2022 Annual Report

Coachella Valley Multiple Species Habitat Conservation Plan
Natural Community Conservation Plan

April 2023

CVCC

Contents

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CVCC

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INTRODUCTION

This Annual Report describes the progress made on implementation of the Coachella Valley Multiple Species Habitat Conservation Plan (CVMSHCP or Plan) for the 2022 calendar year. Acquisition of key properties continued, with 3,560 acres added to the reserve system to protect habitat for our desert plants and animals. The Coachella Valley Conservation Commission (CVCC) acquired 3,470 of those acres, including 2,900 acres through the largest single acquisition in the organization's history. CVCC has made significant progress since the Plan's inception, with over 103,000 acres conserved in just 15 years. Authorized disturbance in Conservation Areas remains infrequent: only 30 acres in 2022, and just under 450 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, Cholla cactus, and the little San Bernardino 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 acquired a drone which has been used to capture aerial photographs of parcels that have been difficult to access or survey. These photos have been used to document illegal dumping, off-roading, and invasive species presence on CVCC lands while reducing demand on staff time. 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 in Mecca in the Stormwater Channel and Delta Conservation Area as well as fountain grass from properties in the Big Morongo Canyon/Upper Mission Creek Conservation Area. CVCC also executed contracts with the Desert Recreation District (DRD) to repair and maintain habitat fencing in vulnerable properties and the Southern California Mountains Foundation Urban Conservation Corps (UCC) to eradicate invasive species in the Stormwater Channel and Delta Conservation Area.

Behind the scenes, CVCC spent significant time auditing internal records of both its acquisitions on behalf of its local Permittees as well as its database of proposed development projects within Conservation Areas. These audits have resulted not only in improved precision in CVCC's conservation progress and authorized disturbance tracking, but also in the creation of more functional data structures that will serve as the foundation of new workflow automation processes and public-facing web applications planned for development over the course of 2023. Nonetheless, these audits did uncover some errors in record keeping, the correction of which may be reflected in the charts and tables throughout this report.

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 CVMSHCP – a joint Habitat Conservation Plan/Natural Community Conservation Plan – is a multi-agency 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 delineated primarily by the watersheds that feed into the Salton Sea. It offers a streamlined development permitting process to its member agencies in exchange for land conservation in priority habitat areas. 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 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 the Coachella Valley Association of Governments (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 CVMSHCP Reserve System.

This Annual Report describes the activities for the calendar year from January 1, 2022 to December 31, 2022. As required by Section 6.4 of the CVMSHCP, this Annual Report will be presented at the CVCC meeting of April 13, 2023, which will serve as a public workshop. The report is also posted and available to the public on the CVMSHCP website, www.cvmshcp.org.

RESERVE ASSEMBLY PROGRESS

As of December 31, 2022, Permittees have conserved 17,377 acres, just over 17% of their conservation goal (Figure 1). State and federal conservation has reached 29,313 acres, or 74% of their required contribution, and complementary conservation has accounted for 56,484 acres, about 82% of the anticipated acreage. Since 1996, 103,270 acres have been conserved under the CVMSHCP, with the assembly of the Reserve System about 49% complete (Table 1, Figure 2). A description of how CVCC allocates acreage credit is included in Appendix I.

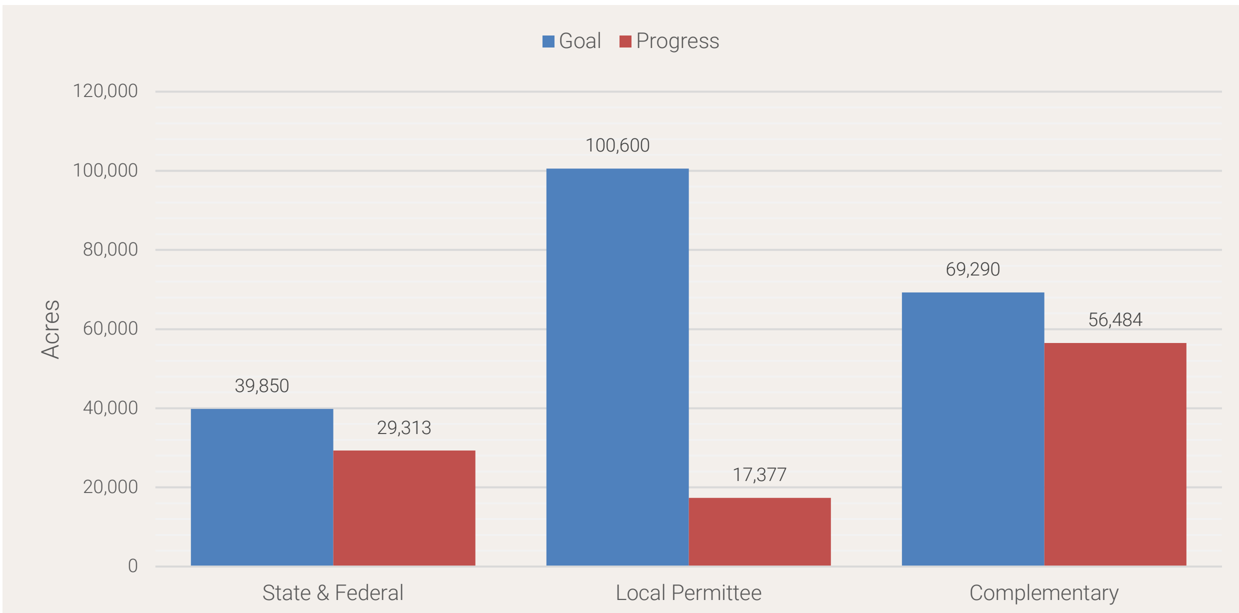

Figure 1: CVMSHCP conservation progress towards conservation goals.

Table 1: Summary of annual progress on Reserve System assembly.

Report Year	*State & Federal Credit Acres*	*Local Permittee Credit Acres*	*Complementary Credit Acres*	*Total Acres*
2013	25,310	7,716	49,353	82,379
2014	1,291	241	1,417	2,949
2015	300	350	1,127	1,778
2016	319	827	613	1,759
2017	446	793	1,699	2,938
2018	711	584	908	2,203
2019	747	422	40	1,209
2020	0	2,125	202	2,326
2021	128	849	1,096	2,073
2022	60	3,470	30	3,560
Acquisition Credit	29,313	17,377	56,484	103,174
Management Credit	54,186	24,967	24,020	103,174

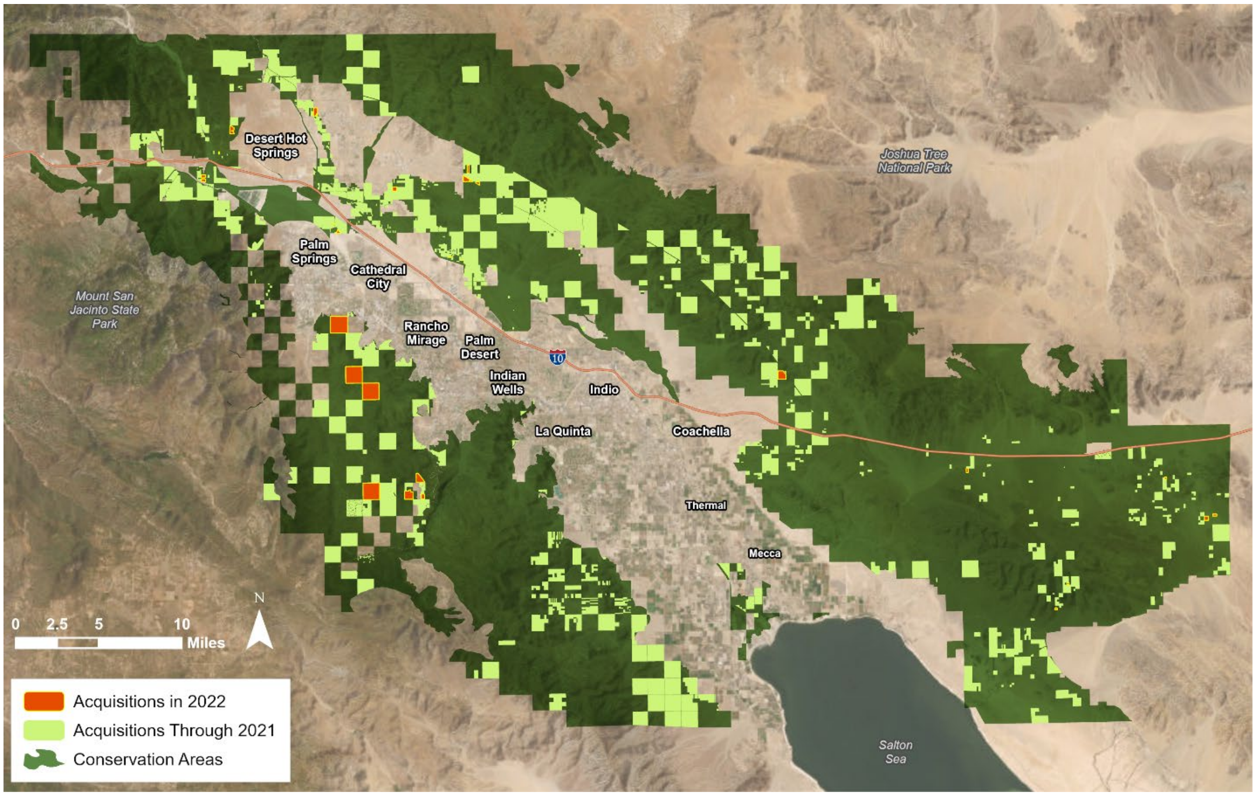

Figure 2: CVMSHCP reserve assembly status, including 2022 acquisitions.

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 CVCC 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.

Land Acquisition to Achieve the Conservation Goals and Objectives

In 2022, CVCC completed 14 transactions acquiring 24 parcels totaling 3,470 acres at a cost of $7,568,023 in CVCC funds, and including one property worth $295,000 donated in accordance with a Joint Project Review requirement (Table 3). Notable among these acquisitions is the Palm Hills project, the largest single acquisition in CVCC history. CVCC coordinated with conservation partners Oswit Land Trust to acquire over 3,000 acres across the City of Palm Springs and County of Riverside; 2,900 acres are located with the Santa Rosa and San Jacinto Mountains Conservation Area. Additional CVCC acquisitions on behalf of local Permittees took place within the Desert Tortoise and Linkage, Edom Hill, Highway 111/I-10, Thousand Palms, Upper Mission Creek/Big Morongo Canyon, Whitewater Canyon, and Whitewater Floodplain Conservation Areas (Figure 3). Local, state, and federal partners acquired an additional 90 acres in the Mecca Hills/Orocopia Mountains Conservation area, for a total of 3,560 acres in nine different Conservation Areas (Figure 4). All lands conserved by CVCC and partner organizations during the period from January 1, 2022 to December 31, 2022 are depicted in Figure 2 and listed in Appendix II.

Table 2: Lands acquired by CVCC in 2022.

Project	Conservation Area	Parcel Count	Project Acreage	Acquisition Cost
Arabian	Desert Tortoise and Linkage	1	146	$66,000
Lynch	Desert Tortoise and Linkage	1	20	$25,000
George	Edom Hill	1	39	$540,000
Suitt	Highway 111/I-10	2	55	$239,000
Palm Hills	Santa Rosa and San Jacinto Mountains	7	2,899	$5,258,233
Scicli	Thousand Palms	1	2	$50,000
Setty Trust	Thousand Palms	1	5	$189,540
Flitt	Upper Mission Creek/Big Morongo Canyon	1	5	$23,000
Shepherd	Upper Mission Creek/Big Morongo Canyon	2	75	$555,000
Terra Gen	Upper Mission Creek/Big Morongo Canyon	1	66	$0*
Kimport-Van Villet	West Deception Canyon	1	40	$40,000
Kading	West Deception Canyon	3	91	$423,040
Mullen	Whitewater Floodplain	1	5	$29,210
W & L Properties	Whitewater Floodplain	1	22	$130,000
Total		**24**	**3,470**	**$7,568,023**

* Donated parcel valued at $295,000.

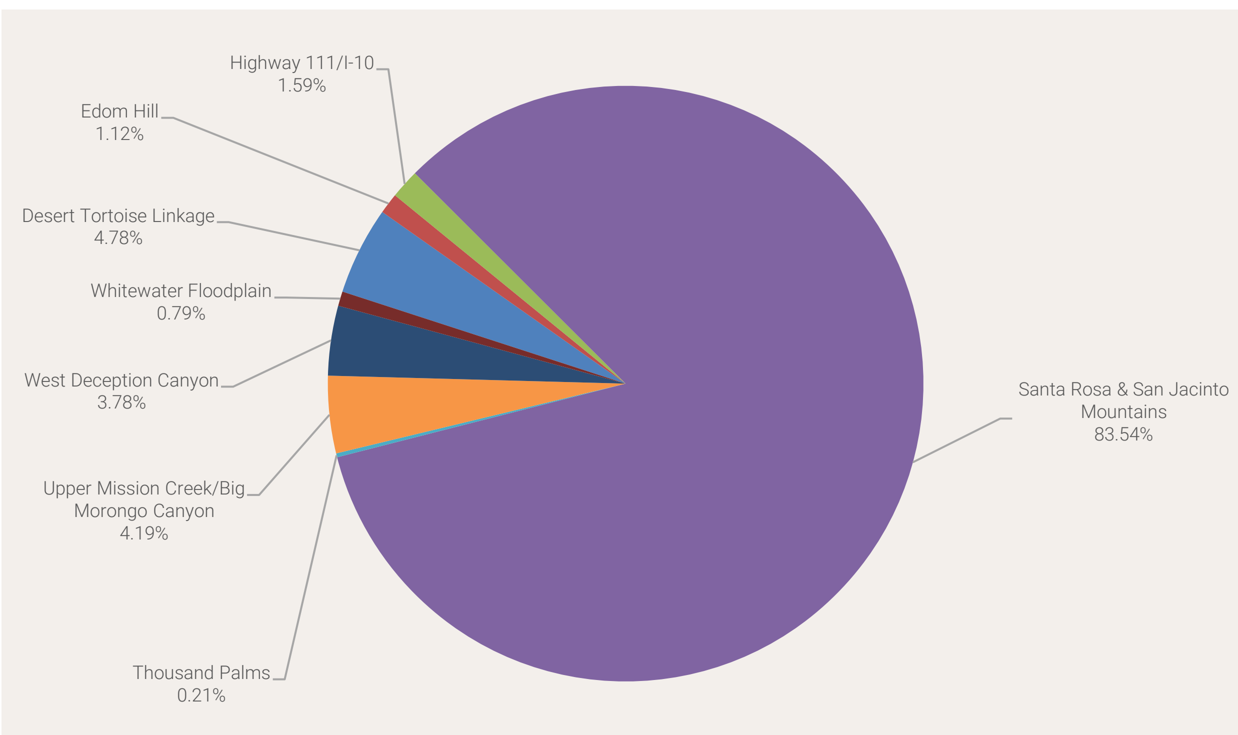

Figure 3: CVCC acquisitions in 2022 by Conservation Area as a proportion of total acreage acquired.

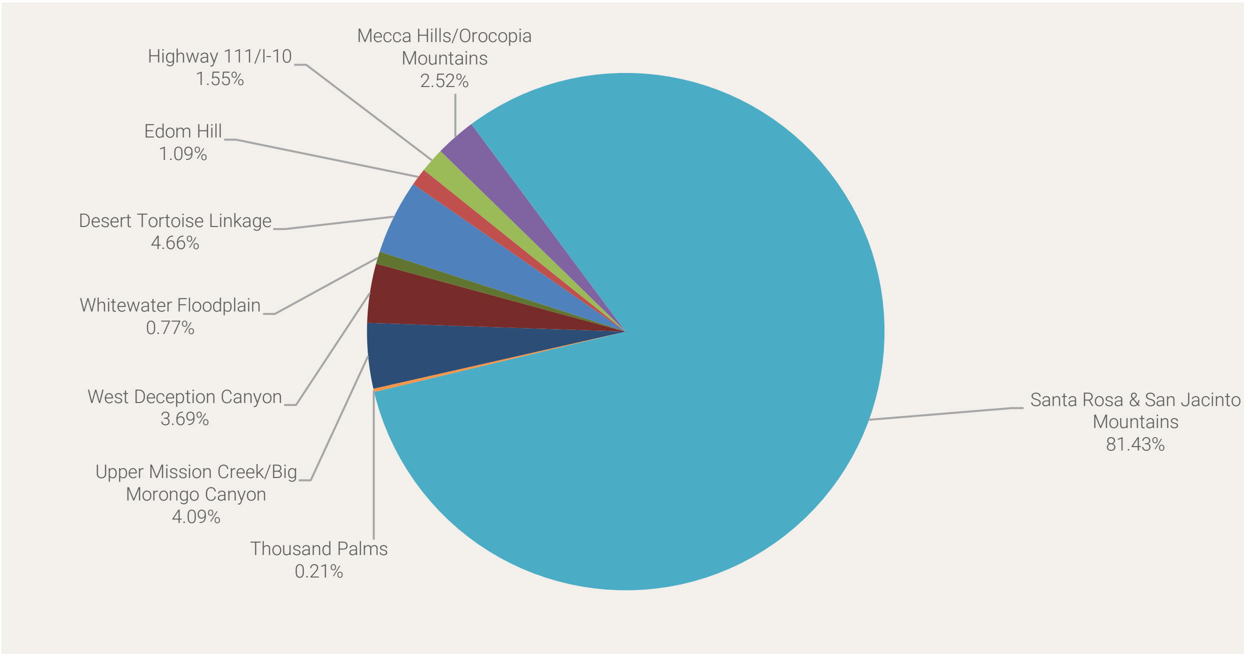

Figure 4: Total acquisitions in 2022 by Conservation Area as a proportion of total acreage acquired.

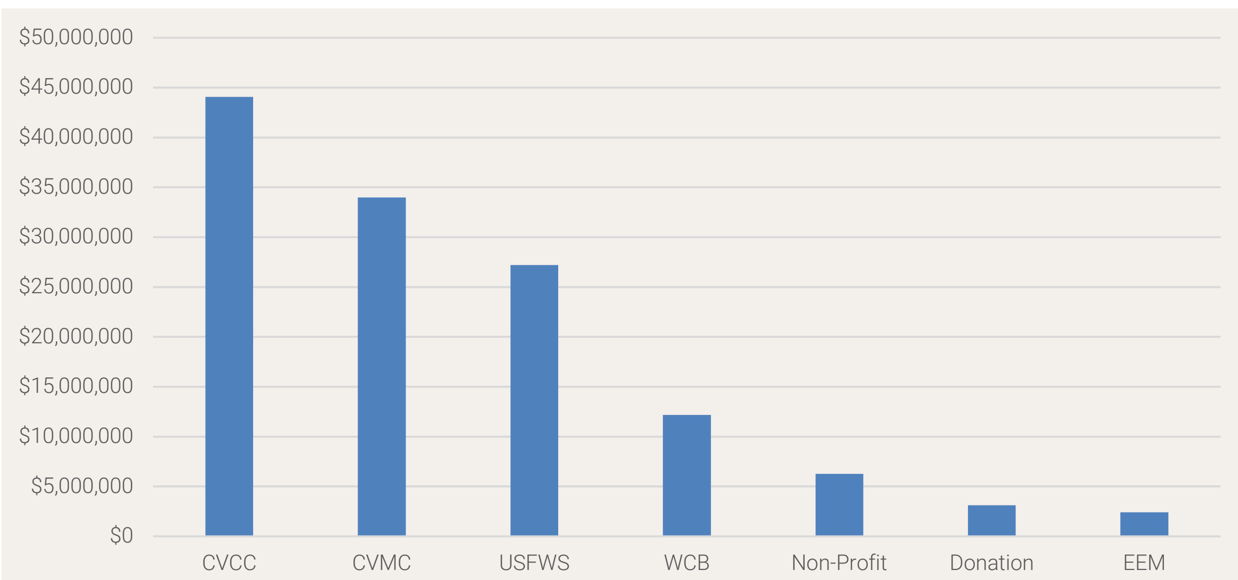

Figure 5: Cumulative acquisition funding per source.

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 (CVMC) 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 (FODM) has acquired lands using grants from CVMC, private donations, and other sources; many of these lands have been transferred to CVCC. In 2022, CVMC provided $20,000 in land acquisition funding, and FODM contributed an additional $9,000 in funding.

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, 2022 (Table 3) In certain cases, disturbance may be permitted by the CVMSHCP but not accrue against the authorized disturbance for a given Conservation Area. These cases include disturbance where the only conservation objective is to maintain fluvial sand transport processes, disturbance incurred as part of a Covered Activity, and disturbance allocated to Participating Special Entities. For the latter two instances, disturbance is allocated directly from the CVMSHCP permits. In 2022, there were 30 acres of authorized disturbance permitted across three Conservation Areas. These disturbances included groundbreaking for a wind energy conversion system in the Stubbe and Cottonwood Canyons and Whitewater Canyon Conservation Areas, and closure of two code compliance cases for previously unauthorized storage yards in the Thousand Palms Conservation Area. To date, less than 450 acres of disturbance have been authorized within the Reserve System boundaries. As previously discussed, 3,560 acres of conservation were recorded.

Status of Covered Species

Covered Species are being adequately conserved under the CVMSHCP, as detailed in Appendix III. Other Conserved Habitat for the Coachella Valley Jerusalem Cricket within the Riverside County portion of Upper Mission Creek/Big Morongo Canyon had previously been overdeveloped following implementation of a wind energy conversion system; however, CVCC finalized the purchase of five acres of Jerusalem Cricket habitat in January 2023 to bring this objective back into compliance with the Rough Step proportionality metric.

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. 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, estimated development acreages between 1996 and 2016 were derived from the Developed area of the California Department of Conservation, Division of Land Resource Protection, Farmland Mapping and Monitoring Program GIS coverages from 1996 and 2016[1]. The coverages provided by the Farmland Mapping and Monitoring Program have not been updated since 2016, and so CVCC has instead utilized imagery provided by the Sentinel-2 10-meter Land Use/Land Cover Time Series[1] for the period between 2017 and 202. The acre figures in Appendix IV are the sum of the two datasets, which gives an estimate of all development impacts between 1996 to 2021. CVCC continues to assess remote sensing technologies and applications to better track development outside of the CVMSHCP-designated Conservation Areas.

Table 3: Conservation and authorized disturbance within Conservation Areas.

Conservation Area	Conservation Goal (ac)	Conserved, 2022 (ac)	Conserved to Date (ac	Disturbed, 2022 (ac)	Disturbed to Date (ac)
Cabazon	2,340	0	0	0	0
Coachella Valley Stormwater Channel and Delta	3,870	0	895	0	5
Desert Tortoise and Linkage	46,350	166	4,656	0	1
Dos Palmas	12,870	0	6,832	0	0
East Indio Hills	2,790	0	35	0	0
Edom Hill	3,060	39	2,120	0	2
Highway 111/I-10	350	55	155	0	0
Indio Hills Palms	2,290	0	8,463	0	0
Indio Hills/Joshua Tree National Park Linkage	10,530	0	1,040	0	6
Joshua Tree National Park	35,600	0	13,171	0	0
Mecca Hills/Orocopia Mountains	23,670	90	8,209	0	0
Santa Rosa and San Jacinto Mountains	55,890	2,899	35,809	0	10
Snow Creek/Windy Point	2,340	0	907	0	0
Stubbe and Cottonwood Canyons	2,430	0	1,056	20	20
Thousand Palms	8,040	7	5,273	7	56
Upper Mission Creek/Big Morongo Canyon	10,810	146	7,618	0	76
West Deception Canyon	1,063	131	2,484	0	0
Whitewater Canyon	1,440	0	957	3	8
Whitewater Floodplain	4,140	27	1,166	0	95
Willow Hole	4,920	0	2,627	0	0
Fluvial Sand Transport	NA	NA	NA	0	18
Direct Permit Take	NA	NA	NA	0.0	161
Total				30	446

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) meets 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 assesses the monitoring priorities to be brought forth to the Reserve Management Oversight Committee as the recommended annual work plan, and each year it recommends a suite of species for monitoring that should be added in years with or following above average rainfall. Both the CVCC Director of Conservation and the Conservation Management Analyst facilitated these meetings of the RMUC/BWG 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 in 2021 but did not receive the Notice to Proceed for these awards until July 2022 due to a budget miscalculation at the State level. 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 2022, a contract with UC Riverside (UCR) Center for Conservation Biology was approved for monitoring of aeolian sand species, Mecca aster, Orocopia sage, and Jerusalem cricket. UCR will also provide coordination of invasive species management, including the Low Desert Weed Management Area, which targets invasive weed populations across the Valley. UCR will also update and refine the Desert tortoise niche model with the data acquired by USGS and use that with the overlay of the Sahara mustard Maxent model to identify priority areas for invasive species management. In coordination with the RMUC/BWG, UCR provides regular guidance and input on the development of the monitoring program tasks and performs the majority of monitoring efforts on aeolian sand species, plants, and arthropods with their team of ecologists who have specialties in various aspects of Coachella Valley desert ecology. The monitoring reports can be found in Appendices V through XIII respectively. Appendix XIII contains the results published by Davis et al. in the journal Madroño entitled, "The range extensions and population decline of the endemic desert perennial Orocopia sage (Salvia greatae [Lamiaceae]) within the Mecca Hills and Orocopia Mountains, California". The San Diego Natural History Museum (SDNHM) was contracted to begin monitoring yellow bat presence and assessing their population demographics using mist-netting. The mist-netting will continue through the Spring of 2023 and the final results will be included in the 2023 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. This annual report includes the publication in Appendix XII titled, "High female desert tortoise mortality in the western Sonoran Desert during California's epic 2012-2016 drought" which was published in Endangered Species Research in January 2023.

Outside of competitive grants, the vast majority of funding for biological monitoring activities, as well as CVCC land management activities, comes from the agency mitigation fees and development impact fees authorized by the CVMSHCP (Figure 6). These funds are distributed across the monitoring and management fund and the management contingency fund.

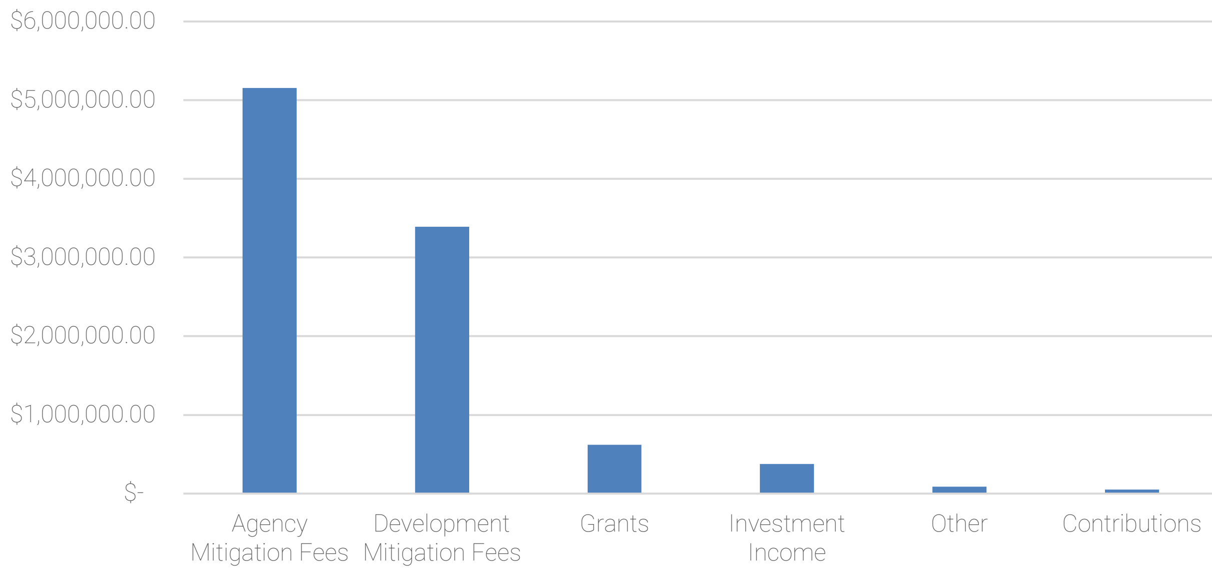

Figure 6: Cumulative monitoring and management funding per source.

Photos: 2022 Biological Monitoring Activities

Photos from left to right / top to bottom: 1: Coachella Valley milk-vetch; 2: Yellow bat; 3: Little San Bernardino mountains linanthus; 4. Coyote in mesquite dunes; 5. Bobcat at a water source; 6. Large cholla; 7. Flat-tailed horned lizard

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.

