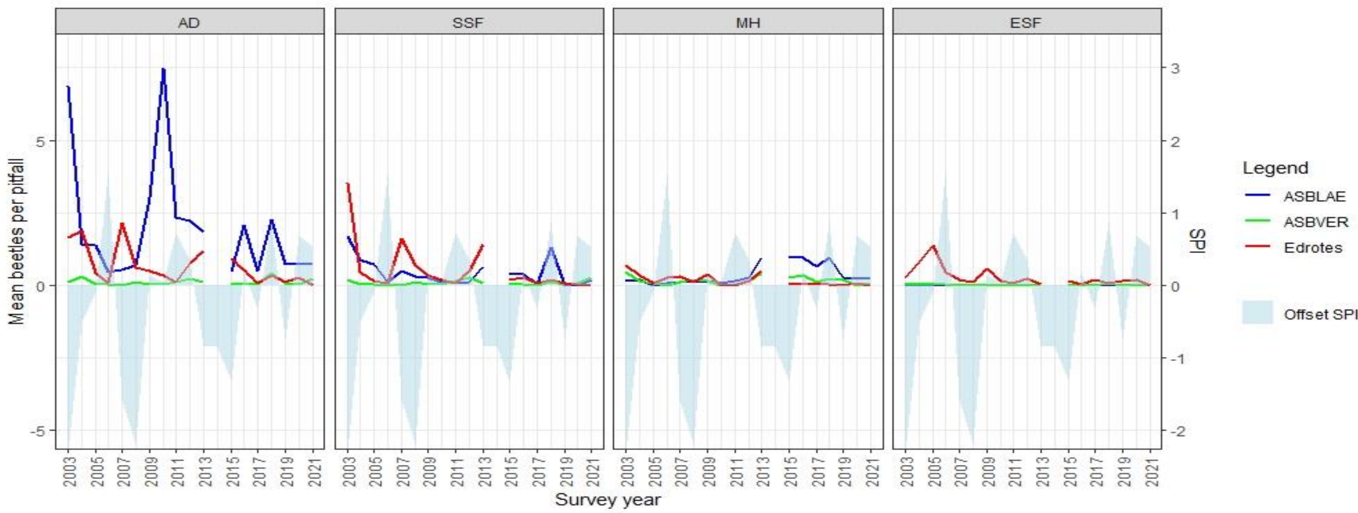

Figure 12. pitfall survey results for darkling beetles *Asbolus laevis* (ASBLAE), *A. verrucosus* (ASBVER), and *Edrotes* sp. since 2003, by aeolian community type. AD = active dune, SSF = stabilized sand field, MH = mesquite hummock, ESF = ephemeral sand field. SPI is offset forward by one year.

Community Composition

We investigated the ant and beetle community composition for each of our plot clusters using PCA. This method can be useful for visualizing the structure of data between samples (mean number of each species per plot cluster, per year, represented on the plot as colored points) which can allow for grouping based on similarity. PCA generates a series of lines which represent the directions of maximum variation throughout the data. These lines are known as "principal components", and the first two principal components with the highest explanatory power (shown as PC1 and PC2) can then be used as axes in a two-dimensional biplot graph. Samples on this biplot that share a similar species composition will be located closer together. The species are plotted as arrows, with the angle between each species arrow representing the correlation between them (i.e. species plotted closer together are more likely to be found together in the same sample). The length of each arrow represents the strength that the species is correlated to each axis. The distance of a sample to the species represents that sample's composition, with closer species represented in higher abundance in that sample.

Figure 13. shows the results of a PCA using mean ant abundance data for ten ant species or species groups per plot cluster for each year the cluster was measured since 2003. Plot clusters that we installed since 2018 are represented as black shapes because we are still assessing which,

if any, of these aeolian community types they are members of. Visualizing the data based on ant abundance reveals plausible groupings following predefined aeolian community assignments: the leftmost portion of the graph contains most of the samples from stabilized sand fields, indicating that these plots are defined by a high relative abundance of *P. californicus*. Mesquite hummock plots border the right side of the stabilized sand field plots, having a higher relative abundance of *P. magnacanthus* and *M. kennedyi*. Active dune plots are found within stabilized sand field and mesquite hummock groups, indicating that active dunes share similar ant assemblages with these two communities. The right side of the graph contains mostly ephemeral sand field plots, characterized by a high abundance of *Dorymyrmex* sp., *F. pruinosus*, *V. pergandei*, and *M. tenuinodis*. Based on ant assemblages, the three new plots (Fingal's Finger, Stebbin's Dune, and Kim Nicol), are most closely aligned to the community types characterized by permanent fine sand. However, more sampling efforts and integration of other environmental and biological components are required to make a confident assessment. Despite the logical groupings that can be inferred from this biplot, the PCA scores for the first two axes only account for a combined 33.9 % explanation of total variance.

Our PCA utilizing darkling beetle assemblages Figure 14 did not reveal the same level of grouping as our PCA using ant assemblages. Mesquite hummock and ephemeral sand field plots are clustered closely on the left side of the graph, indicating that their darkling beetle compositions are relatively similar. However, active dune and stabilized sand field sites are widely dispersed throughout the graph, indicating the beetle composition and abundance of these sites are quite variable from one year to the next. The lack of clarity in this analysis precludes its usefulness for community type assignment of the three new plot clusters.

As noted in Barrows (2000), darkling beetle diversity and abundance at superficially similar sites within the Coachella Valley can vary substantially, and beetle assemblages sometimes follow an east-west precipitation gradient, with more rare species and overall lower abundance in the wetter western portion of the Valley. This phenomenon may account for the lack of resolution between-sites in our PCA, and, specifically, the high separation between plots located in the east (AD and SSF), which are characterized by higher abundance and higher richness, but perhaps also higher inter-site variability. The addition of more rare species to the analysis drastically reduced the PCA's explanatory power.

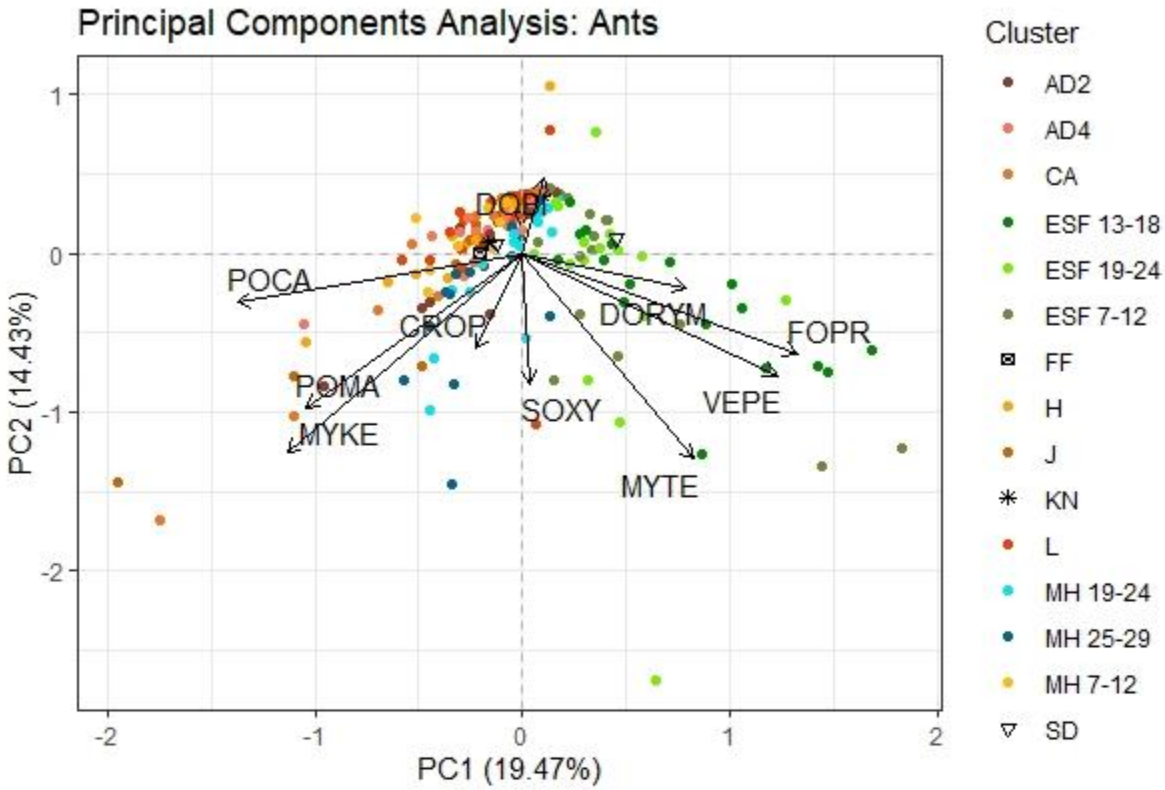

Figure 13: Biplot showing the results of our PCA using 10 ant species/groups. Points indicate yearly mean ant abundance data per cluster for these 10 species. Points are colored based on their predetermined aeolian community type: reds and pinks = active dunes, oranges and yellows = stabilized sand fields, blues = mesquite hummocks, greens = ephemeral sand fields. Principal components (axes 1 and 2) are labeled with respective percent variance explained. POCA = Pogonomyrmex californicus, POMA = P. magnacanthus, MYKE = Myrmecocystus kennedyi, MYTE = M. tenuinodis, CROP = Crematogaster ca. opuntiae., DOBI = Dorymyrmex bicolor, DOIN = Dorymyrmex ca. insanus, SOLEN = Solenopsis spp., VEPE = Veromessor pergandei, FOPR = Forelius pruinosus.

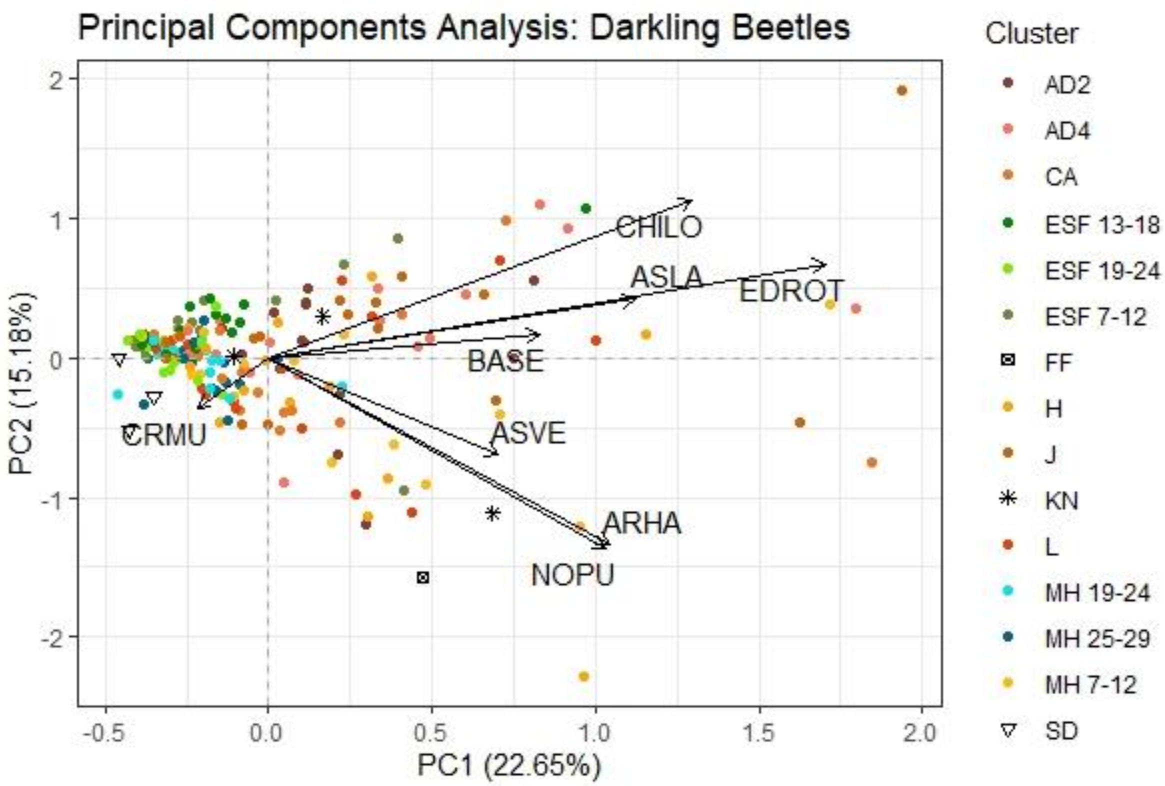

Figure 14: biplot showing the results of our PCA using 8 darkling beetle species/groups. Points indicate yearly mean beetle abundance data per cluster for these 8 species. Points are colored based on their predetermined aeolian community type: reds and pinks = active dunes, oranges and yellows = stabilized sand fields, blues = mesquite hummocks, greens = ephemeral sand fields. Principal components (axes 1 and 2) are labeled with respective percent variance explained. CRMU = Cryptoglossa muricata, NOPU = Notibius puberulus, ASVE = Asbolus verrucosus, ASLA = Asbolus laevis, ARHA = Araeoschizus hardyi, BASE = Batulius setosus, CHILO = Chilometopon spp., EDROT = Edrotes spp.

Future goals

One shortcoming pitfalls have when working in windy environments, such as the Coachella Valley, is that they will quickly fill with sand if deployed on a windy day. It has been a challenge to complete pitfall sampling across all our sites due to unusually windy springs in 2020 and 2021. In the fall of 2021, weather permitting, we will be exploring ways to remedy this issue, such as testing modified pitfall designs that will allow for operation in mildly windy conditions.

Also, we would like to explore the viability of a trapping protocol that relies on just one 24-hour sampling period per season. Ideally, since insect activity is often influenced by daily weather patterns, a researcher would trap for multiple days during the field season to help control for the effects of varying environmental variables, such as wind, temperature, humidity, cloud cover, moon phase, etc. Doing so will help rule out the possibility that observed year-to-year variation is influenced by chance differences in daily weather, instead of by actual yearly variation in species richness and diversity; sampling for one day per year may not accomplish this. However, it is also possible that the Coachella Valley typically does not experience day-to-day weather fluctuations during the field season that are drastic enough to significantly alter insect behavior, or the important insects we are interested in studying closer (such as ants and darkling beetles) do not change their behavior drastically regardless of weather patterns. To test this hypothesis, we will begin by selecting a subset of plots to sample multiple times through a single field season. If successive sampling efforts at the same site are statistically different, we will recommend incorporating multiple sampling efforts per field season to account for daily variation in insect abundance.

Round-tailed Ground Squirrel

Round-tailed ground squirrels (RTGS), *Xerospermophilus tereticaudus chlorus*, occur is fine-textured sandy areas of the Coachella Valley. RTGS 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 can be quite vocal when occurring at high densities; there we use their distinctive alarm calls and tracks (whichever provides the higher number) to quantify occurrences within our plots. However, at low densities, they rarely vocalize, and so we can only use their tracks for surveys. Within the protected aeolian sand habitats of the CVMSHCP RTGS are uncommon, except within the mesquite dunes of the Willow Hole Preserve, where they are relatively abundant. Elsewhere they are ephemeral residents of other sand types, increasing during wet periods and nearly disappearing during extended droughts.

We are concerned about the condition of the mesquite plants within the mesquite dunes of the Willow Hole Preserve; many are dying while others are continuing to show healthy growth and bean production. Our question is that if the mesquite continues to decline, what does that mean for the RTGS? Figure 15 shows a substantial population decline since monitoring began in the early 2000s. However, since 2011 the RTGS has been mostly stable, fluctuating between a mean of two to three squirrels per 0.1 ha plot.

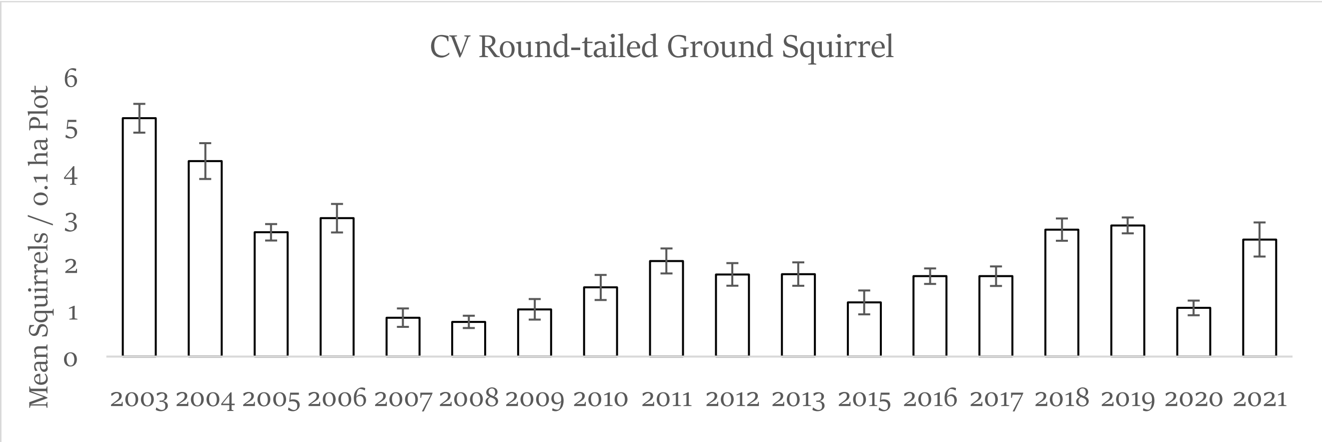

Figure 18. Temporal patterns of abundance of round-tailed ground squirrels within the Willow Hole Preserve. The SPI is off-set by one year to account for the one year lag time most vertebrate show between rain and population responses. We did not collect data in 2014 at the request of the wildlife agencies.

Palm Springs Pocket Mouse

Palm Springs Pocket Mice (PSPM), *Perognathus longimembris bangsii*, occur in fine-textured sandy areas of the Coachella Valley, throughout the valley's aeolian sand communities as well as sandy flats on alluvial bajadas. Our survey method, similar with all the vertebrates included here, is to quantify their abundance based on the mean number of their distinctive track ways left within our 0.1 ha plots.

Based on our 13 years of survey for PSPM, this species appears to not prefer one aeolian sand community over any of the others. It does appear that PSPM avoided active dune communities prior to 2016, after which they were as abundant there as in any other aeolian sand community. This may reflect the incremental stabilization of the active dunes, due to the lack of new sand inputs. It is not clear why PSPM densities increased across all sand communities after 2015. We cannot rule out that increase may be the result of better field identification of this species' tracks over time.

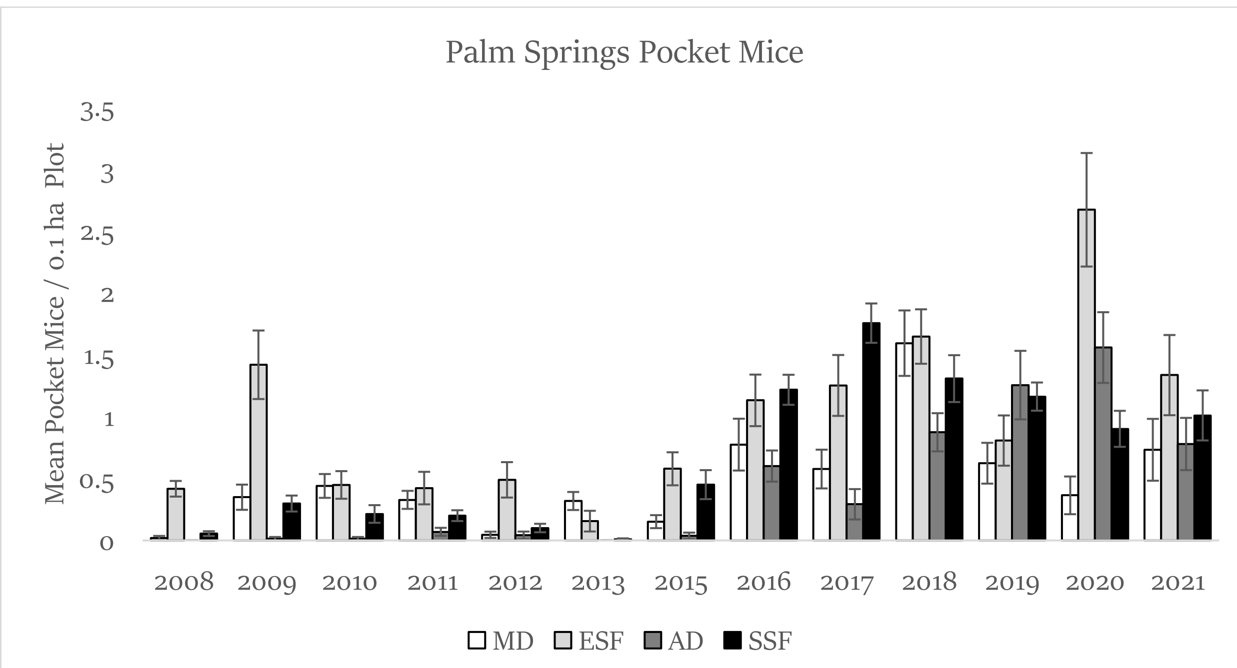

Figure 19. Palm Springs Pocket mouse densities across the Coachella Valley's aeolian sand communities between 2008-2021. MD = Mesquite Dune; ESF = Ephemeral Sand Field; AD = Active Dune; SSF = Stabilized Sand Field

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Appendix VI. Triple-ribbed Milkvetch Monitoring Report 2021

Report begins on following page.