Reserve Management Oversight Committee

The RMOC held Zoom meetings April 27 and October 26, 2022. 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 2022/2023 and presented to the CVCC at their June 2022 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 8, June 14, September 13, and December 13, 2022. The group discussed construction of the Peninsular Bighorn Sheep fence and drinker, fencing repairs by Desert Recreation District, 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 19, March 16, May 18, September 22, and November 16, 2022. Working groups in 2022 included a focus on Palm Hills Trails Management, the Peninsular Bighorn Sheep and Recreational Use Research, North Valley Trails Plan, 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. FODM and their volunteer crew continued to work closely with BLM and the cities to fix trail hazards and install clear directional and safety signage. FODM volunteers are taking the lead on trail restoration throughout the valley. CVCC established a contract with the Southern California Mountains Foundation Urban Conservation Corps to improve and maintain the network of existing trails located on both CVCC and Oswit Land Trust lands in the Palm Hills/Rimrock area of Palm Springs. Finally, CVCC worked with the Coachella Valley Desert and Mountains Recreation and Conservation Authority to grade and widen parking lot and sign the trailhead of the Kim Nicol trail.

Land Improvement: Acquisition Cleanups

In 2022, the CVCC Acquisitions Manager performed pre-acquisition site inspections and job walks on 20 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 5.84 tons of refuse, including 27 tires, from the Coachella Valley, covering more than 3,329 acres and generating over $4,100 in contractor revenue from sellers' property sales.

Property Management & Monitoring

Monitoring the status of CVCC conservation lands is an essential and ongoing activity. CVCC has approximately 16 miles of existing fencing and signage on CVCC lands, and many areas have seen extensive vandalism since the beginning of the COVID-19 pandemic in March 2020. CVCC lands have also been vulnerable to encampments, illegal dumping, shooting, and OHV use. A contract with the Desert Recreation District (DRD) was established in June 2022 to repair and maintain existing fencing, signage, and boulders on CVCC lands as well as remove illegal dumping debris. By the end of 2022, DRD replaced over 7,500-feet of cable and completed 16 work orders submitted by CVCC staff.

CVCC entered into a Cooperative Management Memorandum of Understanding with Oswit Land Trust to better coordinate management of the Goat Trails and Rimrock trailhead at Palm Hills. To begin managing the recently acquired Palm Hills parcels, CVCC staff and Oswit Land Trust volunteers installed "No Parking Overnight" signage in the trailhead parking lot to prohibit encampments and squatting on CVCC land. CVCC staff also worked with Palm Springs Code Compliance and Palm Springs Police Department to establish a similar parking restriction on the adjacent right of way within the jurisdiction of the City of Palm Springs. A contract with the Urban Conservation Corps was developed to go into effect in January 2023. This contract would provide CVCC with a 6-person work crew for 1 year to begin marking and signing trails, cleaning encampments, restoring habitat, and removing graffiti from the most-impacted 350 acres of the acquisition. A new trailhead entrance has been tasked to DRD for a redesign which would include a swinging gate, multi-latch lock and accessibility for equestrians, mountain bikers and hikers.

Invasive species removal in 2022 occurred in both the Upper Mission Creek/Big Morongo Canyon and Coachella Valley Stormwater Channel and Delta Conservation Areas. In May, CVCC staff and volunteers pulled out fountain grass inhabiting a wash near the Big Morongo Canyon. Tamarisk removal took place in Mecca, CA near the intersection of Highway 86 and Avenue 66. CVCC contracted UCC to eradicate 6 acres of mature tamarisk trees in the Coachella Valley Stormwater Channel and Delta Conservation Area in September 2022. Trees were present in a mesquite bosque and were competing with native vegetation for groundwater. Tamarisk trees were cut down to the stump and chipped. The chipped material was left on site to provide organic matter to the soil. Stumps were treated with imazapyr, a selective herbicide permitted for use in this area. Initial treatment was conducted from October through the end of 2022. Retreatment will occur in 2023 as necessary.

Finally, CVCC purchased a drone and mobile Real Time Kinematic base station in the summer of 2022 and CVCC staff acquired an Unmanned Aerial System pilot license through the Federal Aviation Administration. The drone has been used to document and survey CVCC vulnerable properties and difficult to access sites. These surveys provide staff with high-resolution images in real time for ongoing adaptive management. The drone has also been used to create orthomosaic images and 3D terrain models of CVCC lands to be used in CVCC's geospatial information system for advanced mapping and modeling. Future uses of this technology can assist CVCC staff and committees in gaining clear, updated information for land management decision-making.

Unauthorized Activities & Enforcement

In 2022, 13 off-road details were conducted on conservation lands by Desert Hot Springs Police. These details took place on July 7, 21, and 29; August 5, 19, and 25; September 3; October 7; November 27; and December 30. All details took place within the Upper Mission Creek/Big Morongo Canyon Conservation Area. During these details, one vehicle was towed, and no off-roading, shooting, or fencing damage were observed.

Photos: 2022 Land Management Activities

Photos from left to right / top to bottom: 1: Long Canyon trailhead; 2: Desert Recreation District moving boulders for a barrier; 3: Crew works on installing PBS fence in La Quinta; 4. UCC crew plant mesquite at North Shore Ranch; 5. UCC crew analyze large tamarisk removal in Mecca; 6.UCC crew stand over large trunk of tamarisk after removal

SIGNIFICANT ISSUES IN PLAN IMPLEMENTATION

In late 2022 construction began on the La Quinta Peninsular Bighorn Sheep Barrier Project. The primary objective of the La Quinta Peninsular Bighorn Sheep Barrier Project is to protect Peninsular bighorn sheep by preventing them from accessing urban lands, including golf courses and landscaping, artificial water bodies, and roadways which can potentially harm them. 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 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 land on which the fence would be built, access agreements took significant additional time for review and approval. In September 2021, staff completed agreements for use of property owned or managed by PGA WEST. The Coachella Valley Water District (CVWD) completed their review of the plans and approved the encroachment permits in June 2022, and a license agreement with the Bureau of Reclamation was completed soon after in July 2022. Finally, a use permit from Riverside County Regional Parks and Open Space District (for the Lake Cahuilla Veterans Memorial Park) was completed. CVCC awarded a contract to Wood Environmental in November 2021 for biological monitoring during construction activities. A contract was executed in August 2022 with the Agua Caliente Band of Cahuilla Indians Tribal Historic Preservation Office for cultural monitoring, and Magana Project Management in July 2022 for construction management. Fence construction began in October 2022 and is expected to be completed by January 2024. CVCC staff are also working with the wildlife agencies and CVWD to identify a site and design a water source on the western side of the fence. Additionally, CVCC staff and wildlife agencies have been working on a Transfer of Conservation Objectives for La Quinta and Riverside County to adequately track the impact of the PBS fence on the Essential Habitat. Both tasks are expected to be completed before the completion of the fence.

The CVMSHCP receives funding from tipping fees collected at Riverside County waste disposal sites and landfills. In March 2022, CVCC staff were notified that a Waste Delivery Agreement had concluded and one of the tipping fees that provided an important funding source for the implementation of the Plan was discontinued. Section 5.2.1.2 titled "Fees on the Importation of Waste into Landfills and Transfer Stations (Conservation Trust Fund)," of the Final Major Amendment to the CVMSHCP from August 2016 states that the "County collects $1 per ton for all in-county waste deposited in County Landfills." The Plan projects that the tipping fee revenues are needed through year 71 of Plan implementation. In 2015, the Coachella Valley Transfer Station Joint Powers Authority (CVTS JPA) entered into a second amended agreement with the County of Riverside for waste disposal. The Agreement allowed for the continued collection of tipping fees to help fund the Plan until its expiration on June 19, 2021. After its expiration, the County ceased to collect tipping fees from the CVTS JPA. Much of the waste was deposited outside of County landfills and not considered subject to the collection of the $1 per ton for the CVMSHCP. However, in the second amended agreement between the County and the CVTS JPA, the County allowed for up to 130,000 tons of solid waste to be disposed in non-county facilities, but still required collection of $1.00 for CVMSHCP fees and $0.175 for local code enforcement despite waste going to non-county facilities. This loss of funding is critical for the CVMSHCP, and staff are working to resolve the issue with the CVTS JPA and Riverside County.

In November 2022, the CVCC approved the closure of the In Lieu Fee Program (ILF). An Enabling Instrument (EI) for an in-lieu fee program was developed in 2014 to provide mitigation opportunities for impacts to Waters of the United States. Such impacts are authorized by the United States Army Corps of Engineers (USACE) and the Colorado River Basin Regional Water Quality Control Board (RWQCB) through their implementation of the Clean Water Act (CWA). The intention in sponsoring an ILF program was to complement the conservation objectives of the Plan by providing opportunities to conduct ecological uplift above and beyond the CVMSHCP's requirements. The CVMSHCP does not provide for the restoration of degraded aquatic resources like wetlands and riparian systems (except for limited removal of tamarisk and acquisition of intact habitat), so the ability to rehabilitate and reestablish such systems would provide "value added" to the habitat conservation goals of the CVMSHCP, and potentially enable acquisition of seriously disturbed lands like former hunting clubs for the purpose of creating habitat. CVCC anticipated the bulk of its project sites would be located within the Coachella Valley Stormwater Channel and Delta and Dos Palmas Conservation Areas. Upon its establishment, CVCC's ILF program was granted 50 advance credits to generate seed funding for future project sites. CVCC sold its first advance credit in May 2016, and proposed an initial project site in the Coachella Valley Stormwater Channel and Delta Conservation Area (CVSWCD) for approval in May 2017. This site was ultimately rejected by the IRT for a lack of jurisdictional waters and potential take of the protected desert pupfish. CVCC staff then shifted focus to a new project site and was granted a one-year extension from the USACE in October 2019. Up to this point, the CVCC had sold 6.32 advance credits. In March 2020, CVCC submitted a formal Instrument Modification request to initiate review of the new project site, located north of the original site in the CVSWCD. Confirmation of receipt was not provided by USACE until July 2020, and neither a request for comment to the IRT nor a public notice was distributed until September 2020.

In 2021, changes to the Navigable Waters Protection Rule (NWPR) – the language determining what bodies of water constitute Waters of the United States and are thus eligible for mitigation and/or restoration – as well as conflicting requirements between the NWPR and state and regional discharge regulations required substantial revisions to the project site restoration design. CVCC had sold a total of 12.87 advance credits for the ILF Program up to this point. USACE notified CVCC in June 2022 that it was in danger of default of its EI given the lag time between the initial credit sale and implementation of any restoration activities. CVCC staff submitted the final Instrument Modification in September 2022, which included a revised restoration design and development plan, long term management plan, and a proposed legal instrument ensuring perpetual conservation. If approved, this site would account for 3.89 of the advance credits for which the CVCC is responsible. However, the IRT has already signaled concern over the lack of sufficient precipitation to sustain the site while simultaneously questioning the use of groundwater – despite the presence of an artesian well on site – to maintain the proposed hydrological features. Environmental and ecological challenges beyond CVCC's control, including connection to the surrounding agricultural drains precluded due to potential take of desert pupfish, the use of groundwater to sustain the site likely to be rejected, and the increasingly erratic nature of rainfall in the area, are mounting. In addition to the foundational issue of the region's ecological suitability to fulfil the restoration needs of CWA permits, CVCC staff had encountered significant administrative hurdles in coordinating with the relevant regulatory agencies. These difficulties included extended periods without response to CVCC staff's inquiries from USACE, changes in the regulatory language governing mitigation programs, and unanswered questions about ILF program compatibility with the CVMSHCP. CVCC staff has expended significant effort in administering the ILF program and will need to continue to do so until it has satisfied its mitigation obligation for the outstanding 12.87 advance credits. ILF Reporting Requirements will also no longer be included in the CVMSHCP Annual Report although CVCC will remain responsible for the successful completion of ongoing mitigation projects, relevant maintenance, monitoring, reporting, and long-term management requirements.

Finally, on February 10, 2022, the CVCC approved an agreement with Pacific Policy Group for state advocacy services. The Sacramento-based firm was chosen through a competitive solicitation for lobbying services. On November 10, 2022, the CVCC adopted its legislative platform to guide the legislative advocacy work and provide strategic direction on key issues and topics pertinent to the CVCC. With continued state representation, the CVCC staff can be better positioned to advocate for beneficial policies or oppose those that may have negative consequences and prepared to take advantage of forthcoming funding opportunities. The retention of state representation comes at a time when the state has a strong political and investment focus on issues related to climate change, climate resiliency, conservation, outdoor recreation, extreme heat and protecting and restoring natural systems. The recommended contract amendment will allow the CVCC to build on efforts over the past year and continue to elevate its projects and be better positioned to take advantage of the funding opportunities for key programs. Ultimately, the goal is for the Coachella Valley to receive its fair share of funding to strengthen conservation and associated land management and program activities in the Coachella Valley. The agreement is expected to continue through 2024.

COMPLIANCE ACTIVITIES OF PERMITTEES

All Permittees are in compliance with the requirements of the CVMSHCP. CVCC completed four Joint Project Reviews for Permittees in 2022. Permittees are also complying with the fee language in their ordinances by reporting their Local Development Mitigation Fee (LDMF) activity and remitting the revenue to CVCC monthly. CVCC reviews all LDMF reports and receipts. The LDMF generated $3,597,273 in Fiscal Year 2021/2022, representing a 32-percent increase over the $2,727,599 generated in the previous fiscal year.

CVMSHCP ANNUAL BUDGET - FISCAL YEAR 2022/2023

The CVMSHCP budget for fiscal year 2022/2023 is included here. Note that it differs from the budget for the CVCC budget, which includes non-CVMSHCP program funding from the ILF program, endowments for conservation easements required by state lake and streambed alteration agreements, and funding for monitoring of Casey's June beetle.

	Endowment	General Administration	Land Acquisition	Lizard Endowment	Management & Monitoring	Management Contingency	Travertine Point Monitoring	Total
BEGINNING BALANCE	$ 11,981,098	$ 601,662	$ 10,383,156	$ 330,499	$ 602,785	$ 4,417,509	$ 539,749	$ 28,856,458
Revenues / Funding Source								-
Investment Income	$ 67,770	$ 3,403	$ 70,304	$ 2,518	$ 4,529	$ 38,474	$ 4,113	$ 191,112
County Tipping Fees	-	$ 300,000	-	-	-	-	-	$ 300,000
Development Mitigation Fees	-	-	$ 2,446,937	-	$ 501,180	-	-	$ 2,948,116
Agencies Mitigation Fees	$ 1,419,878	-	$ 2,634,212	-	-	-	-	$ 4,054,090
Prop 1 Program	-	-	-	-	$ 90,000	-	-	$ 90,000
Friends of the Desert Mountains	-	-	-	-	$ 18,000	-	-	$ 18,000
Local Assistance Grant	-	-	-	-	$ 90,000	-	-	$ 90,000
Other Revenue	-	-	-	-	$ 12,250	-	-	$ 12,250
Advertising Revenue	-	-	-	-	$ 1,200	-	-	$ 1,200
Total Revenues / Funding Source	$ 1,487,648	$ 303,403	$ 5,151,453	$ 2,518	$ 717,159	$ 38,474	$ 4,113	$ 7,704,768
Expenditures								
Professional Services	-	$ 53,256	$ 118,453	-	$ 619,000	-	-	$ 790,709
Meeting Attendance Stipends	-	$ 12,993	-	-	-	-	-	$ 12,993
Office Operations	-	$ 20,961	-	-	$ 25,000	-	-	$ 45,961
LDMF Admin Fee	-	-	$ 24,469	-	$ 5,012	-	-	$ 29,481
Land Management Costs	-	-	$ 300,000	-	$ 83,500	$ 149,820	-	$ 533,320
Miscellaneous	-	$ 135	$ 500	-	$ 500	-	-	$ 1,135
Land Acquisitions	-	-	$ 5,635,018	-	-	-	-	$ 5,635,018
Equipment	-	-	-	-	$ 20,000	-	-	$ 20,000
CVAG Admin Reimbursement	-	$ 366,068	$ 179,244	-	$ 291,206	$ 48,127	-	$ 884,646
Total Non-Personnel	-	$ 453,413	$ 6,257,685	-	$ 1,044,218	$ 197,947	-	$ 7,953,263
Operating Transfers In	-	-	-	-	($ 2,026,521)	-	-	($ 2,026,521)
Operating Transfers Out	$ 226,521	-	-	-	-	$ 1,800,000	-	$ 2,026,521
Construction In Progress	-	-	-	-	$ 1,800,000	-	-	$ 1,800,000
Total Other	$ 226,521	-	-	-	($ 226,521)	$ 1,800,000	-	$ 1,800,000
Total Expenditures / Expenditure	$ 226,521	$ 453,413	$ 6,257,685	-	$ 817,697	$ 1,997,947	-	$ 9,753,263
Net Excess (Deficit)	$ 1,261,127	($ 150,010)	($ 1,106,232)	$ 2,518	($ 100,538)	($ 1,959,472)	$ 4,113	($ 2,048,495)
ENDING BALANCE	$ 13,242,226	$ 451,652	$ 9,276,924	$ 333,017	$ 502,247	$ 2,458,037	$ 543,862	$ 26,807,963

Annual Audit

CVCC approved their Fiscal Year 2022/2023 budget at the June 9, 2022 meeting.

The audit of the expenditures for the period July 1, 2021 to June 30, 2022 was approved by CVCC at their February 9, 2023 meeting. 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 74-199 El Paseo, Suite 100, Palm Desert, CA 92260. Annual CVCC audits are available at https://cvag.org/cvcc-financial-reports/.

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 2022 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 2022

Conservation Area + *Owner*		Acres
Desert Tortoise and Linkage		166
*CVCC**		
	707290005	146
	715271018	20
Edom Hill		39
CVCC		
	659120009	39
Highway 111/I-10		55
CVCC		
	522070019	29
	522070020	26
Mecca Hills/Orocopia Mountains		90
*FODM***		
	709440005	20
	709440055	40
	709570004	10
	719090026	10
	719090043	10
Santa Rosa and San Jacinto Mountains		2,899
CVCC		
	635060004	642
	635070025	117
	635420003	38
	635430002	161
	686120005	643
	686320003	643
	687020001	656
Thousand Palms		7
CVCC		
	648170006	5
	648220022	2
Upper Mission Creek/Big Morongo Canyon		146
CVCC		
	516120012	5
	664190001	69
	664190002	6
	667160001	66
West Deception Canyon		131
CVCC		
	645350014	40
	645360004	7
	645360005	62
	647080011	22
Whitewater Floodplain		27
CVCC		
	660290014	5
	660300007	22
	Total Acres	3,566

*Coachella Valley Conservation Commission
**Friends of Desert Mountains

APPENDIX III: CONSERVATION OBJECTIVES BY CONSERVATION AREA

Conservation Area, Permittee, and Conservation Element	Total Authorized Disturbance	Disturbed 2020	Disturbance to Date	Required Conservation	Conserved 2022	Conservation to Date	Percent Conserved	Rough Step Value
Cabazon Conservation Area								
Riverside County								
Linkage/Corridor	10	0	0	631	0	0	0%	1
Mesquite Hummocks	1	0	0	12	0	0	0%	0
Peninsular Bighorn Sheep - Essential Habitat	181	0	0	83	0	0	0%	18
Sand Source	181	0	0	1,629	0	0	0%	18
Sand Transport (Fluvial)	0	0	0	631	0	0	0%	0
Southern Sycamore-Alder Riparian Woodland	1	0	0	9	0	0	0%	0
Coachella Valley Stormwater Channel and Delta Conservation Area								
Riverside County								
California Black Rail - Other Conserved Habitat	6	0	0	52	0	0	0%	1
Coastal and Valley Marsh	6	0	0	51	0	0	0%	1
Crissal Thrasher - Core Habitat	87	0	5	781	0	371	48%	41
Desert Saltbush Scrub	79	0	5	713	0	351	49%	38
Desert Sink Scrub	114	0	0	1,026	0	84	8%	20
Le Conte's Thrasher - Other Conserved Habitat	78	0	5	706	0	371	53%	40
Mesquite Hummocks	7	0	0	67	0	20	30%	3
Yuma Clapper Rail - Other Conserved Habitat	6	0	0	52	0	0	0%	1
Desert Tortoise and Linkage Conservation Area								
Coachella								
Desert Dry Wash Woodland	12	0	1	109	0	0	0%	0
Desert Tortoise - Core Habitat	30	0	1	270	0	0	0%	2
Le Conte's Thrasher - Other Conserved Habitat	30	0	1	270	0	0	0%	2
Riverside County								
Desert Dry Wash Woodland	752	0	0	6,771	5	914	14%	167
Desert Tortoise - Core Habitat	4,998	0	0	44,977	166	6,828	15%	1,183
Le Conte's Thrasher - Other Conserved Habitat	2,813	0	0	25,319	20	2,448	10%	526
Linkage/Corridor	1,572	0	0	14,143	166	2,316	16%	389
Mecca Aster - Core Habitat	206	0	0	1,855	0	455	25%	66
Oricopia Sage - Core Habitat	44	0	0	398	0	0	0%	4
Dos Palmas Conservation Area								
Riverside County								
Arrowweed Scrub	13	0	0	121	0	0	0%	1
California Black Rail - Other Conserved Habitat	37	0	0	334	0	280	84%	32
Cismontane Alkali Marsh	23	0	0	205	0	199	97%	22
Crissal Thrasher - Core Habitat	38	0	0	343	0	244	71%	28
Desert Dry Wash Woodland	83	0	0	746	0	268	36%	35
Desert Fan Palm Oasis Woodland	6	0	0	50	0	29	59%	4
Desert Sink Scrub	487	0	0	4,381	0	1,196	27%	168
Flat-Tailed Horned Lizard - Other Conserved Habitat	403	0	0	3,631	0	657	18%	106
Le Conte's Thrasher - Other Conserved Habitat	743	0	0	6,689	0	2,526	38%	327
Mesquite Bosque	36	0	0	320	0	234	73%	27
Mesquite Hummocks	3	0	0	23	0	10	45%	2

Conservation Area, Permittee, and Conservation Element	Total Authorized Disturbance	Disturbed 2020	Disturbance to Date	Required Conservation	Conserved 2022	Conservation to Date	Percent Conserved	Rough Step Value
Yuma Clapper Rail - Other Conserved Habitat	42	0	0	374	0	280	75%	33
East Indio Hills Conservation Area								
Coachella								
Coachella Valley Round-Tailed Ground Squirrel	1	0	0	5	0	1	15%	0
Flat-Tailed Horned Lizard - Other Conserved Habitat	1	0	0	5	0	0	0%	0
Le Conte's Thrasher - Other Conserved Habitat	6	0	0	56	0	0	0%	1
Palm Springs Pocket Mouse - Other Conserved Habitat	1	0	0	7	0	0	0%	0
Indio								
Coachella Valley Round-Tailed Ground Squirrel	11	0	0	103	0	0	0%	1
Flat-Tailed Horned Lizard - Other Conserved Habitat	11	0	0	100	0	0	0%	1
Le Conte's Thrasher - Other Conserved Habitat	12	0	0	105	0	0	0%	1
Mesquite Hummocks	0	0	0	2	0	0	0%	0
Palm Springs Pocket Mouse - Other Conserved Habitat	11	0	0	103	0	0	0%	1
Stabilized & Partially Stabilized Desert Sand Fields	11	0	0	100	0	0	0%	1
Riverside County								
Active Desert Dunes	1	0	0	1	0	0	0%	0
Coachella Valley Round-Tailed Ground Squirrel	100	0	0	896	0	1	0%	10
Desert Saltbush Scrub	1	0	0	7	0	0	0%	0
Flat-Tailed Horned Lizard - Other Conserved Habitat	45	0	0	415	0	0	0%	5
Le Conte's Thrasher - Other Conserved Habitat	139	0	0	1,253	0	35	3%	17
Mecca Aster - Core Habitat	116	0	0	1,045	0	0	0%	12
Mesquite Hummocks	4	0	0	39	0	0	0%	0
Palm Springs Pocket Mouse - Other Conserved Habitat	105	0	0	944	0	33	3%	14
Stabilized & Partially Stabilized Desert Sand Fields	33	0	0	295	0	0	0%	3
Stabilized Shielded Desert Sand Fields	28	0	0	256	0	0	0%	3
Edom Hill Conservation Area								
Cathedral City								
Coachella Valley Fringe-Toed Lizard - Other Conserved Habitat	13	0	0	121	0	101	83%	11
Coachella Valley Round-Tailed Ground Squirrel	15	0	0	136	0	101	75%	12
Le Conte's Thrasher - Other Conserved Habitat	34	0	0	310	0	224	72%	25
Palm Springs Pocket Mouse - Other Conserved Habitat	11	0	0	103	0	86	83%	9
Sand Source	35	0	0	310	0	224	72%	26
Riverside County								
Active Desert Sand Fields	4	0	0	37	0	41	110%	4
Coachella Valley Fringe-Toed Lizard - Other Conserved Habitat	5	0	0	40	0	43	108%	5
Coachella Valley Giant Sand-Treader Cricket - Other Conserved Habitat	5	0	0	40	0	43	108%	5

Conservation Area, Permittee, and Conservation Element	Total Authorized Disturbance	Disturbed 2020	Disturbance to Date	Required Conservation	Conserved 2022	Conservation to Date	Percent Conserved	Rough Step Value
Coachella Valley Milkvetch - Other Conserved Habitat	145	0	0	1,302	38	1,068	82%	122
Coachella Valley Round-Tailed Ground Squirrel	134	0	0	1,205	38	1,157	96%	129
Le Conte's Thrasher - Other Conserved Habitat	194	0	2	1,745	39	1,380	79%	156
Palm Springs Pocket Mouse - Other Conserved Habitat	104	0	0	935	38	836	89%	94
Sand Source	197	0	0	1,770	0	1,475	83%	167
Sand Transport	63	0	1	565	39	421	75%	47
Stabilized & Partially Stabilized Desert Sand Fields	1	0	0	3	0	2	81%	1
Highway 111/I-10 Conservation Area								
Palm Springs								
Coachella Valley Jerusalem Cricket - Other Conserved Habitat	37	0	0	335	28	124	37%	16
Coachella Valley Milkvetch - Other Conserved Habitat	37	0	0	335	36	136	40%	17
Coachella Valley Round-Tailed Ground Squirrel	39	0	0	350	28	124	36%	16
Le Conte's Thrasher - Other Conserved Habitat	39	0	0	350	36	136	39%	18
Palm Springs Pocket Mouse - Other Conserved Habitat	39	0	0	350	36	136	39%	18
Indio Hills Palms Conservation Area								
Riverside County								
Desert Dry Wash Woodland	4	0	0	4	0	36	907%	33
Desert Fan Palm Oasis Woodland	5	0	0	5	0	7	140%	7
Le Conte's Thrasher - Other Conserved Habitat	1	0	0	7	0	0	0%	0
Mecca Aster - Core Habitat	255	0	0	2,290	0	0	0%	26
Mesquite Hummocks	1	0	0	1	0	1,040	103991%	936
Indio Hills/Joshua Tree National Park Linkage Conservation Area								
Riverside County								
Desert Tortoise - Core Habitat	859	0	0	7,735	0	6,544	85%	740
Le Conte's Thrasher - Other Conserved Habitat	606	0	0	5,457	0	5,466	100%	607
Linkage/Corridor	1,141	0	6	10,267	0	8,978	87%	1,006
Sand Source	460	0	6	4,135	0	3,189	77%	360
Sand Transport	681	0	0	6,132	0	5,789	94%	647
Joshua Tree National Park Conservation Area								
Riverside County								
Desert Dry Wash Woodland	13	0	0	119	0	192	161%	20
Desert Fan Palm Oasis Woodland	0	0	0	0	0	0	#DIV/0!	0
Desert Tortoise - Core Habitat	1,708	0	0	15,367	0	12,537	82%	1,425
Gray Vireo - Other Conserved Habitat	134	0	0	1,208	0	1,823	151%	195
Le Conte's Thrasher - Other Conserved Habitat	25	0	0	222	0	103	47%	13
Mixed Mojave Woody Scrub	800	0	0	7,195	0	6,357	88%	716
Mojavean Pinyon & Juniper Woodland	134	0	0	1,208	0	1,823	151%	195
Mecca Hills/Orocopia Mountains Conservation Area								
Riverside County								
Desert Dry Wash Woodland	318	0	0	2,861	60	1,356	47%	167
Desert Fan Palm Oasis Woodland	0	0	0	0	0	0	#DIV/0!	0

Conservation Area, Permittee, and Conservation Element	Total Authorized Disturbance	Disturbed 2020	Disturbance to Date	Required Conservation	Conserved 2022	Conservation to Date	Percent Conserved	Rough Step Value
Desert Tortoise - Core Habitat	2,624	0	0	23,617	90	7,914	34%	1,054
Le Conte's Thrasher - Other Conserved Habitat	652	0	0	5,866	60	1,549	26%	220
Mecca Aster - Core Habitat	465	0	0	4,181	0	1,986	47%	245
Orocopia Sage - Core Habitat	1,803	0	0	16,227	80	5,326	33%	713
Santa Rosa and San Jacinto Mountains Conservation Area								
Cathedral City								
Desert Dry Wash Woodland	2	0	0	18	0	11	60%	1
Desert Tortoise - Other Conserved Habitat	11	0	0	95	0	21	22%	3
Le Conte's Thrasher - Other Conserved Habitat	1	0	0	11	0	1	12%	0
Peninsular Bighorn Sheep - Essential Habitat	11	0	0	97	0	21	22%	3
Indian Wells								
Desert Dry Wash Woodland	7	0	0	66	0	0	0%	1
Desert Tortoise - Other Conserved Habitat	111	0	0	99	0	36	37%	48
Le Conte's Thrasher - Other Conserved Habitat	23	0	0	206	0	0	0%	2
Peninsular Bighorn Sheep - Essential Habitat	114	0	0	1,158	0	36	3%	15
La Quinta								
Desert Dry Wash Woodland	8	0	0	76	0	15	20%	2
Desert Tortoise - Other Conserved Habitat	157	0	0	1,409	0	424	30%	58
Le Conte's Thrasher - Other Conserved Habitat	43	0	0	387	0	125	32%	17
Peninsular Bighorn Sheep - Essential Habitat	159	0	0	2,545	0	430	17%	40
Palm Desert								
Desert Dry Wash Woodland	3	0	0	29	0	1	2%	0
Desert Tortoise - Other Conserved Habitat	48	0	0	436	0	782	179%	82
Le Conte's Thrasher - Other Conserved Habitat	4	0	0	33	0	0	0%	0
Peninsular Bighorn Sheep - Essential Habitat	14	0	0	130	0	761	585%	75
Palm Springs								
Desert Dry Wash Woodland	4	0	0	36	0	36	100%	4
Desert Fan Palm Oasis Woodland	9	0	0	76	0	52	69%	6
Desert Tortoise - Other Conserved Habitat	1,317	0	0	8,856	1,942	7,204	81%	1,096
Gray Vireo - Other Conserved Habitat	431	0	0	3,883	642	2,480	64%	291
Le Conte's Thrasher - Other Conserved Habitat	103	0	0	560	0	524	94%	97
Peninsular Bighorn Sheep - Essential Habitat	1,543	0	0	11,367	2,064	8,451	74%	1,187
Peninsular Juniper Woodland & Scrub	353	0	0	3,177	642	2,480	78%	283
Semi-Desert Chaparral	51	0	0	571	0	0	0%	5
Sonoran Cottonwood-Willow Riparian Forest	0	0	0	58	0	1	3%	0
Southern Arroryo Willow Riparian Forest	0	0	0	0	0	0	#DIV/0!	0
Southern Sycamore-Alder Riparian Woodland	2	0	0	24	0	0	0%	0
Rancho Mirage								
Desert Dry Wash Woodland	1	0	0	9	0	4	45%	1
Desert Tortoise - Other Conserved Habitat	147	0	7	1,326	0	0	0%	8
Le Conte's Thrasher - Other Conserved Habitat	2	0	0	17	0	1,206	7097%	128
Peninsular Bighorn Sheep - Essential Habitat	42	0	0	450	0	1,210	269%	106
Riverside County								
Desert Dry Wash Woodland	298	0	0	1,244	0	1,277	103%	305
Desert Fan Palm Oasis Woodland	45	0	0	404	0	0	0%	5
Desert Tortoise - Other Conserved Habitat	2,950	0	0	23,856	208	16,520	69%	2,134
Gray Vireo - Other Conserved Habitat	881	0	0	7,930	44	6,103	77%	698
Le Conte's Thrasher - Other Conserved Habitat	911	0	0	5,508	0	5,377	98%	892

Conservation Area, Permittee, and Conservation Element	Total Authorized Disturbance	Disturbed 2020	Disturbance to Date	Required Conservation	Conserved 2022	Conservation to Date	Percent Conserved	Rough Step Value
Peninsular Bighorn Sheep - Essential Habitat	2,418	0	0	19,205	315	17,626	92%	2,239
Peninsular Juniper Woodland & Scrub	418	0	0	2,899	44	3,354	116%	477
Redshank Chaparral	253	0	0	2,274	0	1,822	80%	208
Semi-Desert Chaparral	233	0	0	2,093	0	927	44%	116
Southern Arroryo Willow Riparian Forest	2	0	0	15	0	0	0%	0
Southern Sycamore-Alder Riparian Woodland	12	0	0	117	0	5	5%	2
Snow Creek/Windy Point Conservation Area								
Palm Springs								
Active Desert Dunes	7	0	0	62	0	51	82%	6
Coachella Valley Fringe-Toed Lizard - Core Habitat	75	0	0	672	0	310	46%	39
Coachella Valley Giant Sand-Treader Cricket - Core Habitat	75	0	0	672	0	310	46%	39
Coachella Valley Jerusalem Cricket - Core Habitat	93	0	0	838	0	423	50%	52
Coachella Valley Milkvetch - Core Habitat	90	0	0	815	0	424	52%	51
Coachella Valley Round-Tailed Ground Squirrel - Core Habitat	91	0	0	816	0	441	54%	53
Ephemeral Desert Sand Fields	68	0	0	610	0	258	42%	33
Le Conte's Thrasher - Other Conserved Habitat	86	0	0	775	0	389	50%	47
Linkage/Corridor	27	0	0	247	0	249	101%	27
Palm Springs Pocket Mouse - Core Habitat	93	0	0	838	0	441	53%	53
Peninsular Bighorn Sheep - Essential Habitat	16	0	0	144	0	152	105%	17
Sand Transport	93	0	0	838	0	441	53%	53
Riverside County								
Coachella Valley Fringe-Toed Lizard - Core Habitat	55	0	0	502	0	340	68%	39
Coachella Valley Giant Sand-Treader Cricket - Core Habitat	56	0	0	501	0	340	68%	40
Coachella Valley Jerusalem Cricket - Core Habitat	152	0	0	1,371	0	354	26%	51
Coachella Valley Milkvetch - Core Habitat	60	0	0	538	0	683	127%	75
Coachella Valley Round-Tailed Ground Squirrel - Core Habitat	134	0	0	1,210	0	853	70%	98
Ephemeral Desert Sand Fields	10	0	0	93	0	340	366%	34
Le Conte's Thrasher - Other Conserved Habitat	162	0	0	1,453	0	898	62%	106
Linkage/Corridor	46	0	0	415	0	145	35%	19
Palm Springs Pocket Mouse - Core Habitat	148	0	0	1,331	0	898	67%	105
Peninsular Bighorn Sheep - Essential Habitat	49	0	0	443	0	136	31%	18
Sand Transport	165	0	0	1,482	0	900	61%	107
Stubbe and Cottonwood Canyons Conservation Area								
Riverside County								
Desert Dry Wash Woodland	26	0	0	229	0	137	60%	17
Desert Tortoise - Core Habitat	253	20	20	2,276	0	1,000	44%	106
Le Conte's Thrasher - Other Conserved Habitat	1,111	0	0	267	0	824	309%	3,199
Linkage/Corridor	117	0	0	1,058	0	877	83%	99
Sand Source	138	20	20	1,241	0	229	18%	17
Sand Transport	125	0	0	1,129	0	828	73%	95
Sonoran Cottonwood-Willow Riparian Forest	3	0	0	25	0	0	0%	0
Thousand Palms Conservation Area								
Riverside County								

Conservation Area, Permittee, and Conservation Element	Total Authorized Disturbance	Disturbed 2020	Disturbance to Date	Required Conservation	Conserved 2022	Conservation to Date	Percent Conserved	Rough Step Value
Active Desert Dunes	2	0	0	14	0	6	43%	1
Active Desert Sand Fields	91	0	0	820	0	680	83%	77
Coachella Valley Fringe-Toed Lizard - Core Habitat	93	0	0	834	0	684	82%	78
Coachella Valley Giant Sand-Treader Cricket - Core Habitat	93	0	0	834	0	788	95%	88
Coachella Valley Milkvetch - Core Habitat	468	0	4	2,974	0	831	28%	161
Coachella Valley Round-Tailed Ground Squirrel - Core Habitat	111	0	29	1,001	1	1,759	176%	158
Desert Dry Wash Woodland	4	0	0	34	0	16	47%	2
Desert Fan Palm Oasis Woodland	0	0	0	0	0	0	#DIV/0!	0
Flat-Tailed Horned Lizard - Core Habitat	97	0	0	877	0	721	82%	81
Le Conte's Thrasher - Other Conserved Habitat	552	7	23	3,879	6	2,367	61%	335
Linkage/Corridor	983	7	46	7,816	7	5,311	68%	654
Mecca Aster - Core Habitat	297	0	5	2,676	0	2,212	83%	245
Mesquite Hummocks	0	0	0	0	0	0	#DIV/0!	0
Palm Springs Pocket Mouse - Core Habitat	518	7	29	3,588	6	2,315	65%	324
Sand Source	412	0	6	3,712	0	2,956	80%	331
Sand Transport	573	7	40	4,100	7	2,375	58%	316
Sonoran Cottonwood-Willow Riparian Forest	0	0	0	0	0	0	#DIV/0!	0
Upper Mission Creek/Big Morongo Canyon Conservation Area								
Desert Hot Springs								
Coachella Valley Jerusalem Cricket - Other Conserved Habitat	10	0	1	90	0	30	34%	3
Desert Dry Wash Woodland	8	0	0	76	0	32	42%	4
Desert Tortoise - Core Habitat	252	0	10	2,271	236	1,559	69%	171
Le Conte's Thrasher - Other Conserved Habitat	215	0	2	1,931	75	1,162	60%	136
Linkage/Corridor	10	0	0	88	0	10	11%	2
Little San Bernardino Mountain Linanthus - Core Habitat	107	0	0	966	6	669	69%	77
Palm Springs Pocket Mouse - Core Habitat	207	0	2	1,865	75	1,190	64%	137
Sand Source	16	0	7	141	138	138	98%	8
Sand Transport	217	0	2	1,949	75	1,254	64%	145
Palm Springs								
Le Conte's Thrasher - Other Conserved Habitat	2	0	0	22	0	0	0%	0
Palm Springs Pocket Mouse - Core Habitat	2	0	0	22	0	0	0%	0
Sand Transport	2	0	0	22	0	0	0%	0
Riverside County								
Coachella Valley Jerusalem Cricket - Other Conserved Habitat	47	0	16	419	5	56	13%	-5
Desert Dry Wash Woodland	8	0	0	76	0	55	72%	6
Desert Tortoise - Core Habitat	882	0	66	7,936	5	5,470	69%	570
Le Conte's Thrasher - Other Conserved Habitat	119	0	0	1,072	0	711	66%	83
Linkage/Corridor	76	0	0	688	0	348	51%	42
Little San Bernardino Mountain Linanthus - Core Habitat	117	0	0	1,052	0	736	70%	85
Palm Springs Pocket Mouse - Core Habitat	124	0	0	1,112	0	761	68%	89
Sand Source	721	0	66	6,488	5	4,751	73%	482

Conservation Area, Permittee, and Conservation Element	Total Authorized Disturbance	Disturbed 2020	Disturbance to Date	Required Conservation	Conserved 2022	Conservation to Date	Percent Conserved	Rough Step Value
Sand Transport	140	0	0	1,259	0	961	76%	110
Sonoran Cottonwood-Willow Riparian Forest	8	0	0	76	0	78	102%	8
Southern Sycamore-Alder Riparian Woodland	6	0	0	52	0	60	115%	7
Triple-Ribbed Milkvetch - Core Habitat	47	0	0	426	0	421	99%	46
West Deception Canyon Conservation Area								
Riverside County								
Sand Source	118	0	0	1,063	40	944	89%	106
Whitewater Canyon Conservation Area								
Desert Hot Springs								
Desert Tortoise - Core Habitat	0	3	0	0	0	0	#DIV/0!	0
Sand Source	0	3	0	0	0	0	#DIV/0!	0
Riverside County								
Arroyo Toad - Core Habitat	78	0	0	706	0	718	102%	79
Desert Fan Palm Oasis Woodland	0	0	0	0	0	0	#DIV/0!	0
Desert Tortoise - Core Habitat	120	0	5	1,084	0	743	69%	81
Linkage/Corridor	22	0	1	201	0	0	0%	1
Little San Bernardino Mountain Linanthus - Other Conserved Habitat	39	0	0	348	0	278	80%	32
Sand Source	94	0	3	850	0	619	73%	68
Sand Transport	48	0	1	435	0	339	78%	37
Sonoran Cottonwood-Willow Riparian Forest	11	0	0	107	0	105	99%	11
Triple-Ribbed Milkvetch - Core Habitat	41	0	0	368	0	278	75%	32
Whitewater Floodplain Conservation Area								
Cathedral City								
Active Desert Sand Fields	5	0	0	43	0	0	0%	1
Coachella Valley Fringe-Toed Lizard - Core Habitat	7	0	0	61	0	0	0%	1
Coachella Valley Giant Sand-Treader Cricket - Core Habitat	7	0	0	61	0	0	0%	1
Coachella Valley Milkvetch - Core Habitat	7	0	0	59	0	0	0%	1
Coachella Valley Round-Tailed Ground Squirrel - Core Habitat	7	0	0	61	0	0	0%	1
Le Conte's Thrasher - Other Conserved Habitat	7	0	0	61	0	0	0%	1
Linkage/Corridor	2	0	0	18	0	0	0%	0
Palm Springs Pocket Mouse - Core Habitat	7	0	0	61	0	0	0%	1
Sand Transport	7	0	0	61	0	0	0%	1
Palm Springs								
Active Desert Sand Fields	44	0	0	392	22	349	89%	40
Coachella Valley Fringe-Toed Lizard - Core Habitat	295	0	53	2,659	27	880	33%	64
Coachella Valley Giant Sand-Treader Cricket - Core Habitat	295	0	53	2,659	27	880	33%	64
Coachella Valley Milkvetch - Core Habitat	328	0	53	2,955	27	880	30%	67
Coachella Valley Round-Tailed Ground Squirrel - Core Habitat	297	0	60	2,671	41	917	34%	61
Ephemeral Desert Sand Fields	132	0	29	1,185	5	524	44%	37
Le Conte's Thrasher - Other Conserved Habitat	381	0	60	3,433	47	955	28%	74
Linkage/Corridor	90	0	8	809	19	70	9%	8
Palm Springs Pocket Mouse - Core Habitat	347	0	63	3,122	47	941	30%	66

Conservation Area, Permittee, and Conservation Element	Total Authorized Disturbance	Disturbed 2020	Disturbance to Date	Required Conservation	Conserved 2022	Conservation to Date	Percent Conserved	Rough Step Value
Sand Transport	387	0	55	3,484	47	955	27%	79
Stabilized & Partially Stabilized Desert Sand Fields	44	0	0	394	0	6	2%	5
Riverside County								
Coachella Valley Fringe-Toed Lizard - Core Habitat	6	0	0	57	0	0	0%	1
Coachella Valley Giant Sand-Treader Cricket - Core Habitat	6	0	0	57	0	0	0%	1
Coachella Valley Milkvetch - Core Habitat	11	0	0	100	0	0	0%	1
Coachella Valley Round-Tailed Ground Squirrel - Core Habitat	6	0	0	58	0	0	1%	1
Ephemeral Desert Sand Fields	6	0	0	52	0	0	0%	1
Le Conte's Thrasher - Other Conserved Habitat	53	0	30	480	0	247	51%	0
Linkage/Corridor	53	0	30	475	0	247	52%	0
Palm Springs Pocket Mouse - Core Habitat	53	0	30	477	0	245	51%	0
Sand Transport	53	0	30	481	0	247	51%	0
Stabilized & Partially Stabilized Desert Sand Fields	1	0	0	4	0	0	0%	0
Willow Hole Conservation Area								
Cathedral City								
Active Desert Sand Fields	4	0	0	33	0	0	0%	0
Coachella Valley Fringe-Toed Lizard - Core Habitat	24	0	0	211	0	423	200%	46
Coachella Valley Milkvetch - Core Habitat	87	0	0	782	0	0	0%	9
Coachella Valley Round-Tailed Ground Squirrel - Core Habitat	140	0	0	1,256	0	719	57%	86
Ephemeral Desert Sand Fields	20	0	0	178	0	122	69%	14
LeConte's Thrasher - Other Conserved Habitat	168	0	0	1,508	0	752	50%	92
Palm Springs Pocket Mouse - Core Habitat	107	0	0	959	0	705	73%	81
Sand Source	79	0	0	710	0	66	9%	15
Sand Transport	89	0	0	798	0	686	86%	78
Stabilized & Partially Stabilized Desert Sand Dunes	0	0	0	1	0	0	0%	0
Stabilized & Partially Stabilized Desert Sand Fields	6	0	0	51	0	0	0%	1
Desert Hot Springs								
Coachella Valley Fringe-Toed Lizard - Core Habitat	0	0	0	3	0	513	17088%	0
Coachella Valley Milkvetch	96	0	0	863	0	0	0%	10
Coachella Valley Round-Tailed Ground Squirrel - Core Habitat	0	0	0	3	0	0	1%	0
Ephemeral Desert Sand Fields	61	0	0	549	0	269	49%	33
LeConte's Thrasher - Other Conserved Habitat	167	0	0	1,499	0	902	60%	107
Linkage/Corridor	31	0	0	277	0	140	51%	17
Mesquite Hummocks	3	0	0	27	0	22	81%	2
Palm Springs Pocket Mouse - Core Habitat	171	0	0	1,542	0	882	57%	105
Sand Transport	171	0	0	1,542	0	882	57%	105
Stabilized & Partially Stabilized Desert Sand Dunes	14	0	0	125	0	74	59%	9

Conservation Area, Permittee, and Conservation Element	Total Authorized Disturbance	Disturbed 2020	Disturbance to Date	Required Conservation	Conserved 2022	Conservation to Date	Percent Conserved	Rough Step Value
Stabilized & Partially Stabilized Desert Sand Fields	5	0	0	49	0	26	52%	3
Riverside County								
Coachella Valley Fringe-Toed Lizard - Core Habitat	50	0	0	452	0	1,223	271%	126
Coachella Valley Milkvetch - Core Habitat	99	0	0	88	0	0	0%	10
Coachella Valley Round-Tailed Ground Squirrel - Core Habitat	120	0	0	1,078	0	929	86%	105
Desert Fan Palm Oasis Woodland	0	0	0	0	0	0	#DIV/0!	0
Desert Saltbush Scrub	17	0	0	152	0	142	94%	16
Ephemeral Desert Sand Fields	20	0	0	179	0	101	57%	12
LeConte's Thrasher - Other Conserved Habitat	131	0	0	1,178	0	959	81%	109
Linkage/Corridor	13	0	0	120	0	0	0%	1
Mesquite Hummocks	8	0	0	71	0	78	110%	9
Palm Springs Pocket Mouse - Core Habitat	127	0	0	1,142	0	937	82%	106
Sand Source Area	20	0	0	17	0	8	48%	11
Sand Transport Area	133	0	0	1,193	0	951	80%	108
Stabilized & Partially Stabilized Desert Sand Dunes	21	0	0	194	0	179	92%	19
Stabilized & Partially Stabilized Desert Sand Fields	9	0	0	79	0	69	87%	8

APPENDIX IV: DEVELOPMENT OUTSIDE CONSERVATION AREAS

Conservation Element and Jurisdiction	Acres Disturbed
Active Desert Dunes	7
Palm Springs	0
Riverside County	7
Active Desert Sand Fields	282
Cathedral City	0
Indio	0
Palm Springs	0
Riverside County	282
Arrowweed Scrub	0
Riverside County	0
Arroyo Toad	0
Riverside County	0
California Black Rail	3
Coachella	1
Indio	1
Riverside County	0
Chamise Chaparral	0
Riverside County	0
Cismontane Alkali Marsh	0
Riverside County	0
Coachella Valley Fringe-Toed Lizard	8,397
Cathedral City	993
Coachella	9
Indian Wells	718
Indio	1,091
La Quinta	571
Palm Desert	1,127
Palm Springs	1,676
Rancho Mirage	1,199
Riverside County	1,014
Coachella Valley Giant Sand-Treader Cricket	8,388
Cathedral City	993
Coachella	0
Indian Wells	718
Indio	1,091
La Quinta	571
Palm Desert	1,127
Palm Springs	1,676
Rancho Mirage	1,199
Riverside County	1,013
Coachella Valley Jerusalem Cricket	4,423
Cathedral City	1,015
Desert Hot Springs	58
Palm Desert	21
Palm Springs	1,680
Rancho Mirage	1,101
Riverside County	548
Coachella Valley Milkvetch	6,262
Cathedral City	885
Desert Hot Springs	68
Indian Wells	617
La Quinta	1
Palm Desert	1,115
Palm Springs	1,203
Rancho Mirage	988
Riverside County	1,386
Coachella Valley Round-Tailed Ground Squirrel	14,820
Cathedral City	1,272

Coachella	130
Desert Hot Springs	683
Indian Wells	1,036
Indio	1,932
La Quinta	1,494
Palm Desert	1,470
Palm Springs	2,075
Rancho Mirage	1,378
Riverside County	3,349
Coastal and Valley Freshwater Marsh	3
Coachella	1
Indio	1
Riverside County	0
Crissal Thrasher	1,728
Cathedral City	0
Coachella	122
Desert Hot Springs	9
Indian Wells	21
Indio	274
La Quinta	690
Riverside County	611
Desert Dry Wash Woodland	712
Cathedral City	9
Coachella	0
Desert Hot Springs	0
Indian Wells	181
Indio	0
La Quinta	33
Palm Desert	180
Palm Springs	9
Rancho Mirage	28
Riverside County	273
Desert Fan Palm Oasis Woodland	0
Cathedral City	0
Desert Hot Springs	0
Palm Springs	0
Rancho Mirage	0
Riverside County	0
Desert Saltbush Scrub	636
Coachella	56
Indio	180
La Quinta	43
Riverside County	357
Desert Sink Scrub	112
Riverside County	112
Desert Tortoise	3,307
Cathedral City	33
Coachella	1
Desert Hot Springs	690
Indian Wells	201
Indio	0
La Quinta	418
Palm Desert	473
Palm Springs	125
Rancho Mirage	174
Riverside County	1,191
Ephemeral Sand Fields	80
Cathedral City	0
Palm Springs	73
Riverside County	7
Flat-tailed Horned Lizard	8,521
Cathedral City	922
Coachella	6

Desert Hot Springs	49
Indian Wells	718
Indio	992
La Quinta	585
Palm Desert	1,127
Palm Springs	1,670
Rancho Mirage	1,191
Riverside County	1,261
Gray Vireo	161
Palm Springs	0
Riverside County	161
Interior Live Oak Chaparral	0
Palm Springs	0
Riverside County	0
Le Conte's Thrasher	17,600
Cathedral City	1,287
Coachella	143
Desert Hot Springs	1,234
Indian Wells	1,188
Indio	1,737
La Quinta	1,755
Palm Desert	1,970
Palm Springs	2,045
Rancho Mirage	1,402
Riverside County	4,840
Least Bell's Vireo	2,235
Cathedral City	9
Coachella	124
Desert Hot Springs	10
Indian Wells	202
Indio	276
La Quinta	723
Palm Desert	180
Palm Springs	9
Rancho Mirage	28
Riverside County	674
Little San Bernardino Mountains Linanthus	1
Desert Hot Springs	1
Riverside County	0
Mecca Aster	1
Indio	0
Riverside County	1
Mesquite Bosque	0
Riverside County	0
Mesquite Hummocks	250
Cathedral City	0
Coachella	17
Desert Hot Springs	9
Indian Wells	22
Indio	80
La Quinta	73
Riverside County	49
Mojave Mixed Woody Scrub	7
Desert Hot Springs	2
Riverside County	5
Mojavean Pinyon & Juniper Woodland	0
Riverside County	0
Orocopia Sage	18
Riverside County	18
Palm Springs Pocket Mouse	14,946
Cathedral City	1,286
Coachella	72

Desert Hot Springs	700
Indian Wells	1,045
Indio	1,811
La Quinta	1,315
Palm Desert	1,549
Palm Springs	2,213
Rancho Mirage	1,416
Riverside County	3,538
Peninsular Bighorn Sheep	516
Cathedral City	10
Indian Wells	2
La Quinta	137
Palm Desert	217
Palm Springs	97
Rancho Mirage	19
Riverside County	35
Peninsular Juniper Woodland & Scrub	1
Palm Springs	0
Riverside County	1
Red Shank Chaparral	0
Riverside County	0
Semi-Desert Chaparral	0
Palm Springs	0
Riverside County	0
Sonoran Cottonwood-Willow Riparian Forest	1
Coachella	0
Indio	0
Palm Springs	0
Riverside County	1
Sonoran Creosote Bush Scrub	1,505
Cathedral City	0
Coachella	55
Desert Hot Springs	0
Indian Wells	25
Indio	275
La Quinta	188
Palm Desert	192
Palm Springs	4
Rancho Mirage	24
Riverside County	742
Sonoran Mixed Woody & Succulent Scrub	905
Cathedral City	21
Desert Hot Springs	69
Indian Wells	0
Indio	9
La Quinta	10
Palm Desert	242
Palm Springs	45
Rancho Mirage	0
Riverside County	509
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	2,264
Cathedral City	5
Coachella	97
Desert Hot Springs	3
Indian Wells	214
Indio	271
La Quinta	793
Palm Desert	195
Palm Springs	7
Rancho Mirage	46
Riverside County	633
Stabilized & Partially Stabilied Desert Sand Fields	1
Cathedral City	0
Indio	0
Palm Springs	0
Riverside County	0
Stabilized & Partially Stabilized Desert Sand Dunes	0
Cathedral City	0
Riverside County	0
Stabilized Shielded Sand Fields	7,562
Cathedral City	971
Coachella	9
Indian Wells	718
Indio	1,090
La Quinta	571
Palm Desert	1,033
Palm Springs	1,411
Rancho Mirage	1,199
Riverside County	560
Summer Tanager	2,234
Cathedral City	9
Coachella	124
Desert Hot Springs	9
Indian Wells	202
Indio	276
La Quinta	723
Palm Desert	180
Palm Springs	9
Rancho Mirage	28
Riverside County	674
Triple-ribbed Milkvetch	0
Palm Springs	0
Riverside County	0
Yellow Warbler	2,285
Cathedral City	9
Coachella	125
Desert Hot Springs	10
Indian Wells	202
Indio	311
La Quinta	723
Palm Desert	180
Palm Springs	9
Rancho Mirage	28
Riverside County	688
Yellow-breasted Chat	2,235
Cathedral City	9
Coachella	124
Desert Hot Springs	10
Indian Wells	202
Indio	276
La Quinta	723
Palm Desert	180
Palm Springs	9

Rancho Mirage	28
Riverside County	674
Yuma Clapper Rail	3
Coachella	1
Indio	1
Riverside County	0

APPENDIX V: 2022 AEOLIAN SAND SPECIES MONITORING REPORT

Report begins on following page

Coachella Valley Multiple Species Habitat Conservation Plan

2021–2022 BIOLOGICAL MONITORING RESULTS FOR THE COACHELLA VALLEY AEOLIAN SAND SPECIES

2021-2022 FINAL REPORT

FINAL REPORT

COACHELLA VALLEY MULTIPLE SPECIES HABITAT CONSERVATION PLAN 2021–2022 BIOLOGICAL MONITORING RESULTS FOR THE COACHELLA VALLEY AEOLIAN SAND SPECIES

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1 INTRODUCTION

Monitoring species without ecological context does not provide insights as to why populations rise or fall in any year, and if or when a declining population could be rescued through targeted adaptive management (Barrows et al. 2005). Biological monitoring elsewhere has typically focused on periodic counts of a species; results were limited to successful detection or not, or whether populations are increasing or decreasing. 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 warrant management intervention or indicate concerns over the design and implementation of a conservation program aimed at protecting that species. Occupancy or abundance data alone do not inform landowners and managers as to why changes are happening, and if intervention is appropriate, what if any management prescriptions might support population persistence. A different monitoring approach was necessary and was developed in parallel with the negotiations that resulted in the Coachella Valley MSHCP/NCCP (CVMSHCP-NCCP) (Barrows et al. 2005; Barrows and Allen 2007a; Barrows and Allen 2007b). That approach considered 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.

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. Additional factors that potentially impact sand dune species include:

- **habitat patch size** (is the populations large enough and have sufficient genetic diversity to adapt to environmental changes?),
- **sand transport processes** (is the amount of sand delivered to a given habitat through fluvial and aeolian ecosystem process sufficient to balance sand leaving that habitat and to sustain appropriate sand compaction diversity?),

- **invasive species** (are invasive species competing with native species with a result of reduced biodiversity?). and,
- **climate change** (desert dune species are adapted to sustain populations under typical annual hot and dry fluctuations, however, as a result of anthropogenic climate change, is it becoming consistently too hot and/or arid, outside of typical annual oscillations for native species and/or the food resources those species depend on to sustain populations?).