Coachella Valley Conservation Commission

CVCC

2021

Coachella Valley Multiple Species Habitat Conservation Plan

& Natural Community Conservation Plan

2018-2021 Study Results for the Triple-Ribbed Milkvetch (*Astragalus tricarinatus*) within the Coachella Valley MSHCP Area

UNIVERSITY OF CALIFORNIA UC RIVERSIDE

Center for Conservation Biology

Prepared by Lynn Sweet, Scott Heacox, Melanie Davis, Paisley Ramstead, Lorena Torres-Martinez and Cameron Barrows for the University of California Riverside's Center for Conservation Biology

Contents

PROJECT REPORT 3
i. INTRODUCTION AND OBJECTIVES 3
ii. METHODOLOGY 4
Background 4
Survey Area 4
Data Collection 7
iii. RESULTS 8
iii. DISCUSSION 14
iv. RECOMMENDATIONS 15
V. LITERATURE CITED 15

PROJECT REPORT

i. INTRODUCTION AND OBJECTIVES

Triple-ribbed milkvetch, *Astragalus tricarinatus* 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, with disjunct occurrences in the Santa Rosa Mountains (Fraga *et al.* 2021; 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 this is unverified (USFWS 2009; Bell *et al.* 2017). A specimen collected by M. F. Spencer dated April 6, 1921 indicates the locality as "Chuckwalla Mtns" [sic] and this resides at Harvard University Herbarium where it is indexed and an image is available online (Harvard University Herbaria and Libraries 2020).

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 groups of plants on benches along desert washes and canyon bottomlands; such occurrences are now believed to be waif groups (Barneby 1959; Sanders 1999; USFWS 2009; Fraga *et al.* 2015); plants dispersed by chance events from local populations that don't always persist. Core habitat is now recognized as further upland in topographically rugged, friable soils, often in upper watersheds, difficult to reach for study (White 2004; USFWS 2009; Fraga *et al.* 2015; Bell *et al.* 2017).

We (UCR Center for Conservation Biology; UCR CCB) initiated study of this protected species 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 known occurrences of this species in the Little San Bernardino, 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 UCR 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 USFWS Special Status Assessment of this species or a recovery plan (none has been produced to our knowledge). Specifically, we seek to follow up on a genetic analysis done by Fraga and others (2015) using different methodology (ISSR, inter simple sequence repeat) that did not detect isolation of three populations sampled within Joshua Tree National Park. New rangewide genetic information and analysis may help determine a) population genetic variation and viability of populations and b) to determine what function, if any, the waif groups serve in terms of their contribution to local and regional gene flow. Two key questions this study aims to answer include:

1) Is the Santa Rosa Mountains (Riverside County, CA) group of plants 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.
2) Are the waifs functioning as "genetic bridges" or are they simply a genetic dead end, not contributing further to sustained, permanent source populations?

Sampling and determining the presence and type of root symbionts (rhizobia, nitrogen-fixing bacteria), and contrasting these among upland and waif populations may also 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.

This study year was dedicated to lab and statistical analysis of the samples collected in prior study years and the conservation interpretation of findings, which is ongoing. The genomic analysis was primarily funded from a USFWS - Joshua Tree National Park Interagency Agreement/California Ecosystem Studies Unit agreement and the conservation genomics analysis is ongoing in partnership with the lab of Dr. Joel Sachs and post-doctoral scholar, Dr. Lorena Torres-Martinez at UCR, as well as research partners at Joshua Tree National Park and the California Botanic Garden (formerly Rancho Santa Ana Botanic Garden).

ii. METHODOLOGY

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. The BLM/USFS Letter was renewed for the 2020 season. We applied and received a modified Recovery Permit in spring 2020 to allow for specific instances of sampling (sampling of tissue from solo individuals at some sites), seed collection, and to add personnel to the Recovery Permit. Site access for assessment of occurrence at Thousand Palms was provided via special permission under a Site Access Research Agreement from the Center for Natural Lands Management. During the California stay-at-home order, permission was granted by the University of California, Riverside College of Natural and Agricultural Sciences administration to continue limited lab analysis though this was delayed due to occupancy limits at UCR facilities. Once samples were prepared, the sequencing was ultimately completed at the UC Davis Genomics Core facility due to pandemic-related delays at the UCR facility.

Survey Area

Surveys were conducted from February to July 2019 and February to July 2020 within the CVMSHCP areas: Upper Mission Creek/Big Morongo Canyon Conservation Area (UMCBMC) and the Santa Rosa and San Jacinto Mountains Conservation Area (SRSJM); and in San Bernardino County (just to the north of the CVMSCHP area). Surveys in San Bernardino County were aimed at more complete coverage of the occupied habitat, especially as some of the earliest-documented sites in Big Morongo Canyon were relevant to the ESA listing (Fig 1). Due to restrictions for personnel safety surrounding the COVID-19 pandemic, several sites without research exemptions for access during 2020 and/or requiring lengthy hikes, such as some Joshua Tree National Park (within the CVMSHCP Joshua Tree National Park Conservation Area) partner sites and the Wathier Landing area, were not sampled.

Searches were performed by the Permittee and one or more experienced individuals traversing wash habitat enroute to upland populations, using binoculars and focusing on areas exhibiting the typical “distressed granite” substrate in which triple-ribbed milkvetch appears to thrive (White 2004). Surveys included sites of previous surveys by UCR CCB, herbarium specimen localities, localities from the CNDDB, and locations provided by local experts and the California Botanic Garden.

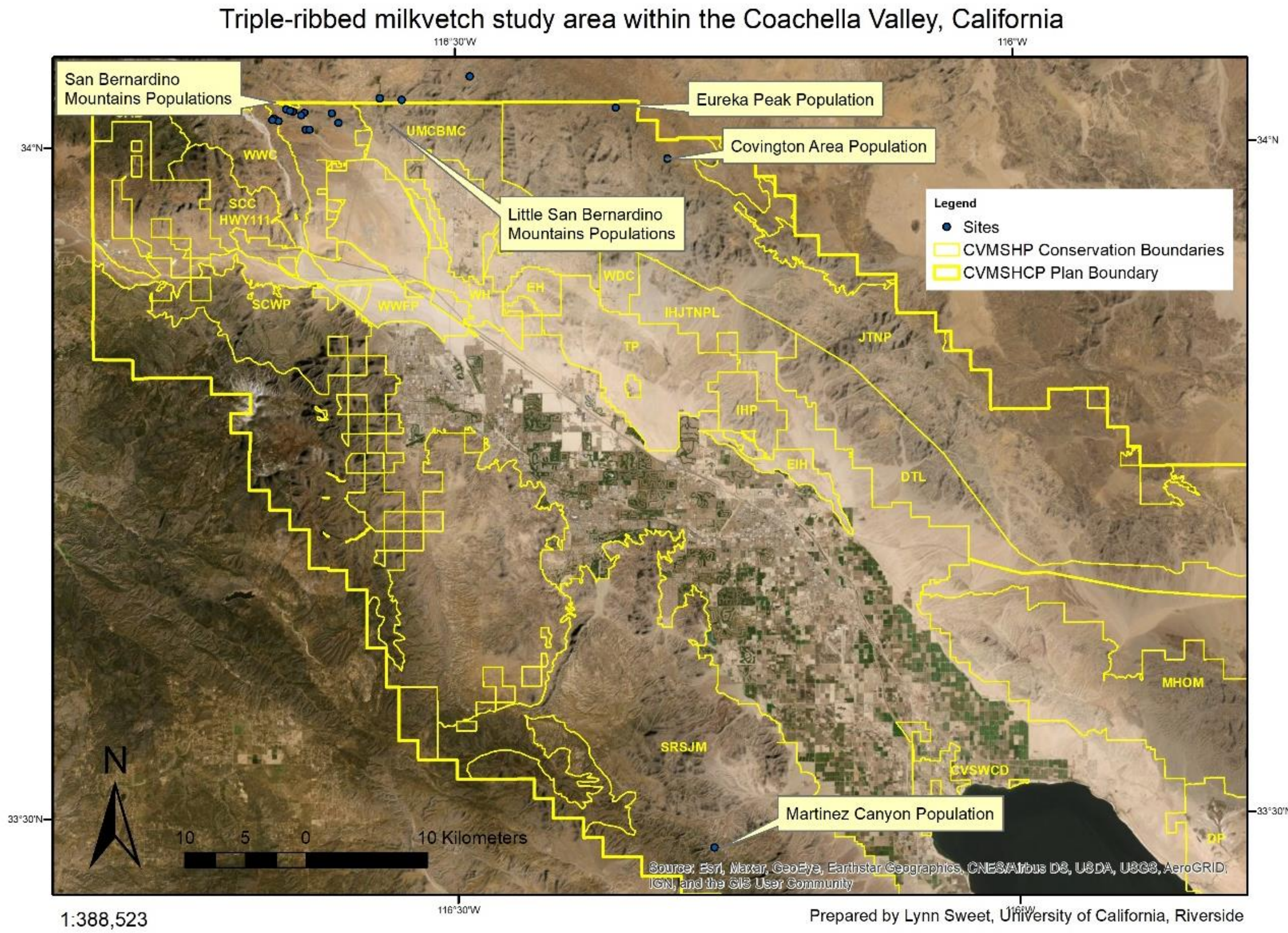

Figure 1: Triple-ribbed milkvetch populations visited during 2019 and 2020 within the known range of the species. Also shown are surveys by study partners that contributed information to the range-wide genetic study.

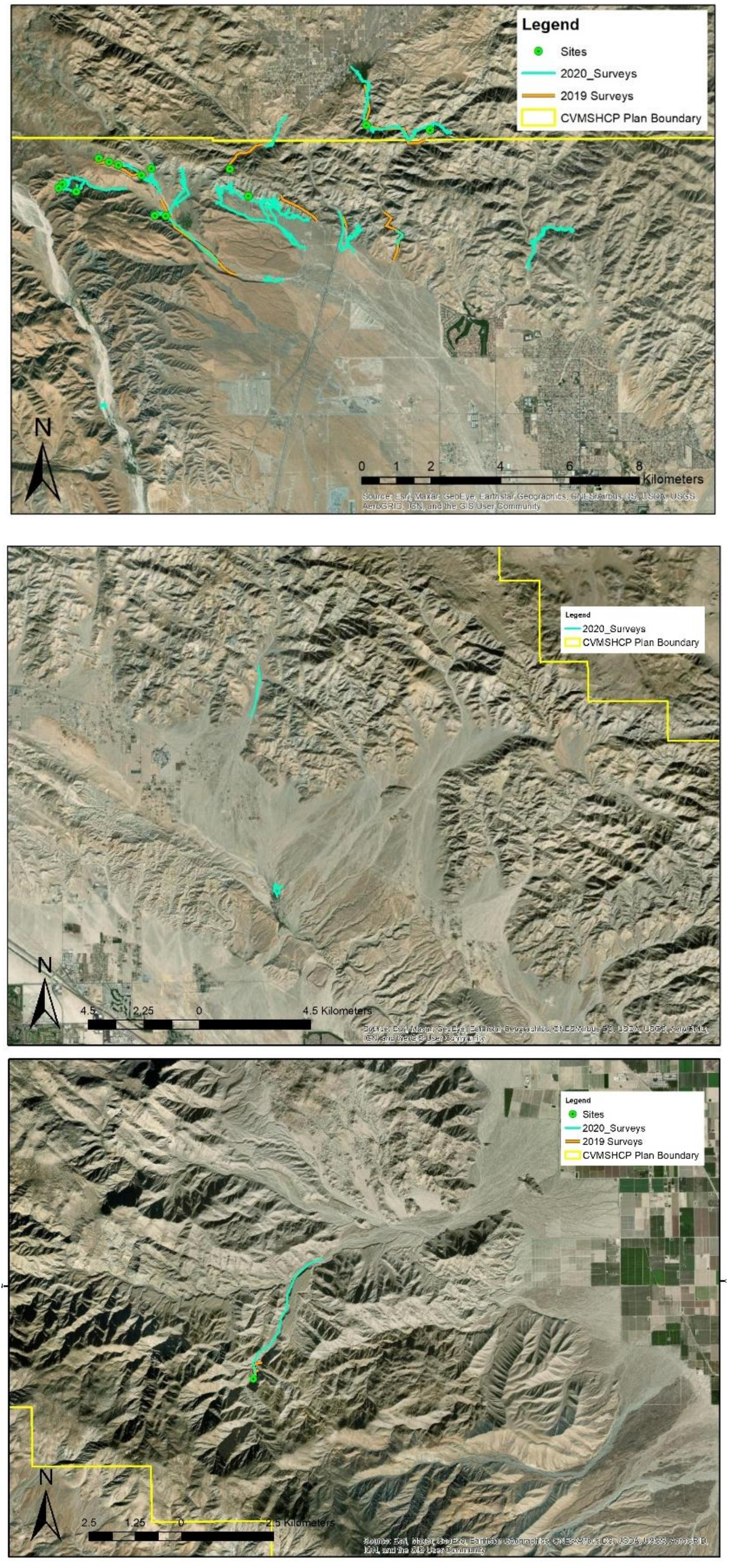

Figure 2: Triple-ribbed milkvetch surveys and populations visited during 2019 (orange) and 2020 (light blue) within the northwest range of the species, Upper Mission Canyon and Big Morongo Canyon (top), Thousand Palms Canyon and East Deception Canyon (middle) and within the Santa Rosa and San Jacinto National Monument Conservation Area (bottom). All survey lines are approximate.

Data Collection
Between February and July of 2019 and February and June of 2020 (late spring revisits were to sample seeds), we located the plants for study, recorded abundance, sampled tissue for analysis, and collected seeds for experimentation. 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, Site Access Research Agreement, referencing Center for Plant Conservation guidelines (CPC 2017). For each initial survey, GPS tracks were generally recorded to document the survey area (shown in Fig 2). We documented all *Astragalus tricarinatus* plants, in known and previously unknown locations as GPS point locations (WGS84 UTM 11S) recorded using Avenza PDF maps (www.avenza.com) on an iPhone 8, with no additional receiver. In many cases, the GPS signal was poor due to multipath error and limited sky visibility in canyon locations, and an effort was made to correct the point locations post-collection using georeferenced aerial photos. We estimated the total number of individuals present per grouping and recorded this as a range based on the density of plants in the area accessed and the estimated extent of the grouping, except where a single number is reported, indicating that individuals were counted. We did not survey the full extent of the grouping at every location due to the survey focus on accessing the minimum necessary plants to sample in an area. Where necessary for presence location data, coordinates were projected/estimated from a safe location, as noted. Locations listed also include absences and all of these were submitted to the CNDDB.

Plant sampling was performed by permitted individuals only, following the CPC and permit guidelines for the number of samples and the method of collection. We took a photo of each study plant, noted the life stage and GPS coordinates. We sampled leaf tissue from mature plants or plants with >10 leaves and/or sampled a whole seedling, including root tissue, and additionally collected seeds. Leaf samples were placed into small centrifuge tubes kept fresh within a vacuum-insulated canister with (water) ice. 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 UCR. When sampling whole seedlings for leaf tissue and roots, water was applied to the plant while a small hole was excavated around the root, until nodules were seen, or the taproot was able to be removed (Fig 3). We placed the seedling in wet paper towels and transported them unfrozen but below ambient temperature in a soft cooler, stored in a refrigerator and transported within one day to Dr. Torres-Martinez for isolation of the symbionts and long-term storage of the leaf tissue.

Rhizobia were isolated from the nodules of each young seedling and clonal cultures were grown and archived for whole-genome sequencing to identify species of the symbionts. Nodules were surface sterilized with bleach and rinsed with sterile water before being crushed with glass rods. The exposed contents were then plated on glucose-based rhizobium-defined medium (RDM) with cyclohexamide as an antifungal and bromothymol blue as a pH indicator. Among the resultant colonies, we selected those that grew on arabinose gluconate medium (MAG) and GRDM but not on Luria–Bertani (LB) medium within 5-8 days after inoculation. Selected colonies were archived in a 1:1 solution of liquid MAG and glycerol at -80C for further studies.

We collected seeds from plants later in the season, May-July in 2020, on revisits to our sampling locations when pods were dry and splitting. Plants with both tissue and seeds collected at different times were matched using GPS points and visually using substrate/woody debris landmarks in photos of the plants. Seeds were generally collected into small envelopes and we extracted seeds from the dry fruits in lab within two months and transported them to Dr. Torres-Martinez.

One set of samples for genomic analysis was processed in 2019 as a test of the methodology, before subsequent processing of all samples in 2020. Plants were genotyped using genome-wide molecular markers through reduced representation sequencing (RR-Seq). Briefly, this is a genotyping-by-sequencing (GBS) technique where the DNA was digested with the restriction enzyme ApeKI and resulting fragments were sequenced in an Illumina-4000. Prior to library preparation for the RR-seq, genomic DNA was extracted from the fresh leaf tissue using a Qiagen kit. DNA quantity was assessed with a Qubit fluorometer. Library preparation and sequencing were performed at UC Davis Genomics Core. Rhizobial samples were prepped and sent for sequencing and results are still being analyzed.

As has been noted, this species seems to occur on particular soil types, a gray-green "decomposed granite" (Sanders 1999) and some carbonate types (Bell and Fraga 2021) and although soil samples have been collected by various entities, results have not been disseminated (Fraga and Palapil 2012). We sampled soil in areas that have self-sustaining, stable populations as well as ephemeral waif/wash bottom populations to identify the properties of the soils on which triple-ribbed milkvetch occurs. These soil samples were sent to lab for analysis.

iii. RESULTS

We located/confirmed approximately 20 areas supporting groups/populations of plants (depending on how they are grouped) during the survey period and presumed absences at other locations (Table 1). Of the presences, nine areas were either new occurrences or were adjacent and not within previous CNDDB "Element Occurrence" (EO) polygons. In the second study year, we located "wash bottom" plants in an area of the North Fork of Mission Creek nearby upland populations (Fig. 4), an area where plants were not detected by our team in 2016-2019. Surveys in search of plants at and around older localities within the warmer edge of the range of the plant (canyon mouths and foothills in Desert Hot Springs and the Devils Garden foothills) resulted in just two plants found. In the Indio Hills, which had not been previously surveyed, we visited the site of the 2019 Thousand Palms Canyon specimen identified by Center for Natural Lands Management (CNLM) staff and confirmed the presence of a recently-dead plant. Searches in East Deception Canyon did not result in any findings. Surveys within the Mecca Hills and Orocopia Mountains for Mecca aster and Orocopia sage by searchers trained to identify *A. tricarinatus* also did not result in any incidental sightings of this species within those areas (see CVMSCHP 2019-2020 monitoring report on Mecca aster and Orocopia sage for the description of the areas visited). Similarly, searches by the California Botanic Garden for historic occurrences in the Orocopia and Chuckwalla Mountains between 2014-2017 did not result in any positive findings (Bell and Fraga 2020).

Over the two years of the study, we collected 134 samples for analysis from populations spanning the range of the species. Seeds were gathered from 17 live plants paired with leaf samples from the same plants, and four dead plants for which we were unable to collect leaf tissue. Unfortunately, the Thousand Palms Canyon plant did not have any seeds to collect. Whole seedlings with roots were collected from five different areas. Overall, patterns from the genomic analysis indicate regional population structure by mountain range (San Bernardino, Little San Bernardino and Santa Rosa Mountains) and preliminary results suggest moderate diversity. The lowest genetic diversity was found among the samples in the disjunct local population in the Santa Rosa Mountains, however, it was still moderate, and no inbreeding was found, thus supporting an explanation of genetic drift. Further specific results will be available by the end of 2021.

We successfully isolated a total of 60 rhizobial isolates. Based on colony coloration and growth in GRDM media these are from the *Mesorhizobium* genus, as this genus has been found in other *Astragalus* species worldwide (Yan *et al.* 2016). Further molecular work will inform the species identity and functional diversity associated with the soil type where they were collected. Basic chemical analysis of soil collected at several sites was just completed and analysis and interpretation is in-process, but preliminary results indicate that they may differ in the levels of calcium, in relation to standard reference soils.

Figure 3: Upper photo: *Astragalus tricarinatus* root nodules indicative of the development of rhizobial symbiont colonies for extraction of nitrogen from the soil (Photo, Larry Heronema). Lower Photo: Colony coloration and shape in GRDM of rhizobia isolated from a single nodule of *A. tricarinatus* from a seedling collected in the wash at the North Fork of Mission Creek. The diversity of colonies from one nodule suggests the association of *A. tricarinatus* with a broad-range of Mesorhizobium symbionts (Dr. Lorena Torres-Martinez photo).

Table 1: Locations surveyed for *Astragalus tricarinatus* during the study period. Precise coordinates were provided to CNDDB, USFWS and other cooperating agencies (CVCC, BLM). EO's refer to any prior Element Occurrence number assigned for the California Natural Diversity Database (CNDDB). We did not sample plants at every location.