2 VERTEBRATES: HERPETOFAUNA

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 widespread, 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 to 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 (early versus late morning) – if individuals were active on a plot during or prior to the survey we could detect them by the diagnostic tracks they 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 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. 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 / 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 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*

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

The Standard Precipitation Index, (SPI) (McKee et al. 1993, 1995; Livada, and Assimakopoulos 2007) provides a means of illustrating the relative intensity of drought or non-drought, wet conditions. Analyzing SPI relationships between rainfall and lizard population dynamics throughout the lizards' range allows us to assess how drought or wetter conditions influence the lizards' population responses. Using an equiprobable transformation, the cumulative density function (CDF) of the gamma distribution was then transformed to the CDF of the standard normal distribution. The transformed standard deviate is the SPI for the given precipitation total. The SPI is computed by dividing the difference between the normalized seasonal precipitation and its long-term seasonal mean by the standard deviation. Since the SPI is equal to the z-value of the normal distribution, McKee et al. (1993, 1995) proposed a seven-category classification for the SPI: extremely wet (>2.0), very wet (1.5 to 1.99), moderately wet (1.0 to 1.49), near normal (−0.99 to 0.99), moderately dry (−1.49 to 1.0), severely dry (−1.99 to 1.5), and extremely dry (<−2.0). Although this region receives occasional isolated summer rain that can result in localized flooding, primary productivity is catalyzed by cool season rains (Noy-Meir 1973; Kearney *et al*. 2018). For analyzing the relationship between rainfall and the lizards' population dynamics we compared annual November-April SPI values to mean densities of lizards found on each belt transect. 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).

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 % 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;

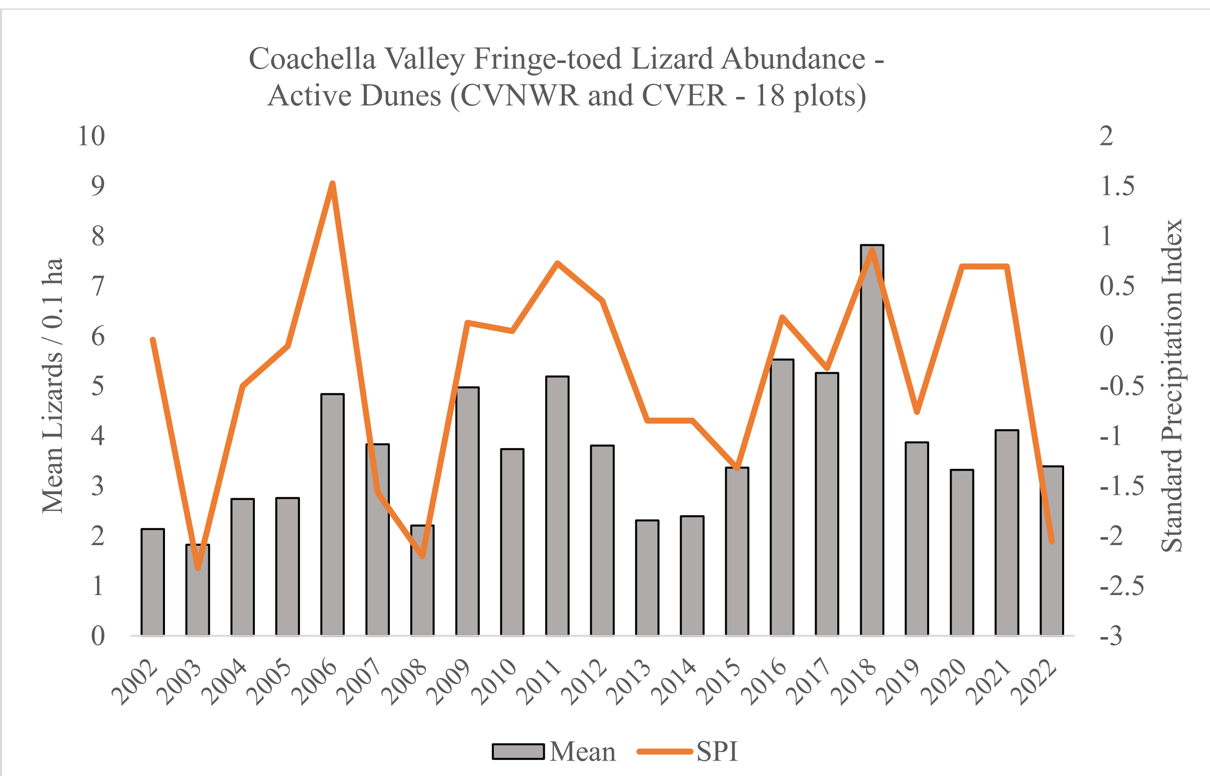
both the roadrunner (except on the mesquite dune natural community) and kestrel were dependent on planted non-native trees and shrubs for nesting sites. Others are possible competitors such as zebra-tailed lizards (*Callisaurus draconoides*) and flat-tailed horned lizards (*Phrynosoma mcallii*), but none are as habitat specific to active aeolian sand as are fringe-toed lizards.

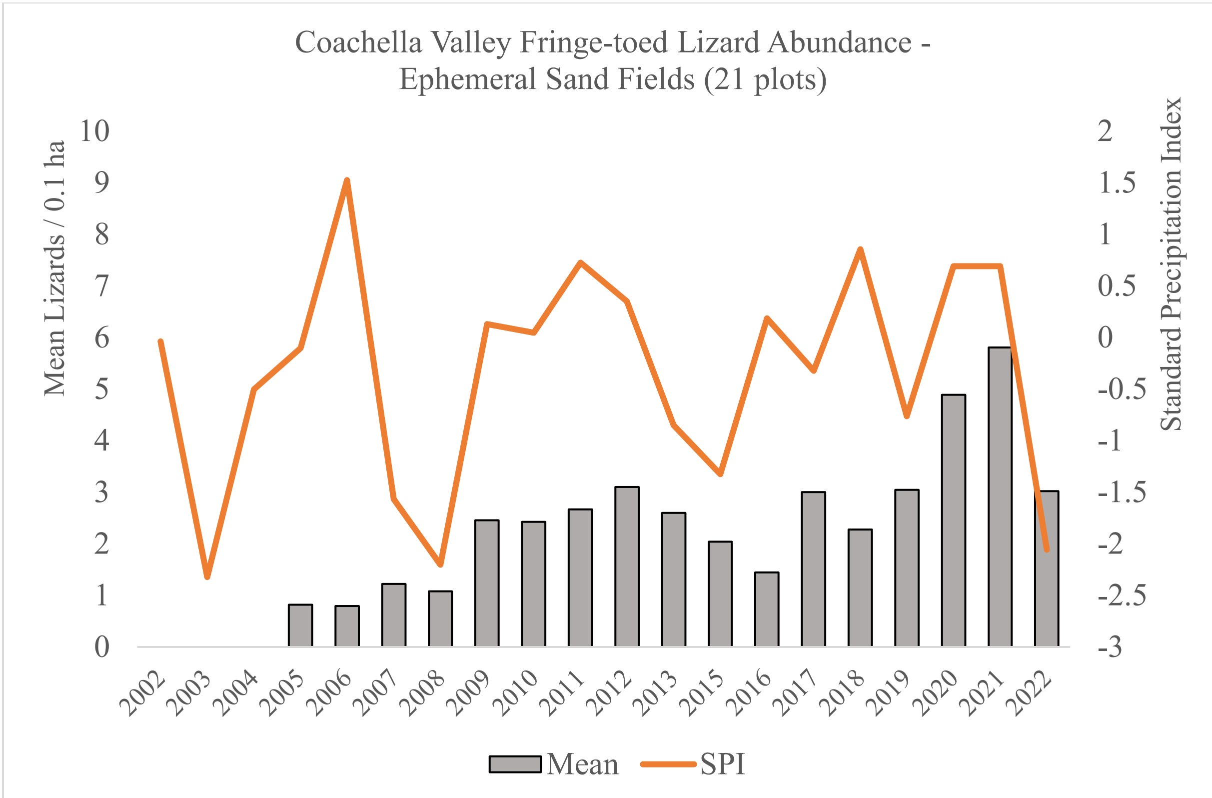
2.1 Coachella Valley Fringe-toed Lizards

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 asynchronous, or non-significant correlations between precipitation and lizard densities indicate a need for management intervention? For the active dunes and mesquite dunes precipitation levels positively correlate with lizard densities (Active Dunes: r = 0.591, $P = 0.0048$; Mesquite Dunes: r = 0.615, $P = 0.0039$) (Figure 1). However, for the Ephemeral Sand Fields there was no significant correlation with rainfall (r = 0.239, P = 0.3556). The lack of correlation here is likely due to the ephemeral nature of the substrate quality; fringe-toed numbers increase when there were both large/deep aeolian sand drifts and hummocks and adequate rainfall, however, if the sand drifts and hummocks were reduced; no amount of rainfall increased the lizard population. This underlines the extreme importance of maintaining natural sand transport, a process that is in jeopardy due to water percolation ponds redirecting sand flow in the west valley north of Palm Springs, planned sand control efforts along Indian Avenue, and (an illegal) diversion of sand flow into a sand and gravel mining pit immediately east of Indian Avenue on the Whitewater Floodplain Preserve.

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). Fringe-toed lizards were largely absent from the Stabilized Sand Fields, occurring only where occasional deep sand drifts occurred. For this reason, Stabilized sand fields were not included in further analyses related to fringe-toed lizard abundance. 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 plots designated *a priori* as active dunes, 75% had sand compaction levels fitting to that natural community. However, those plots with compaction levels ≤ 0.125 kg / cm^2, but otherwise identified as active dunes, but now with sand compaction and lizard densities well within the stabilized sand field range, indicate 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 were warranted.

The low numbers of fringe-toed lizards on the mesquite dunes were also a potential indication of that population being at risk. This habitat naturally has high predator densities, including sidewinders, roadrunners, kestrels, shrikes, and round-tailed ground squirrels. Those predator impacts likely keep this already small lizard population from expanding, but those impacts are not anthropogenic (predator densities and not related to humans or human-caused habitat change). The primary concern is that this is the smallest, most isolated habitat patch with no connectivity to other patches. Vandergast et al. (2016) identified relatively low genetic diversity here compared with other larger habitats and fringe-toed lizard populations.





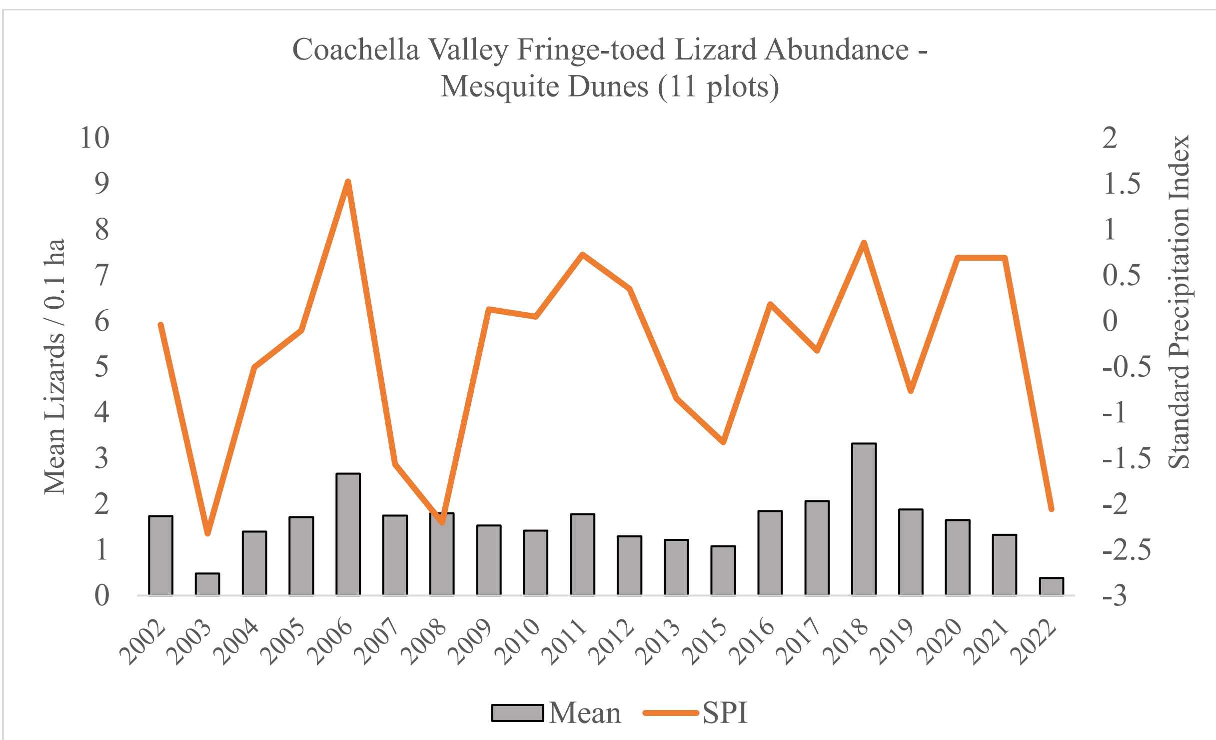


Figure 1. Annual changes in Coachella Valley fringe-toed lizard densities within the context of precipitation to show how the lizards' population fluctuations are often synchronized with rainfall patterns. CVNWR = Coachella Valley National Wildlife Refuge (USFWS); CVER = Coachella Valley Ecological Reserve (CDFW). The SPI is off-set by one year to account for the one year lag time most vertebrate show between rain and population responses.

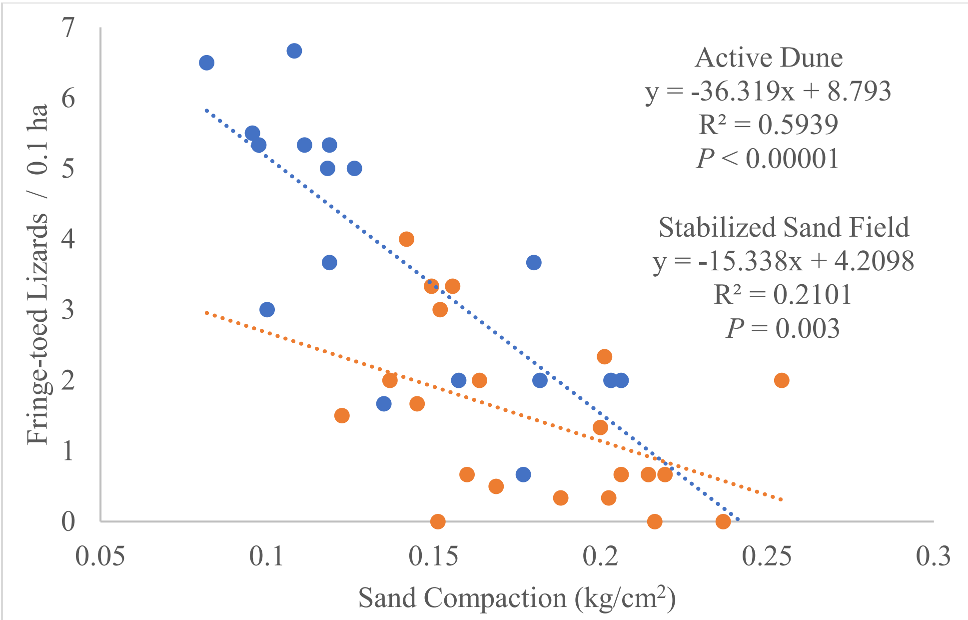


Figure 2. Patterns of Fringe-toed lizard densities in relationship to sand compaction in 2020. Active dunes (each plot indicated by a blue circle) generally have less compacted sand and higher lizard densities, whereas stabilized sand field plots (orange circles) have more compacted sand and fewer lizards. 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.

The only location where illegal off-road vehicle recreation is occurring at levels that negatively impact these lizards is at the western edge of the Indio Hills, along the Kim Nicol trail. To be clear, the new trail is not the problem, the illegal ORV activity there predates the trail establishment by decades. Ironically, the trail and ORV use restricted to that trail appears somewhat beneficial to the lizards in that it maintains sand corridors that connect larger sand patches and so creates a metapopulation comprised of small sand patches that together appear to be able to sustain large fringe-toed lizard densities. However, when the ORV activity increases and moves beyond the confines of the trail, they are killing lizards. We have three plots in this area, two of which have regularly some of the highest fringe-toed lizards we have found throughout the Coachella Valley (means of 5-10 lizards / 0.1 ha plot). One of those plots received extra-trail vehicle trespass in 2022, and its lizard density dropped to 2.5 lizards. The other plot, without the extracurricular vehicle impacts, maintained a density of 6.5 lizards. Controlling illegal ORV recreation there is clearly a difficult challenge, but if beyond-trail trespass continues and expands, the lizard population there will be at risk.

2.2 FLAT-TAILED HORNED LIZARDS

Flat-tailed horned lizards were once widespread within the Coachella Valley, with populations recorded on what is now the Whitewater Floodplain Preserve, the slopes of Edom Hill, to the eastern edge of the Indio Hills and the aeolian sand flats extending east and south from there. Today this lizard within the Coachella Valley is restricted to the Coachella Valley National Wildlife Refuge (USFWS) and the Coachella Valley Ecological Reserve (CDFW). 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 on that remaining habitat (Barrows et al, 2006), for understanding what those broader habitat metrics are, we have excluded data collected from plots < 100 m from habitat edges from analyses of those broader habitat constraints, as lizard densities there are predominantly influenced by edge effects and would therefore not be as sensitive to habitat features affecting lizards occupying habitats further distant from the habitat edges. 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, that metric has no explanatory value for flat-tailed horned lizards.

Temporal patterns of annual rainfall also appear to have little influence on the differences in this species' density (Figure 5). This lack of a relationship is puzzling. But may be explained by the abundance of Sahara mustard the periodically becomes extremely dense across the flat-tail's habitat. This was true for the period of 2008-2011 (see annual plant monitoring section), a time span with relatively high rainfall, but corresponding to very low horned lizard densities. The correlation between mustard cover and horned lizard densities is negative and statistically significant ($r = -0.509$, $P = 0.0373$; ANOVA, d. f. = 1, $F = 7.71$, $P = 0.009$); higher Sahara mustard densities are associated with fewer horned lizards.

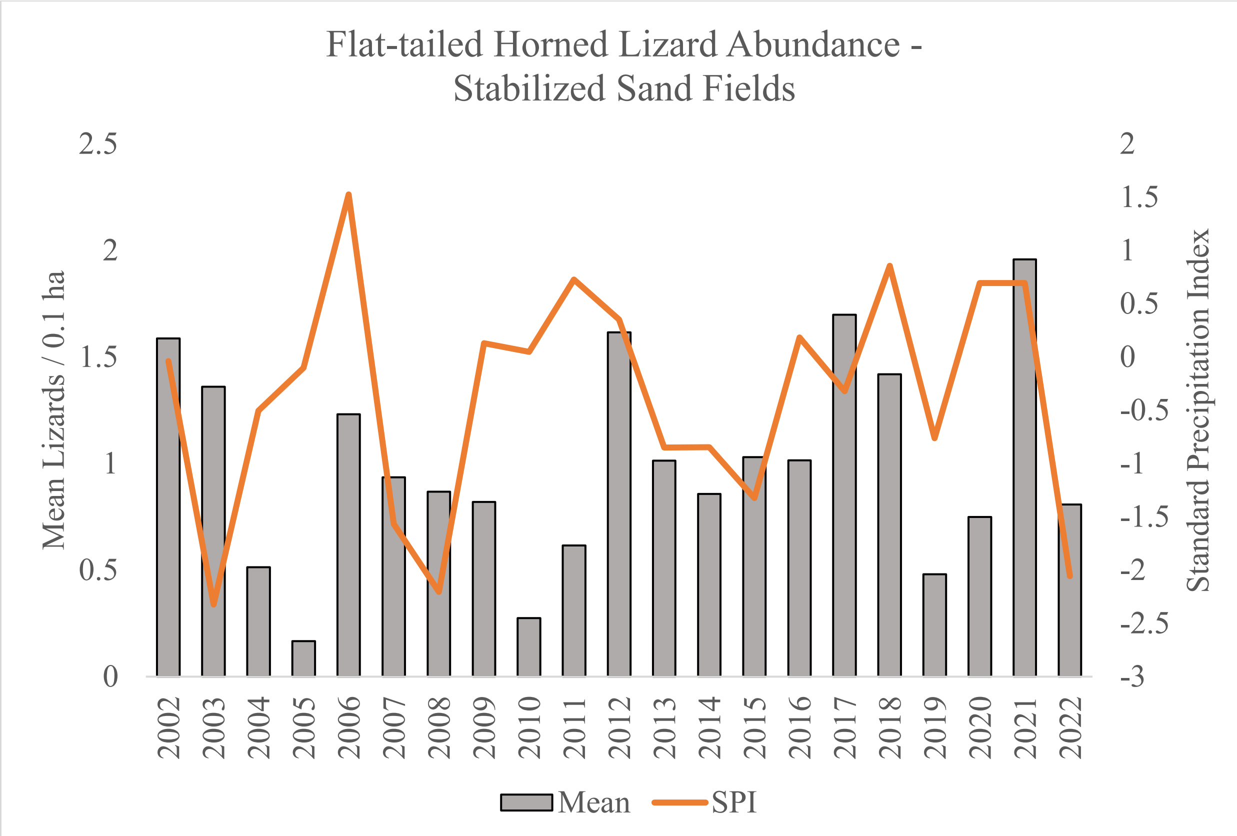


Figure 3. The relationship between annual rainfall and flat-tailed horned lizard densities on the L, H, CA, and MH plot clusters (19 plots). The SPI is off-set by one year to account for the one year lag time most vertebrate show between rain and population responses.

The primary food for flat-tails, like all horned lizards, are 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. However, there does not appear to be a broad spatial congruence in temporal ant abundance nor flat-tail abundance, rather each plot cluster seems to be fluctuating independently. Second, early, from 2002-2007 there appears to be synchronous fluctuations with ants and flat-tails, as we hypothesized. However, from 2008-2020, that relationship evaporated into asynchrony. We can only speculate why this apparent shift occurred. The onset of the shift was coincident with the dense Sahara mustard cover from 2008-2011, but if related, the mechanism and the reason for the on-going asynchrony even though the mustard has fluctuated since then, remains elusive. Another factor may be that our ability to quantify harvester ant population fluctuations using pitfall trapping maybe insufficient. Efforts are now underway to identify better methods to assess ant populations.

2.3 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 local 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.

3 VERTEBRATES: MAMMALS

3.1 ROUND-TAILED GROUND SQUIRREL

Round-tailed ground squirrels (RTGS), *Xerospermophilus tereticaudus chlorus*, occur is fine-textured sandy areas of the Coachella Valley. Antelope ground squirrels replace RTGS in gravely and rocky soils. RTGS are mostly restricted to aeolian sands, and occur throughout the valley's aeolian sand communities, as well as in urban gardens along wildland-urban interfaces where soils are appropriate. Our survey method, similar with all the vertebrates included here, is to quantify their abundance based on the mean number to their distinctive track ways left within our 0.1 ha plots. Unlike other (non-avian) vertebrates, RTGS are quite vocal when at high densities; there we use their distinctive alarm calls and tracks (whichever provides the higher number) to tabulate occurrences within our plots. However, at low densities, they rarely vocalize, and so we can only use their tracks for surveys. Within the protected aeolian sand habitats of the RTGS are irregular and uncommon within the CVNWR and CVER, and within the Windy Point and Fingal's Finger protected lands at the western edge of the Coachella Valley's aeolian sand habitats. Population levels at those locations appear tied to annual rainfall amounts, becoming rare or absent during drought periods. The only location where RTGS are common and regularly encountered is within the mesquite dunes of the Willow Hole Preserve.

Within the mesquite dunes, they show year-to-year variation in numbers that do not correlate with annual in precipitation ($r = 0.275$, $p = 0.27$) (Figure 4). The explanation for the lack of a stronger rainfall response is that the mesquite is typically tapped into aquifer-based water sources and not reliant on annual rainfall. In areas where the mesquite has died, RTGS densities drop to match those on non-mesquite aeolian communities.

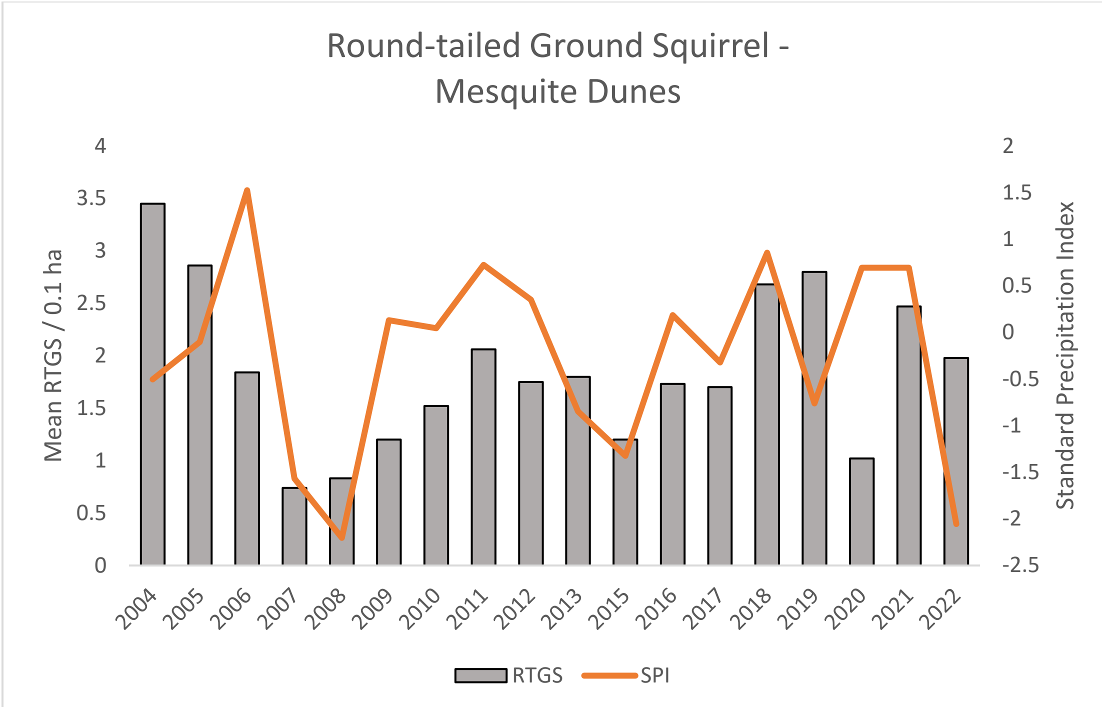
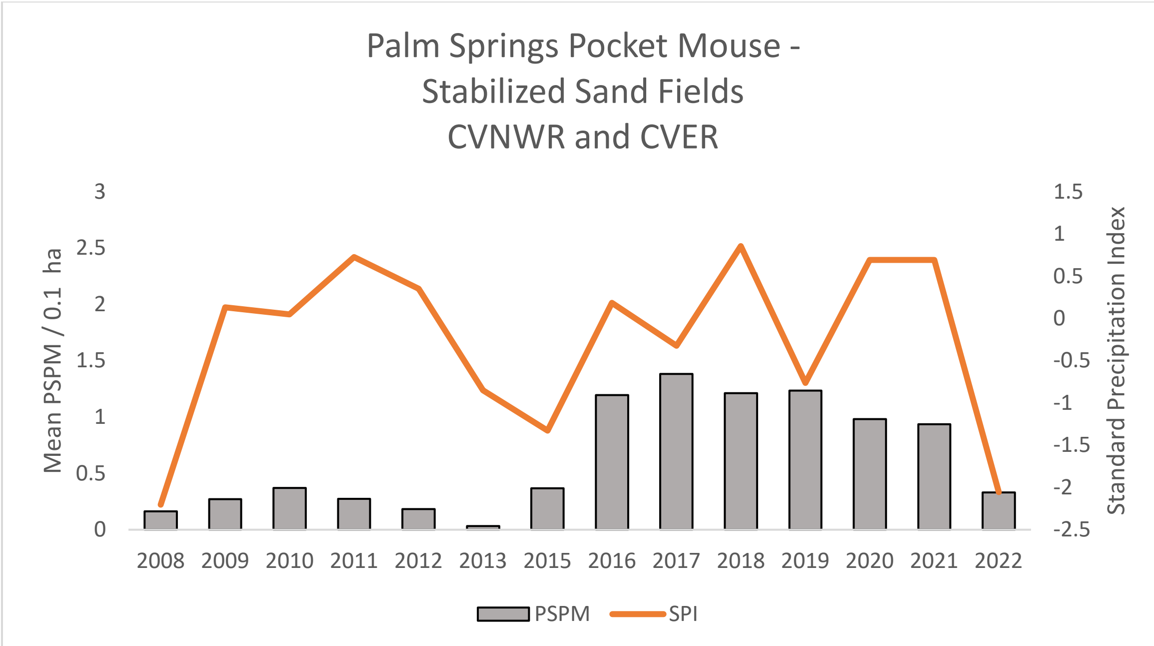


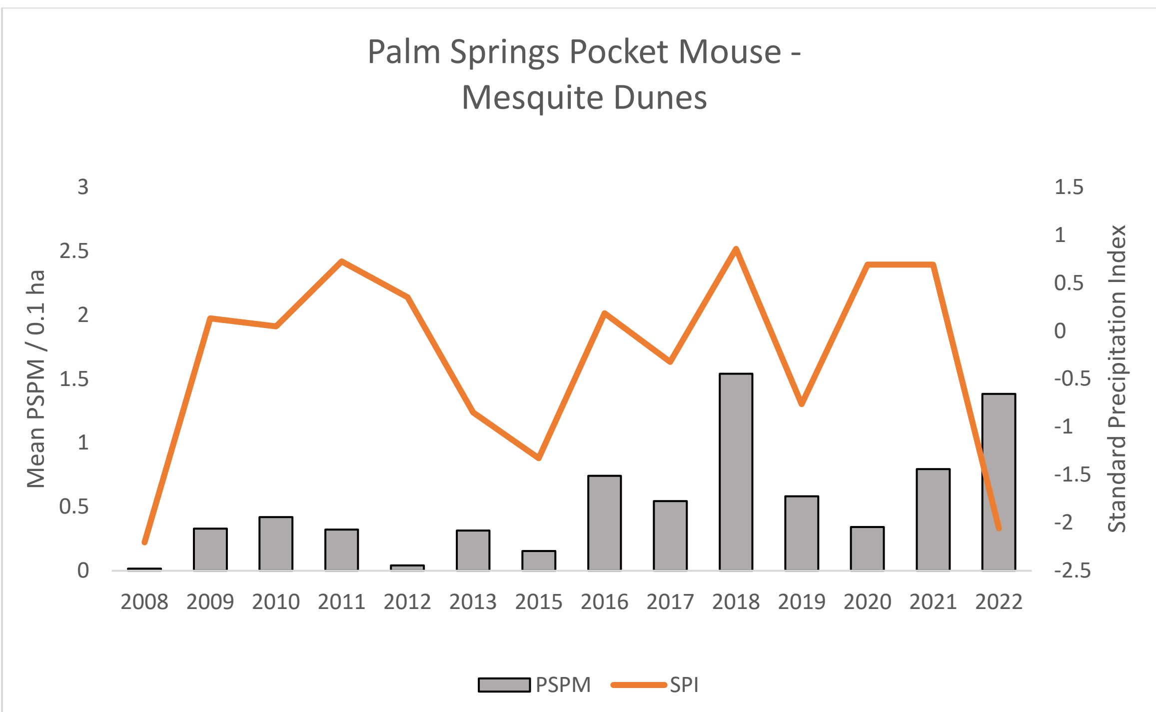
Figure 4: Temporal patterns of abundance of round-tailed ground squirrels within the Willow Hole Preserve. The SPI is off-set by one year to account for the one year lag time most vertebrate show between rain and population responses. We did not collect data in 2014 at the request of the wildlife agencies.

3.2 PALM SPRINGS POCKET MICE

Palm Springs pocket mice, *Perognathus longimembris bangsi*, (PSPM) are the smallest Heteromyid rodent within our region, and are confined to fine-textured soils, sand and silts across the Coachella Valley floor, extending from Fingal's Finger and Windy Point through to the CVNWR and CVER. Further east their numbers decline rapidly, likely due to increased aridity. Although not restricted to aeolian sand habitats, they occupy all of the protected areas where aeolian sand habitats are found. Our data indicate a larger, more stable population at all sites following the 2015-2016 field seasons. While thought provoking, this may simply be due to our biologists developing better identification skills and/or more of a focus on this species than they had previously. Using only the 2015-2022 data, within those protected areas this species is consistently found at higher densities on the western ephemeral sand fields, indicating that temperature and aridity may limit their ability find suitable habitat. Support for that hypothesis is found when comparing correlations between PSPM abundance and rainfall. At the driest, easter sited PSPM abundance correlation with rainfall almost reaches traditional levels of statistical significance ($r = 0.667$, $p = 0.07$), whereas on the cooler-wetter wester sites, correlations were nowhere near statistical significance.

This species appears secure on all sites surveyed.


Palm Springs Pocket Mouse -
Stabilized Sand Fields
CVNWR and CVER
Mean PSPM / 0.1 ha
Standard Precipitation Index
3
2.5
2
1.5
1
0.5
0
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
2008 2009 2010 2011 2012 2013 2015 2016 2017 2018 2019 2020 2021 2022
PSPM
SPI


Palm Springs Pocket Mouse -
Mesquite Dunes
Mean PSPM / 0.1 ha
Standard Precipitation Index
3
2.5
2
1.5
1
0.5
0
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
2008 2009 2010 2011 2012 2013 2015 2016 2017 2018 2019 2020 2021 2022
PSPM
SPI

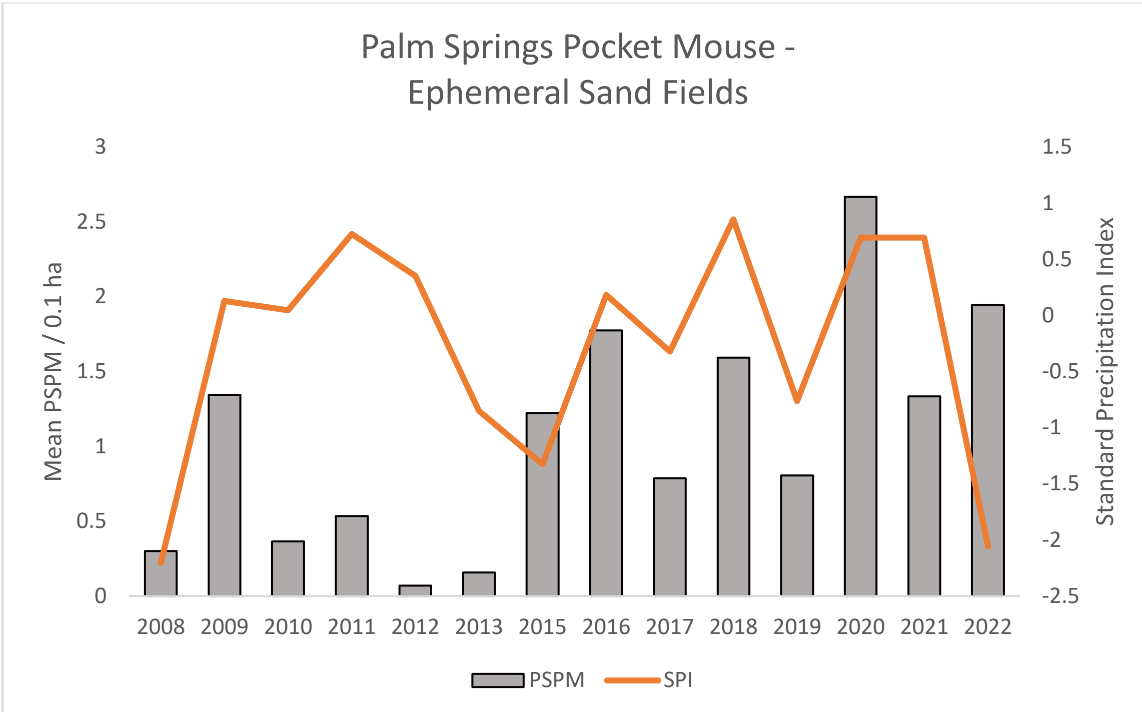


Figure 5: Temporal patterns of abundance of Palm Springs pocket mice across the aeolian sand habitats of the Coachella Valley. The SPI is off-set by one year to account for the one year lag time most vertebrate show between rain and population responses. We did not collect data in 2014 at the request of the wildlife agencies.

4 Vegetation

4.1 Annual Plant Monitoring

We conducted annual plant monitoring surveys across the Coachella Valley in spring 2022 using the one-square-meter quadrat sampling design used in previous years. Our goals were to document species richness, abundance, and coverage in annual forbs, both native and non-native, across the different sand communities covered by our plot network.

Our quadrat sampling protocol uses a PVC frame, 1m x 1m, placed on alternating sides of the plot midline four times at the beginning, middle, and end of the 0.1 ha plot, for a total of 12 samples (Figure 6). Within the quadrat, all plant species that germinated in the past year are identified, counted, and the percent cover of the species within the quadrat is estimated.

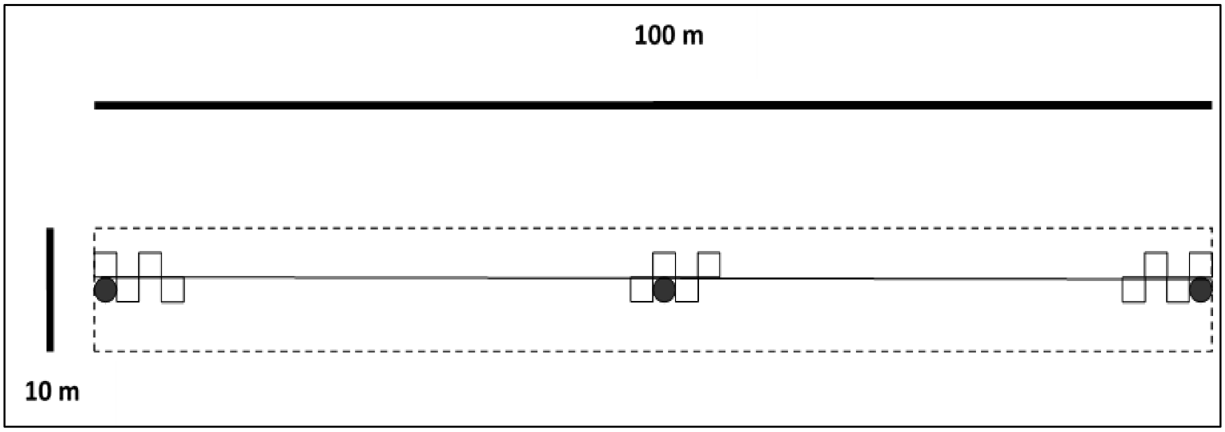


Figure 6. Sampling design for annual plant monitoring. The twelve small squares show the layout of the 1 m^2 frames where annual vegetation density and cover is measured. The three solid circles represent the 0, 50, and 100 m poles.

In spring 2022, we repeated the quadrat sampling method on 84 0.1 ha plots (Figure 7; all of our current monitoring plots in the Coachella Valley), for a total of 1,008 individual quadrat samples. We designated each plot a sand community type: active sand dune (n=20), ephemeral sand field (n=26), mesquite hummock (n=11), and stable sand field (n=27) (Figure 8).

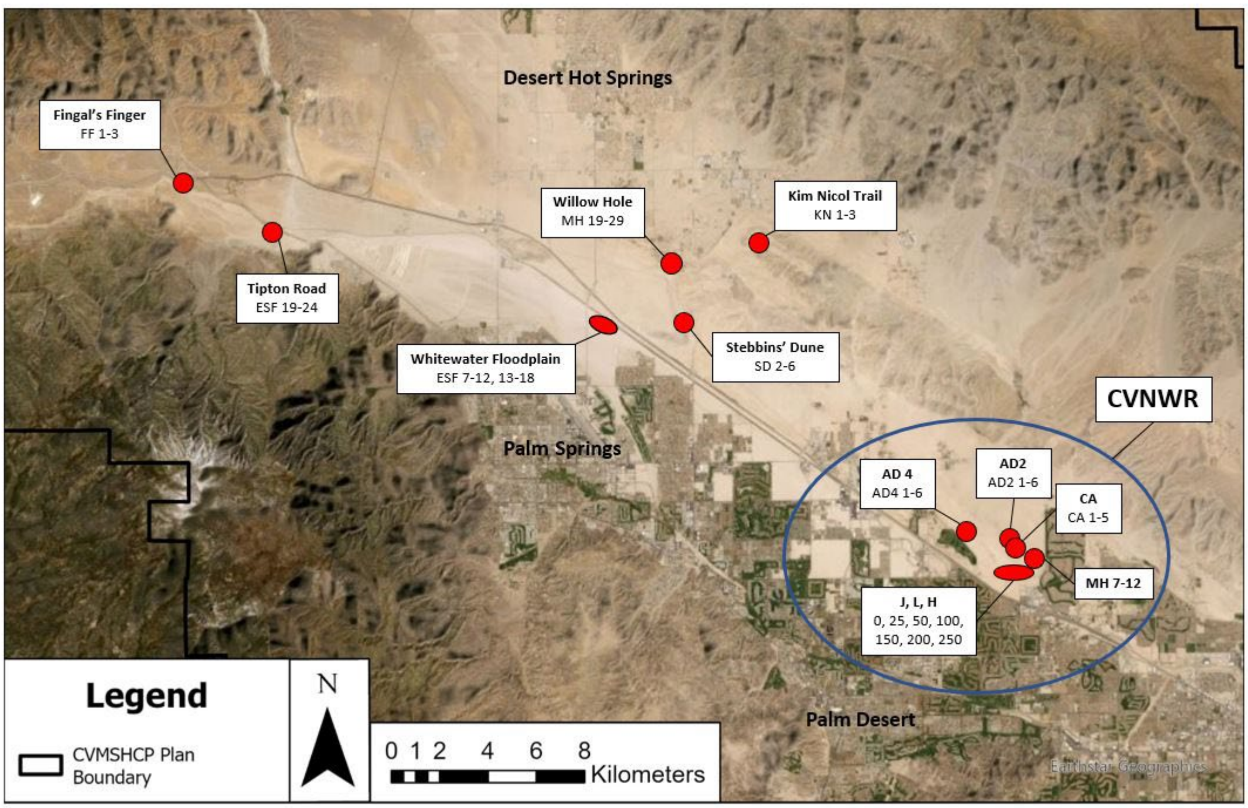
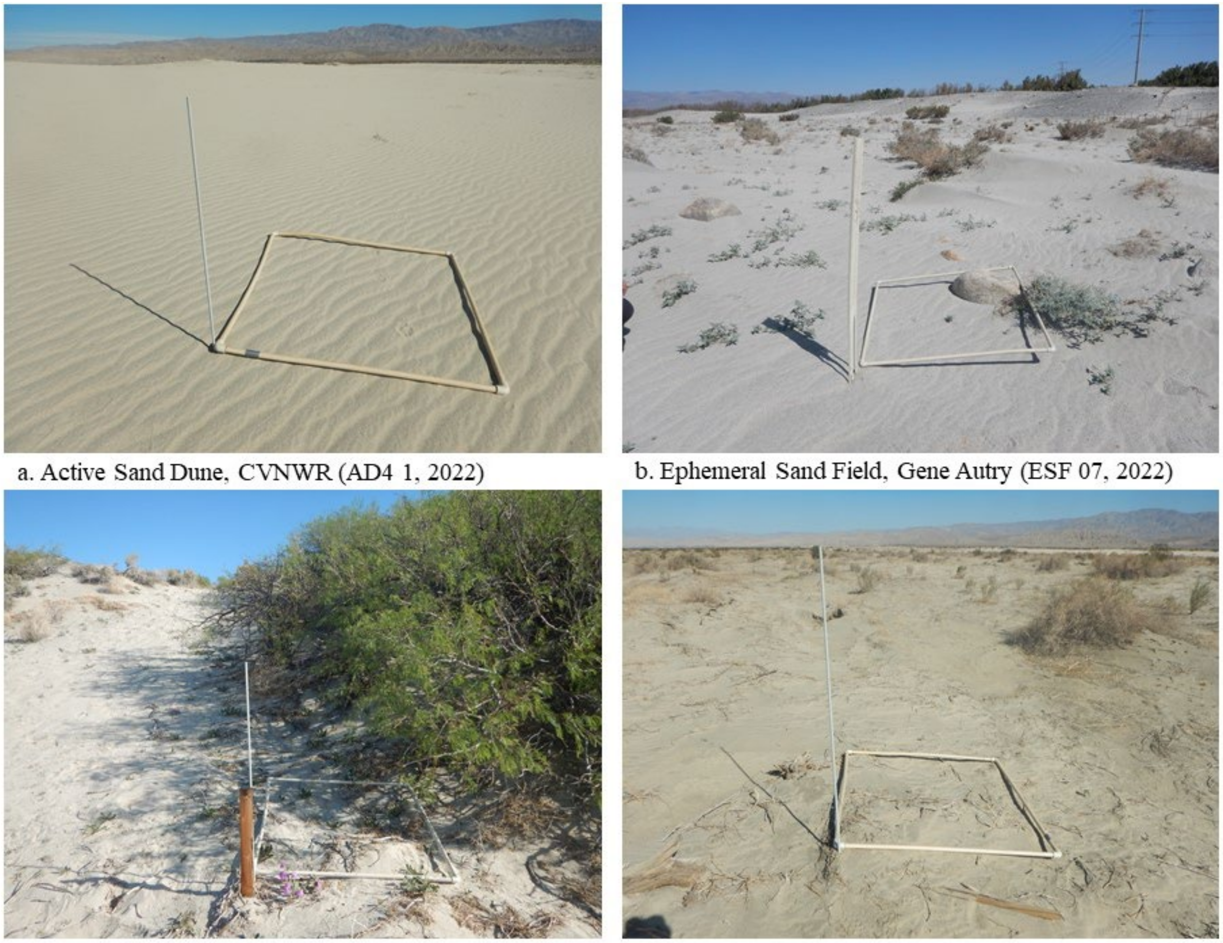


Figure 7. Map of 14 plot clusters (84 plots) for long-term sampling across the Coachella Valley

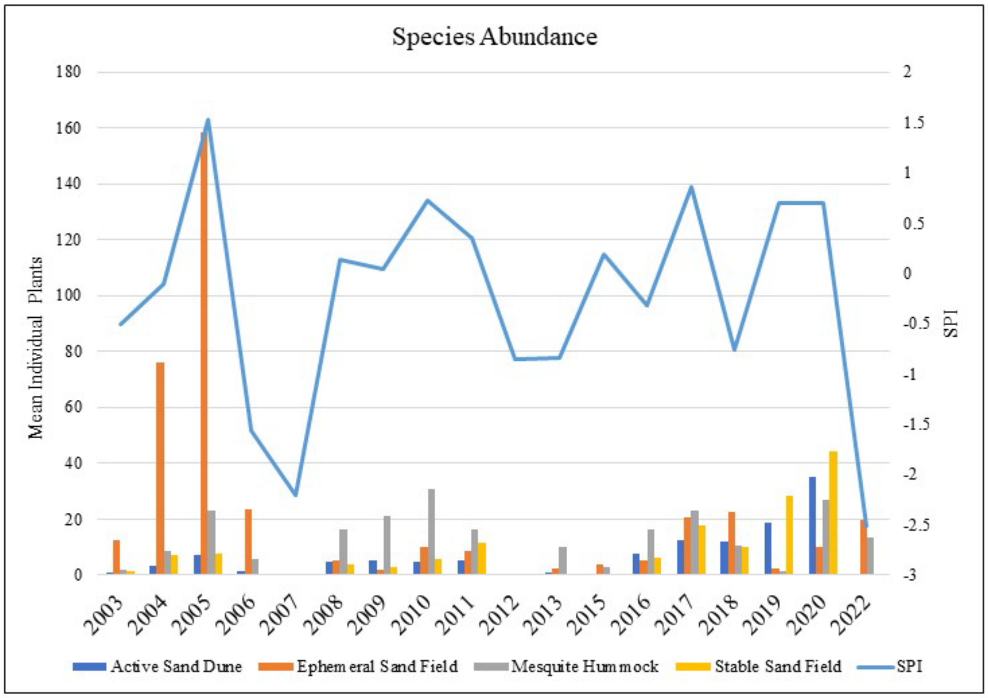


a. Active Sand Dune, CVNWR (AD4 1, 2022)
b. Ephemeral Sand Field, Gene Autry (ESF 07, 2022)
c. Mesquite Hummock, Willow Hole (MH 25, 2022)
d. Stable Sand Field, CVNWR (CA 3, 2022)

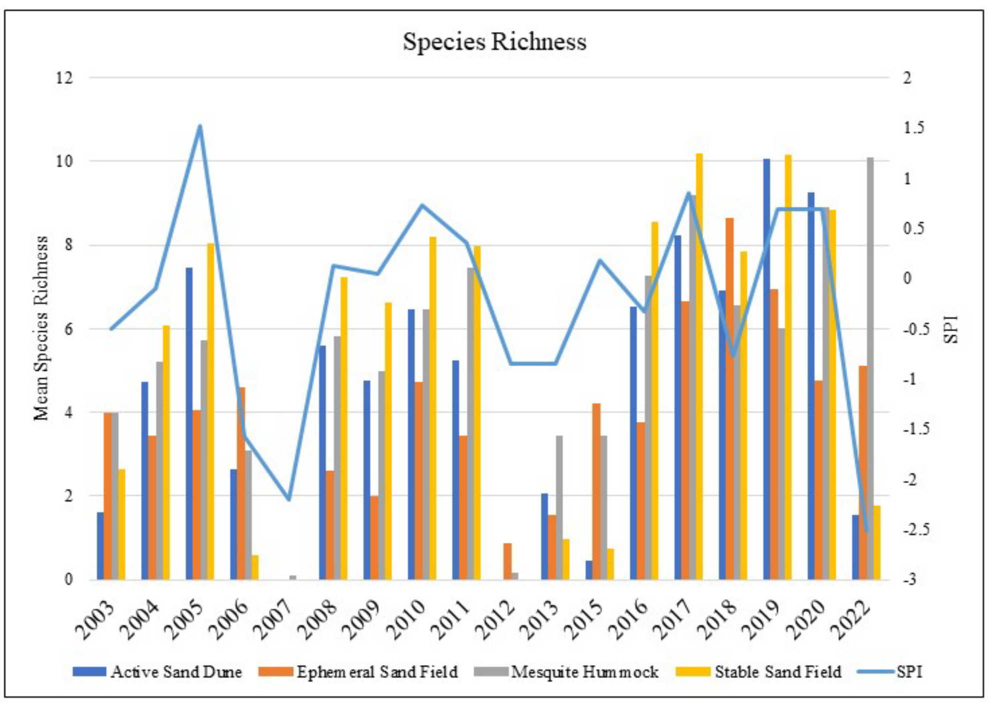
Figure 8. Quadrat frames at the A point (0m) of a 0.1 ha plot in each of the sand community types. Photos takes between March 2, 2022 and April 7, 2022.

Overall, our findings for species richness, abundance, and coverage were low, as expected for 2022 being a dry year during an historic drought period. Active sand dunes and stable sand fields had the lowest species richness and abundance of native annuals. Ephemeral sand fields were consistent with 2020, where richness and abundance were low but there were still annual plants present with the highest number of individual plants of all the sand community types this year. Mesquite hummocks had the highest mean species richness this year, but low abundance (Figure 9a&b).

Native Annual Plant Richness and Abundance by Sand Community Type



a.



b.

Figure 9. Mean annual plant species richness (a.) and abundance (b.) by sand community type across the Coachella Valley. We did not collect annual plant data in 2014 and 2021. SPI = Standard Precipitation Index for winter months.

Non-Native Annual Plants Percent Cover Across the Coachella Valley

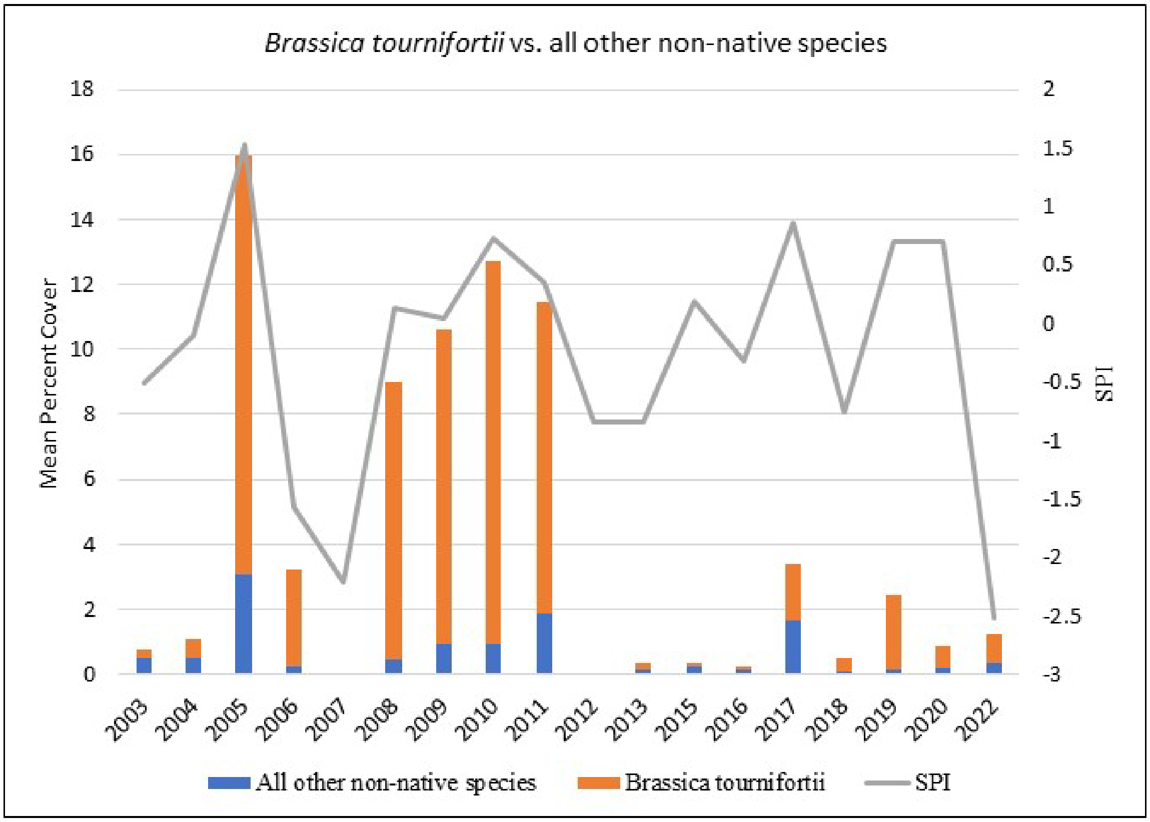


Figure 10. Mean percent cover of invasive plant species: a. Brassica tournefortii (Sahara mustard) across the sand community types within the Coachella Valley. Other invasive species include Amaranthus albus, Bromus spp., Chenopodium macrospermum, Erodium cicutarium, Hordeum marinum, Salsola tragus, Sisymbrium irio, and Tribulus terrestris. We did not collect annual plant data in 2014 and 2021. SPI = Standard Precipitation Index for winter months.

From 2008 to 2011, there was significantly higher invasive annual coverage on the mesquite hummock, active dune and stabilized sand field sites (Figure 10). Those same community types increased their native species richness in 2016 through 2022, when there was less coverage of non-natives (Figure 9a). This may be due to factors such as changes in precipitation patterns, temperatures, levels of sand activity, and/or reduction of invasive species.

Additionally, we have observed the invasive annual plant species stinknet, *Oncosiphon pilulifer*, on the western edge of the valley. While it was not documented in our quadrat frames, and has not been observed in or near our survey plots, we recorded incidental sightings for this species during searching surveys in the Whitewater Floodplain. These locations were recorded in iNaturalist, which has been useful as an early detection tool for management.

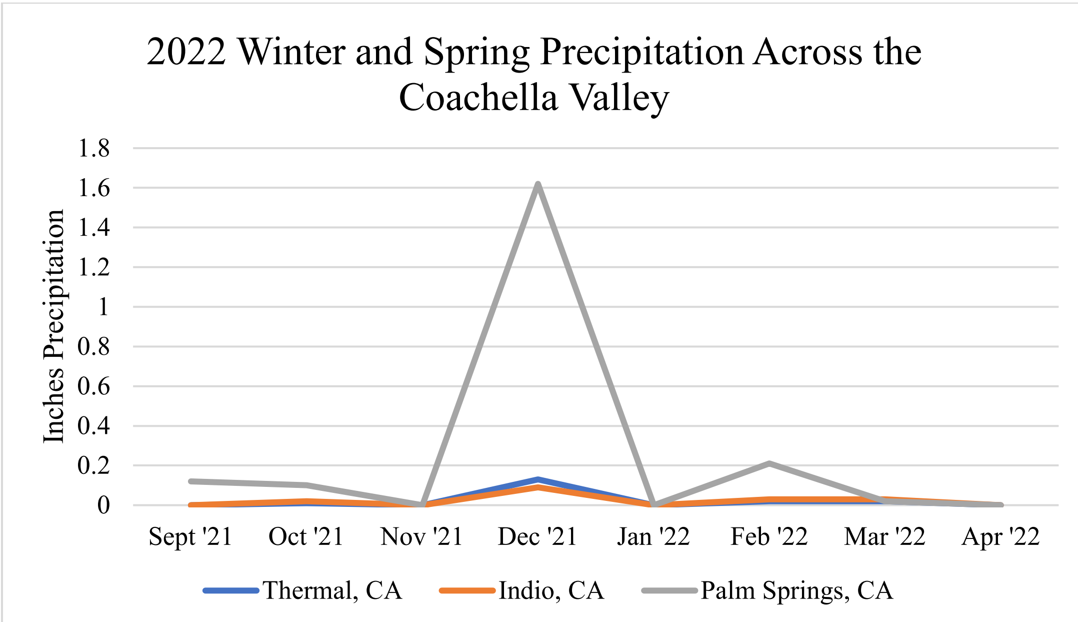


Figure 11. Monthly total precipitation from September 2021 to April 2022 for Palm Springs, Indio, and Thermal, CA. NOAA Online Weather Data, 2022.