Findings	Mountain Range	Area	Site	CNDDB Element Occurrence	CVMSHCP Cons. Area
Present	Indio Hills	Indio Hills	Thousand Palms	77298	UMCBMCCA
	Little San Bernardino Mountains	Big Morongo Canyon	Big Morongo Canyon	77302	N/A
	Little San Bernardino Mountains	Big Morongo Canyon	Big Morongo Canyon	Near 77302	N/A
	Little San Bernardino Mountains	Big Morongo Canyon	Big Morongo Canyon	New (North of 77302)	N/A
	Little San Bernardino Mountains	Big Morongo Canyon	Big Morongo Canyon County Line	New (North of 18924)	N/A
	Little San Bernardino Mountains	Covington Crest	Covington Crest	Near 87507	JTNPCA
	Little San Bernardino Mountains	Eureka Peak	Eureka Peak 1	87511	JTNPCA
	San Bernardino Mountains	Dry Morongo Wash	Wade Canyon	111397	UMCBMCCA
	San Bernardino Mountains	Mission Creek Canyon	Devils Garden Foothills	New (between 11396 & 11397)	UMCBMCCA
	San Bernardino Mountains	Mission Creek Canyon	Devils Garden Road	111396	UMCBMCCA
	San Bernardino Mountains	Mission Creek Canyon	Mission Creek North Fork Upland	87504	UMCBMCCA
	San Bernardino Mountains	Mission Creek Canyon	Mission Creek North Fork Wash	Between 87504 & 32960	UMCBMCCA
	San Bernardino Mountains	Mission Creek Canyon	Mission Creek Pass	Near 87534	UMCBMCCA
	San Bernardino Mountains	Mission Creek Canyon	Mission Creek Silver Mound	Between 117321 & 87594	UMCBMCCA
	San Bernardino Mountains	Mission Creek Canyon	Mission Creek True North Fork	32960	UMCBMCCA
	San Bernardino Mountains	Mission Creek Canyon	Spire	87534	UMCBMCCA
	San Bernardino Mountains	Mission Creek Canyon	Stone House Area	60718	UMCBMCCA
	San Bernardino Mountains	Mission Creek Canyon	Stone House Area Adjacent	60718	UMCBMCCA
	San Bernardino Mountains	Whitewater Canyon	Whitewater-Mission Creek Pass	87534	WWCCA
	Santa Rosa Mountains	Martinez Canyon	Martinez Canyon	Near 117314	SRSJMCA
Absent	Little San Bernardino Mountains	Big Morongo Canyon	Big Morongo Canyon County Line	117318	UMCBMCCA
	Little San Bernardino Mountains	Big Morongo Canyon	Big Morongo Canyon South of marsh	18928	UMCBMCCA
	Little San Bernardino Mountains	Dry Morongo Wash	South end, Dry Morongo Wash	18927	UMCBMCCA
	Little San Bernardino Mountains	East Deception Canyon	East Deception Canyon South	80591	JTNPCA
	Little San Bernardino Mountains	Little Morongo Canyon	Little Morongo Canyon Southeast	117317	UMCBMCCA
	San Bernardino Mountains	Mission Creek Canyon	Mission Creek Canyon Gauge	60718	UMCBMCCA
	San Bernardino Mountains	Whitewater Canyon	Whitewater River Channel	53494	WWCCA
	Santa Rosa Mountains	Martinez Canyon	Martinez Canyon North	117312	SRSJMCA

Although we did not strictly revisit the study plants from the UCR CCB 2017-2018 study, many of the plants from prior years were observed to be still live or had died but were still evident on the landscape, and new plant establishment was clearly evident. Throughout the study, we observed several apparent stage-classes of plants. 1) We detected apparent first year seedlings on the landscape March through April and noted some persisting into May as small plants (Figure 4, bottom pair of photos), showing pigmentation changes due to perhaps extreme radiation or phenology. These plants lacked inflorescences. We did not follow plants from seedlings stage through the season, but also did not observe any apparent first year seedling flowering at the end of the season; only those larger plants. 2) We saw what appeared to be a class of second year plants, plants that were flowering that lacked old rachises, which were larger than the apparent first-year seedlings. 3) We observed very large adult plants present for >2 years, that had many old rachises present. Only one reproductively-mature adult plant was observed in a wash, and this was one of the plants sampled in the Mission Creek North Fork wash. All others within wash habitat were apparent first-year plants (Figure 5).

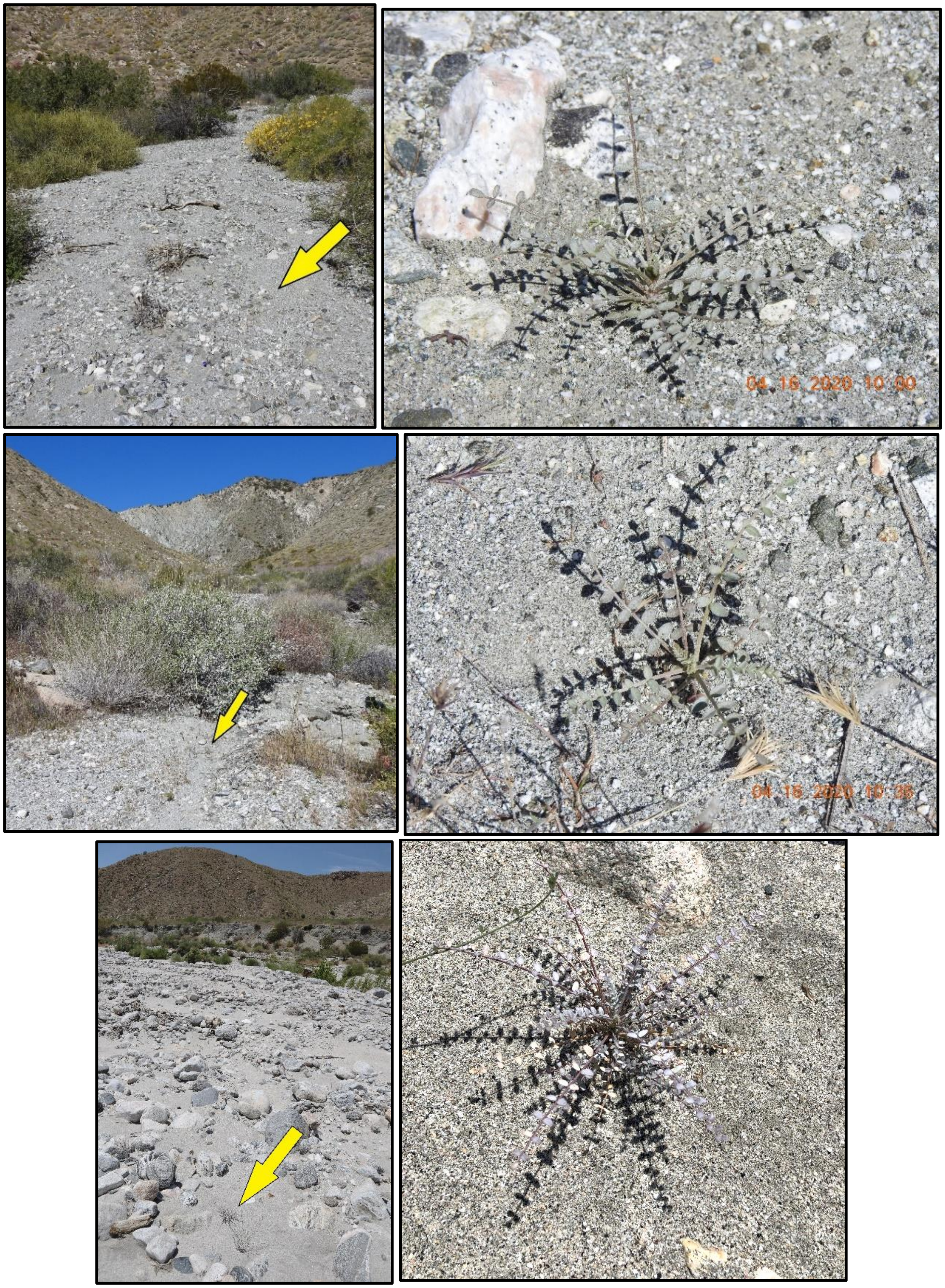

Figure 4: Paired landscape and close-up photos of *Astragalus tricarinatus* seedlings in wash bottoms along a Mission Creek North Fork minor wash (first, second pair) and Mission Creek North Fork main wash (last pair) (Lynn Sweet and Larry Heronema photos).

Figure 5: Fruiting-stage mature *Astragalus tricarinatus* in the Mission Creek North Fork wash (Lynn Sweet photo) in a natural area within the wash, about 20m southwest of a road.

In general, plants were seen flowering from the beginning of March until at least late April, when searches and tissue collection generally concluded. We collected seeds from live plants starting in late March (early), several times in April (peak), once in mid-May (past peak), and in July (well past peak). We noted that plants visited in early July in Big Morongo Canyon had fully senesced, likely the predominant pattern, but all populations were not visited during the summer.

A few, very limited, potentially negative biotic interactions were noted. We did not reinvestigate in 2020 the observation of herbivory by aphids and Largus bugs from 2019 (see UCR CCB 2019 report to the CVMSHCP). At the Big Morongo site, three plants were present that had brown patterning affecting their pods and leaves (Fig. 6). These plants were located very low on a rock outcrop, adjacent to thick stand of invasive grass and shrubs, about 20m from the creek bed, an unusually humid microsite for this plant. Samples were approved by USFWS to be given to a plant pathologist at UCR, but due to COVID-19-related lab restrictions, definitive results have not been reached, and it has not been confirmed that the origin of the issue was a pathogen. We can conclude that whatever was causing the patterning on the pods did not prevent seed formation. In terms of other impacts, we did not note any adverse effects of herbivory on leaves, however, at the upland North Fork of Mission Creek site, we noted that one single plant showed unusual amount of herbivory on the pods, which may have affected seed formation, but did not entirely prevent it (Fig. 6, right-hand photo). It should be noted that this plant was somewhat buried by the excavation of a fossorial mammal burrow.

Figure 6: *Astragalus tricarinatus* pods showing the unusual brown patterning found on plants in Big Morongo Canyon (left), and a high amount of herbivory (right) (Lynn Sweet photo).

In terms of natural symbionts, we did not conclusively identify pollinators and seed dispersers, although we briefly observed an unidentified native bee seen presumably pollinating a plant at the Mission Creek site (Stone House Adjacent), and a European honeybee (*Apis mellifera*) on a flower at the Big Morongo Site (Fig. 7). As in past years, canyon wrens (*Catherpes mexicanus*), rock wrens (*Salpinctes obsoletus*) and lesser goldfinches (*Spinus psaltria*) were commonly seen within the habitat in proximity to the plants. On examination, the pods have a triple hook structure when incompletely dehisced at the time they abscise (tardy dehiscence noted also by Sanders, 1999), and pods were observed caught on microfeatures of the habitat (soil mounds, roots, branches). As mentioned, Dr. Torres-Martinez was able to isolate rhizobial symbionts from root nodules, and the results of the genomic analyses are being analyzed.

Figure 7: A European honeybee (*Apis mellifera*) on the flower of *Astragalus tricarinatus* in Big Morongo Canyon (Lynn Sweet photo).

Within the habitat, there was clear evidence of significant ephemeral streamflow likely from the October 2018 and February 2019 major precipitation events and possibly subsequent events, including washouts within canyons, scouring, new runnels and gullies. Particularly in the steepest upland habitat, erosional processes were evident and unvegetated substrate was exposed. Many canyon walls looked recently-eroded and debris was piled at the base of slot canyons, although this is likely a common geo-morphological process in the habitats in which it occurs. *A. tricarinatus* plants were found recruited in the North Fork of Mission Creek on newly-eroded material within the dry creekbed, as well as on canyon walls that were clearly eroding. At this site, the plants that had occupied particular small canyon wall in previous years had disappeared and the slope was barren. Information from the CNLM staff at Thousand Palms Preserve and our assessment of the location/phenology of that specimen indicates these plants possibly established as waif seedlings or seeds from the October floods of 2018 that washed down from East Deception Canyon. If seeds arrived in this manner, these sprouted and grew to a small size in the spring of 2019, flowered and set a limited amount of fruit, senesced in the summer of 2019, and then regrew only a limited amount of foliage in spring 2020 and died.

In terms of threats to the species, we noted OHV tracks on several surveys in the wash bottoms, though tracks were not seen affecting the upland populations. In the Dry Morongo Wash area, which had previously very little traffic, tracks were visible in the main wash in the side canyon at the south end of the wash as well as at the northwest end in the area where an unconfirmed seedling had been seen in the past. Many of the flatter areas face these threats, in Little Morongo Canyon, Devils Garden Foothills (one single track seen in the main wash). New fencing should prevent incursions in the Thousand Palms Preserve. Foot traffic was limited where the plants occurred, often in remote areas and on slopes that were not traversable for recreationalists. Wash bottom populations in Mission Creek were in areas where some foot traffic occurs but the plants were sparse and we did not see them affected. Over the two years of this study we have noted three plants occurring either in or on the immediate shoulder of an established, unpaved road: in Devils Garden in 2019 and in 2020 the North Fork of Mission Creek. No specific engineering of banks or flood control was seen to be impacting the species.

iii. 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 plants documented in wash bottoms have often been single plants in extremely wide, rugged, seasonally-active streambeds, making detection, as well as marking/monumentation for long-term study, very difficult. The goal of this study was to search out more extant populations in the Plan area and sample genetic material to determine regional population structure, especially relatedness of the Santa Rosa Mountains group.

Known populations of the species were sampled from a broad swath of the species' range, following on the 2015 Joshua Tree National Park study (Fraga *et al.* 2015), including those in the Santa Rosa Mountains. Thus, when complete, 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.

As stated, many upland populations appeared to be persisting and recruiting new individuals and we noted more wash-bottom plants than we had in surveys in the past, possibly because of flooding in the most recent two years, adequate time for seeds to be distributed from upland populations and for seedling emergence. This may be a feature of the dynamics of this species, distributing widely during intense flood events, occupying wash habitat for several years, and then the local range constricting to upland habitat during drought periods. We were not able to confirm this pattern throughout the range with our limited time and the extensive area of potential habitat, however, in the North Fork of Mission Creek, we were able to detect patterns that could indicate movement of genotypes via plants found in the washes (waifs). Ongoing analysis of the genetic information gathered from leaf samples should help answer the relative importance of seed vs. pollen movement in dynamics of the species.

Although very few threats to plants were visually apparent during this study, the potential negative impacts of temperature increases with climate change, recent droughts, and nitrogen deposition cannot be discounted. Genetic analysis results are forthcoming, which will be essential to more definitively answer questions related to conservation genetics.

iv. RECOMMENDATIONS

We recommend continuing to monitor local population dynamics throughout the range, due to the known dramatic year-to-year fluctuation in numbers of plants located at bottomland and upland sites (Fraga *et al.* 2015; Heintz *et al.* 2019; Bell and Fraga 2020). Continued collaboration with botanists surveying within historic occurrence areas such as the Orocopia and Chuckwalla Mountains is recommended to be sure we are not missing fragmented, isolated populations. Further, continual mapping of bottomland (waif) occurrences of the species over time may help us understand the dynamics of those individuals in space and time. Now that it is known that these local sites do not represent the most stable populations, but that they are related to individuals at different places within the watershed, their occurrence can be put within the context of their importance for conservation. Third, ongoing work should be done on understanding the biology of the species (pollination, seed dispersal, and demographics) especially in partnership with intensive long-term monitoring by NPS within the Joshua Tree Conservation Area of the MSHCP. We recommend continuing to monitor threats noted including the local OHV traffic that is ever-expanding and should be a priority for management of most species within and surrounding conserved areas.

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Appendix VII. Coachella Valley Milkvetch Monitoring Report 2021

Report begins on following page.

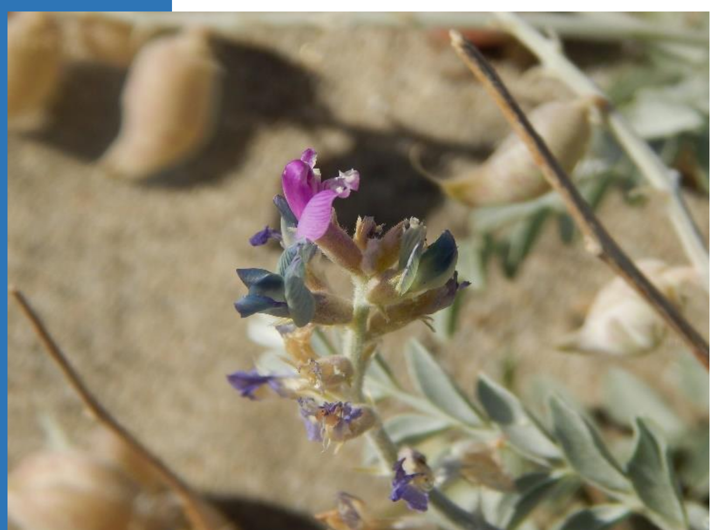
Coachella Valley Conservation Commission

2021

Coachella Valley Multiple Species Habitat Conservation Plan

& Natural Community Conservation Plan

2020-2021 Coachella Valley Milkvetch (*Astragalus lentiginosus var. coachellae*)



Prepared by Melanie Davis, Lynn Sweet, Scott Heacox, Paisley Ramstead and Cameron Barrows for the University of California Riverside's Center for Conservation Biology

Contents

Coachella Valley Milkvetch 3

Objectives & Recommendations 5

Methods: Data Mining .... **Error! Bookmark not defined.**

References 6

Coachella Valley Milkvetch

Coachella Valley Milkvetch (*Astragalus lentiginosus* (Douglas) Barneyby var. *coachellae*, hereafter CVMV; Fig. 1) is federally endangered and a narrow endemic to the Coachella Valley and occurs throughout a wide portion of the Coachella Valley Multiple Species Habitat Conservation Plan (hereafter "Plan") area. CVMV is categorized as California Rare Plant Rank 1B.2 (fairly endangered in California and elsewhere, with 20-80% occurrences threatened / moderate degree and immediacy of threat; CNPS 2015). It is found only in areas with abundant loose sand, as it is thought that its seeds require sand scarification to germinate. It occurs at its highest density on the ephemeral sand fields of the Whitewater Floodplain Conservation Area but can also be found as far east as the Coachella Valley National Wildlife Refuge (CVNWR) and as far west as Cabazon (Fig. 2). This plant is usually an annual, but with sufficient resources it can survive multiple years; one robust specimen in Desert Hot Springs has been alive for at least three years (UCR 2020).

We monitored the abundance of this species at our aeolian community monitoring plots throughout the Plan area on an annual basis, however the full extent of the species' habitat and range has not been recently reviewed and documented. Due to the species' already very narrow distribution and specific habitat preferences, changes in climate and land use can affect a large portion of CVMV populations, therefore a better understanding of the habitat niches, microclimates, and threats is needed to continue protecting this species going forward.

In 2002, a dataset of historical occurrence records was compiled for all five plant species covered under the Coachella Valley Multiple Species Habitat Conservation Plan (CVMSHCP; Allen et al. 2005). Data were obtained from various herbaria and museums and included locations that were precise enough for geo-referencing. A University of California, Riverside research team then attempted to locate historical occurrence locations on public land for each species and document the existing populations through 500m^2 vegetation relevés. For CVMV, five unique records were identified on public lands. Researchers found that of the five locations, CVMV occupied three of them. (Allen et at. 2005). Many new records for the species have been documented since the 2002 study, and we know more about the range of the species within the Plan area and where the species occurs more reliably with adequate rainfall. As new locations are still being discovered for the species, an important goal remains to confirm any shift its range by visiting and identifying range edge populations.

Figure 1: *Astragalus lentiginosus var. coachellae* plant in flower, taken March 2020, Coachella Valley, CA.

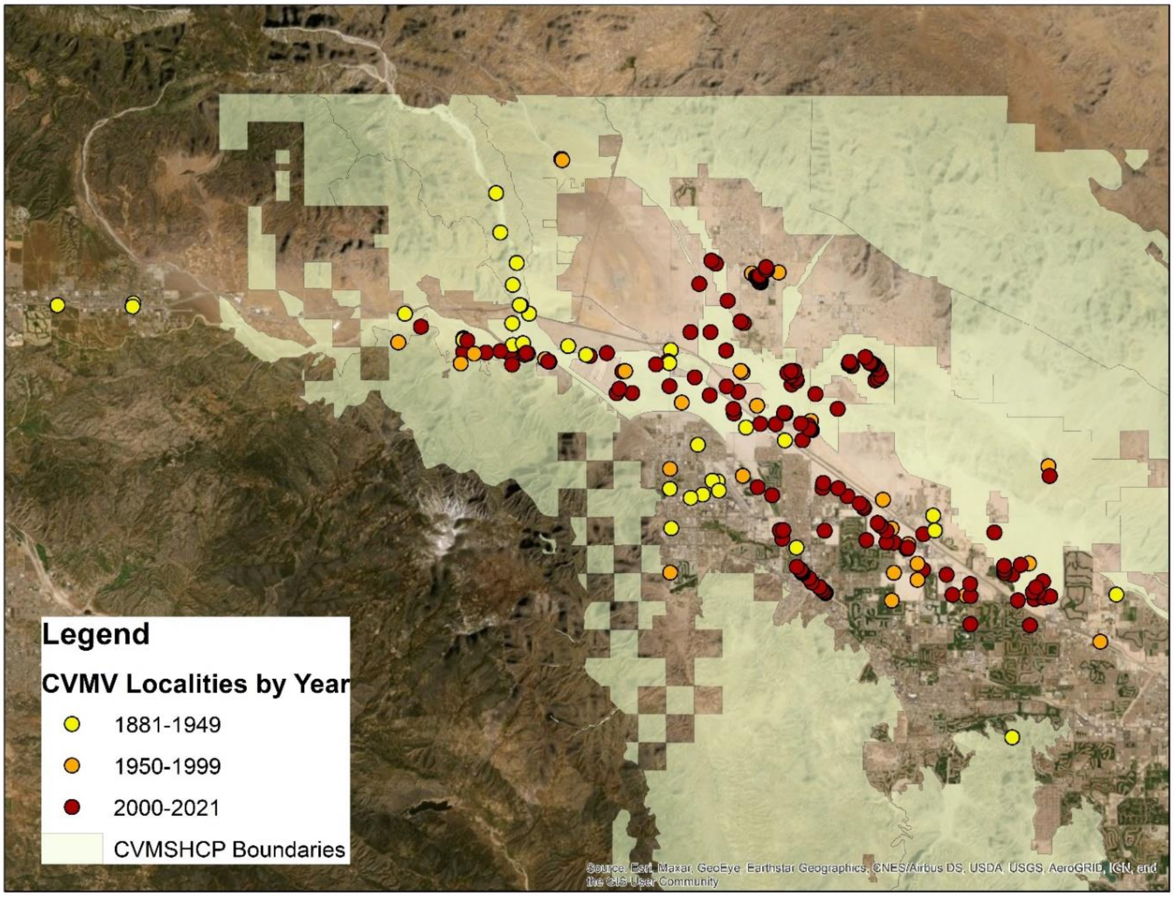


Figure 2: Distribution of *Astragalus lentiginosus var. coachellae* records based on georeferenced records color-coded by year. Occurrence points taken prior 1949 are georeferenced to the best of our ability using collection notations.

Accomplishments & Recommendations

In accordance with the 2020-2021 Scope of Work, our objectives for studying CVMV were to create an updated occurrence dataset from available online sources as well as survey on the ground to investigate the edges of CVMV range.

To build upon the dataset that was created in 2002, we first sourced observations from iNaturalist. Due to CVMV status as federally endangered, records of the plant are obscured from the public. By reaching out to individuals users who observed CVMV, we were able to compile a dataset of current and precise 153 observations from 2009 to 2021. Additionally, we also sourced localities from California Natural Diversity Database, Global Biodiversity Information Facility, and California Consortium of Herberia. Our final dataset will submitted with the final report along with planned work on creating habitat suitability models next year (2021-2022).