The high species richness on mesquite hummocks (Figure 9a) is likely due to the geographic locations of the plots and varying rainfall amounts across the Coachella Valley (Figure 11). The active sand dune and stable sand field plots are primarily on the CVNWR, closest to the National Oceanic and Atmospheric Administration (NOAA) Indio weather station, whereas the ephemeral sand fields and mesquite hummocks are closer to the NOAA Palm Springs weather station. This year, the western edge of the valley experienced enough rain to produce a high amount of annual plant cover, whereas the CVNWR, receiving very little precipitation, was practically devoid of annual plants.

As seen, abundance of annual plants and the relative abundance of native annuals and invasive annual plants continues to be driven by winter precipitation. If drought and variability of these amounts continues to change with anthropogenic climate change, these data become even more important-- they are key to understanding the habitat and the trophic structure on these aeolian communities that supports the CV fringe-toed lizard and flat-tailed horned lizard.

4.2 PERENNIAL PLANT MONITORING

4.2.1 Introduction

Our objective for monitoring perennial plants this year was to evaluate relative abundance and substrate types across aeolian sand habitats of the Coachella Valley. Perennial plants form an important structural and biological component of the aeolian habitats, and are therefore critical to monitor. Sparse shrublands such as the dune systems of the Coachella Valley are difficult to quantify with consistent precision that is greater than sources of error using ground-based methodology. Because of the importance of detecting changes in shrub density, we updated our methodology, described below.

We updated our protocol to the Line Point Intercept (LPI) methodology, a widely used methodology in studies performing biological monitoring (Mueller-Dombois *et al* 1974, University of Idaho 2009, Drezner *et al* 2021, USDA n.d.), which we found to be more repeatable and consistent than the most recently-implemented method from 2018, Line Intercept (LI; Canfield 1941, Hormay 1949, Bruin *et al* 1963, BLM 1996). While LI is an often used and well-vetted methodology for surveying perennial plant abundance and cover, it was not serving our purposes for two reasons: 1) With aeolian sand habitats already having a relatively low abundance of perennial plant cover, very few (and sometimes no) plants crossed the line intercept line, even with 100 m long samples, and 2) due to high observer variability and conditions, the 100 m transect line was difficult to place consistently. These problems importantly interfere with our ability to tell if the perennial plant populations are responding to climate and threats, or if there is an observer error, as described.

4.2.2 Methods

In order to verify our field observations and theories about LI, we tested LPI for evaluating ground and shrub cover. To test the new LPI methodology against LI, we performed an experiment at existing plots at the Coachella Valley National Wildlife Refuge (CVNWR) where three of our biologists independently surveyed the same series of plots using the LPI method, and we then compared the mean difference between observations to that of previous years at the same site using the LI method. After verifying the efficacy of LPI for use within our Coachella Valley study area (see results), this method was used for subsequent monitoring on the long-term aeolian plots.

We used our pre-established long-term 84 0.1 ha (10 x 100 m) aeolian sand community monitoring plots as the plot network for LPI. At each location we laid out a 100 m transect tape, running down the center of the 0.1 ha plot. Each transect had a permanent fiberglass pole marking the start of the line (0 m), center (50 m), and end (100 m). We laid the transect line as close to the ground as possible and pulled it taut. During fall 2021 we installed additional transect poles at the quarter points (25 and 75 m) to make laying the transect line easier and more accurate and to provide further stability for the line in windy conditions.

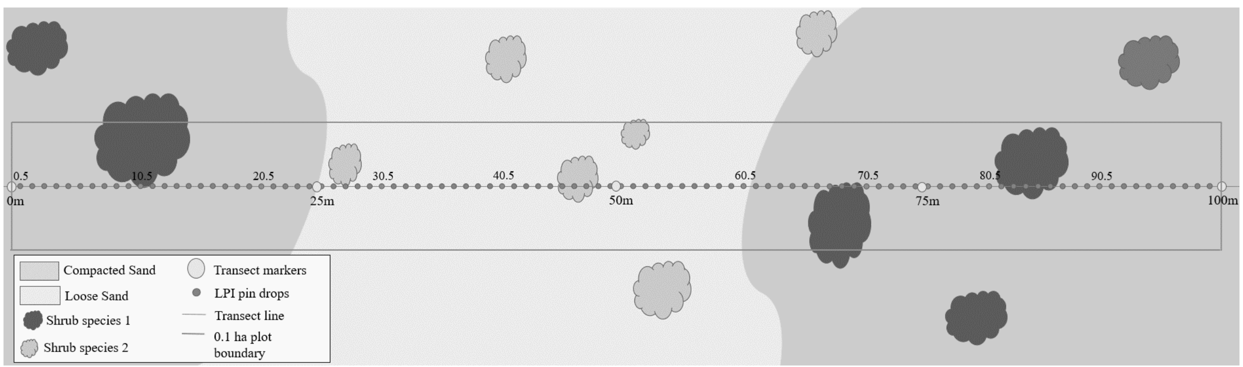


Figure 12. Line-point intercept diagram showing pin drops every meter on the half meter across 100m, within the 0.1 ha plot. This example shows 9 hits for shrub species 1 (9% cover), 5 hits for shrub species 2 (5% cover), 35 hits for loose sand (35% cover), and 65 hits for compacted sand (65% cover).

Beginning at the 0 m pole and working towards the 100 m pole, we walked on the right side of the line and dropped a 30” long, 15.5 gauge (1.75 mm) wire pin flag (hereafter referred to as the pin) on the left side of the line. The pin was marked 3 cm above the tip. We took measurements every meter on the half meter (0.5, 1.5, 2.5…99.5) to avoid the fiberglass poles (Figure 12). We held the pin vertically and perpendicular to the tape, lined it up at each half meter point, and released it approximately 12” from the ground. In order to avoid bias, we did not guide the pin from the tape to the ground, allowing the pin to fall freely rather than precisely on the mark. We then recorded

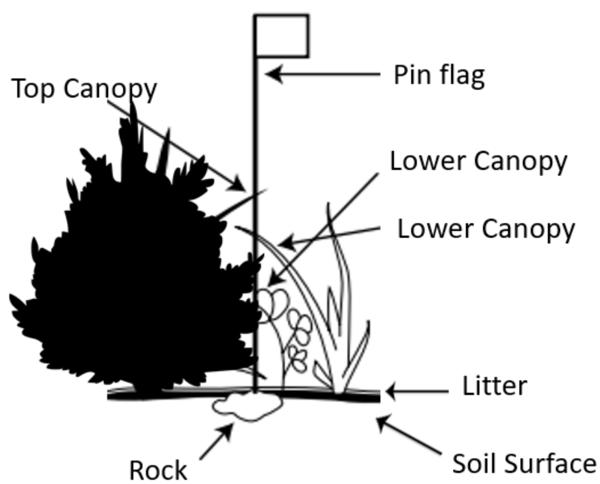


Figure 13. Diagram of pin intersecting cover categories. Edited image from USDA, n.d..

everything that was touching the pin in the four categories: Top Canopy, Lower Canopy, Litter, and Soil Surface (Figure 13).

We recorded top canopy as the first rooted perennial plant the pin touched, alive or dead. We determined that a plant was only dead if the entirety of the individual was dead. If the pin hit a dead portion of a live plant we counted the plant as live. If we could not identify a dead perennial we recorded it as a dead shrub. We identified all live plants to species, or variety if known.

Plants that we recorded under lower canopy had to be rooted, and could be perennials or annuals, live or dead. Due to the time of year we were surveying, there were very few live annual plants in lower canopy, so we identified the plant skeletons if they were non-native (*Brassica tournefortii, Salsola tragus, Erodium cicutarium* and *Schismus* spp. have distinct forms even when dead or dried) and documented other annuals as native forbs. We recorded litter as anything that was on top of the soil, but not rooted. Litter could be debris -windblown plant material, duff - permanent understory leaf litter, or wood. Lastly, we recorded the soil surface type. If the pin landed on sand and sunk past the 3 cm mark it was recorded as loose sand, if it did not sink pass the 3 cm mark it was considered compacted sand. Other soil surface types recorded were large rocks, small rocks, silt, and basal stems.

All cover types are calculated as a percent for each plot by averaging the number of hits per category across the number of pin drops total at the site, using the following equation:

$$Cover\ of\ Spp\ A = \left(\frac{\#hits\ Spp\ A}{total\ \#points}\right) \times 100$$

4.2.3 **Results**

The results of testing LPI against LI at the same sites verified that LI is subject to high observer-based variability when applied to our monitoring framework (Tables 2 & 3). While there is still a margin of error between surveyors, LPI decreased the mean difference by about 43%. Not only does LPI decrease the observer-based variability, this methodology also collects more data on ground cover as well as sand and substrate types that can be used to categorize study sites and track how sand flow changes between them over time. We calculated the mean cover of each species across the four aeolian habitat types covered in this survey: Active Sand Dune, Ephemeral Sand Field, Mesquite Hummock, and Stable Sand Field (Figure 14, Table 4).

Table 2. Percent cover results using line intercept (LI) from 2018 to 2021 at plot H on the CVNWR.

Line-Intercept (LI) Percent Cover: CVNWR H025, H100, H200; n=3			
Year	*Larrea tridentata* % cover	*Atriplex species* % cover	**Total Veg % cover**
2018	1.62	2.94	4.56
2019	1.58	1.46	3.04
2021	2.48	2.17	4.65
Mean Difference	**0.60**	**0.98**	**1.07**

Table 3. Percent cover results for trial of line point intercept (LPI) in the same location as Table 1, repeated by 3 different surveyors on the same day.

Line Point Intercept (LPI) Percent Cover Pilot Test: CVNWR H025, H100, H200; n=3			
Observer	*Larrea tridentata* % cover	*Atriplex species* % cover	**Total Veg % cover**
A	2.46	2.44	4.90
B	1.77	2.12	3.89
C	1.77	2.47	4.25
Mean Difference	**0.46**	**0.24**	**0.67**

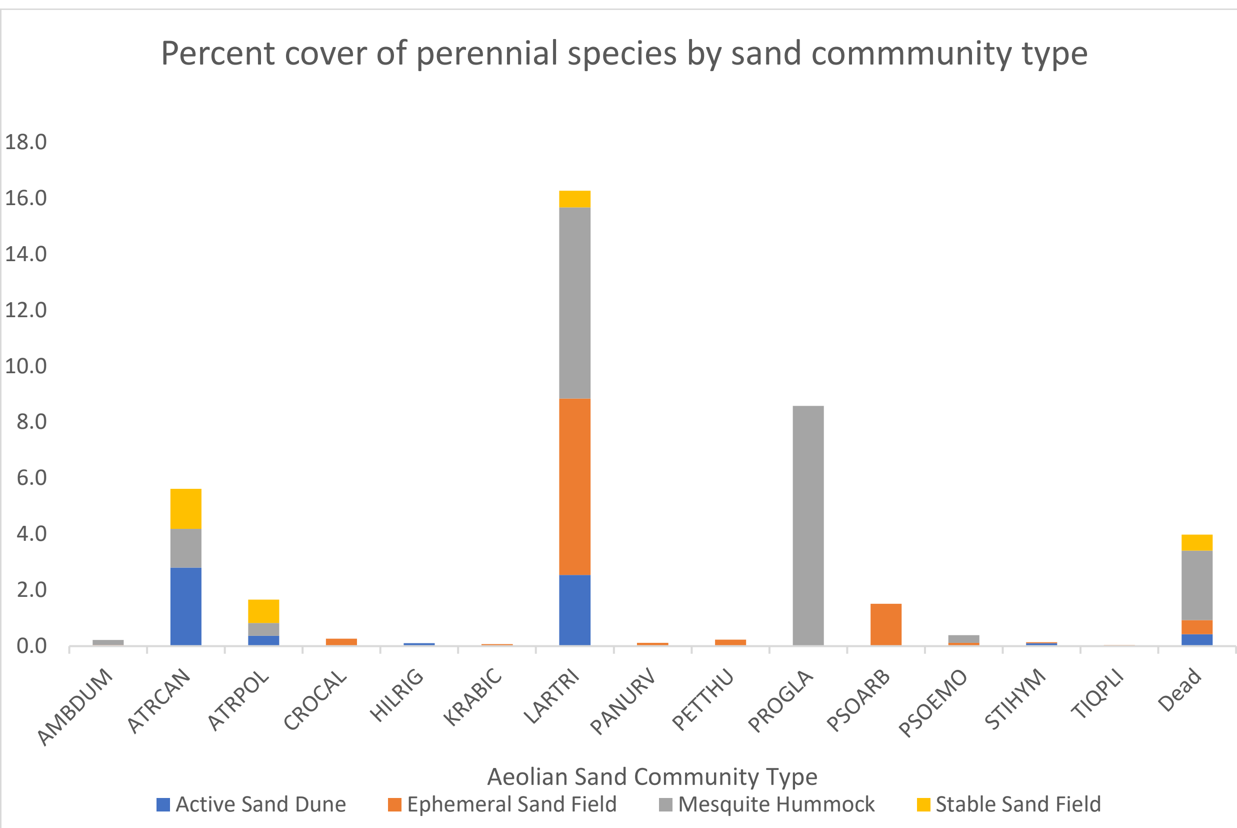


Figure 14. LPI percent cover results for perennial plant species by aeolian sand community type. AMBDUM = *Ambrosia dumosa,* ATRCAN = *Atriplex canescens*, ATRPOL = *Atriplex polycarpa*, CROCAL = *Croton californicus*, HILRIG = *Hilaria rigida*, KRABIC = *Krameria bicolor*, LARTRI = *Larrea tridentata*, PANURV = *Panicum urvilleanum*, PETTHU = *Petalonyx thurberi*, PROGLA = *Prosopis glandulosa*, PSOARB = *Psorothamnus arborescence*, PSOEMO = *Psorothamnus emoryi*, STIHYM = *Stipa hymenoides*, TIQPLI = *Tiquilia plicata*, Dead = any fully dead shrub species.

Creosote bush (*Larrea tridentata*) is the most prevalent perennial plant species across all habitat types. Mesquite (*Prosopis glandulata* var. *torreyana*) hummocks have the highest density of perennial plant cover, and ephemeral sand dunes hold the greatest diversity of perennial plant species (Figure 14). This year was the first year that we recorded *Panicum urvilleanum*, or desert panic grass (PANUVA), on western ephemeral sand dune plots. PANUVA was primarily occupying areas that were previously dominated by rice grass, *Stipa hymenoides*. Based on informal observations by UCR CCB and others, PANUVA populations appear to be moving steadily eastward into the Coachella Valley along the Whitewater flood plain and ephemeral sand fields. While this is a native grass to California and its eastward movement could be tied to natural range fluctuations within the dynamic wash habitat, and moving sand, it is has not been recorded in such density at this site in the last 20 years and should continue to be closely monitored.

Table 4. LPI results of cover categories across our aeolian sand community plots. We carried out LPI at 84 100 m transects across the valley during Fall 2021

	AEOLIAN SAND COMMUNITY TYPE			
	Active Sand Dune	**Ephemeral Sand Field**	**Mesquite Hummock**	**Stable Sand Field**
# OF 100M PLOTS	*20*	*26*	*11*	*27*
# OF PIN DROPS	*1890*	*2586*	*1084*	*2646*
PERENNIAL SHRUBS % COVER	5.43	10.04	20.2	3.45
INVASIVE FORBS % COVER	2.42	2.69	1.57	2.93
NATIVE FORBS % COVER	0.5	0.59	0.83	1.21
BARE GROUND % COVER	82.03	78.67	69.19	90.79
LOOSE SAND % COVER	31.46	29.75	40.87	24.54
COMPACTED SAND % COVER	63.67	67.31	58.86	64.54
SILT % COVER	4.76	1.91	0	10.72

DUFF % COVER	1.14	1.15	4.8	0.56
DEBRIS % COVER	10.33	7.13	10.61	11.65

4.2.4 **Discussion**

Understanding how sand is moving through aeolian systems in the Coachella Valley is necessary to predict how decreasing available habitat will affect aeolian species. This updated LPI data improved information capture about ground cover composition across the different sand communities, providing a more detailed baseline and assessment of soil surface changes. LPI surveys should be performed on a yearly basis. For the 2021-2022 year they were performed in the fall and it is our recommendation that they continue to be performed in the fall.

4.3 COACHELLA VALLEY MILKVETCH

Coachella Valley Milkvetch (*Astragalus lentiginosus* (Douglas) Barneyby var. *coachellae*, hereafter CVMV; Figure 15) is a federally endangered endemic plant to the Coachella Valley and occurs throughout a wide portion of the CVMSHCP 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. This plant is usually an annual, but with sufficient resources it can survive multiple years.

Figure 15. Astragalus lentiginosus var. coachellae in flower and fruit, March 17, 2022, near Tipton Rd (ESF 19-24; Melanie Davis)

During March 2022 we tallied CVMV within all 84 long-term 0.1ha plots across the Coachella Valley. We counted a total of 906 individual CVMV plants, 46 individuals on active sand dunes (n=20), 825 on ephemeral sand fields (n=26), 15 on mesquite hummocks (n=11), and 0 on stable sand fields (n=27). Despite 2022 being a drought year, these numbers are consistent with what we know about the life history and preferred habitat of CVMV.

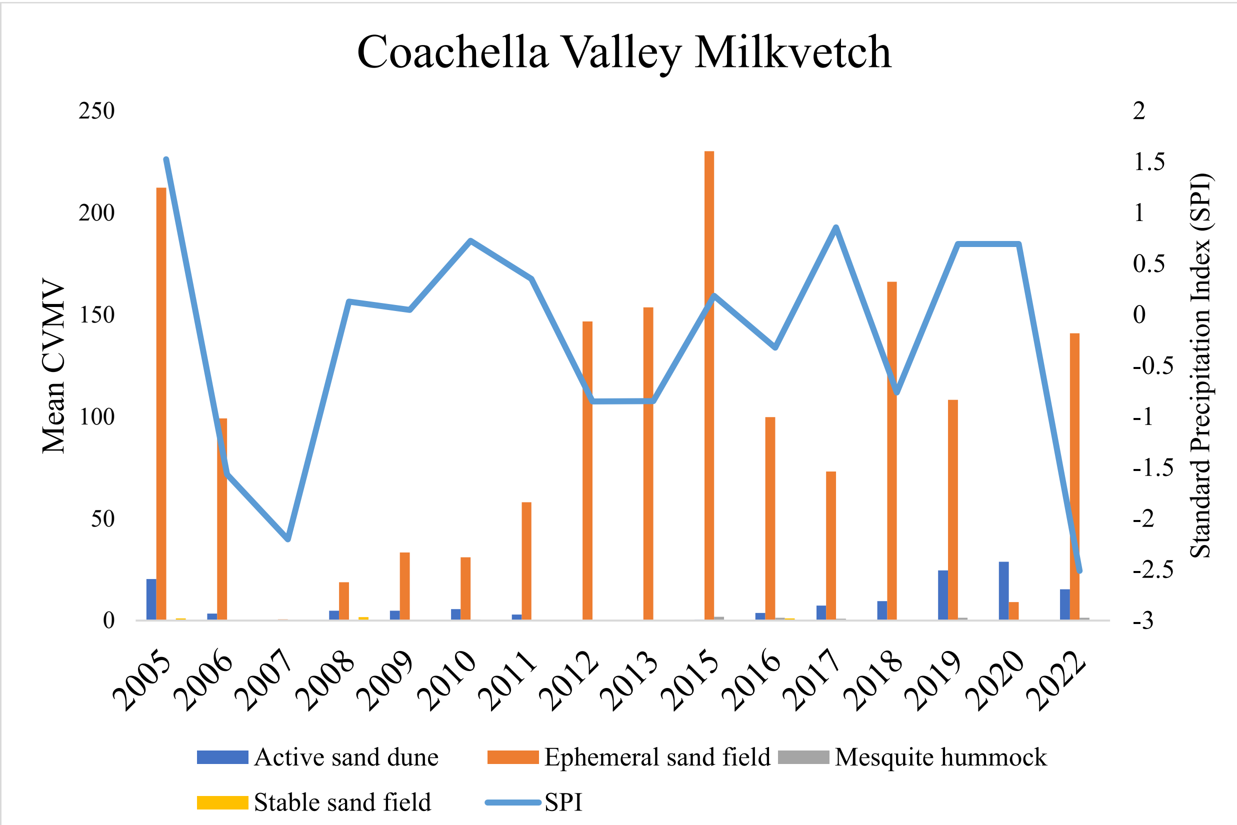


Figure 16. Mean CVMV abundance since 2005 by aeolian sand community type across the Coachella Valley. We did not collect data in 2014 and 2021. SPI = Standard Precipitation Index for winter months.

Figure 16 illustrates a pattern addressed in 2019 (UCR CCB 2019), that rainfall does not always positively correlate with high CVMV abundance. Rather, there appears to often be a negative correlation. It may be that stabilization of aeolian sand habitats occurs during years with abundant precipitation, but no flooding, which reduces sand transport by wind and thus prevents the scarification that is thought to be important for germination. While there was high abundance of CVMV this year despite it being a dry year, many of the individual plants counted were seedlings, and when visited later in the season it was noted that these seedlings did not reach reproductive maturity this year, and many had perished in the early season heat waves. This year's high winds and sand movement may have provided the scarification necessary for germination, but a lack of precipitation across many parts of its range would have impacted survival. However, plants that germinated this year and survive the summer may reach reproductive maturity next year. Another possibly confounding factor in our ability to make conclusions from these results is the unusually patchy localized patterns of spring and winter precipitation in the west of the valley. These rains often ceased abruptly before reaching the CVNWR (personal observation). The SPI shown here, calculated from weather data at a station in Indio and normally closely approximating conditions across the entire Plan area. This year, the SPI more closely matches conditions experienced at the CVNWR, while it is likely that many areas to the west received more precipitation which may contribute to increased germination. As mentioned though, many of these seedlings did not reach maturity. Ultimately, there appears to be a delicate balance between precipitation and sand movement required for germination and survival that is not always met across all parts of the CVMV's range.

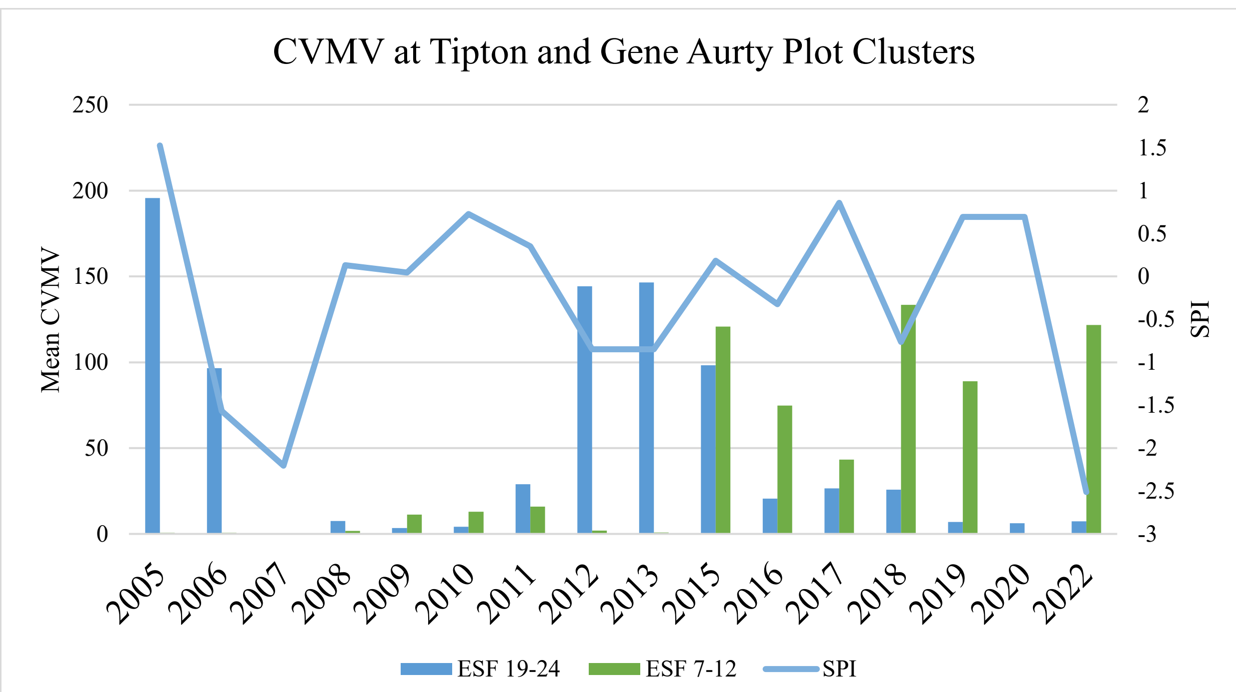


Figure 17. Shifting densities of CVMV at ESF 19-24 (Tipton) and ESF 7-12 (Gene Autry) plot clusters. SPI = Standard Precipitation Index for winter months.

Another trend discussed in our 2019 report is the shifting CVMV densities from ESF 19-24 to ESF 7-12 (Figure 17). The cluster ESF 19-24 (near Tipton road) is associated with the Windy

Point region. This region is west of the Whitewater river sand source, where the cluster ESF 7-12 (near Gene Autry road) receives its sand source. Historically, the Windy Point sand would be dependent on sand input from the San Gorgonio Wash further west. Areas along the San Gorgonio Wash have been considerably developed in the last decade and it is unclear if future floods will transport new sands to this area. The current trends show that the habitat is not as suitable as it once was in that region and may be an indicator of early effects of a compromised sand corridor for this protected area. This should be closely monitored in future years.

5 ARTHROPODS

5.1 AEOLIAN COMMUNITY ARTHROPODS

5.1.1 Introduction

Pitfall sampling has been a favorite of entomologists for many decades because they are cheap, easy to install, effective, passive (collects samples without a researcher present), and easily repeatable (Brown and Matthews 2016). However, pitfall traps are difficult to implement and manage for accurate results in windy conditions, especially on dunes. Pitfall trapping is feasible in windy conditions if vegetation cover is relatively high and sand movement low. However, this is not the case when trapping on dunes – vegetation cover is low, leaving many traps exposed to blowing sand and plant debris, which easily fills or clogs the traps, rendering them inoperative. Sand on the dunes within the Coachella Valley starts to move at approximately 17-20 mph wind speeds. On an exposed active dune, it can take just a couple of hours for winds around 20 mph to completely fill and cover a pitfall trap. To avoid this, we only set pitfalls when wind speeds are forecast to stay mostly below this threshold. When trapping in marginal conditions, we also place traps in slightly sheltered locations, when possible, behind vegetation.

Previously, these tactics have allowed us to successfully deploy traps during the spring monitoring season, however a trend has become apparent over the last few years that is challenging this method. Calm nights have become increasingly rare during the spring (NCEI 2022), hampering our ability to complete pitfall trapping at all our sand community plots. In addition to more frequent windy nights, there has been an increase in sand moving through the valley, thus increasing the risk of trap burial.

In response, we have begun experimenting with other methods to monitor important arthropod groups, namely ants. Ants are critical components of desert ecosystems, especially harvester ants (*Pogonomyrmex* spp. and *Veromessor* spp.). These ants are abundant, important seed predators that help shape and maintain plant community structure, cycle nutrients through soil, and provide a source of food for other animals (MacMahon and Crist 2000). Harvester ants are a required food of horned lizards, including the MSHCP-listed flat-tailed horned lizard (*Phrynosoma mccallii*) (Barrows and Allen 2009) and are an important dietary component of the state-endangered Coachella Valley fringe-toed lizard (*Uma inornata*) (Barrows 2006). Thus, changes in ant community composition and abundance should directly affect the success of these two endemic species. As such, we believe, in the light of recent pitfall trapping difficulties, ants are an appropriate candidate for supplemental focused monitoring.

Ant sampling can be an effective part of conservation monitoring (Underwood and Fisher 2006). However, there is considerable argument about which sampling techniques are best suited for quantifying various aspects of ant population dynamics (e.g. Bernstein and Gobbel 1979, Schlick and Steiner 2006). Ant diversity and abundance research in low-vegetation habitat is most often conducted via methods such as pitfall trapping, which is not possible during windy conditions on dunes. Few other methods of ant sampling in desert dune ecosystems have been presented in literature, so we have devised two new protocols which we are testing for efficacy. First, foraging worker ants are tallied during a walking survey along our plots, which can be completed in conjunction with vertebrate tracking. This will provide important information on levels of forager activity both spatially and temporally and in relation to environmental variables, most notably sand surface temperature. Second, ant colony locations can be recorded to produce a detailed colony density map. Mapping ant colony density is useful for investigating ant abundance and population changes over time (Agosti et al 2000, Schlick and Steiner 2006). Together, we believe these two sampling methods, in conjunction with pitfall trapping, when possible, will provide a realistic way to continue collecting useful information on ant abundance and diversity which can be conducted in early morning hours when it is cool and usually wind-free.

5.1.2 **Methods**

Pitfall Trapping

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 18). 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 wood 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 record the sampled species and abundance with the assistance of magnifying loupes and aspirators. We release captured nocturnal arthropods into a shady area, 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 13 to June 28.

This year, we focused on describing changes in abundance for two species of harvester ants, which are important food sources for flat-tailed horned lizards and CV fringe-toed lizards, as well as three of the dominant darkling beetle (Tenebrionidae) species which, due to their often distinct habitat preferences, may have potential as indicator species (Barrows and Heacox 2021).

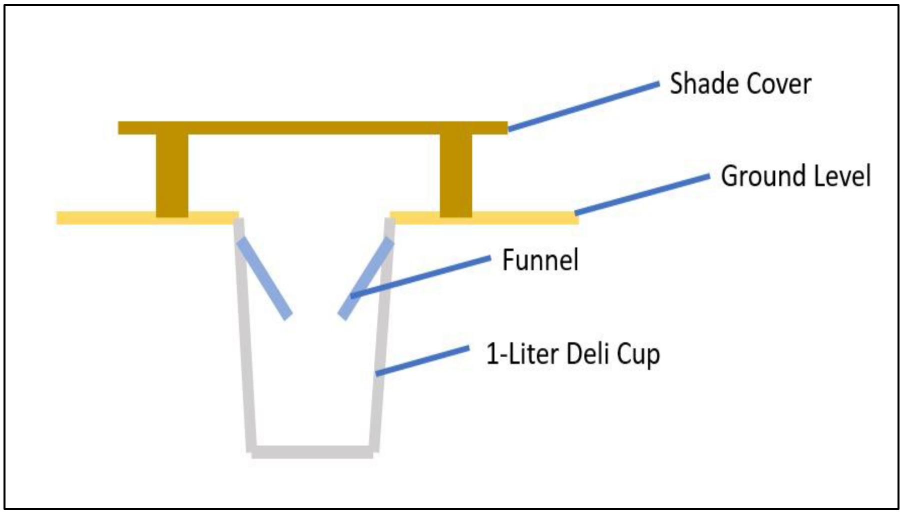


Figure 18. Diagram of the pitfall traps used in our study.

Ant Counts

We trialed a newly devised protocol with the goal of quantifying ant activity during the vertebrate tracking season (approximately May-June). This method involves walking our 10x100m plots and tallying all ant species observed. This can be conducted with a single trained biologist, or preferably at least one trained biologist and another assistant. Ants on the Coachella Valley National Wildlife Refuge (CVNWR) are fairly easy to diagnose to species at a glance given a small amount of training. Most ant species on the CVNWR will retreat underground when temperatures become unsuitably high, so surveys should take place in the morning. Because ant activity is often directly proportional to temperature, we used a laser temperature gun to read sand surface temperature at five points along the plot as the survey was taking place – starting at 0 meters and every 25 meters until the end of the plot. The resulting mean sand surface temperature can then be used to construct a model of ant activity to correct for differences in temperature between surveys (see results).

Colony Mapping

Usually, harvester ant colonies are conspicuous features of a desert landscape. They often are marked by large craters of tailings from soil excavation and/or surrounding discs of stripped vegetation. Unfortunately, this is not the case on dunes because a single night of strong wind will obliterate these features, rendering colony entrances almost invisible. However, it is still possible to track down nest entrances by utilizing the behavior of foraging ants – once a foraging harvester ant finds a food item, it will usually hastily transport it directly back to the nest. So, a biologist can easily provide a small piece of food (e.g. a cookie crumb) and then follow the ant back to its nest. Once the nest is located, coordinates are recorded and a small flag or marker installed. We used this technique on a small plot of land, approximately 50m x 50m, on the CVNWR to test the feasibility of using this method in future monitoring efforts.

Analyses

We conducted simple regression analyses in RStudio Build 492 running R programming language version 4.1.0 (R Core Team 2021) using stats v4.1.0 for simple linear regressions (R Core Team 2021) and ggplot2 v3.3.5 for plot visualization (Wickham 2016).

5.1.3 **Results**

Ant Counts and Nest Mapping

Our experimentation with quantifying ant abundance via walking surveys yielded encouraging results. Harvester ant activity is strongly correlated to sand surface temperature, with activity steadily decreasing as the sand warms to dangerous levels. As seen in Figure 19, it is possible to model ant activity as a function of mean sand surface temperature, which will allow us to correct for between-survey variation due to differing temperature at time of survey. In other words, while it is still necessary to conduct this walking survey in mornings before sand surface temperature becomes too warm and ant activity ceases, we hope that further refinement of this model will increase the time window by which we can conduct walking surveys and still yield accurate data. This year, we trialed and refined our survey methodology on a subset of plots at the Coachella Valley National Wildlife Refuge, and we will conduct a more complete array of surveys, including a number of repeats, in coming field seasons.

We trialed nest mapping techniques on only a small area of stabilized sand fields on the Coachella Valley National Wildlife Refuge, resulting in the location of approximately 12 nests (data not shown). The trial proved that it is possible to locate a number of otherwise hidden ant colonies in a relatively short amount of time via baiting. We plan on continuing experimentation with this technique in the Fall of 2022 to collect more definitive results and refine this technique.

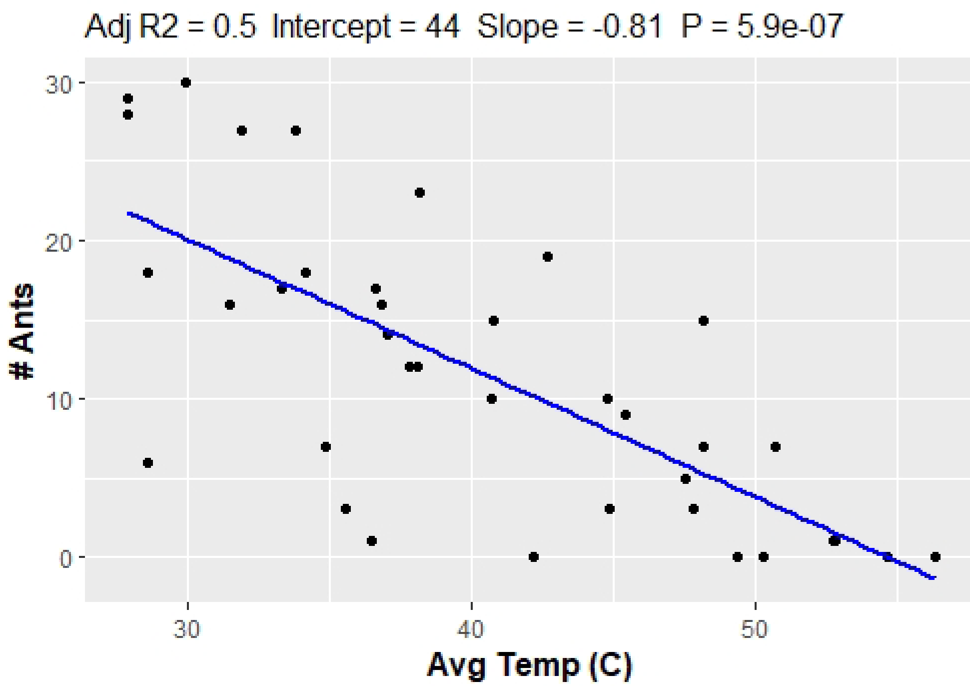


Figure 19. Number of ants per 100 x 10m transect within one site shown as related to sand temperature. N=4 repetitions, with 5 transects per site.

Pitfall Trapping

As previously noted, the monitoring season this year was unusually windy, especially at night. This year, we completed trapping at five of fourteen plot clusters, at the CVNWR (stable sand fields and active dunes) and Willow Hole (mesquite hummocks). Change in mean abundance of a selection of important arthropod species at these three aeolian habitat types are shown in Figure 20, plotted against winter SPI. Despite a notable lack of precipitation this year, California bearded harvester ants (*Pogonomyrmex californicus*, POGCAL), the dominant ant on most local dunes and critical food source for horned lizards and CV fringe-toed lizards, have increased in abundance in trap samples on active dunes and, especially, stable sand fields at the Coachella Valley National Wildlife Refuge (Figure 20a). Similarly, this year saw an increase in the presence of a darkling beetle, *Edrotes ventricosus* (EDRVEN), most notably on the stable sand fields (Figure 20b). The reason for these increases in abundance in pitfalls despite drought conditions is currently unknown. However, increases in abundance of some species may be hypothesized to be due to complex ecological processes resulting from drought conditions – e.g.

these species may be forced to forage across a wider area and for longer times, hence increasing the chances they will encounter a pitfall, or predator abundance may be low, allowing prey species to flourish. This hypothesis is difficult to test without gathering much more detailed behavioral information on individual species.

Figure 21 shows the changes in total species diversity at three aeolian community types over time. Species diversity for these three community types is typically similar but subject to drastic change interannually. Again, this is likely due to changes in abundance and/or behavior of certain insect species due to precipitation conditions which alters their chances of contacting a pitfall. For example, 2015 was at the tail end of a multi-year drought, which coincides with a reduction in the detected number of species for that year. Alternately, 2019 saw abundant precipitation and an exceptional increase in annual plant cover, which likely resulted in the recorded sharp increase in number of detected species. This indicates that while individual species may occassionally respond in unpredictable ways to drought years (increasing abundance in pitfall traps), overall trends of species diversity often tend to follow more expected trajectories – detected number of species increases in years where precipitation, and hence resources, are more abundant.

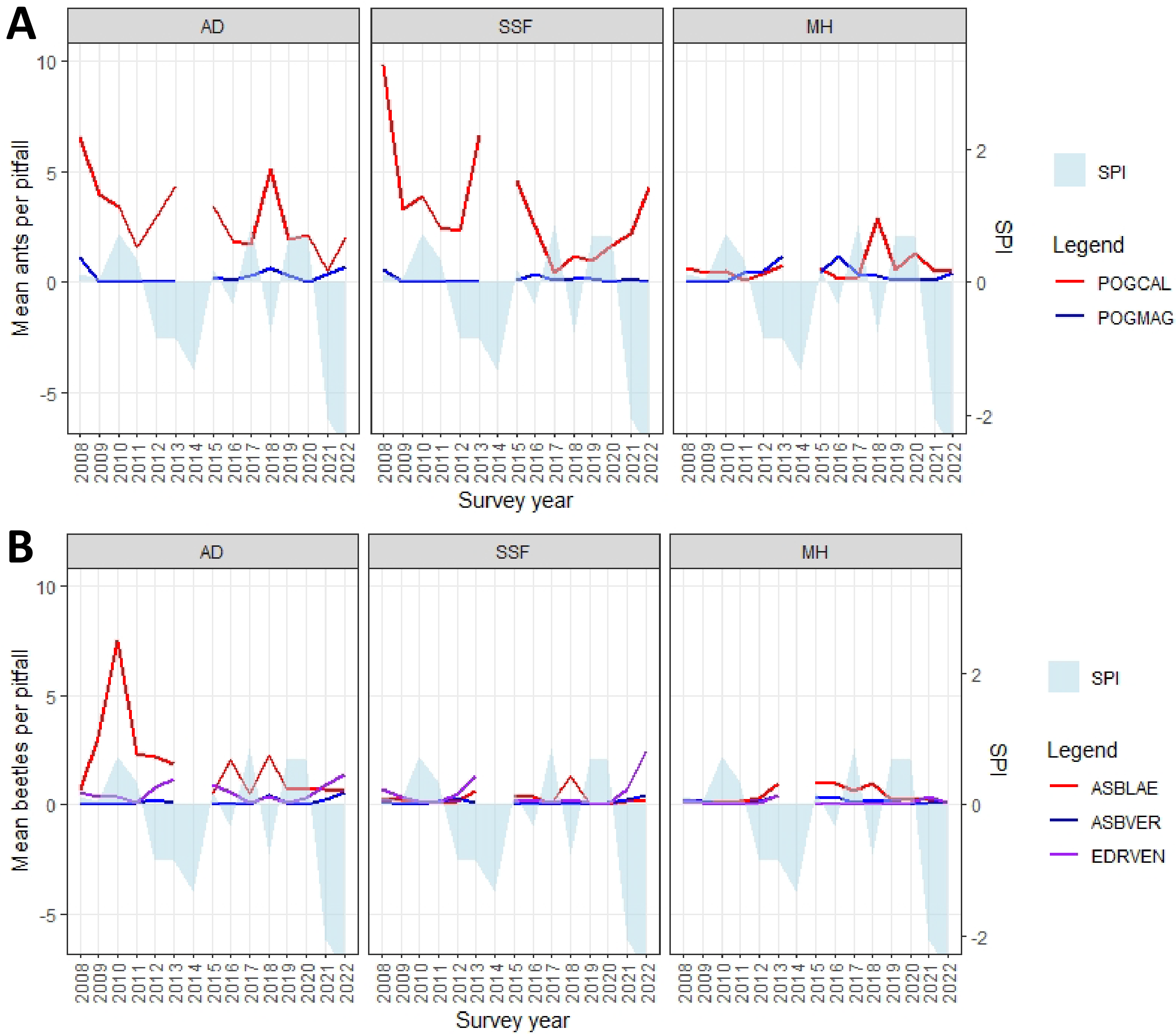


Figure 20. mean abundance of five common insect species in pitfalls: A) harvester ants and B) darkling beetles, from 2008 to 2022, at three aeolian community types. We did not conduct pitfall surveys in 2014. We were not able to set traps at ephemeral sand field communities this year due to high wind. AD = Active Dune, SSF = Stable Sand Field, MH = Mesquite Hummock, POGCAL = *Pogonomyrmex californicus* (California harvester ant), POGMAG = *Pogonomyrmex magnacanthus*, ASBLAE = *Asbolus laevis* (smooth death-feigning beetle), ASBVER = *Asbolus verrucosus* (blue death-feigning beetle), EDRVEN = *Edrotes vetricosus*, SPI = winter standardized precipitation index.

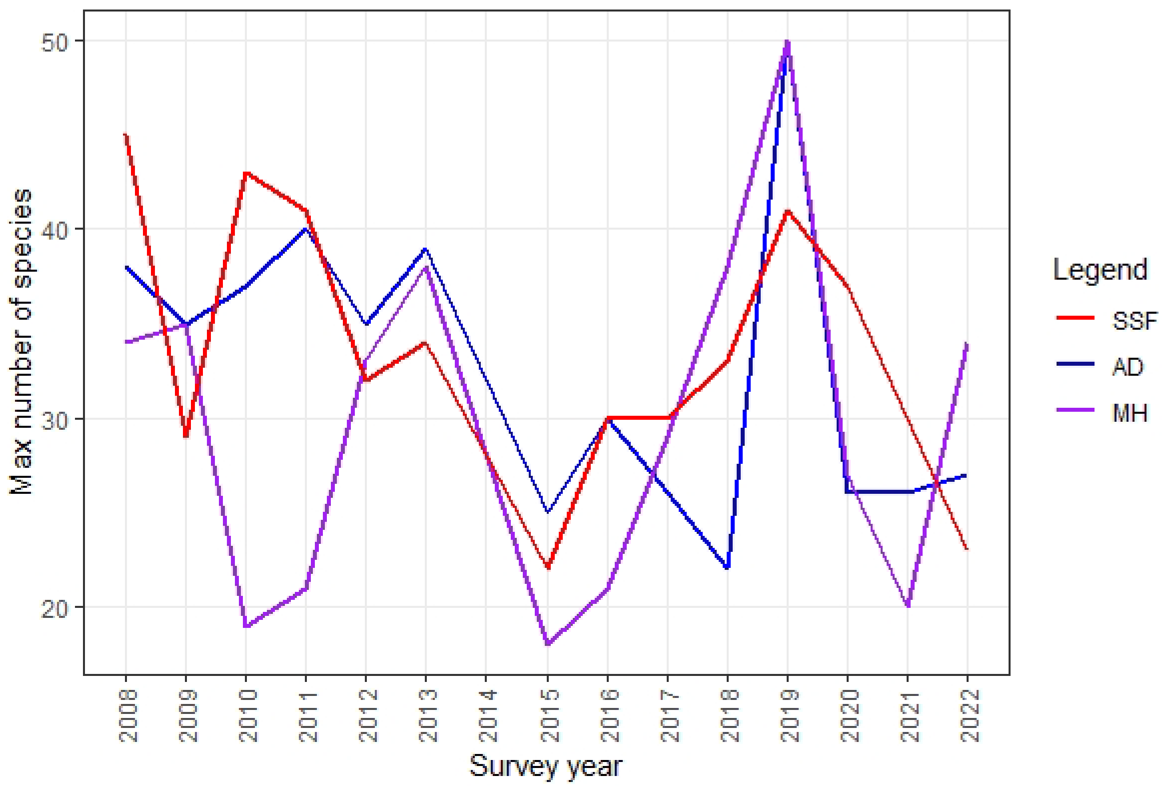


Figure 21. invertebrate species richness via pitfall sampling at three aeolian community types from 2008 to 2022. SSF = stable sand fields, AD = active dune, MH = mesquite hummock. We did not conduct pitfall surveys in 2014.

5.1.4 **Discussion**

Pitfall trapping has proven effective at detecting a wide variety of dune-dwelling species that would otherwise be invisible to researchers. In spite of an apparent trend of increasing springtime wind speeds, making pitfall setting on dunes difficult, we do not propose discarding pitfall trapping in favor of another arthropod sampling method. The efficiency and results of pitfall trapping are too important to discount, even if complete sampling coverage of our plots is not possible each year. However, as we continue to understand the intricacies of ground-dwelling arthropod communities of the Coachella Valley, it has become apparent that some important groups deserve more detailed study. Harvester ants are a prime candidate for further study due to their integral role in a variety of ecological processes, and we propose continued efforts to refine new monitoring methods for this important group that can be used to answer long-standing questions directly related to conservation of protected dune species, such as how harvester ant activity and density changes over time, if these changes are related to overall changes in quality of dune habitat, and how monitoring of ants can be applied to conservation management of sensitive dune habitat and the protected species that live there.

5.2 COACHELLA VALLEY GIANT SAND-TREADER CRICKET

5.2.1 Introduction

The Coachella Valley Giant Sand-Treader Cricket (*Macrobaenetes valgum*, hereafter CVGST) is a large, wingless camel cricket of the family Rhaphidophoridae (Figure 22). It is protected under the CVMSHCP is due to its habitat restriction to areas with large amounts of fine, active sand which have drastically declined in area because of development and blocking/alteration of sand movement from sand sources. However, within remaining healthy dune habitats, 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 detect. 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, and the population is carried on by dormant offspring.

Figure 22. Male and female giant Sand-Treader Crickets (*Macrobaenetes valgum*,) in pitfall trap.

5.2.2 Methods

Our surveys of CVGST take place in late winter to early spring, when the crickets are large enough and as near to peak abundance as possible for detection. We conduct surveys across all our long-term 0.1 ha aeolian community plots. This year, we conducted surveys from 22 February to 23 March. 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 non-specialist observer. Secondly, counting burrows is an activity that can be conducted during daylight hours. Nighttime surveys during their above-ground activity period and excavation of burrows were both ruled out due to safety and potential negative impacts on the animals. Only burrows that are "closed" (the entrance is blocked with sand) are recorded, as this indicates that a CVGST is truly occupying the burrow. Additionally, because a single cricket 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).

5.2.3 **Results**

CVGST populations are showing increases in abundance at all community types except mesquite hummocks (Figure 23). This is despite two years of notably low SPI (severe drought conditions). All plot clusters at the CVNWR show a slight increase in abundance from last year, with larger increases present at active dune plots (Figure 24). Of our most recently established plot clusters at Fingal's Finger, Kim Nicol Trail, and Stebbins' Dune, only Fingal's Finger showed CVGST population abundance comparable to our plots on the CVNWR (Figure 25). CVGST abundance at Kim Nicol Trail steeply increased, while abundance at Stebbins' Dune fell to zero.

As we discussed in our previous year's report on CVGST (UCR-CCB 2021), winter precipitation is sometimes statistically correlated to CVGST abundance, which is intuitive with what we know about this insect's life history. However, there is also considerable variability in CVGST population trends that does not appear explainable by precipitation patterns alone. Such examples include the slight rise in abundance at the CVNWR (active dunes and stable sand fields) and ephemeral sand fields, despite severe lack of precipitation. In the case of the

CVNWR, it is possible that drought has altered other environmental pressures, such as a depression of the predator population or decreased risk of disease. In the case of the ephemeral sand fields, and other plots located in the western regions of the Coachella Valley such as Fingal's Finger and Kim Nicol Trail, it is known that these plots received considerably more precipitation this year than at the CVNWR, which would help explain population increases there. Particularly at the Kim Nicol Trail, which saw the most drastic increase in CVGST abundance this year, we noted a surprising diversity and abundance of vigorously growing annuals, indicating that this area received more precipitation than other areas in the valley where little or no annual plants were seen. The drop-off of precipitation moving from west to east across the valley was quite abrupt; precipitation often occurred in very localized areas, which almost certainly resulted in drastic differences in the populations of the organisms living there. Finally, changes in abundance of loose, fine sand can also affect CVGST success. At Stebbins' Dune, where we counted no CVGST this year, we noted a distinct lack of loose sand. This almost certainly played a large role in the worrying lack of CVGST here, and future monitoring efforts at this location should include repeat surveys and also searches of surrounding areas if CVGST continue to be absent.

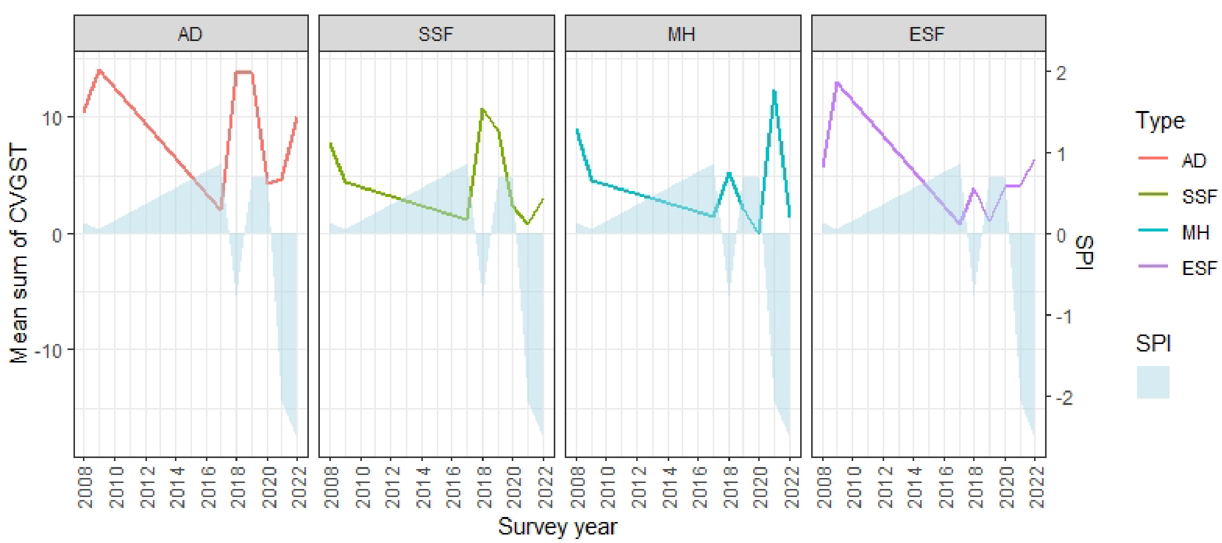


Figure 23. CVGST population trends (mean abundance per plot) and winter SPI during our sampling effort from 2008 to 2022 by aeolian community type. AD = active dune, SSF = stabilized sand field, MH = mesquite hummock, ESF = ephemeral sand field.

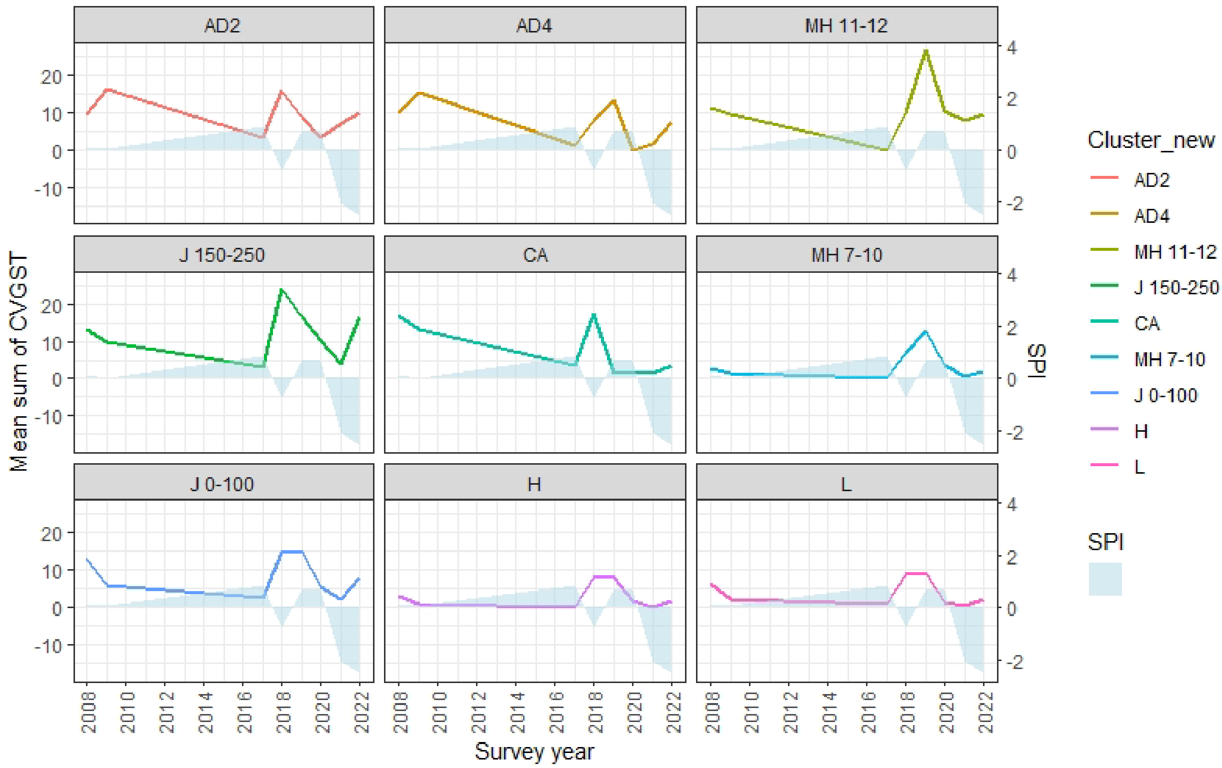


Figure 24. CVGST population trends (mean abundance per plot cluster) and winter SPI at our CVNWR plots, 2008 to 2022. Clusters AD2, AD4, MH 11-12, and J 150-250 are active dunes. Clusters CA, MH 7-10, J 0-100, H, and L are stable sand fields.

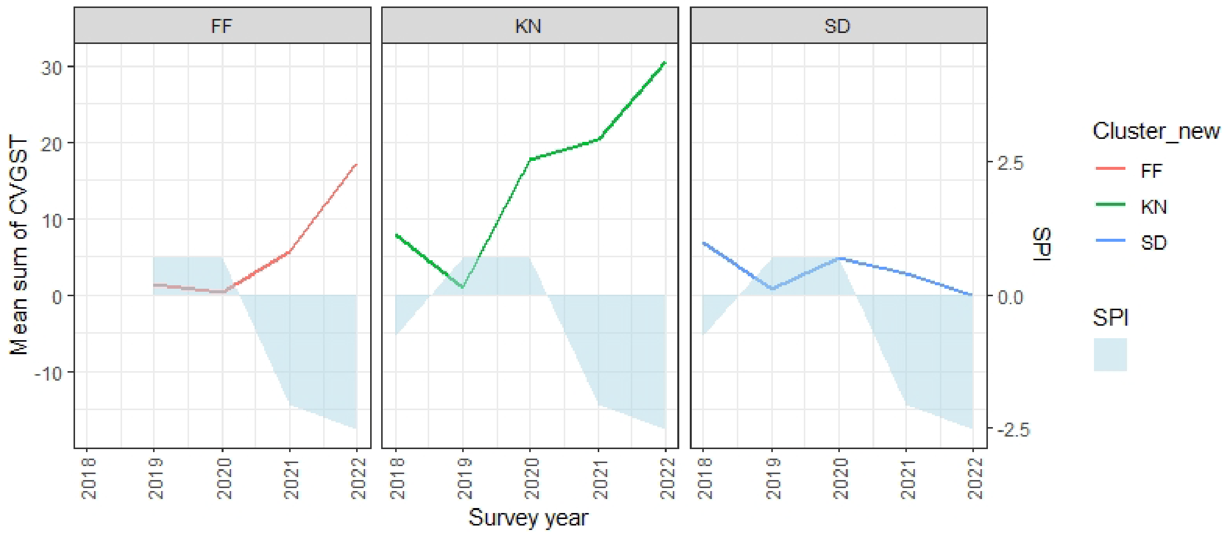


Figure 25. CVGST population trends (mean abundance per plot) and winter SPI during our sampling effort from 2018 to 2022 at our newly established plot clusters. FF = Fingal's Finger, KN = Kim Nicol Trail, SD = Stebbins' Dune.