We identified the areas that required field work for determining CVMV range and distribution, and developed a protocol and field data forms to use on the ground. However, due to lack of precipitation during the 2020-2021 winter, no annuals, including this species, germinated in the aeolian dunes and sand fields in Spring of 2021. Therefore, we were unable to conduct field surveys of CVMV in Spring 2021 due to apparently very low recruitment and survival this season. We are recommending that these plans are returned to in the winter/spring of 2021-2022 or as soon as conditions provide enough rain to result in enough germination and emergence of CVMV to determine the edges of its range.

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Appendix VIII. Little San Bernardino Mountains Linanthus Monitoring Report 2021

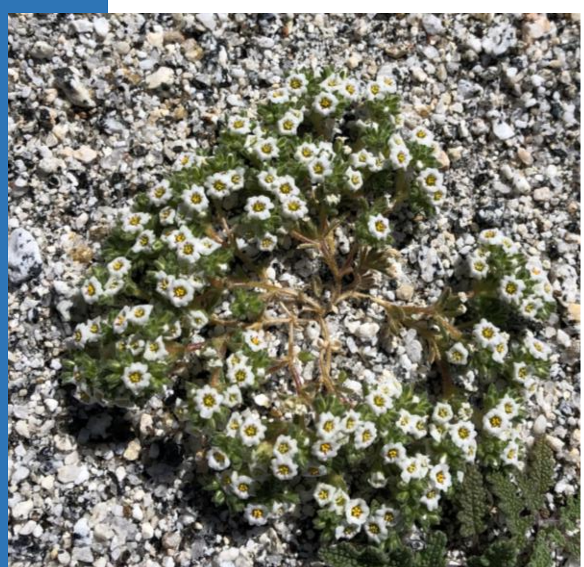
Report begins on following page.

Coachella Valley Conservation Commission

Coachella Valley Multiple Species Habitat Conservation Plan

& Natural Community Conservation Plan

2020-2021 Monitoring Results for the Little San Bernardino Mountains Linanthus (*Linanthus maculatus*) within the Coachella Valley



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Contents

LITTLE SAN BERNARDINO MOUNTAINS LINANTHUS MONITORING 3

Objectives 6

Methods 7

Data Collection 7

Results 8

Discussion 9

Recommendations 10

References 11

LITTLE SAN BERNARDINO MOUNTAINS LINANTHUS MONITORING

Little San Bernardino Mountains Linanthus (*Linanthus maculatus* (Parish) Milliken ssp. *maculatus*, hereafter Linanthus; Fig. 1) is a small annual herb endemic to southern California. Within the Coachella Valley area in Riverside County, it is found within the mouth of Dry Morongo Canyon, Big Morongo Canyon and Little Morongo Canyon, all near Desert Hot Springs, as well as Snow Creek and Whitewater Canyon (Sweet et al. 2017; Sanders 2006). Populations also exist in San Bernardino County on the north and east sides of the San Bernardino Mountains (e.g. Hondo Wash, Homestead Valley and the Bighorn Mountains), east of the Fry Mountains in Upper Johnson Valley, and at the northern edge of Joshua Tree National Park at the mouth of Rattlesnake Canyon and in the Little San Bernardino Mountains; these northern localities are part of the West Mojave Planning Area (Figure 2). Much of the newly documented range to the north has been discovered in the last 10 years by botanists at California Botanic Garden (formerly Rancho Santa Ana Botanic Garden) and others. Linanthus is categorized as California Rare Plant Rank 1B.2 (defined as follows: "fairly endangered in California and elsewhere, with 20-80% occurrences threatened / moderate degree and immediacy of threat"; CNPS 2015).

This species has in the past been elusive to botanists (Sanders 2006) and little is known about its biology and ecological relationships. During the century following its first collection and description in 1889, only a few populations were discovered. Over the last few decades, more populations have been identified and Linanthus habitat has become better understood (Sanders 2006); however, because of the extreme fluctuations in abundance and distribution year to year, more information is needed in order to understand the habitat niche of this species, as well as threats to plants within those microhabitats.

In 2002, a database of historic occurrence records was compiled for all five plant species covered under the Coachella Valley Multiple Species Habitat Conservation Plan (CVMSHCP; Allen et al. 2005, hereafter Plan area). Data were queried from various herbaria and museums and many records were not precise enough for geo-referencing. A University of California, Riverside Center for Conservation Biology (UCR CCB) research team then attempted to locate historic occurrence locations on public land for each species and document the existing populations through 500m^2 vegetation relevés. For Linanthus, only 2 unique historic records occurred on public lands. In 2003 no Linanthus were found at either plot, however in 2004 individuals were observed at one of those plots (n = 1781), and the population was found again in 2005 (n = 2800; Allen et al. 2005). Many new records for the species have been documented since the 2002 study, and we know more about the range of the species within the Plan area and where the species occurs more reliably when abiotic (or biotic) conditions are met for the plant, such as adequate rainfall. In 2017, while Linanthus appeared to be undergoing one of its "boom" years, several older occurrences were confirmed extant. As new locations are still being discovered for the species, an important goal remains to confirm any shift in the range of the species, visiting range edge populations annually.

Figure 1: *Linanthus maculatus* ssp. *maculatus* plant in flower, March 23, 2021, Snow Creek floodplain, Coachella Valley, CA. (Lynn Sweet photo)

The microhabitat in which it grows is composed of loose, well-aerated sand flats on low sandy benches at the margins of washes, dry canyons and alluvial fans in Sonoran and Mojave Desert scrub and Joshua tree woodland communities at elevations between 195-2075m (CNPS 2015, Sanders 2006) (Fig. 2). To germinate, the species may require fine sheet floods that inundate the soil with moisture but do not incise wash channels or erode the sandy topsoil or leave fluvial deposits, but this has not been determined empirically. It does not occupy substrates with hard surface layers of clay or rock, or loose aeolian sand within and away from washes. On a fine scale, the open microsites this species occupies are absent of shrubs or trees and contain few competing species or dense stands of weedy annuals (UCR CCB 2017, Sanders 2006), but the surrounding vegetation in some areas is composed of creosote bush (*Larrea tridentata*), California ephedra (*Ephedra californica*) and Mojave indigobush (*Psorothamnus arborescens*).

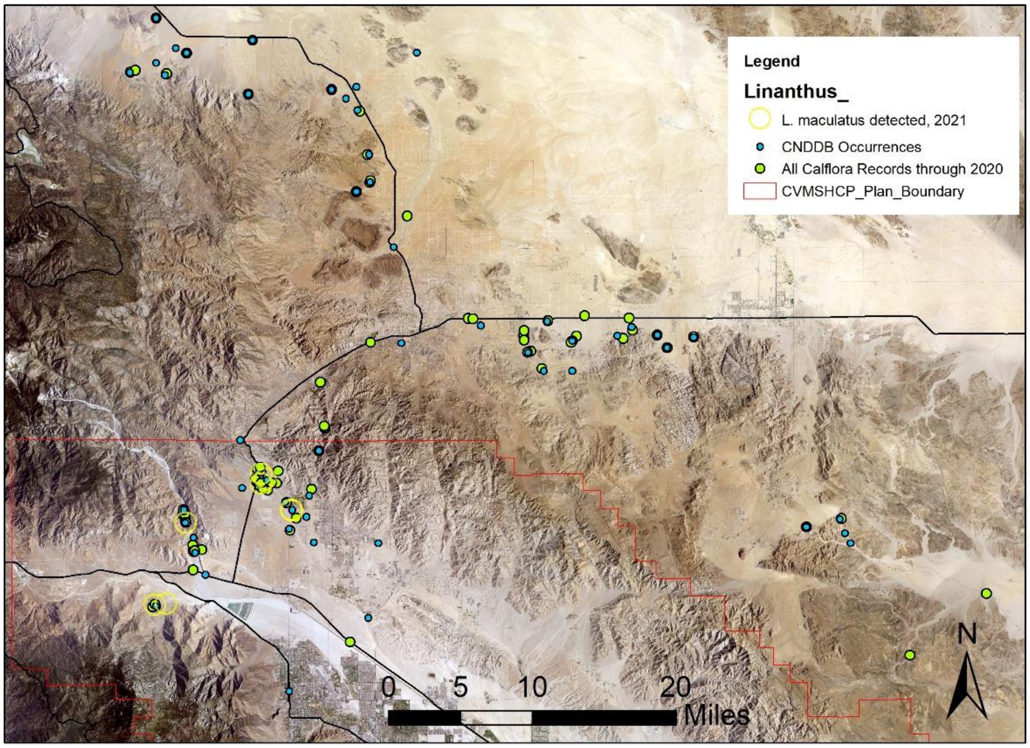

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Figure 2: Distribution of *Linanthus maculatus* ssp. *maculatus* georeferenced records available in Calflora and CNDDB, August 2021.

We have employed several approaches to better understand the distribution and abundance of this species. In 2014, an approach was implemented to use permanent plots to monitor the species presence, set up at historic locations of Linanthus (see 2014 CVMSCHP annual monitoring report); however, the species was detected at just three of them, though it was documented at several adjacent locations. In 2015-2016, Linanthus was found to be present at only two of the original 12 permanent plots. In order to be more effective in monitoring this small, cryptic species, a more targeted approach was warranted. Towards a better understanding of the factors that influence presence and absence in the habitat is necessary for efficient range-wide monitoring of the species in the future, a newer protocol was established in 2016. Here we used plots with confirmed presence of the species to look at microhabitat preferences, species associations, substrate type and possible competition with invasive species. This protocol was used in the spring of 2016, 2017 (with additional plots) and in 2020.

We first documented year-to-year variation in the density of plants present on the plots. Within the seven plots that we monitored in both 2016 and 2017, Linanthus showed an increase in all but one plot, with an overall increase of over 22-fold. Native associated species also showed an approximate doubling between the two years, while interestingly; *Schismus barbatus* cover did not change significantly. We further documented a possible competitive relationship *between* Linanthus and *S. barbatus* in this microhabitat. We found in 2016 and in 2017 that plots with a high percent cover of Linanthus had significantly lower cover of *S. barbatus* and vice versa, although the effect was weaker in 2017 when rainfall was higher.

Although we found a negative correlation between abundance in the two species, we could not prove causality in whether *Schismus* may be impacting Linanthus. To rule out microhabitat differences, we looked at the sampled mean particle size in the habitats dominated by each respective species and found that the means overlapped and were therefore not different. Soil samples analyzed from Linanthus-dominated plots showed a mean particle diameter of 837.6 µm (very fine gravelly coarse sand) while samples from *S. barbatus*-dominated plots showed a mean particle size of 613.7 µm (slightly very fine gravelly medium sandy soils that are poorly sorted). Since the sample particle ranges overlap and the means are similar, at this time there is no evidence to suggest that the two species inhabit different soil types, and *S. barbatus* remains a likely threat to Linanthus habitat. Additionally, although not detected during our surveys, a new invasive species, stinknet (*Oncosiphon piluliferum*), has been occurring near Linanthus habitat and may be a threat to the species in the future.

We have made strides in better understanding the microhabitat of this species, and it is reassuring that we have continued to find occurrences in places new and old in recent years within the Plan area. Threats to this species include invasive species, climate change, urban development and off-highway vehicle (OHV) recreation, but more work is necessary to understand how to best manage to conserve this plant. Many of the Linanthus occurrences, especially adjacent to developed areas, occurred in areas with light to moderate human foot traffic and OHV use. It is unknown how long these trails have been in use, and how heavily they are used, but we observed many Linanthus growing inside tire tracks or on berms caused by OHV's. The openness, lack of large shrubs and absence of channeling that is characteristic of Linanthus habitat makes it particularly susceptible to foot traffic, as these are the same conditions that make off trail travel the easiest for both hikers and OHV operators, and so an important question remains whether these two are just correlated in space, or there is a causal relationship. It is unknown if there is a threshold for disturbance that would cause the decline of the species. In recent years, fencing installed along some urban interfaces has reduced this traffic in some locations, and due to the highly variable interannual abundance of Linanthus, it has not been possible to tie any trends to a reduction in OHV use.

Finally, most aspects of this species' biology, including mode of pollination, dispersal, germination requirements and seed longevity, remain unknown (Patterson 1989). Most of these items would require intensive effort to study, as the species' stature is so minute and the plants are so ephemeral on the landscape.

Objectives

Surveys for Linanthus were carried out as part of research and monitoring for the CVMSHCP by the UC Riverside Center for Conservation Biology (CCB). In order to gather more information about population trends and threats to the species, we surveyed for presence on the long-term transect locations, as well as piloted a study of the hypothesis that overland fine floods/sheet flow is required for the species to germinate.

Our primary objectives for this monitoring effort were to assess the current abundance and distribution for populations of this species, document habitat attributes and identify potential stressors that may affect its persistence, in particular its tolerance to the presence of *Schismus barbatus*, but including other invasive species, OHV operations and trampling by foot traffic.

Methods

Data Collection

Permission was granted by the University of California, Riverside College of Natural and Agricultural Sciences administration to allow ongoing research during the COVID-19 pandemic. We surveyed for Linanthus within the original and the newer 10x100 m plots that were selected based upon previous occurrence records along the Mission Creek and Dry Morongo drainages. We also sought to confirm persistence for the species in several other locations, following up from the range-wide surveys in 2017 and 2020, as well as within the eastern side of Snow Creek on CVCC land identified as possible habitat based on proximity and similarity to occupied habitat. We recorded location and an estimate of the number of individuals along with threats identified in proximity; all locations will be supplied to CVCC and CNDDB.

We did not repeat the focused plot-based surveys (read in 2016, 2017 and 2020) due to the sparse presence of Linanthus on the landscape this year.

On January 29, 2021, we installed polycarbonate posts and wooden posts within the microhabitat at the long-term site #7 in Desert Hot Springs with a goal of detecting differences in overland sheet flow of water due to (micro-) topographic differences and whether these influence abundance of Linanthus over the same landscape (Figure 3).

Figure 3. Pilot hydro-topographic study installation in Desert Hot Springs, CA. Posts established in microhabitats within and adjacent to those that hosted Linanthus plants in prior years.

Results

Habitat

In all cases, Linanthus occurred in open, course-sandy microhabitats, generally beyond the dripline of large shrubs. We did not detect the presence of the new invasive, *Oncosiphon pilulifer* (stinknet). We identified the co-occurring shrubs to be similar to the mapped vegetation classification for occurrences. That is, within generally the Larrea tridentata—Encelia farinosa Shrubland Alliance, and in particular, in or near the preliminarily-identified vegetation association, Larrea tridentata—Encelia farinosa—Ephedra californica—Psorothamnus arborescens—Ambrosia salsola Association; See UCR-CCB Vegetation Mapping Report, Sweet et al. 2017) within the Desert Hot Springs area (Figure 4) and the eastern bajada at Snow Creek. At higher-energy wash locations, Whitewater, the western bajada at Snow Creek and at the end of Big Morongo Wash (2020) observation), the plant grows in proximity to desert willow (*Chilopsis linearis*), Ephedra and *Lepidospartum* species.

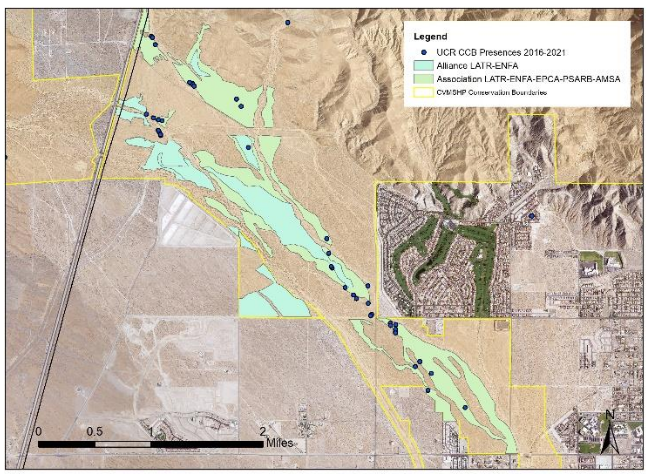

Figure 4: Little San Bernardino Linanthus observation points within the Desert Hot Springs area, in relation to vegetation classification and mapping polygons for the Coachella Valley Floor Map (Sweet et al. 2017). The vegetation alliance Larrea tridentata--Encelia farinosa shrubland (LATR-ENFA) and the association Larrea tridentata--Encelia farinosa--Ephedra californica--Psorothamnus arborescens--Ambrosia salsola (LATR-ENFA-EPCA-PSOAR-AMSA) are shown in the legend.

Long-term Plots and Extent mapping

During this dry year, we were able to verify that occurrences of Linanthus known from 2017 surveys were apparent, both in Snow Creek, Whitewater, Big Morongo (southern edge) and in the Mission Lakes area (Fig. 5). Thus, we did not find an east-west gradient in detection. We did not find Linanthus on any of those transects where it has never been field-documented to contain Linanthus and we did detect it on many of the plots that have contained populations in recent years.

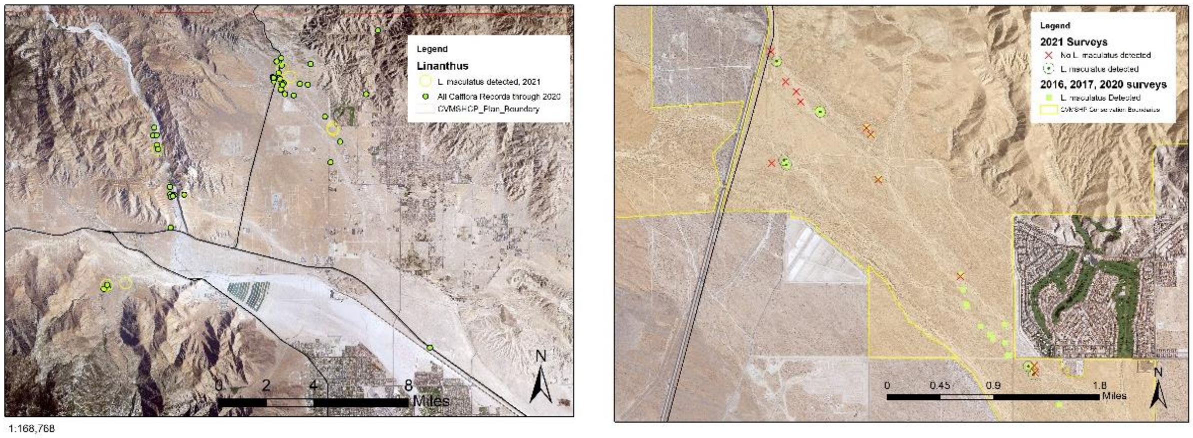

Figure 5: Detections of *Linanthus maculatus* in the CVMHSCP Plan Area (left) and within the long-term transects at the northwest end of the Coachella Valley in Desert Hot Springs, CA.

A new location was documented in the east bajada within Snow Creek >1/4 mile from the known local population, on BLM land just outside of CVCC-owned land. This small occurrence (two small groups of plants near each other) was discovered during a search based on aerial imagery of braided, sandy washes fitting habitat criteria for the species within the bajada. The CVCC parcel does contain some more of this habitat that could be searched, but overall it is fairly rocky and vegetated, lacking the gentle benches as you go eastward.

Topo-hydrography Study

While we were hoping to measure some overland flow as a test of methodology, we did not detect any surface flow of water over the site during the following rain events (based on precipitation recorded at RAWS Data for Cathedral Canyon NWS ID 045629): 0.11" on 1/29; 0.08" on 3/10. Unfortunately, since we anticipated more rainfall that did not materialize, the experiment was installed *after* the first and only significant rainfall event (0.51" on 1/25/2021) that might have been measurable in the area this season. We first detected Linanthus emerging on the landscape on 3/8/2021 this year.

Discussion

Overall, the results of our study underscore the variability in abundance of this desert annual and the difficulties involved in rare plant study, including detection at a useful scale for surveys, the unpredictable window available for detection, and the large variability in time and space in *Linanthus maculatus* abundance. However, we found that the species correlates in abundance inter-annually with native annual species, as this year, very few annuals germinated. This species is relegated to the wetter end of the Coachella Valley; therefore, there was some emergence in these places together with other common annual species. We did not detect range contraction, even in the drier 2020, as the plants were found in very low numbers scattered in eastern and western areas. We were not able to further study the association between this plant and the abundance of annual grasses, primarily *Schismus barbatus*, which we found to be negative, as in the past.

From the pilot project using posts to detect overland flow, we were not able to confirm or eliminate the hypothesis that sheet flow is needed for germination. This is likely because this type of flow does not occur during <0.5" events; but could also be that overland flow is not detectable using our methods. Since plants emerged in the areas in which we did not detect flow, we cannot be sure whether to rule out that this is necessary for germination, whether our methods simply failed to detect it, or whether the one rainfall event prior to installation did produce adequate sheet flow and was responsible for emergence of the plants observed.

As last year, we did not focus on the impacts of foot traffic and OHV's, but they were clearly evident, at least historically, at most sites. Linanthus tended to occur in the same gently-sloping, well-aerated substrate as also hosted corridors within the desert. As mentioned in previous years, many plants occurred in areas with light to moderate human foot traffic and OHV use. It is unknown how long these trails have been in use, but we observed many Linanthus growing inside tire tracks or caused by OHV's. The openness, lack of large shrubs and absence of channeling that is characteristic of Linanthus habitat makes it particularly susceptible to foot traffic, as these are the same conditions that make off trail travel the easiest for both hikers and OHV operators, but it is unknown what the plants threshold for disturbance is currently.

Our surveys resulted in a contribution to the publicly available Calflora database, an update/extension to the intra-regional extent of Linanthus, and we were able to confirm that known local populations seem to be persisting and emerging even through two dry years.

Since so little is known about the natural history, microhabitat requirements, effects of changes in hydrology and tolerance to invasive species of Linanthus, it is anticipated that the data collected in our additional study and future surveys will elicit more complex relationships to the habitat in the course of additional analysis.

Recommendations

It is recommended that surveys continue on a frequent basis to establish the precipitation threshold and conditions required for this species to germinate successfully, its tolerance to invasive species and to better understand its current range within the Coachella Valley. Plots with known occurrence locations should continue to be revisited with each future survey effort, however, a shift in placement from areas that have always had negative occurrence to areas in the west end of the valley (e.g. Snow Creek) would allow a better gradient of rainfall and climate to be sampled. This should be paired with ongoing searches on the margins of Linanthus' known habitat for additional local populations as well as within modeled suitable habitat. Revisiting historical plots and suitable microhabitats along the periphery of the historical records and the modeled habitat will allow the ability to detect if the range is expanding, contracting or even shifting due to various pressures (e.g., development, invasive species, nitrogen deposition, climate change). We also suggest a pollination and seed dispersal study to find out what factors are responsible for these portions of the plant's lifecycle. We recommend continuing to discuss results and methodology with rare plant biologists in adjacent jurisdictions (e.g. Joshua Tree National Park) with the aim of providing useful information for effective management. This information will enable surveys to be timed more effectively, cited appropriately, and allow for continued evaluation of OHV recreational activity and invasive species impacts to this species.

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Appendix IX. Peer-reviewed Research: *Forty Years Later: Monitoring and Status of the Coachella Valley Fringe-toed Lizard*

Article begins on following page.

Forty years later: monitoring and status of the endangered Coachella Valley fringe-toed lizard

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FULL RESEARCH ARTICLE

Forty years later: monitoring and status of the endangered Coachella Valley fringe-toed lizard

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The Coachella Valley fringe-toed lizard, *Uma inornata*, was listed as endangered under the California Endangered Species Act in 1980. By that time, the lizard's habitat was already reduced by 90%, fragmented into isolated habitat islands on private property among hundreds of landowners. Ecosystem processes that are essential for delivering sand and maintaining the lizard's sand dune habitat were already compromised. As challenging as it was to protect its habitat under these conditions, populations of this lizard still occur across much of the area where it was found forty years ago. Annual monitoring was designed to assess the ongoing viability of these populations by quantifying the effects of potential threats and stressors and focusing adaptive management actions where they are most needed. Here we demonstrate how hypothesis-based monitoring identified specific locations where invasive plant control and sand corridor management were needed to maintain the lizard's populations. By monitoring lizard densities within the context of environmental variables that either drive or inhibit population growth, this monitoring approach informs if, when, and where management actions are needed.

Key words: aeolian sand, California, hypothesis-based monitoring, management intervention, natural versus anthropogenic-driven population fluctuations, nested-scale monitoring, reptile, stressors, *Uma inornata*

The Coachella Valley fringe-toed lizard, *Uma inornata*, (the lizard) (Fig. 1) was listed in 1980 as endangered under the California Endangered Species Act (CESA) and threatened under the federal Endangered Species Act (ESA). Listing a species as endangered requires evidence that habitat loss and/or impacts from other stressors have put that species on a trajectory to extinction. However, the act of listing a species does not alone ensure its protection. The habitat loss and associated stressors that warranted listing need to be managed to halt or reverse population declines. Monitoring informs and assesses the success of ongoing critical management tasks. Here we present a case study underlining the importance of monitoring and management for the protection of the lizard. Now, forty years after those listings, we assess this species' status and the successes and failures of efforts to protect it.

Figure 1. An adult male Coachella Valley fringe-toed lizard, *Uma inornata*. Fringes along the trailing edges of their toes, countersunk lower jaw, overlapping eyelids, and valvular nostrils that keep sand that protect their respiratory tract from breathing in sand particles all provide adaptations for living in an aeolian sand habitat.

The conservation planning and implementation steps for the protection of the lizard have been detailed elsewhere (Barrows 2019). In short, the federal ESA initially took precedence as it offered flexibility under 1982 amendments that allowed the creation of Habitat Conservation Plans (HCPs). HCPs facilitate regional landscape scale conservation planning, not just project by project regulatory requirements for mitigation in response to proposed development impacting endangered species' habitat. Regional planning was an essential and critical task to protect ecosystem processes that transport sand to the lizard's habitat. Since the lizard did not occupy key sand transport corridors, those corridors would not necessarily receive protection under traditional regulatory approaches. With the creation of the Natural Community Conservation Planning Act (NCCP) in 1991, protection efforts for CESA-listed species were given an analogous regional conservation planning approach. The initial single-species HCP for the lizard was signed in 1986 with the fanfare of being the first-ever approved after the 1982 amendments to the ESA. The Coachella Valley Fringe-toed Lizard HCP included multiple municipalities and hundreds of landowners. Being first also meant that there was no template outlining how to proceed and no criteria for defining success or failure.

The lizard's habitat was once a continuous landscape of 33,500 ha of aeolian-sand; however, prior to the 1980 listing and the onset of conservation planning and implementation for this species, the sand dunes had already been reduced by close to 90%, with remaining habitat fragments isolated by roads, freeways, rail corridors, golf courses, agriculture, and suburban developments (Barrows et al. 2008; Fig. 2). A critical concern was that the sand transport corridors were all compromised to one degree or another. A decade after the original lizard HCP was signed it became increasingly clear that the sand corridors were not being adequately protected. Planning began in 1996 to create a federal multiple species HCP (MSHCP) and state NCCP with an explicit ecosystem focus. This effort recognized the need to correct the shortcomings in the original lizard HCP and to extend protection for 27 plant and animal species (including the fringe-toed lizard) and 27 natural communities. Four of the natural communities together encompass the range of aeolian-sand habitats occupied by the lizard: 1) active dunes, 2) stabilized sand fields, 3) ephemeral sand fields, and 4) honey mesquite hummocks and dunes. The state and federal permits for the joint MSHCP/NCCP were signed in 2008.

A monitoring program to assess the degree to which the plan was successful in protecting the lizard and other covered species was developed concurrent with conservation planning efforts. Historically, biological monitoring has focused on periodic counts of a species. Results were limited to determining presence or absence and occupancy trends. However, even healthy populations increase and decrease over time in response to natural fluctuations of limiting resources, predator densities, and other factors. Such natural fluctuations do not necessarily warrant management intervention. Occupancy or abundance data alone do not provide insights as to why changes are happening or what, if any, management prescription might enhance population persistence.

Precipitation is the primary driver of population growth in arid environments (Noy-Meir 1973; Kearney *et al*. 2018). However, the relationship between the lizard's population growth and rainfall is not linear; the seasonality, intensity, and amount of rainfall all have differential effects (Barrows et al. 2009). Monitoring in arid habitats must be able to partition the complex effects of rainfall from other anthropogenic effects to identify if management actions are warranted to reverse population declines. A novel monitoring approach was developed as the MSHCP/NCCP was being negotiated (Barrows et al. 2005; Barrows and Allen 2007a,b). That approach considered monitoring as a series of hypothesis-driven

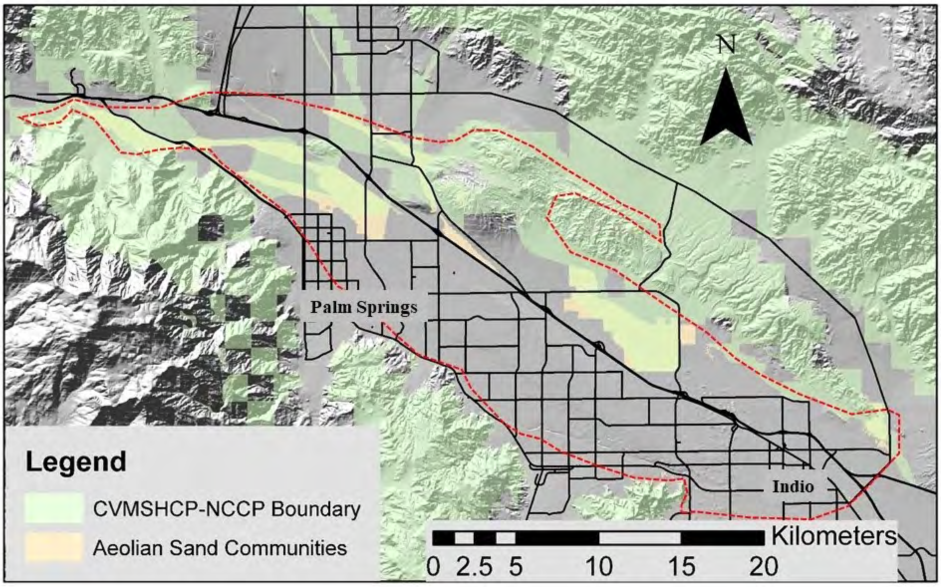

Figure 2. The entire historical range of the Coachella Valley fringe-toed lizard (red-dashed line), as well as remaining aeolian sand habitat, land designated for protection (CVMSHCP-NCCP boundary), and the level of existing fragmentation of those remaining habitats. The aeolian sand habitats shown here are based on US Geologic Survey soil maps but are not precise equivalents to habitat occupied by the lizard. Smaller, isolated habitat fragments and peripheral areas within larger mapped habitat polygons no longer support lizard populations.

experiments using the varying intensity of drivers and stressors over time and space as independent variables, and changes in the lizard's abundance as the dependent, or response variable. Here we present results of monitoring data, employing this hypothesis-driven approach for Coachella Valley fringe-toed lizards covering a 19-year period from 2002–2020.

METHODS

Study Area

The Coachella Valley is located at the northwestern corner of the Colorado Desert, a drier subset of the Sonoran Desert with less influence from summer monsoonal precipitation, broadly stretching west from the Colorado River. This valley is bounded to the west by the Santa Rosa and San Jacinto Mountains, and to the east by the Little San Bernardino Mountains (Fig. 2). The northern boundary of the Coachella Valley is delineated by the southeastern terminus of the San Bernardino Mountains, and the valley extends south to the Salton Sea. The Coachella Valley includes nine incorporated municipalities with a year-round resident population of roughly 400,000 people, from Palm Springs and Desert Hot Springs in the west to Indio and Coachella in the east. However, the number of residents can more than triple during the cooler winter and spring months when seasonal "snowbirds" swell the human population. The regional economy is focused on tourism, second homes, and agriculture.

Habitat conservation efforts are coordinated by the Coachella Valley Conservation Commission (CVCC), a Joint Powers Authority whose members are elected representatives of Coachella Valley cities, indigenous tribes, water districts, and Riverside County. While the lizard's habitat was initially a patchwork of hundreds of privately-owned parcels, current conservation landownership of that habitat includes the U.S. Fish and Wildlife Service National Wildlife Refuges, California Department of Fish and Wildlife Ecological Reserves, U.S. Bureau of Land Management, Coachella Valley Water District, Coachella Valley Association of Governments (CVAG), Coachella Valley Mountains Conservancy (a State of California conservancy), and Friends of the Desert Mountains (a private, non-profit organization). Individual conservation landowners are responsible for land management, while biological monitoring is funded and coordinated by the CVCC. Monitoring protocols are therefore applied evenly across the remaining lizard habitat, independent of land ownership.

Coachella Valley fringe-toed lizards are among six species of the genus *Uma* occupying the Mojave and Colorado Deserts in California, Arizona, and northwestern Mexico (Gottscho et al. 2017; Derycke et al. 2020). Two additional *Uma* species occur in the Chihuahua Desert in north-central Mexico. All species of *Uma* are restricted to or are found at their highest densities on fine, well-sorted, aeolian sand landscapes, with many confined to discrete sand dune systems. Among those eight *Uma* species, two are especially impacted by expanding human development (*U. inornata* and *U. exsul*; García-De La Peña et al. 2015), with the degree of habitat loss and fragmentation most severe for *U. inornata*, the Coachella Valley fringe-toed lizard (Barrows et al. 2008).

Survey Protocol and Dependent Variables

The lizard's sand dune habitat is extremely dynamic. Aeolian sand habitats are continuously shifting down wind, while new upwind sand additions are dependent on stochastic flood events bringing sediments out of the surrounding mountains (Barrows 1996). The aeolian sand habitat includes four different natural community types that comprise the remnants of the original aeolian sand landscape; they are defined by unique wind, sand, and vegetation characteristics (Table 1). Protection goals included maintaining sustaining populations of the lizard within each of these community types. Monitoring goals focused on quantifying lizard densities in response to precipitation, the variation in habitat quality due to aeolian and fluvial sand dynamics, and anthropogenic stressors (Table 2) across each of the four natural communities. We tested and rejected multiple approaches for visual counts of the lizards. Fisher et al. (2020) monitored this species via a mark/recapture approach on a single 2.25 ha plot for +31 years, marking each resident lizard with a unique combination of three colored beads attached to the base of their tails (Fisher and Muth 1989). They were able to acquire both accurate annual population estimates and delineation of home ranges for resident lizards. However, their method was time and effort intensive, typically requiring dozens of surveys per year, and so was impractical to apply to more than one or two plots.

Our solution was to not count the lizards directly, but to quantify lizard densities using their tracks left in the fine aeolian sand. By using tracks, we eliminated the problem of the lizard's variable, inconsistent activity patterns—if any individual was active on a plot during or prior to the survey we could detect it by the diagnostic tracks it left behind. However, determining which species had left tracks, and how many individuals were present introduced challenges. To determine how many lizards were represented by the tracks observed on each transect we used four criteria. First, we only surveyed on mornings after a night with strong enough winds to clear all tracks from the previous day. Second, we followed each set of tracks to determine if it connected with the tracks of a previously counted lizard. Third, we looked for interactions between lizards to determine if we were looking at one or multiple individuals. Fourth, there are considerable size differences between male and female lizards and between juveniles and adults (Barrows and Fisher 2009) and those differences are mirrored in the track widths. Ensuring that the species-track identification was accurate was resolved with adequate training, and when in doubt following the tracks to the lizard that created them. Much like learning to count birds by their calls and songs, accurately identifying tracks is a learnable skill.

A benefit of this method was that we could detect many more lizards, and so could reduce plot size to just 0.1 ha and still have adequate numbers of lizard sightings for robust statistical analyses. With smaller plots and smaller time and effort per plot, we were able to survey 68 core plots (plots resurveyed every year) across the entire range of the lizard, with 4–6 repeated surveys per plot within a six-week survey window. We configured the 0.1 ha plots as 10-m × 100-m rectangles. Those plots were then clustered (3–7 plots) within separate dunes or habitats within the same natural community type, with plot clusters > 500 m apart, (with the exception two clusters that were < 500 m apart as a result of a random placement) from an adjacent plot cluster. Placement of the initial plot within a cluster was random. Thereafter additional plots were either placed randomly or regularly to answer specific questions (such as edge effects). Non-random plot placements occurred within three clusters where we wanted to measure the effect of distance from a road/powerline that formed a habitat edge. Within a cluster we placed plots ≥ 50 m apart to avoid individual lizards overlapping adjacent plots. Fisher et al. (2020) identified home range sizes for females ($\overline{x}$ = 505 m^2) and males ($\overline{x}$ = 662 m^2), which, assuming roughly circular home ranges, equate to home range diameters of 25–29 m, well below the 50-m separation between plots.

Population densities can vary as habitat characteristics vary, and responses to those shifting habitat qualities can become apparent at different scales (Morris 1987; Smith and

Table 1. Characteristics that distinguish the four aeolian sand natural communities found in the Coachella Valley that provide habitat for the Coachella Valley fringe-toed lizard.

Aeolian Community Characteristics	Active Dunes	Stabilized Sand Fields	Ephemeral Sand Fields	Honey Mesquite Dunes
Habitat Area / Number of Habitat Fragments	1370 ha / 5	400 ha / 1	1700 ha / 4	200 ha / 1
Sand	Deep, continuous, well-sorted fine sand with low silt or finer particle content	Well-sorted fine sands form discontinuous shallow layers over compacted layers with higher silt content.	Discontinuous patches of well-sorted fine sands, coarse sands, gravel, rocks, and boulders	Deep, well-sorted fine sand with low silt or finer particle content
Sand Movement	High mobility shifting dunes	Low mobility	Extremely high mobility	Low mobility
Perennial and annual Plant Composition	Sparse perennial and annual cover: *Larrea* sp. and *Atriplex* sp.	Moderate cover of perennials, seasonally high cover of annuals *Larrea* sp. and *Atriplex* sp.	Moderate cover of perennials, sparse annual cover: *Larrea* sp., *Psorothamnus* sp., *Croton* sp., and *Petalonyx* sp.	High cover of mesquite, low to moderate cover of other shrubs: *Prosopis* sp., *Larrea* sp., *Atriplex*, and *Isocoma* sp.
Invasive Plant Species	Low to moderate cover of *Brassica* sp.	Moderate to high cover of *Brassica* sp. and *Schismus* sp.	Low to zero cover of invasive species	Moderate cover of *Brassica* sp. and *Schismus* sp.

Ballinger 2001). Collecting lizard densities at a plot scale (0.1 ha) that can be combined and analyzed as plot clusters provides analytic flexibility at multiple scales. Plot clusters can be combined at the natural community or landscape scale. Our 68 core plots included replicates within the four natural communities as follows (plot clusters/total # of plots): active dunes (4/18); mesquite dunes (1/11); ephemeral sand fields (3/18); and stabilized sand fields (3/21).

Two to three people surveyed each plot: a professional biologist plus 1–2 volunteer community scientists. Surveyors slowly walked equidistant from each other along the length of the plot, noting and identifying all vertebrate tracks, which were then verified and recorded by the biologist. The addition of the community scientists significantly increased detection rates for lizards and their tracks (Barrows et al. 2016).

While population density is a useful metric, it is dependent on long-term habitat conditions. It can take multiple years for a population to substantially increase density due to the finite number of breeding adults. Similarly, it can take years for densities to decline due to multiple-year lifespans. Population growth rate (γ) can prove to be a more sensitive response variable to shorter term changes in independent variables. Here population growth was calculated as $\gamma = \ln(N_{i+1}/N_i)$, where N_i is the population density in year $_i$, and N_{i+1} is the population density the following year.

Table 2. Primary stressors impacting the Coachella Valley fringe-toed lizard, their effects, and management responses for reducing those impacts.

Stressor	Scale	Effect	Management Response
Climate Change	Broad, but most severe at the eastern, hotter/drier conserved habitats	Reduced surface activity for the lizards, more severe droughts, reduced vegetation cover. Higher mortality and lower recruitment rates	Reduce impacts from other stressors
Invasive Plant Species	Localized, varies between sites, and between species. Most severe where there are lower sand transport rates	Sand stabilization, outcompetes native annuals, reducing both plant and insect food resources for the lizards. Notably, insect abundance and diversity are reduced as Sahara mustard increases	Hand removal is the safest, but the scale of the infestations easily overwhelms staff or volunteers for large scale removal efforts. Removal efforts then need to be strategically targeted to the habitats with the greatest benefits
Edge Effects	Localized	Increased predation from greater roadrunners, American kestrels, and common ravens	Remove anthropogenic nesting sites and power lines used as perches by predators
Loss of Genetic Heterogeneity	Broad, but most severe on the smallest habitat patches	Potential reduced adaptability to climate change and other stressors. Otherwise unexplained population declines	Translocation of gravid females and/or hatchlings to increase heterogeneity. Adults do not appear to translocate as successfully.
Loss of Ecosystem Processes	Localized	Increased sand stabilization, reduced active, loose sand habitats	Keep sand corridors open. Recycle fugitive sand (sand on roads or otherwise unwanted areas) to sand corridors
Off-road Vehicle Trespass	Localized	Reduced perennial vegetation cover. Increased debris dumping	Maintain fencing, increased law enforcement patrols

Independent Variables

Although this region receives occasional isolated summer rain that can result in localized flooding, primary productivity and breeding success of the lizards is usually catalyzed by cool season rains (Noy-Meir 1973; Kearney *et al*. 2018). To illustrate the relationship between rainfall and the lizards' population dynamics we compared annual November-April rainfall totals from the eastern-most protected habitat, the Coachella Valley National Wildlife Refuge and California State Ecological Reserve. Rainfall data were collected on site and were found to be nearly identical to a nearby, internet accessible weather station in the city of Indio (https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca4259). Rainfall levels do vary across the Coachella Valley, with an increase toward the western edge of the valley at the western limits of the lizards' remaining habitat; however, the relative trajectories (drought, average rainfall, or relatively wet conditions) are consistent throughout the region. Using this rainfall metric to illustrate relationships between rainfall and lizard population dynamics throughout the lizards' range, while not precise for specific locations, provides the opportunity to assess how drought or wetter conditions influence the lizards' population densities. Rainfall levels provide a coarse-scale expectation of population growth rate trajectories.

Additional independent data that we collected annually on each 0.1 ha plot included: 1) spring annual and perennial plant abundance and density by species, including both native and non-native species; 2) arthropod abundance and species diversity, 3) sand compaction, and 4) associated vertebrates, using track counts collected at the same time that the lizards were surveyed. These metrics provided fine-scale, plot-specific indicators of habitat characteristics. For annual vegetation cover we measured both and density and percent cover by species, on 12, 1-m^2 sub-plots, four at each end and one in the center of each 0.1 ha plot. We measured arthropods using three pitfall traps placed overnight, one at each end and one in the center of each 0.1 ha plot. One of those arthropods, the beetle *Asbolus* (previously *Cryptoglossa*) *laevis*, (Tenebrionidae) proved to be a useful indicator of sand compaction, only occurring on the less compacted sands of active dunes (Barrows 2000). Sand compaction was measured using a Pocket Penetrometer (AMS Inc.). Twenty-five compaction measurements, each separated by roughly 4 m, were made along the mid-line of each plot. We measured associated vertebrates using the same track protocol used to measure the lizard densities. Some of the associated vertebrates are predators and so could influence fringe-toed lizard abundance. Potential predators include leopard lizards (*Gambelia wislenzenii*), sidewinders (*Crotalus cerastes*), coachwhips (*Masticophis flagellum*), glossy snakes (*Arizona elegans*), greater roadrunners (*Geococcyx californianus*), loggerheaded shrikes (*Lanius ludovicianus*), common ravens (*Corvus corax*), American kestrels (*Falco sparverius*), coyotes (*Canis latrans*), and potentially some species of rodents (Timberlake and Washburne 1989). Others are possible competitors such as zebra-tailed lizards (*Callisaurus draconoides*) and flat-tailed horned lizards (*Phrynosoma mcallii*), but none are as habitat specific to active aeolian sand as are fringe-toed lizards.

RESULTS

Figure 3 illustrates the nested-scale character of the fringe-toed lizard monitoring data. At the finest scale (Fig. 3a) are individual plots clustered within a single active dune (AD2). Means for the combined plots within each of the four individual active dune plot clusters (replicates within the active dune natural community) are shown in Figure 3b (middle scale). Finally, at the coarsest scale (Fig. 3c) are the combined means for each of the four natural communities across the lizards' entire range. At each of these scales the data can reveal patterns that provide insights regarding the status of the lizard. At both the fine-scale plot level for the AD2/active dune cluster (Fig. 3a) and the combined active dune natural community (Fig. 3b) scale, precipitation levels positively correlate with lizard densities (Pearson's Correlation: AD2 plot cluster: df = 17, r = 0.717, P = 0.0008; all active dune communities: df = 17, r = 0.581, P = 0.011). At the coarsest natural community scale (Fig. 3c), the correlation (r) between lizard density and precipitation was uneven. The strongest correlation was with active dunes. Next was the mesquite dunes (df = 17, r = 0.514, P = 0.029), followed by non-significant rainfall-lizard density correlations for stabilized sand fields (df = 17, r = 0.317, P = 0.199), and ephemeral sand fields (df = 14, r = 0.077, P = 0.785).

Since the plots are replicate surveys within each dune, and the dunes are replicates within the natural community, the general within year synchrony provides validation for

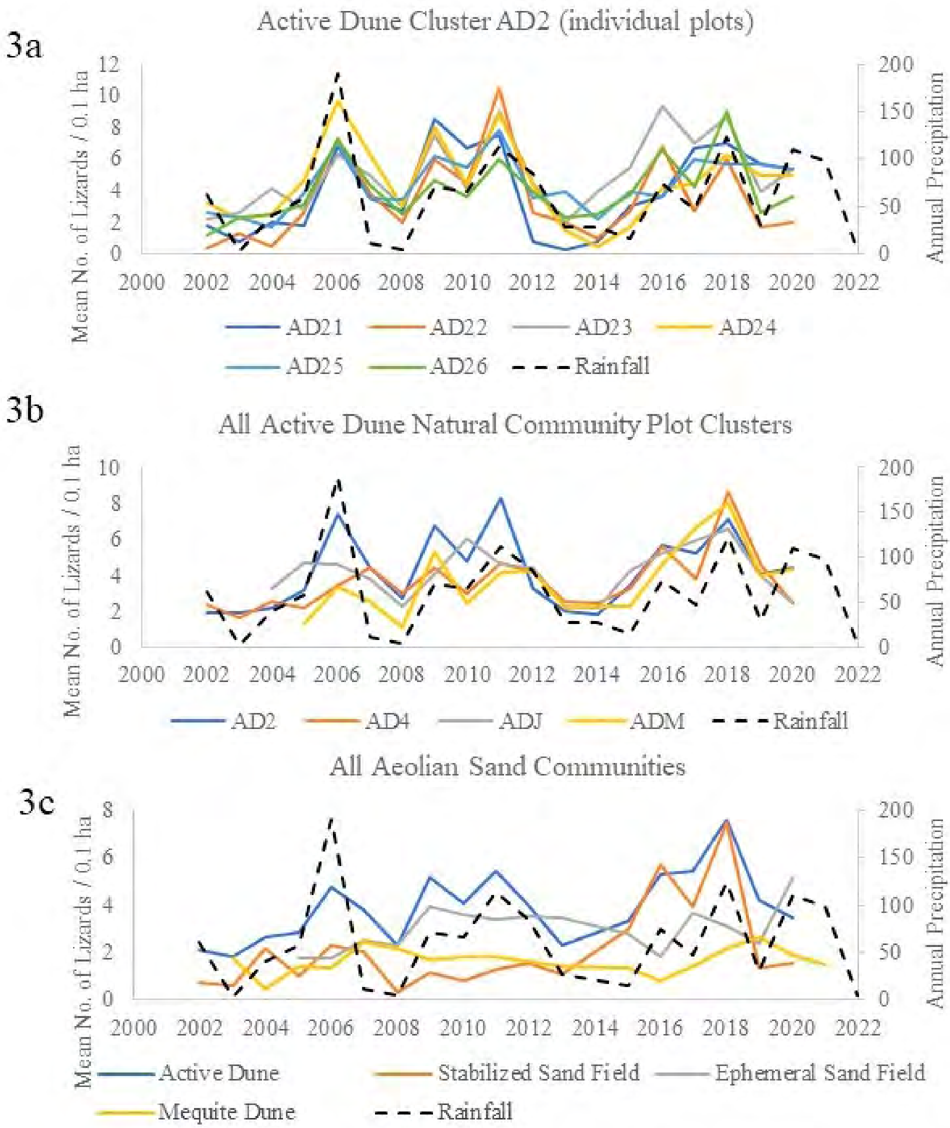

Figure 3. Annual changes in lizard density at multiple scales within the context of precipitation to show how the lizards' population fluctuations are often synchronized with rainfall patterns. Since lizard density is in part a reflection of the previous year's reproductive recruitment, precipitation is shifted back by one year so that lizard density aligns with the precipitation effects.

the ability of the plot size and survey methodology to detect real change when it happens. Large population swings are a regular occurrence and should not influence management responses if they are synchronized in direction and amplitude with shifting rainfall levels. The question then is when does asynchronous, or non-significant correlations between precipitation and lizard densities indicate a need for management intervention?

A list of potential stressors that could warrant management responses is shown in Table 2. Of those that have localized impacts, off-road vehicles could be discounted as no recent vehicle trespasses were observed. Invasive species impacts and losses of ecosystem processes (reduced sand delivery) can be interrelated and so are difficult to partition. However, looking at that middle scale graph, in 2020 there were opposite population trajectories for the AD2 and ADM plot clusters (increasing) versus the AD4 and ADJ clusters (decreasing). Those divergent trajectories warranted further analyses. The AD2 and ADM plot clusters did have significantly less Sahara mustard, *Brassica tournefortii*, than the AD4 and ADJ sites (Means 13.23 versus 24.75 plants/m^2; ANOVA df = 1, F = 4.5313, P = 0.049), and had a significantly higher (and positive) population growth rate (means $\gamma = 0.103$ versus -0.644; ANOVA df = 1, F = 18.9855, P = 0.00049). While densities AD2 and ADM were less than that for the Ephemeral Sand Field natural community (Fig. 1), a habitat that lacked Sahara mustard, their respective population growth rates were not significantly different (means $\gamma =$ 0.103 versus 0.57; ANOVA df = 1, F = 4.0887, P = 0.0561). The mustard densities on AD4 and ADJ appear to have exceeded a tipping point for negatively impacting the lizards. An illustration of the varying Sahara mustard densities that can occur across the active dunes and stabilized sand fields are shown in Figure 4.

The regression of 2020 lizard density versus sand compaction was significant for both active dunes ($R^2 = 0.5939$; $P < 0.00001$) and stabilized sand fields ($R^2 = 0.2101$; $P < 0.003$); less compacted sand in correlated with higher densities of fringe-toed lizards (Fig. 5). There appears to be a sand compaction level of approximately 0.125 kg / cm^2 that distinguishes most active dunes from stabilized sand fields. Of the AD2 and ADM plots designated *a priori* as active dunes, 75% had sand compaction levels fitting to that natural community. However, for the AD4 and ADJ active dune plots, just 30% had sand compaction levels $\leq$ 0.125 kg / cm^2. The occurrence of plots previously identified as active dunes, but now with sand compaction and lizard densities well within the stabilized sand field range, identified a need to initiate remedial management. Although roadrunner, kestrel, and raven densities increased with proximity to human development, we did not find any support for other additional explanations, such as edge effects which are manifested by increases in potentially anthropogenically augmented predator densities (i.e., roadrunners, ravens, or kestrels). However, both the roadrunner (except on the mesquite dune natural community) and kestrel were dependent on planted non-native trees and shrubs for nesting sites. Our data identified that management intervention to remove mustard as well as remove any other barriers to aeolian sand movement was warranted on the AD4 and ADJ dunes. The lack of synchrony between lizard density and coarse scale precipitation data identified that a potential problem existed; finer scale invasive species densities and sand compaction data identified the cause and management solutions.

DISCUSSION

Wild populations fluctuate naturally in size from year to year. The challenge for managing endangered species that are facing multiple stressors is distinguishing natural population

Figure 4. The top image shows the infestation of Sahara mustard (the dense, straw colored plants) on an active dune (AD2) during the wet spring of 2005. The lower image shows the density of mustard on an adjacent stabilized sand field that same year.

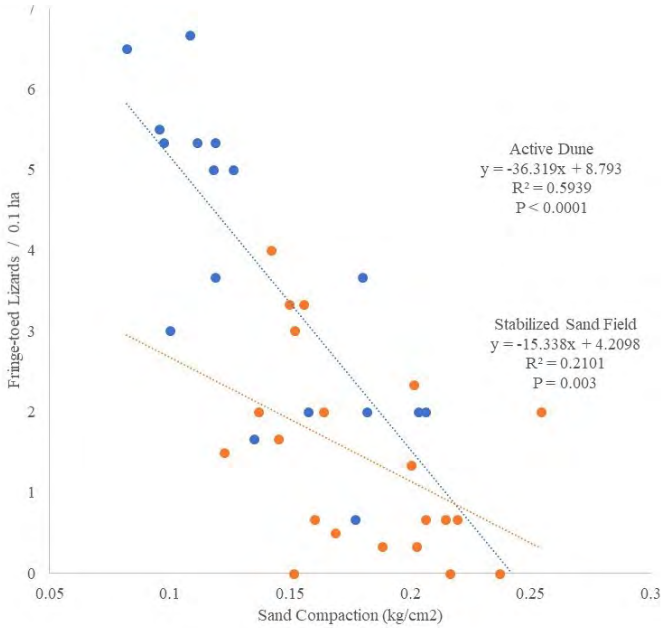

Figure 5. Patterns of Fringe-toed lizard densities in relationship to sand compaction in 2020. Active dunes (each plot indicated by a blue circle) generally have less compacted sand and higher lizard densities, whereas stabilized sand field plots (orange circles) have more compacted sand and fewer lizards. The regression of lizard density versus sand compaction for each habitat type show statistically significant correlations. The plots identified as active dunes, but that have values that are well within those for stabilized sand fields are not receiving new sand and are being invaded by Sahara mustard.

oscillations from population shifts that are anthropogenic driven that, if not managed, could result in population declines leading to extinction. Here we provided examples of how the hypothesis-driven monitoring approach employed for the Coachella Valley fringe-toed lizard has clarified those distinctions and identified site-specific management recommendations. Using two abiotic metrics, precipitation (coarse scale) and sand compaction (fine scale), plus a biotic metric (invasive plant densities), we identified site-specific priorities for managing an invasive weed, Sahara mustard, to promote more sustainable lizard populations. Without management intervention, some active dune communities, habitats that where the lizard populations are consistently the densest throughout its range, appear to be transitioning to stabilized sand fields, a natural community with consistently the lowest lizard densities.

We continue to find that increasing mustard density decreases native plant abundance (Barrows et al. 2009), decreases arthropod abundance (Hulton et al. 2013), and increases sand compaction. As Sahara mustard density increased, lizards became increasingly scarce, and ultimately absent. Our findings indicate that the mustard continues to be a significant threat to the sustainability of the lizard populations, especially on stabilized sand fields and active dunes. This is in contrast to our findings that another invasive weed, Russian thistle, *Salsola tragus,* had a benign to positive impact on the lizards (Barrows 1997).

The density of mustard is tied to both the amount of rainfall and sand transport rates - the more rainfall and the more stable the sand, the denser the mustard. Mustard density is influenced by both the amount of rainfall and the timing of rainfall. Heavy early December rains guarantee a dense growth of mustard, but if the rains do not start until late February or March, little mustard germinates (Barrows et al. 2009). If there is a sequence of storms beginning in December and continuing through February, a new cohort of mustard germinates after each storm. These patterns complicate control efforts. Herbicides that kill mustard will also kill native annual plant species, and mustard will still germinate following an herbicide treatment if more storms occur. Accordingly, "surgical" hand pulling, focusing on areas where mustard removal will yield the greatest benefits, is the preferred control method. Unless a safe, species-specific biological control for the mustard is identified, hand pulling will be an ongoing management task.

Stabilized sand fields did not have significant correlations with precipitation. Stabilized sand fields have the highest levels of Sahara mustard infestation as well as the highest sand compaction levels of any of the aeolian sand communities. *Asbolis laevis* beetles were not detected in this dune type, and fringe-toed lizards only rarely exceeded a mean of 2 lizards/plot (Figs. 3, 5).

Ephemeral sand fields also did not have significant correlations with precipitation; this community occurs in a region of the Coachella Valley where wind and sand transport are so strong as to continue to blow deposited sand downwind and scour rocks into ventifacts (Table 1). Within the ephemeral sand fields, due to these strong winds, sand residence time is relatively short compared to the other aeolian sand-based natural communities. These scouring winds also inhibit annual plant growth (including non-native invasive species), so higher annual rainfall that supports annual plant growth and arthropod prey for the lizards elsewhere has less of an impact on the lizard's population dynamics here, and a close correlation between annual precipitation and the lizard's population growth is not expected. Rather, when sand delivery is sufficient to build sand hummocks, and when that coincides with sequential years of average or greater rainfall to maintain high soil moisture to support leaf and flower production of perennial shrubs, the lizard population grows, as it did in 2020. Understanding site-specific interactions between abiotic inputs and biotic responses is critical for developing models from which the need for management interventions can be determined. For this natural community there are up-wind sand corridor challenges, such as sand and gravel mining, channelization for aquifer re-charging, and conflicts associated with roadways that cross the sand corridor. Each of these could restrict sand delivery to this habitat, and each needs to be monitored to ensure sand delivery is not constrained.

We have previously addressed questions that included whether the high degree of habitat fragmentation had resulted in a loss of genetic diversity in the lizards. Based on tissue samples collected in the mid-1990s, Hedtke et al. (2007) found no genetic structure associated with the lizard populations occupying the different fragments; their genetic profile reflected the pre-fragmentation, panmictic condition. A follow-up study analyzing tissues collected in 2008, (Vandergast et al. 2016) found a different result; lizard populations occupying each habitat fragment had a unique genetic signature, and each population had lost genetic diversity relative to that 1990s baseline. Climate change also looms as a threat to the lizards. Barrows et al. (2010) modeled the response of the fringe-toed lizards to expected levels of climate change if no significant reductions in anthropogenic greenhouse gases occur and found that only the westernmost habitat areas will likely continue to provide the climate envelope currently preferred by the lizards. For the present, we found lizards are sustaining populations as expected with respect to annual rainfall and Sahara mustard densities in all the remaining protected habitats. Given that land managers do not have the capacity to alter the course of climate change, it is imperative that they address those threats that they can affect. These include controlling invasive plants and keeping sand corridors unobstructed, and reducing other stressors that might, together with climate change, result in local extirpations.

Forty years after the listing of the Coachella Valley fringe-toed lizard as endangered, this species continues to occupy much of the same landscape they occupied in 1980. Land protection efforts, purchasing essential private parcels and so taking them out of a trajectory toward future development, has been extremely successful. However, long-term success, defined as maintaining sustaining fringe-toed lizard populations across those protected lands, will depend on effective management informed by hypothesis-based monitoring.

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Appendix X. Brown-headed Cowbird Management Report 2021

Report begins on following page.

Brown-headed Cowbird Management in the Coachella Valley 2021

October 15, 2021

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Table of Contents

List of Tables i

List of Figures i

Introduction 2

Methods 3

Cowbird Trapping 3

Results 5

Cowbird Trapping: 5

Discussion and Recommendations 10

Acknowledgments 11

References 12

Appendix A. 14

List of Tables

Table 1. Riparian bird species identified by the CVMSHCP for conservation monitoring. 2
Table 2. Locations of cowbird traps in the Coachella Valley, 2021. 3
Table 3. Summary of cowbird trapping data, Whitewater Channel, 2021. Cowbird numbers do not include recaptures. 6
Table 4. Banded male cowbirds from previous years recaptured in 2021. 8
Table 5. Male cowbirds newly banded in 2021. 9

List of Figures

Figure 1. Locations of cowbird traps operated in the Coachella Valley in 2021 4
Figure 2. Brown-headed Cowbird trap located at site WW2 5
Figure 3. Western Tanager captured and released from WW1 on 17 May 2021 7
Figure 4. Brown-headed Cowbird captures by year. 8
Figure 5. Female cowbird. Photo taken June 19, 2021. 10

Introduction

The Coachella Valley Multiple Species Habitat Conservation Plan (CVMSHCP 2007) identifies five species of riparian birds as targets for conservation, the Willow Flycatcher, Least Bell's Vireo, Yellow-breasted Chat, Yellow Warbler, and Summer Tanager. Additionally, the plan covers Crissal Thrasher, which inhabits both dense mesquite scrub and riparian habitat, and identifies the Brown-headed Cowbird as a potential threat with management concern (Table 1). In order to conserve and manage these species, CVMSHCP program goals include the conservation of 3,870 acres of the Coachella Valley Stormwater Channel and Delta Conservation Area, the permanent establishment of 44 acres of Sonoran cottonwood-willow riparian forest, and the conservation of at least 781 acres of core habitat for Crissal Thrasher.

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	*Empidonax traillii (Empidonax traillii extimus)*	State Endangered (Federally Endangered)
Least Bell's Vireo	LBVI	*Vireo bellii pusillus*	State Endangered/ Federally Endangered
Yellow Warbler	YEWA	*Setophaga petechia*	State Species of Special Concern
Yellow-breasted Chat	YBCH	*Icteria virens*	State Species of Special Concern
Summer Tanager	SUTA	*Piranga rubra*	State Species of Special Concern
Crissal Thrasher	CRTH	*Toxostoma crissale*	State Species of Special Concern
Brown-headed Cowbird	BHCO	*Molothrus ater*	None (potential threat)

From 2002 to 2004, the Center for Conservation Biology conducted baseline surveys for these 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 repeat surveys 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 2002-2004 levels in the Coachella Valley, and in comparison to neighbouring regions, such as Anza-Borrego Desert State Park. The study also found high numbers of Brown-headed Cowbirds, with 100% nest parasitism of the Least Bell's Vireo at Chino Canyon (Hargrove et al. 2014). 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, 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). Two traps were placed at each site, and 75 cowbirds were captured at Whitewater Channel while nine were captured at Dos

Palmas Preserve, using modified Australian Crow traps (Griffith and Griffith 2004). Due to the low number of cowbirds captured at Dos Palmas Preserve, alternative methods of cowbird capture were recommended, namely targeted mist-netting.

In 2018, 55 Brown-headed Cowbirds were trapped in the two Whitewater Channel traps (San Diego Natural History Museum 2018). In 2019, four traps were established in the Whitewater Channel, and a total of 79 cowbirds were trapped (San Diego Natural History Museum 2019*a*). In 2020 four traps were established in the Whitewater Channel, and a total of 57 cowbirds were trapped (San Diego Natural History Museum 2020).

This report summarizes trapping efforts in the Coachella Valley in 2021. Cowbird removals at Dos Palmas Preserve have been discontinued due to low capture rates, and two traps were placed in the vicinity of the Whitewater Channel.

Methods

Cowbird Trapping

Two cowbird traps were installed and opened on 13 April 2021, near the Whitewater Channel (Table 2, Figure 1). Traps were checked and maintained on a daily basis, and were labelled with signage (Figure 2). Traps were shut down on 19 June, with all remaining birds collected or banded and released. Traps were disassembled and removed on 12 August.

Table 2. Locations of cowbird traps in the Coachella Valley, 2021.

Trap	Latitude	Longitude	Dates in operation
Whitewater Delta Trap #1 (WW1)	33.512734	-116.063309	13 Apr - 19 June
Whitewater Delta Trap #2 (WW2)	33.568267	-116.106378	13 Apr - 19 June

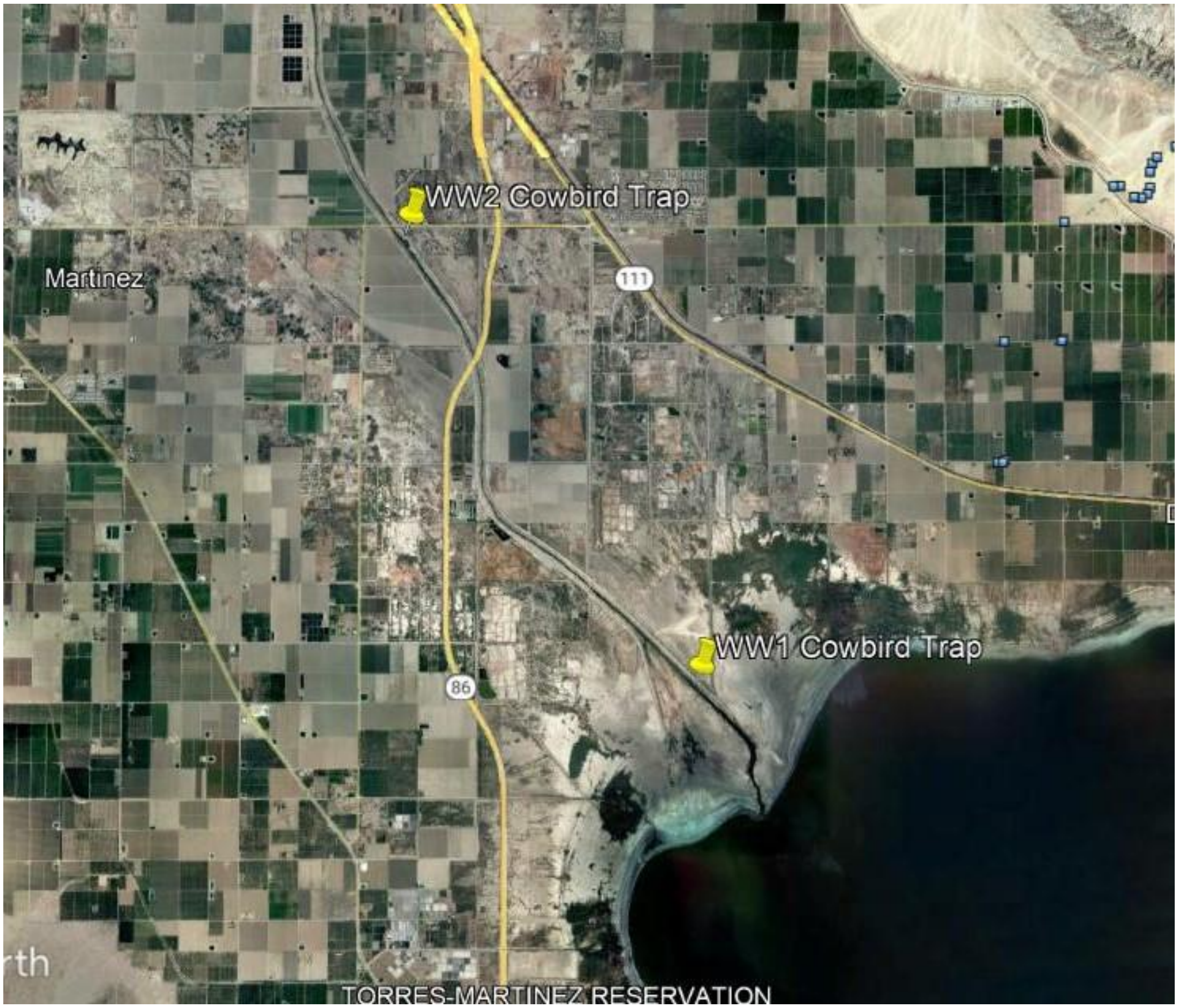

Figure 1. Locations of cowbird traps operated in the Coachella Valley in 2021.

Figure 2. Brown-headed Cowbird trap located at site WW2.

Results

Cowbird Trapping:

A total of 41 cowbirds were trapped at the two Whitewater Channel traps (Table 3). This includes 29 males, nine females, and three juveniles. The lack of juveniles captured in comparison to previous years is likely due to the earlier start and end dates of the trapping, before the bulk of juveniles have left the nests, in addition to the generally dry year which likely limited reproduction for a number of host species. The earlier trapping dates also resulted in relatively higher numbers of trapped females. Breeding females are the primary target of the trapping effort, and maximizing their numbers limits the number of parasitized nests of host birds in the region (see further discussion below).

Table 3. Summary of cowbird trapping data, Whitewater Channel, 2021. Cowbird numbers do not include recaptures.

Totals	Males	Females	Juveniles	Totals	Bycatch	Dates
WW 1						13 Apr - 19 June
collected		6	3	9		
Banded/released	18			18	2 BHGR, WETA	
Trap Total	18	6	3	27		
WW 2						13 Apr - 19 June
collected		3	0	3		
Banded/released	11			11	BHGR	
Trap Total	11	3	0	14		
Both Traps Total	**29**	**9**	**3**	**41**		

BHGR= Black-headed Grosbeak; WETA= Western Tanager.

Non-target species captured included three Black-headed Grosbeak (*Pheucticus melanocephalus*), and one Western Tanager (*Piranga ludoviciana*; Figure 3). All were safely released.

Figure 3. Western Tanager captured and released from WW1 on 17 May 2021.

In comparison with previous years, the 2021 trapping resulted in 9 female captures with only the two traps, in contrast to the four traps placed in the area during 2019 and 2020 that captured 10 and 3 females, respectively (Figure 4). This shows that a modest trapping effort timed at the appropriate period can be effective in trapping female cowbirds (Figure 5). The 2020 trapping effort began in late May and continued through July, resulting in only three female captures but 36 captured fledglings in four traps.

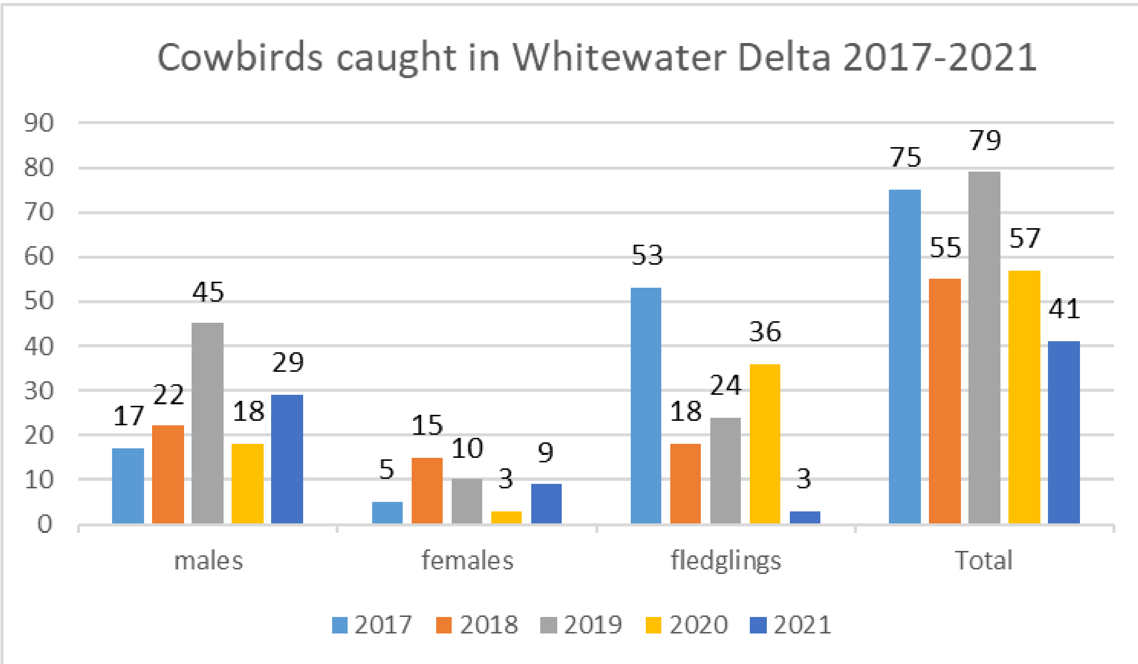

Figure 4. Brown-headed Cowbird captures by year.

Recaptured Banded Cowbirds:

Two male Brown-headed cowbirds that had been banded in previous years were captured again in the 2021 season (Table 4). Since 2017, 101 male cowbirds have been banded in the area, including 27 this year (Table 5), and twelve have been recaptured at least one year later. Nine of these have been recaptured within a few miles of their banding location, however one cowbird banded at Dos Palmas Preserve in 2017 was recaptured at the Whitewater Delta in 2019 and in 2021, a distance of 14 miles. These results demonstrate the wide-ranging nature of male cowbirds in the area, and that the entire Whitewater Delta area should be considered a single population in terms of management.

Table 4. Banded male cowbirds from previous years recaptured in 2021.

Band number	Trap	Release Date	Notes
2891-14005	WW2	5 May	First banded as adult at WW2 on 18 June 2019.
1751-48124	WW1	19 June	First banded at Dos Palmas Preserve on 13 July 2017; Recaptured at WW4 June/July 2019.

Table 5. Male cowbirds newly banded in 2021.

Band number	trap	Date	Notes
2891-14049	WW1	5 May	Adult male.
2891-14050	WW1	5 May	Adult male.
2891-14051	WW1	5 May	Adult male.
2891-14052	WW1	5 May	Adult male.
2891-14053	WW1	5 May	Adult male.
2891-14054	WW1	5 May	Adult male.
2891-14055	WW1	5 May	Adult male.
2891-14056	WW1	5 May	Adult male.
2891-14057	WW1	5 May	Adult male.
2891-14058	WW2	5 May	Adult male.
2891-14059	WW2	5 May	Adult male.
2891-14060	WW2	5 May	Adult male.
2891-14061	WW2	5 May	Adult male.
2891-14062	WW2	5 May	Adult male.
2891-14063	WW2	19 June	Adult male.
2891-14064	WW2	19 June	Adult male.
2891-14065	WW2	19 June	Adult male.
2891-14066	WW2	19 June	Adult male.
2891-14067	WW1	19 June	Adult male.
2891-14068	WW1	19 June	Adult male.
2891-14069	WW1	19 June	Adult male.
2891-14070	WW1	19 June	Adult male.
2891-14071	WW1	19 June	Adult male.
2891-14072	WW1	19 June	Adult male.
2891-14073	WW1	19 June	Adult male.
2891-14074	WW1	19 June	Adult male.
2891-14075	WW1	19 June	Adult male.

Figure 5. Female cowbird. Photo taken June 19, 2021.

Discussion and Recommendations

This is the first year since trapping began in 2017 that more adult females were captured than juveniles (9 females vs. 3 juveniles). This is likely a result of the earlier trapping effort that began on April 13, and the dry year which resulted in reduced nesting among host species. However, it may also be indicative of a declining cowbird population that is resulting in fewer successful parasitism events.

As the last survey of breeding birds in this area was accomplished in 2014, it is unclear if the trapping since 2017 is having the desired effect of increased breeding productivity and population sizes of target bird species, while reducing the overall population of cowbirds. Point count surveys would determine whether common cowbird hosts such as Common Yellowthroat and Song Sparrow are increasing, as well as sensitive breeding species including Yellow-breasted Chat, Yellow Warbler, and Crissal Thrasher. Therefore, targeted surveys of breeding birds in this area is advisable.

Recommendations

- Initiate cowbird trapping in early April again in future years in order to cover the entire breeding season and maximize adult female captures.

- Initiate targeted mist-netting of female cowbirds at sites south of Lincoln St. to increase female cowbird captures in this area, which hosts high numbers of sensitive species.
- Repeat point count surveys to compare current cowbird populations to previous levels.

Acknowledgments

Cowbird management in 2021 was conducted by Marco Combs and Kevin Clark. Susan Lienau of the Coachella Valley Water District facilitated access to the Whitewater Channel. Funding was provided through contract with the Coachella Valley Conservation Commission. Kathleen Brundige facilitated site access and overall contract management.

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Appendix A.

Avian species detected at Whitewater Channel, 13 April – 12 August 2021.	
Common Name	**Scientific Name**
American White Pelican	*Pelecanus erythrorhynchos*
Double-crested Cormorant	*Phalacrocorax auritus*
Great Blue Heron	*Ardea herodias*
Great Egret	*Ardea alba*
Green Heron	*Butorides virescens*
Bald Eagle	*Haliaeetus leucocephalus*
Osprey	*Pandion haliaetus*
Northern Harrier	*Circus hudsonius*
Gambel's Quail	*Callipepla gambelii*
American Avocet	*Recurvirostra americana*
Caspian Tern	*Hydroprogne caspia*
Mourning Dove	*Zenaida macroura*
White-winged Dove	*Zenaida asiatica*
Lesser Nighthawk	*Chordeiles acutipennis*
Common Poorwill	*Phalaenoptilus nuttallii*
Ladder-backed Woodpecker	*Picoides scalaris*
Ash-throated Flycatcher	*Myiarchus cinerascens*
Western Kingbird	*Tyrannus verticalis*
Black Phoebe	*Sayornis nigricans*
Loggerhead Shrike	*Lanius ludovicianus*
Warbling Vireo	*Vireo gilvus*
Bewick's Wren	*Thryomanes bewickii*
Verdin	*Auriparus flaviceps*
Black-tailed Gnatcatcher	*Polioptila melanura*

Avian species detected at Whitewater Channel, 13 April – 12 August 2021.	
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
Cliff Swallow	*Petrochelidon pyrrhonota*
Song Sparrow	*Melospiza melodia*
Abert's Towhee	*Melozone aberti*
Yellow Warbler	*Setophaga petechia*
Wilson’s Warbler	*Cardellina pusilla*
Nashville Warbler	*Leiothlypis ruficapilla*
Common Yellowthroat	*Geothlypis trichas*
Yellow-breasted Chat	*Icteria virens*
Blue Grosbeak	*Passerina caerulea*
Western Tanager	*Piranga ludoviciana*
Black-headed Grosbeak	*Pheucticus melanocephalus*
Bullock's Oriole	*Icterus bullockii*
Brown-headed Cowbird	*Molothrus ater*

Appendix XI. Final Report of Local Assistance Grant: Sand Dune Restoration in the Coachella Valley NCCP

Report begins on following page.

Coachella Valley Conservation Commission

June 2021

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

Final Report for Local Assistance Grant P1886005
Restoring Ecosystem Processes:
Sand Dune Restoration in the Coachella Valley NCCP

Prepared by

Coachella Valley Conservation Commission
73710 Fred Waring Drive, Suite 200
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for

California Department of Fish and Wildlife
P.O. Box 944209
Sacramento, CA 94244-2090

For the Period of May 24, 2019
through June 30, 2021

PROJECT: **Restoring Ecosystem Processes: Sand Dune Restoration in the Coachella Valley NCCP**

GRANTEE: **Coachella Valley Conservation Commission**

TERM: **May 24, 2019 to June 30, 2021**

Abstract:
The Coachella Valley Conservation Commission (CVCC) was awarded $55,320 in funding through a Local Assistance Grant from the California Department of Fish and Wildlife (CDFW). The project "Restoring Ecosystem Processes: Sand Dune Restoration in the Coachella Valley NCCP" focused on a pilot project to determine whether experimental sand dune restoration can be successful. A specific objective of this Project is to evaluate the potential to provide sand to enhance the habitat value of sand dune reserves protected under the Coachella Valley Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan (CVNCCP). The sand dune ecosystem includes several of the primary natural communities covered by the CVNCCP. Sand dunes provide essential habitat for many of the covered species, including the Coachella Valley fringe-toed lizard, Coachella Valley round-tailed ground squirrel, Palm Springs pocket mouse, and Coachella Valley milkvetch. These sand dune areas have experienced declining input of blow sand as a result of development. This experimental restoration, a pilot project, evaluated whether clean blow sand removed from local roadways as part of street sweeping operations can be deposited upwind of a sand dune to enhance the habitat. The implementation of this project as a pilot or "proof of concept" focused on the Stebbins Dune site. Stebbins Dune was selected because the natural aeolian flow of sand has been severed, and it had been previously degraded by recreational off-road vehicle trespass. Sand was loaded into dump trucks from various locations and deposited at the northwest end of Stebbins Dune where it can be transported by the wind into the dune habitat. The CVCC, the implementing agency for the Coachella Valley Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan (CVNCCP), worked with partner agencies including the Coachella Valley Water District (CVWD), the City of Rancho Mirage (a local permittee under the CVNCCP), and CDFW to implement this project. Grant agreement P1886005 between CDFW and CVCC was entered into on May 24, 2019. The term of this agreement was May 24, 2019, through June 30, 2021. This report covers the entire term of the project. The project area is within the Willow Hole Conservation Area of the CVNCCP. Significant delays in the project resulted from the COVID-19 pandemic and shelter-in-place orders.

Project Summary:
Prior to the 1950s, the dominant landscape feature of the Coachella Valley floor was aeolian sand fields. Once covering over 100 square miles, these aeolian sand communities included plant and animal associations that were often restricted to these habitats, and for many species, found nowhere else on earth. Six of the 27 species covered under the CVNCCP occur within the sand dune ecosystem, 95% of which has been lost or altered due to residential and resort developments within the Coachella Valley. These sand dune-associated species include the Coachella Valley fringe-toed lizard, Coachella Valley round-tailed ground squirrel, Palm Springs pocket mouse, and Coachella Valley milkvetch. Conservation and persistence of the sand dune ecosystem is a critical goal of the CVNCCP.

Ongoing natural sand delivery is a critical ecosystem process for maintaining the aeolian sand landscape for those species dependent on these habitats, and the CVNCCP reserve system design captured what remained of the sand transport corridors. Nevertheless, despite the successful efforts to acquire and protect these habitats, all of the protected sand dune habitats have sand transport corridors that are compromised to some degree. The purpose of this experimental restoration, a pilot project, was to determine whether experimental sand dune restoration could be successful, by bringing in new sand.

Protection of the sand transport system as an ecosystem process is a major feature of the CVNCCP. Stebbins Dune provides an example of the challenges that CVCC's ongoing biological monitoring program have identified for various reserve sites that are part of the sand dune ecosystem in the Coachella Valley. Stebbins Dune was so named because it was the circa 1940s study site of Dr. Robert C. Stebbins, who did pioneering research on Coachella Valley fringe-toed lizards there. Stebbins went on to author the Peterson Field Guide to Western Reptiles and Amphibians, still the premier field guide to western North American herps. Figure 1 shows the historical and current areas where sand is deposited as a result of waterborne (fluvial) and wind-borne (aeolian) transport. As development has increased and interrupted the sand transport processes in some locations, the amount of sand being delivered to these dune areas has declined. In some cases, the dunes are "sand starved" as the amount of blow sand is reduced, impacting the value of the habitat for species such as the Coachella Valley fringe-toed lizard. The location of Stebbins Dune is shown, with the aeolian transport zone at the northern end of the dune area. This is the area where sand was deposited through this project.

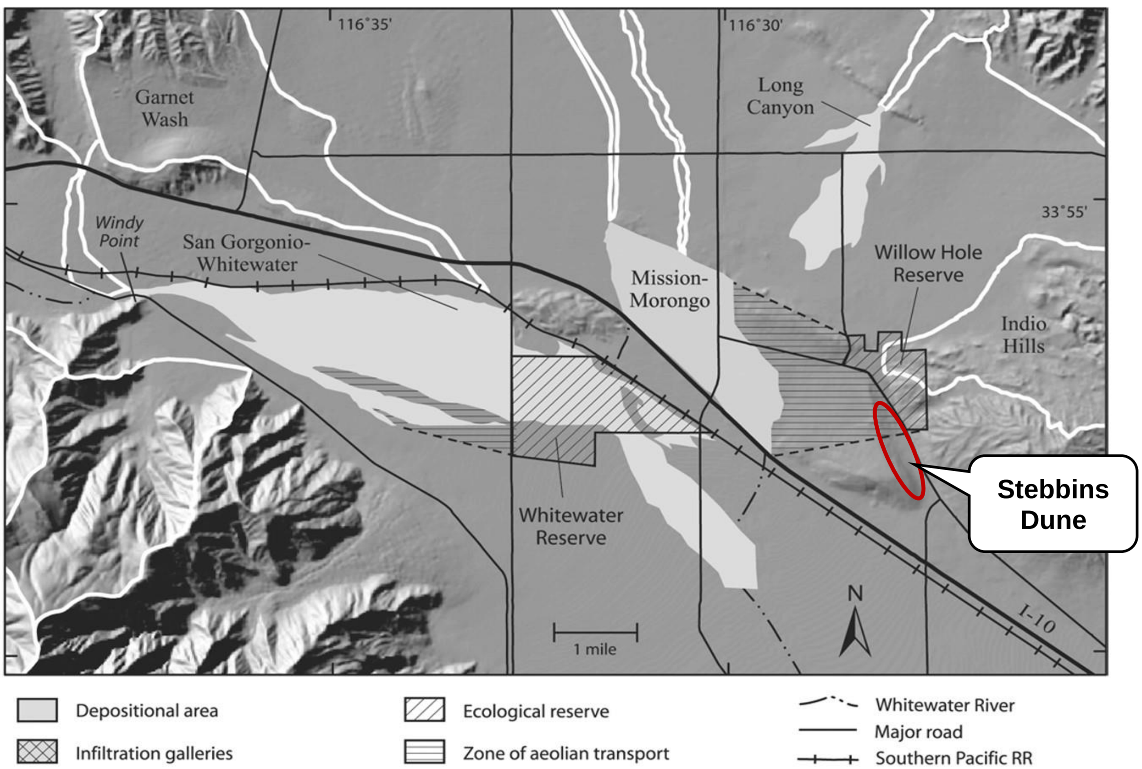


Figure 1. Shaded relief map showing the location of the historic and current areas of fluvial deposition for the San Gorgonio – Whitewater River, Mission Creek – Morongo Wash, and Long Canyon drainages. White lines indicate drainage boundaries. Location of Stebbins Dune is shown with respect to zones of aeolian transport and fluvial deposition areas. From *Long-term sand supply to Coachella Valley Fringe-toed Lizard Habitat in the Northern Coachella Valley, California.*[1]

In areas where blow sand is not being deposited at the levels seen in the past, parts of the dune habitat become armored. This occurs when blow sand is not replenished by natural processes and a crust forms, making some patches undesirable for the fringe-toed lizard. The fringe-toed

[1] P. Griffiths, R. Webb, N. Lancaster, C. Kaehler, and S. Lundstrom. 2002. *Long-term sand supply to Coachella Valley Fringe-toed Lizard Habitat in the Northern Coachella Valley, California.* U.S. Geological Survey, Water-Resources Investigations Report 02-4013.

lizard escapes predators and the heat by burrowing into loose, uncompacted sand. Figure 2 shows a patch of compacted sand on Stebbins Dune. Bringing in new sand is intended to add more of the desirable loose, uncompacted sand to these patches.

Figure 2. Area of Stebbins Dune illustrating loss of blowsand preferred by the Coachella Valley fringe-toed lizard and other covered species. In areas where the natural supply of sand from aeolian and fluvial transport has been reduced, sand becomes armored and stabilized, reducing its viability as habitat. Restoration of blowsand is the goal of the project.

The goal of the project was to determine if sand transport could be re-established with clean blow sand collected from roadways and deposited upwind of a sand dune site to enhance the habitat value. Through a partnership with the Coachella Valley Association of Governments (CVAG), which carries out a regional street sweeping program, sand was collected from locations where it otherwise would blow onto roadways. CVAG's regional street sweeping program focuses on control of an air pollutant, PM10 (particulate matter of less than 10 microns). PM10 in the Coachella Valley comes from dust-generating activities, including vehicles traveling over paved or unpaved streets, and construction. In a secondary effect, sand deposits on road surfaces (blow sand) are ground into PM10 by moving vehicles and resuspended in the air as manmade PM10. Street sweeping is one of the primary air quality control measures to reduce PM10. In areas where wind-blown sand is deposited on or adjacent to roadways, street sweepers collect the sand and deliver it to Desert Recycling, a local business that then uses the sand for fill and other purposes. Through this project, the sand was collected from roadways and instead transported to Stebbins Dune where it was deposited upwind of the dune habitat areas, to restore blow sand conditions to the site. Sand was obtained with the assistance of the City of Rancho Mirage, a member of the CVCC.

The project funding was used to cover the cost of transporting sand from various locations and depositing it on the Stebbins Dune reserve where it will be allowed to blow across the landscape, enhancing the habitat value. This pilot project determined that sand could be obtained from street sweeping operations and delivered to the sand dune restoration site. To assess the effectiveness of sand dune restoration, species and habitat monitoring was completed on an ongoing basis at Stebbins Dune as part of the overall CVNCCP annual monitoring of sand dune species including the Coachella Valley fringe-toed lizard. The pre-monitoring of the Stebbins Dune restoration site was completed in 2019 and 2020 to document pre-sand delivery. The monitoring data pre- and post-delivery of sand will allow CVCC to continue to assess the changes to species and habitats within the sand dune ecosystem over time.

<u>Project Implementation and Task Summary</u>:
This section of the report provides a summary of the activities involved in project implementation and a review of the individual tasks that were set forth in the grant agreement. This report summarizes the activities completed by the CVCC as part of the LAG Project P1886005, *Restoring Ecosystem Processes: Sand Dune Restoration in the Coachella Valley NCCP*. The grant agreement between CDFW and CVCC was signed on May 24, 2019, and the Acknowledgement of Work Commencement Authorization Disclaimer was signed by the CVCC Executive Director on May 17, 2019. This report covers the entire term of the project, from May 24, 2019, to June 30, 2021.

The grant agreement P1886005 between CDFW and the CVCC was amended in September 2020 to extend the term and end date for the project from March 31, 2021 to June 30, 2021. This extension was provided to allow completion of the project given the delays resulting from impacts of the COVID-19 pandemic. Preliminary work in the fall of 2019 focused on establishing agreements with various project partners including UC Riverside (UCR) Center for Conservation Biology and discussing options for collecting and cleaning sand with Desert Recycling. The shelter-in-place orders in March 2020 and other necessary provisions of the health and safety requirements in response to the pandemic halted progress on the project. In-person meetings and site visits to review the potential options for sand collection and cleaning were not possible. One specific task, Task 3, was to complete analysis of sand for contaminants. The intent was for this analysis to be completed through an agreement with UCR. Due to COVID-19 restrictions, laboratory facilities at UCR were unavailable through 2020 and into mid-2021. Ultimately it was determined that this task could not be completed during the project term as described in the following task summary. As a result of the pandemic, very limited progress was made on the project during much of 2020 and early 2021.

CVCC staff were responsible for project coordination including establishing agreements with project partners, locating sources of clean blow sand, and coordinating monitoring before and after delivery of sand to the Stebbins Dune site. The following summary describes the various project tasks listed in the project agreement:

<u>Task 1</u>: Project Management and Administration. The initial steps in the project were to establish agreements with the various partners involved in this project. A contract between CVCC and UCR, Center for Conservation Biology, is in place with the sand dune restoration project identified as a task for the UCR team of biologists. It was anticipated that M&M Street Sweeping, the company that is under contract with CVCC's sister agency, the CVAG, to pick up sand as part of a regional street sweeping program, would assist with sand collection. The sand they collect is delivered to Desert Recycling where it could be available for this project. It was later determined that Desert Recycling could collect the sand directly and deposit it at the restoration site. A written agreement between CVCC and Desert Recycling was executed by both parties. Another necessary agreement was with the CVWD to allow access to the west end of Stebbins Dune via a road to one of their reservoirs. An encroachment permit from CVWD was obtained, giving CVCC permission to use their road which was accessible through a locked gate. A fee was required to cover the costs of CVWD personnel opening and closing the gate. CVWD also required a certificate of insurance from CVCC. An agreement was also developed with the City of Rancho Mirage which assisted in the collection of sand from roadway areas within their city, using their equipment to load sand into dump trucks for delivery to the restoration site. Permission was also obtained from a shopping center in Rancho Mirage, Monterey Marketplace, for sand picked up adjacent to one of their parking lots; a certificate of insurance was also provided to the management company for the shopping center. Finally, the matching funds provided by CVCC were included in CVCC's Fiscal Year 2020/2021 budget.

Task 2: Sand collection and processing/cleaning, if needed: As described in prior quarterly reports, before sand was deposited on the restoration site, an evaluation needed to be completed to determine if the quality of the sand is suitable for the sand dune site. CVCC and UCR staff met with Desert Recycling representatives at their site where sand and other materials are collected on March 12, 2021. This is a critical step to ensure that the transported sand is suitable for providing clean sand of the appropriate particle size for fringe-toed lizard habitat. As it turned out this step resulted in identifying a lack of a common understanding of what constituted suitable sand. Desert Recycling receives the sand collected through the Coachella Valley regional street sweeping program and has the equipment to filter and clean the sand. Sand that had been collected from street sweeping operations had been mixed with organic materials. While the sand had been cleaned and filtered to remove any unwanted coarse material (trash, vegetation, leaves, branches), it was of an inappropriate particle size (too small) and included a high component of fine organic material, rendering it a darker grey color rather than the clean white sand needed for this project. The dark grey color would have made the lizards such as the Coachella Valley fringe-toed lizard and other animals more susceptible to predation from visual predators such as loggerhead shrikes and greater roadrunners. These lizards' light coloration provides a high level of camouflage on the white blowsand typical of their habitat. The darker sand color could also alter the thermal characteristic of the sand, potentially reducing foraging time for the lizards (making it too hot). Additionally, the too fine particle size may have prevented the lizards from breathing when buried in the sand (fine particles entering their lungs). Clearly It would not work for the restoration site. Unfortunately, the outcome resulted in additional delays as it became necessary to seek other sources of clean blowsand. The cleaning equipment used by Desert Recycling also became unavailable.

An alternative sand source was required. Several Coachella Valley cities collect blowsand from their roads and CVCC staff reached out to them. The city of Rancho Mirage had several locations where clean blow sand accumulates on the sides of the roadways and other locations. Their public works crews regularly clear the sand and deposit it on empty lots owned by the city. CVCC staff arranged to have the city crews pick up this sand and load it into a 10 cubic yard dump truck from Desert Recycling to be delivered to Stebbins Dune. The sand collected from these roadway areas was clean, as it was picked up during the spring windy season, after wind events.

Task 3: Analysis of sand for contaminants: The original intent for this project was to send sand samples to UCR where they would be analyzed for contaminants. Due to the COVID-19 restrictions, activity in laboratories at UCR is very limited and has not been available for this service. Based on current restrictions, the laboratory analysis will not be conducted. As noted in the last quarterly report, sand collected on streets is usually from recent wind events. The sand received by Desert Recycling through street sweeping operations is blow sand that is removed soon after it is deposited from Coachella Valley roads and screened to remove unwanted material, and it is generally clean. Previous tests by Desert Recycling for other purposes have found the sand to be clean and generally free of contaminants. The sand obtained in Rancho Mirage was also clean blow sand.

Task 4: Delivery of sand to restoration site: The most favorable time for delivery of sand to the restoration site at Stebbins Dune is during the windy season in the Coachella Valley, which is generally from mid-February into June.

The access road for the sand deliveries is located on CVWD property adjacent to the Stebbins Dune restoration site which is on land owned by the CVCC. The location of the delivery site is shown in Figure 3. For each delivery, CVWD inspectors needed to unlock the gate for the delivery trucks.

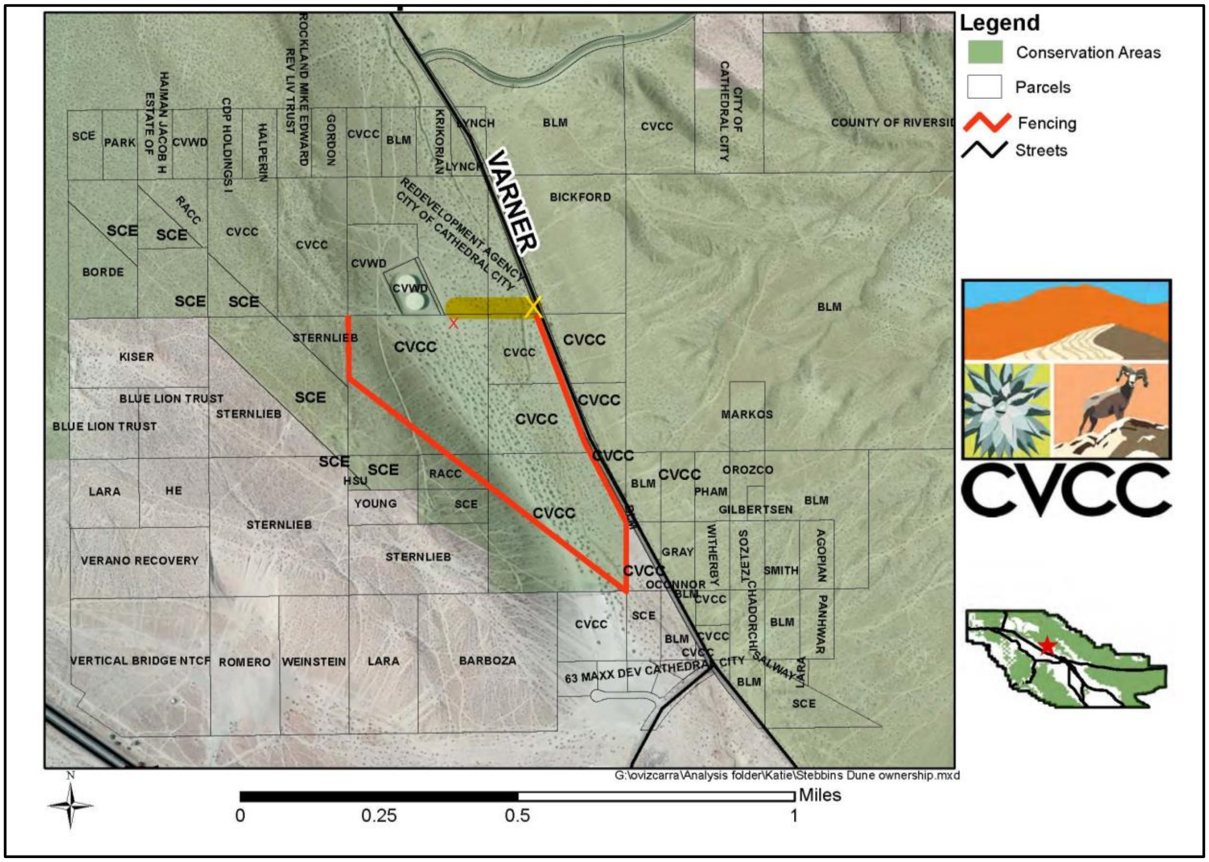
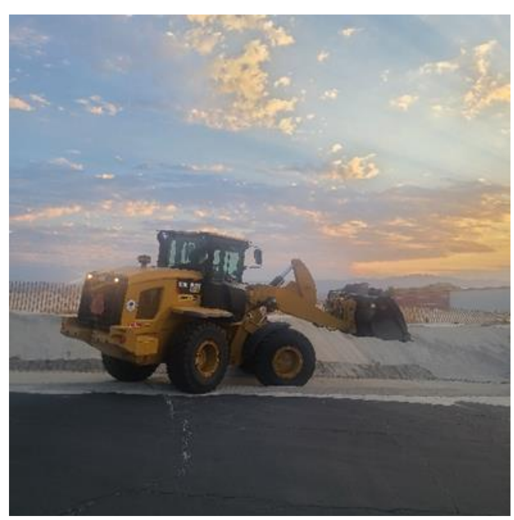


Figure 3. Location of Stebbins dune within the Willow Hole Conservation Area of the Coachella Valley Natural Communities Conservation Plan. The properties labeled "CVCC" are owned by the Coachella Valley Conservation Commission. A post and cable fence surrounds the properties to limit access by off-highway vehicles and dumping. Access to the site where sand was deposited, shown by red 'X', is via a dirt road through a locked gate across Coachella Valley Water District (CVWD) property

As noted under Task 2, the expected deliveries of sand to the restoration site at Stebbins Dune using sand collected from street sweeping operations by Desert Recycling did not occur; sand contaminated with other materials resulted in a dark grey color that was not acceptable. Alternate arrangements for a source of sand and the means to have it picked up and delivered were made with the City of Rancho Mirage. The city graciously provided their loader to pick up sand at various locations and load it into the two dump trucks used for delivery. The first delivery of sand was on May 20, 2021, with subsequent deliveries in late May and June. Two dump trucks, a ten cubic yard truck provided by Desert Recycling and a five cubic yard truck provided by Rancho Mirage, were used to transport the sand and dump it at the west end of Stebbins Dune. Deliveries started early in the morning and continued until all the



sand from a given collection site had been dumped at Stebbins Dune. Sand was collected from various locations including along Dinah Shore Drive and adjacent to a parking lot at Monterey Marketplace.

Additional deliveries have continued during May and June, with the plan to deliver as much sand as available before the project closes on June 30, 2021. At the Stebbins Dune restoration site, sand was deposited at the west end of the habitat area (see Figure 4), so prevailing winds from the northwest would pick it up and move it across the dune. Biologists from UCR inspected the site prior to sand delivery and placed posts to delineate the area where the sand should be deposited. Clearance surveys prior to sand delivery were conducted by UCR biologists under the existing contract with CVCC. To date, approximately 50 cubic yards of sand have been deposited at Stebbins Dune. Images of the sand collection and delivery are shown in Figure 5.

Figure 4. Location of sand deposits at west end of Stebbins Dune.

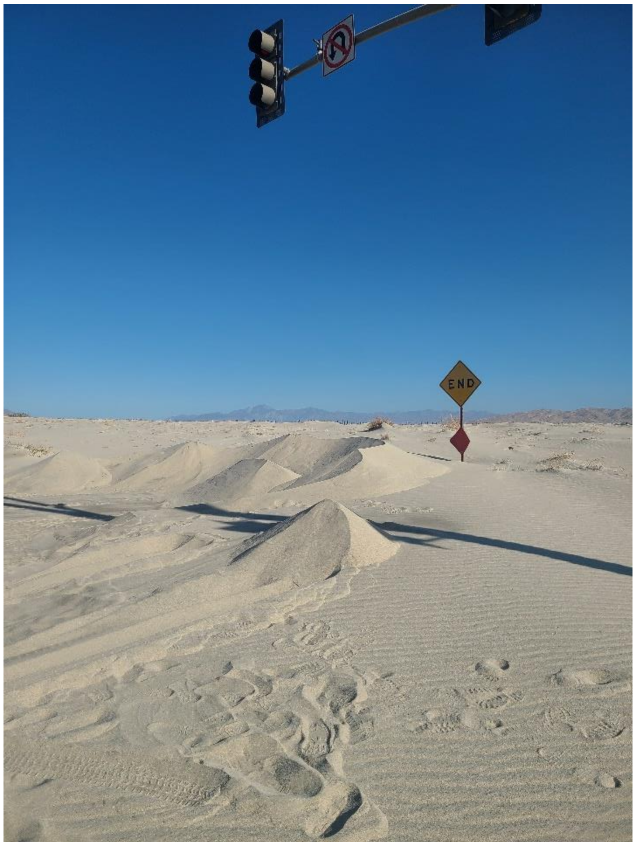


Photo 1

Photo 2

Photo 3

Photo 4

Photo 5

Figure 5. Sand collection at various locations in Rancho Mirage. Photos: 1- Accumulated blow sand along Dinah Shore Dr. in Rancho Mirage before collection; 2 – blow sand at edge of parking lot, Monterey Marketplace; 3 – dump truck ready for sand to be loaded; 4 – loader dropping sand in dump truck; 5 – sand deposited at restoration site.

<u>Task 5</u> - Species and habitat monitoring, pre- and post-sand delivery: Species and habitat monitoring is conducted on an ongoing basis at this site as part of the overall CVNCCP monitoring of sand dune species including the Coachella Valley fringe-toed lizard. The pre-monitoring of the Stebbins Dune restoration site was completed in 2019 and 2020 to document pre-sand delivery. Biological monitoring of sand dune sites including the Stebbins Dune restoration site was delayed during the spring of 2021 due to high winds. Monitoring of the Coachella Valley fringe-toed lizard is done when temperatures are warm enough for them to be active; temperatures in the 100-degree range can occur in April through May/June. Monitoring of arthropods including the Coachella Valley giant sand-treader cricket and plant species was also completed in late April/early May. Monitoring is completed by July 1 of each year as temperatures in July and August are often extreme.

One of the variables that is monitored at Stebbins Dune and other sand dunes is sand compaction. Coachella Valley fringe-toed lizards depend on the availability of loose, non-compacted sand to escape predators and extreme temperatures on the surface. The UCR monitoring team uses a sand penetrometer to assess the relative sand compaction, measured in kg/cm^2 at the various sand dunes in the CVNCCP reserve system. Figure 7 shows fringe-toed lizard abundance relative to sand dune compaction at these sand dunes, including Stebbins Dune. As sand becomes more compacted, lizard abundance decreases. While fringe-toed lizards occur at Stebbins Dune, their abundance is low compared to other sites. Monitoring of fringe-toed lizards and other species will continue beyond the term of the project to assess whether the influx of new sand will enhance the habitat and increase lizard abundance.

Figure 6. First deposit of sand at Stebbins Dune in May 2021.

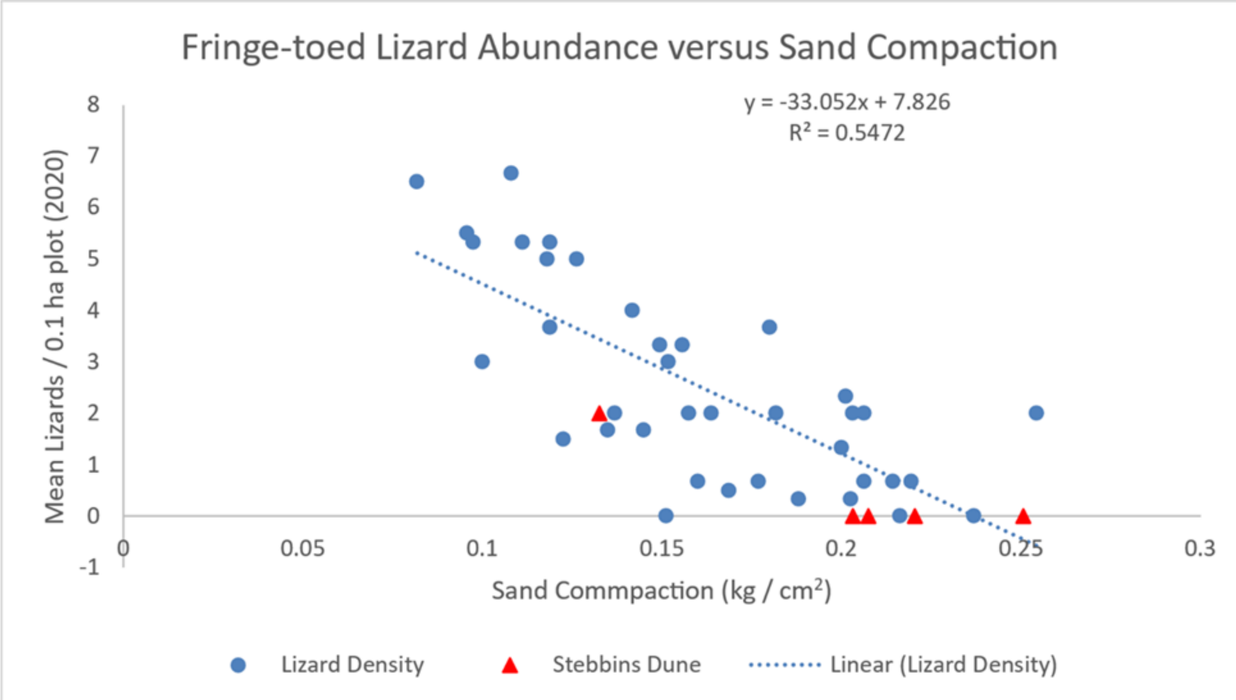


Figure 7. Abundance of the Coachella Valley fringe-toed lizard related to sand compaction on various sand dune habitats within the Coachella Valley. Lizard abundance declines as sand compaction increases. The red triangles identify monitoring plots on Stebbins Dune, indicating the low abundance of fringe-toed lizards as sand compaction increases.

Figure 8. Fringe-toed lizard tracks on piles of sand deposited at Stebbins Dune.

<u>Task 6</u> - Data analysis and report preparation: This final report summarizes the progress made on the various tasks identified in the grant agreement. Due to the delays that affected implementation of this project, delivery of sand was completed near the end of the project period. Additional data analysis from monitoring activities completed in spring 2021 is being analyzed and will be included in a final report. Additional monitoring and data analysis will be completed by CVCC following the end of the grant term with a full report to be provided to CDFW by fall 2021.

<u>Conclusion</u>:
This pilot project evaluated the efficacy of sand delivery and assessed the changes to species and habitats within the sand dune ecosystem. The success of the project is based on completion of the following:

1. Monitoring data for Coachella Valley fringe-toed lizard indicated that Stebbins Dune is "sand starved," resulting in areas of sand compaction unsuitable for this species.
2. A process for obtaining clean blowsand adjacent to roadways in the Coachella Valley was tested and found to be feasible.
3. Clean blowsand was transported from various locations and deposited on the Stebbins Dune site where it will be allowed to blow across the landscape, enhancing the habitat value.
4. Monitoring will continue in 2021 and 2022 to assess the effectiveness of sand delivery as a means to enhance the habitat for sand dunes species.

This effort to re-establish aeolian sand transport into a sand-starved habitat is not a "one and done" task; rather, this will need to be ongoing. We were able to secure what should be a seasonally continuous sand supply and delivery system and develop agreements with municipal road cleaning efforts that are mutually beneficial. In so doing we have demonstrated a successful "proof of concept" for the restoration and ongoing maintenance of critical habitat for California State Endangered species and species covered by the CVNCCP.

Figure 9. New aeolian sand deposits on Stebbins Dune from recently trucked in sand.