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APPENDIX VI: 2022 CHOLLA REPORT

Report begins on following page.

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

2021–2022 COACHELLA VALLEY CHOLLA CACTUS MONITORING RESULTS

2021-2022 FINAL REPORT

FINAL REPORT

COACHELLA VALLEY MULTIPLE SPECIES HABITAT CONSERVATION PLAN & NATURAL COMMUNITY CONSERVATION PLAN 2021–2022 COACHELLA VALLEY CHOLLA CACTUS MONITORING RESULTS

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1 INTRODUCTION

Cholla cacti (*Cylindropuntia* spp.) are an iconic feature of the American Southwest. Several species occur in the Coachella Valley Multiple Species Habitat Conservation Plan area (hearafter Plan), including silver cholla (*C. echinocarpa*), pencil cholla (*C. ramosissima*), teddybear cholla (*C. bigelovii*), California cholla (*C. californica*), and Gander's cholla (*C. ganderi*). Researchers have noted the worrying trend of increased mortality of many cholla species presumably due to more frequent and severe drought events (Bobich 2014, Cortes et al. 2021). Other environmental and anthropogenic factors also likely influence changes in cholla distribution within the Coachella Valley, including urban development and fire history.

Cholla also play a critical role in the natural histories of a variety of local species, and the decline of cholla could contribute to the decline of these species as well. The LeConte's Thrasher (*Toxostoma lecontei*) is one species that relies heavily on cholla. This elusive bird nests in several types of dense perennial shrubs, including saltbush (*Atriplex* spp.) and mesquite (*Prosopis* spp.), however, within much of its range, its preferred nesting substrate is large, dense cholla (Merriam 1895, Stephens 1884, Grinnell 1904, Sheppard 1970, Fletcher 2009, Hargrove et al 2019). Early reports from ornithologists exploring the Coachella Valley documented a thriving population of LeConte's Thrasher amongst dense stands of cholla, and all note this bird's propensity for nesting in cholla (Stephens 1884, Gilman 1904, Grinnell 1904). However, consistent, systematic data was not collected in the years prior to Plan implementation, and since the establishment of the Plan, it has been repeatedly noted that LeConte's Thrasher populations in the Coachella Valley have sharply declined, and no Thrashers were found in 2016 or 2019 even after extensive and systematic searches, including call-back surveys (Allen et al 2005, UCR-CCB 2014, 2016, Hargrove et al 2019).

Relevant to the abundance of this community regionally, these early researchers paint an image of a Coachella Valley quite different from the one we see today. Stephens (1884) described the area around Palm Springs as a "cactus-covered desert", while Grinnell (1904) noted a landscape "more or less closely dotted with several peculiar species of cacti". It is hypothesized that one potential cause for the extirpation of LeConte's Thrasher from the Coachella Valley is due to the drastic decline in cholla density (Hargrove et al 2019). As such our goals for this project were to:

- Assess the status of the native cholla species throughout the Coachella Valley, with a focus on silver cholla
- Characterize current cholla habitat and investigate how environmental differences and human impacts may affect cholla health
- Determine areas within the Coachella Valley where cholla still thrive, and thus may be considered for future habitat restoration efforts as suggested in the Coachella Valley Conservation Commission's 2019 report on LeConte's Thrashers (Hargrove et al 2019)

2 METHODS

Study site selection

Most of our study sites were selected due to the presence of previous survey data at locations throughout the Coachella Valley (Fig. 1). We targeted areas where cholla had been noted during past vegetation mapping efforts, and/or locations where LeConte's thrashers have been recorded or searched for (UCR-CCB 2014, 2016, Sweet et al. 2019, Hargrove et al 2019). This provided a baseline dataset by which to compare current findings to. We also visited new areas where cholla and/or LeConte's thrashers had been documented in online resources including CalFlora (www.calflora.org), iNaturalist (www.inaturalist.org), and eBird (www.ebird.org). We performed surveys at a total of 72 locations across the Coachella Valley, from as far west as Cabazon and as far east as Chiriaco Summit and Dos Palmas Preserve. The far-western portion of the Coachella Valley has the highest mean annual rainfall of 39.9 cm. Mean annual precipitation becomes much lower moving eastward, through Palm Springs (13.9 cm), Indio (8.4 cm), and Mecca (7.9 cm) (WRCC 2022).

Data collection

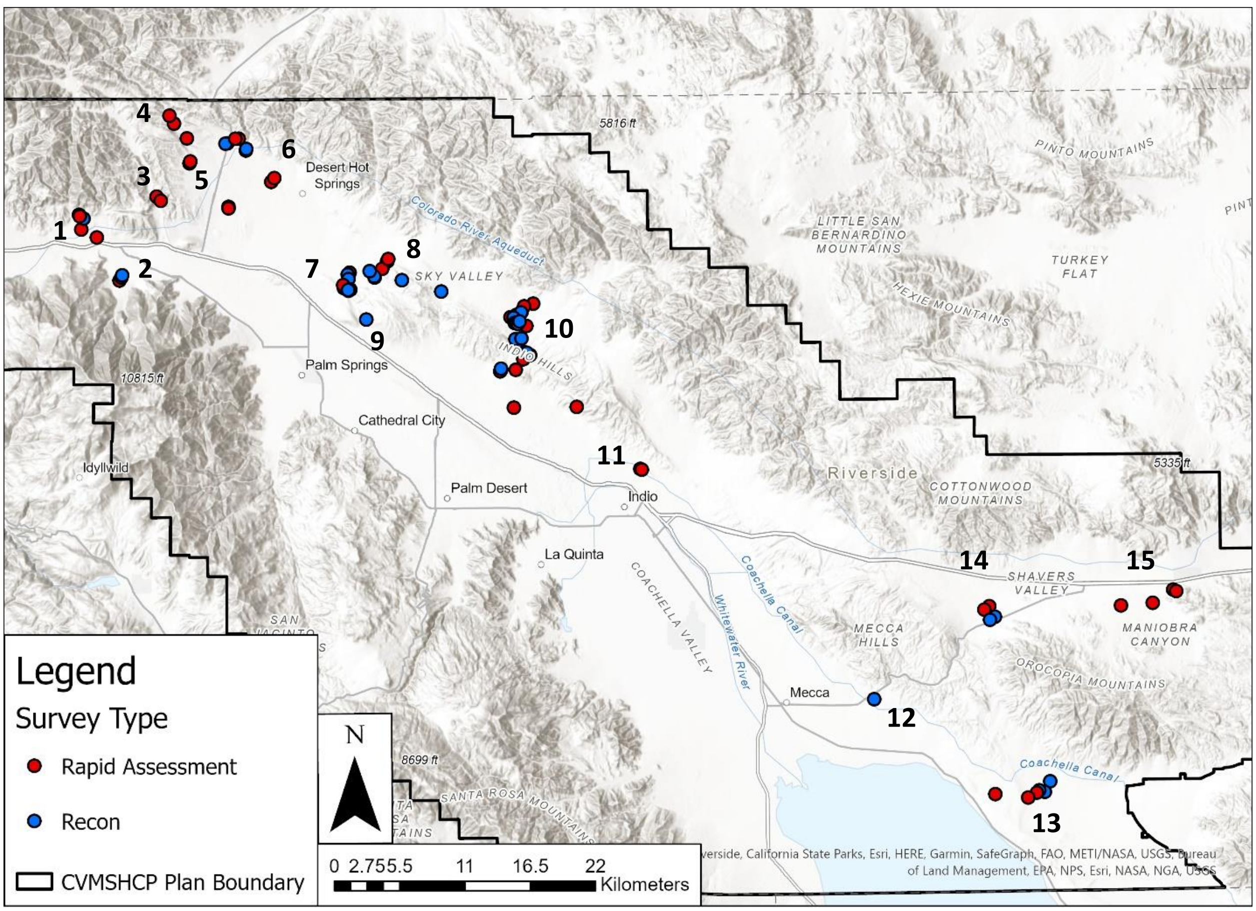

Figure 1: Map of the Coachella Valley Multiple Species Habitat Conservation Area and the points visited in this study. Numbers refer to broad areas mentioned in the text: 1 = Stubbe Canyon, 2 = Snow Creek, 3 = Whitewater Canyon, 4 = Mission Creek, 5 = Devil's Garden, 6 = Desert Hot Springs, 7 = Willow Hole, 8 = Desert Edge, 9 = Edom Hill, 10 = Thousand Palms Canyon, 11 = East Indio Hills, 12 = Mecca, 13 = Dos Palmas Preserve, 14 = Shavers Valley, 15 = Chiriaco Summit.

Data collection at each survey site was comprised of two parts. To characterize a site's perennial plant community, soil characteristics, and disturbances, we performed a California Native Plant Society (CNPS) Rapid Assessment within a 20m-radius circular plot, or alternatively at those sites listed as "Recon" (Figure 1), we simply quantified the cover of the most dominant species and recorded general notes on habitat attributes. We identified cholla species using The Desert Jepson Manual (Baldwin et al. 2002) using non-floral characters. We then characterized the status of cholla within the 20m-radius plot locating each cholla by recording the following items for each cholla:

- GPS coordinates (UTM Zone 11 NAD 83)
- Species
- Condition of dead plants as binned categories (Dead Condition, or D-Con):
    - D0 = extremely decomposed, barely recognizable, est. >20 years since death
    - D1 = skeleton present, at least partially intact, little or no epidermis remaining, est. 10-20 years since death
    - D2 = skeleton mostly intact, 25% or more epidermis remaining, some spines may be present, est. 5-10 years since death
    - D3 = recently dead, spines and epidermis mostly or completely intact, est. 0-5 years since death
- Condition of live plants as binned categories (Living Condition, or L-Con):
    - L2 = less than 25% of crown alive
    - L3 = 26% to 50% of crown alive
    - L4 = 51% to 75% of crown alive
    - L5 = 76% to 100% of crown alive
- Plant dimensions as binned categories, height and crown width, to assess nesting substrate quality:
    - 1 = <0.5m, 2 = 0.5-1m, 3 = 1-2m, 4 = >2m
- Number of branch tips as binned categories, to assess nesting substrate quality:
    - 1 = <10, 2 = 10-25, 3 = 25-50, 4 = 50-100, 5 = 100-200, 6 = >200
- Presence of nest
- Photograph of plant

Analyses

We used ArcGIS Pro v2.9.3 (Ezri Inc, Redlands, California) to create maps to display survey results and extract values from raster layers containing information on environmental conditions at study plots. These environmental variables consist of average maximum temperature, June-August 1981-2010; average minimum temperature, December-February 1981-2010; elevation, soil composition as percent sand, silt, and clay, available water content, climatic water deficit, and average precipitation for July to October and November to June, 1981-2010 (see Appendix A for variable details). We conducted analyses in RStudio Build 492 running R programming language version 4.1.0 (R Core Team 2021) using the packages polycor v0.8.1 for polychoric correlation of ordinal variables (Fox 2022), stats v4.1.0 for simple linear regressions (R Core Team 2021), ggplot2 v3.3.5 for plot visualization (Wickham 2016), and cowplot v1.1.1 for figure labeling and assembly (Wilke 2020).

We chose to incorporate only data collected on silver cholla for in-depth analysis because it is the dominant cholla species within the Coachella Valley and the most commonly reported thrasher nest host in this area. Pencil cholla is common throughout the Coachella Valley, but typically at much lower density than silver cholla. We only recorded California cholla at one location at our western-most plot in Cabazon, where it was extremely abundant and healthy. However, it was an obvious outlier in analyses and not comparable to the other study plots, so we chose to omit this species.

3 RESULTS

Species Presence

Across our 72 sampling plots, we recorded information for 1159 individual cholla across three species: silver cholla (*Cylindropuntia. echinocarpa*), California cholla (*C. californica*), and pencil cholla (*C. ramosissima*) (Table 1). We noted that the cholla present at the westernmost sites such as Whitewater Canyon and Mission Creek seemed to have a slightly different morphology compared to silver cholla throughout the rest of the valley (spines appeared less dense), in spite of keying to silver cholla, consistent with other identifications in the area (e.g. 1976 collection by R.G. Swinney, UCR0110232). This may be due to growing under different environmental conditions (higher precipitation, cooler), or possibly hybridizing with California cholla. We did not observe any LeConte's Thrashers during this study. We investigated areas where LeConte's Thrashers were reported within iNaturalist and eBird (as above) within approximately the last 10 years, however we were unable to verify the accuracy of these records. It is possible that many or all of these records were misidentified California Thrashers (*Toxostoma redivivum*). We found only a small number of nests within cholla, and almost all of them were old and weathered beyond recognition (data not shown). More recently-constructed nests were likely of either Cactus Wren (*Campylorhynchus brunneicapillus*) or Black-Throated Sparrows (*Amphispiza bilineata*).

Table 1: Number of live and dead cholla per species observed during this study.

Cholla species	Common Name	# Live	# Dead	Total
Cylindropuntia echinocarpa	Silver cholla	196	788	984
Cylindropuntia californica	California cholla	98	2	100
Cylindropuntia ramosissima	Pencil cholla	34	41	75

Morphology, density and condition of cholla

Most live silver cholla we observed were less than one meter in height and crown width and possessed more than 200 branch tips (Fig. 2). Most of the live silver cholla in our plots had a branch tip density toward the upper range of our predefined categories (>200 branch tips), indicating that we should have included additional categories to account for cholla with denser branch tips. Regardless, we used polychoric correlation of ordinal variables to demonstrate that all three of these growth metrics are strongly positively correlated. In other words, as height increases, so does crown width and branch tip density in a predictable linear fashion. As such, to simplify visualization of cholla growth form variation throughout our plots, we decided to use the height of the live silver cholla as a proxy for cholla size and branch density. Calculating the mean cholla height for each plot reveals the largest, densely branching cholla present at several locations across the Coachella Valley, including Snow Creek, Whitewater

Canyon, Mission Creek, Desert Edge, Thousand Palms Canyon, Shavers Valley, and Dos Palmas Preserve (Fig. 3).

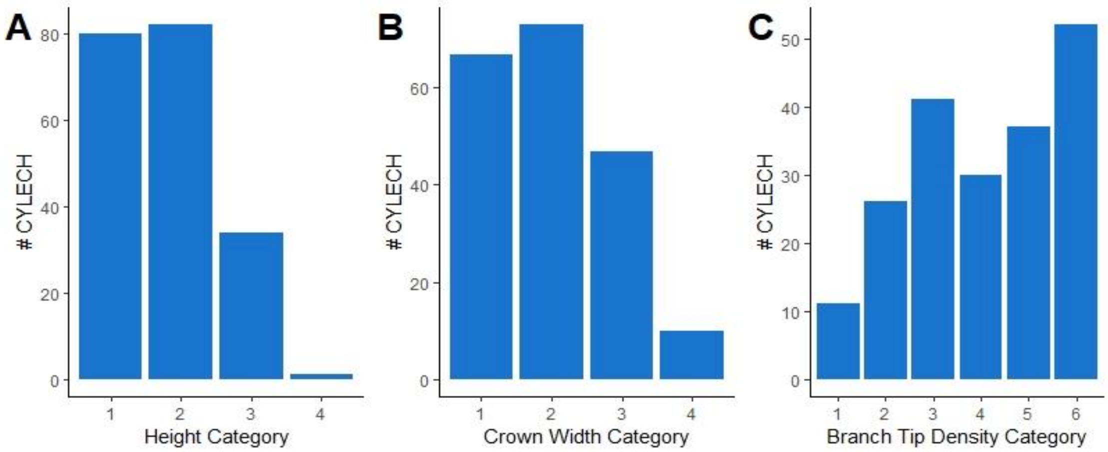

Figure 2: Number of individuals within silver cholla size categories. A) height, B. crown width, C) branch tip density.

Live silver cholla were at their highest density in the canyons of the far western end of the Coachella Valley, in areas such as Snow Creek, Whitewater Canyon, and Mission Creek (Fig. 3). We also found several areas of higher-than-average density of live cholla throughout Sky Valley and eastern Desert Hot Springs. Approximately 80% of the silver cholla we observed were dead and at highest density in the far western end of the Coachella Valley (Fig. 5).

An estimation of live cholla health, represented as the mean percent of live branch tips per individual plant, reveals several geographic areas where silver cholla appear to be healthy (Fig. 6). Areas in the western end of the valley such as Snow Creek, Stubbe Canyon, Whitewater Canyon, and Mission Creek, contain sites with a high mean cholla health. Healthy cholla can also be found in parts of Desert Edge and Sky Valley along the north margin of the Indio Hills, as well as within Thousand Palms Canyon and the broad alluvial fan directly to its north. However, while healthy, the cholla in Thousand Palms Canyon are sparsely distributed (Fig. 3). A summary of the density of D-Con categories for dead cholla in the far-western part of the Coachella Valley, where dead plants are abundant enough to draw conclusions, shows that, in general, category D1 (second-lowest category, only woody tissue remaining) is the most abundant. However, multiple plots in Mission Creek Canyon contained an unusually high abundance of D2 category plants, indicating that this area may have experienced a more recent die-off of cholla compared to nearby areas. Also, these westernmost plots contain the highest density of D3 category plants (most recently dead, within the past 5 years). At some plots, including in Mission Creek, Devil's Garden, Stubbe Canyon, and Snow Creek, the number of D3 dead cholla reaches approximately half or greater than the number of total live plants (Fig. 7).

As noted, many of the sites visited in this study show a disproportionate amount of dead cholla that fall into the D1 category (the oldest class for which woody tissue was still largely in evidence). If we assume this is connected to this early-2000's silver cholla die-off, it is possible to roughly estimate time since death for the various categories as follows: D0 = > ~20 years since death, D1 = ~10-20 years since death, D2 = ~5-10 years since death, and D3 = ~5-0 years since death. We counted 198 total dead silver cholla in the D2 category that likely died within the last 5-20 years and 31 in the D3 category that died in the last 5 years. Considering that we found only 16 live young silver cholla, likely having sprouted in the last 5 years, this produces a 52% replacement rate.

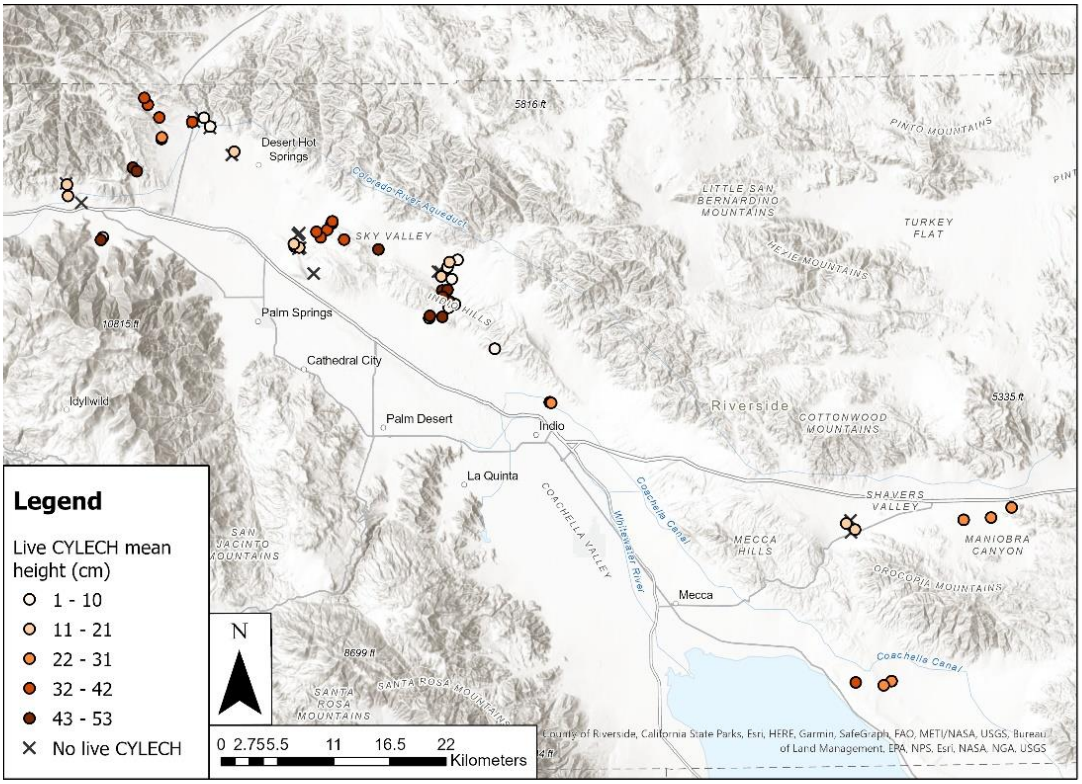

Figure 3. Map showing mean silver cholla height per plot. Darker colored points indicate taller mean heights

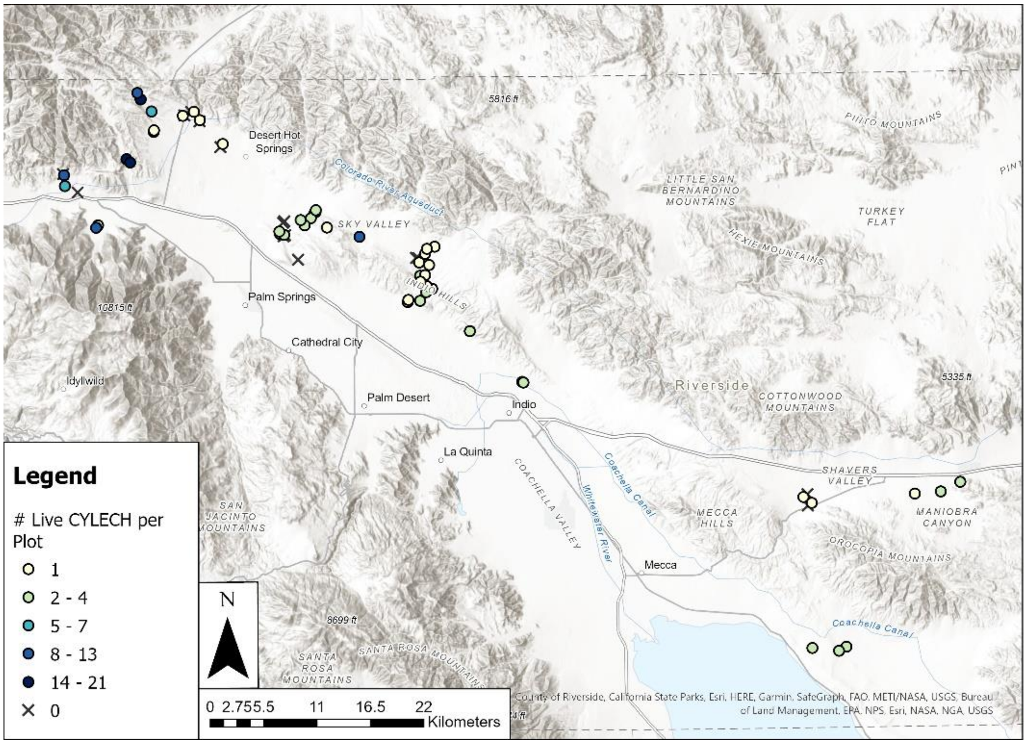

Figure 5. Map showing density of live silver cholla per plot. Darker colored points indicate higher density of live cholla.

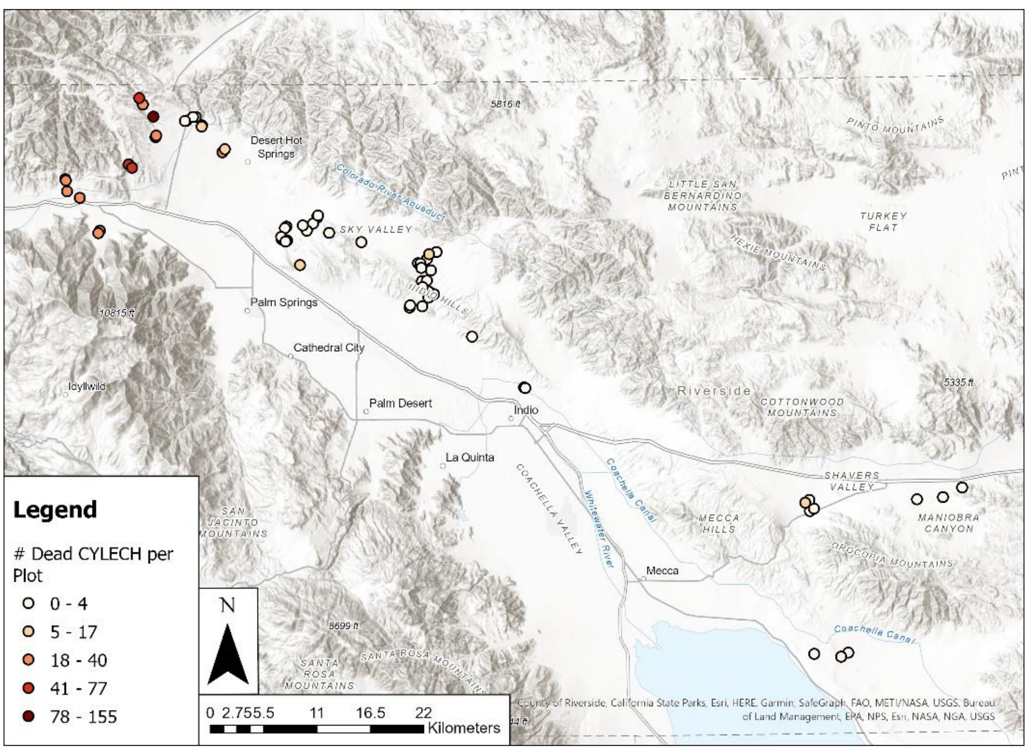

Figure 4. Map showing the density of dead silver cholla per plot. Darker colored points indicate higher density of dead cholla.

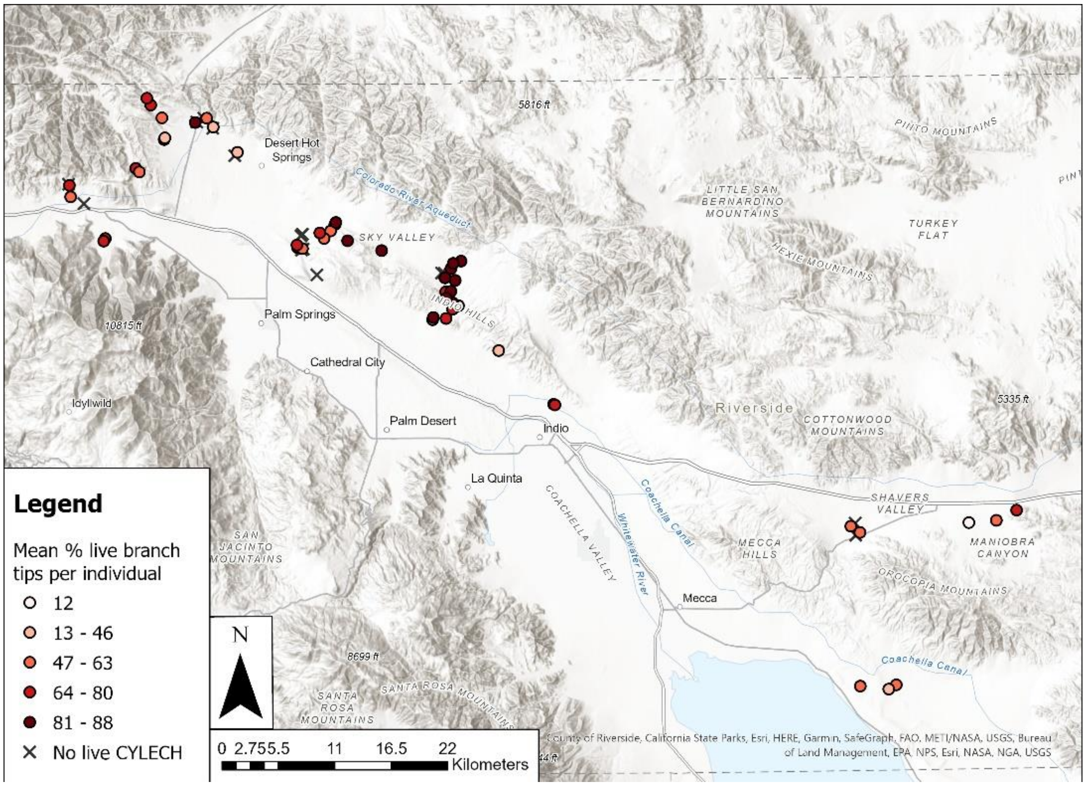

Figure 6. Map showing mean health of live cholla per plot. Health here is defined as the percent of live branch tips per plant. Darker colors indicate higher health.

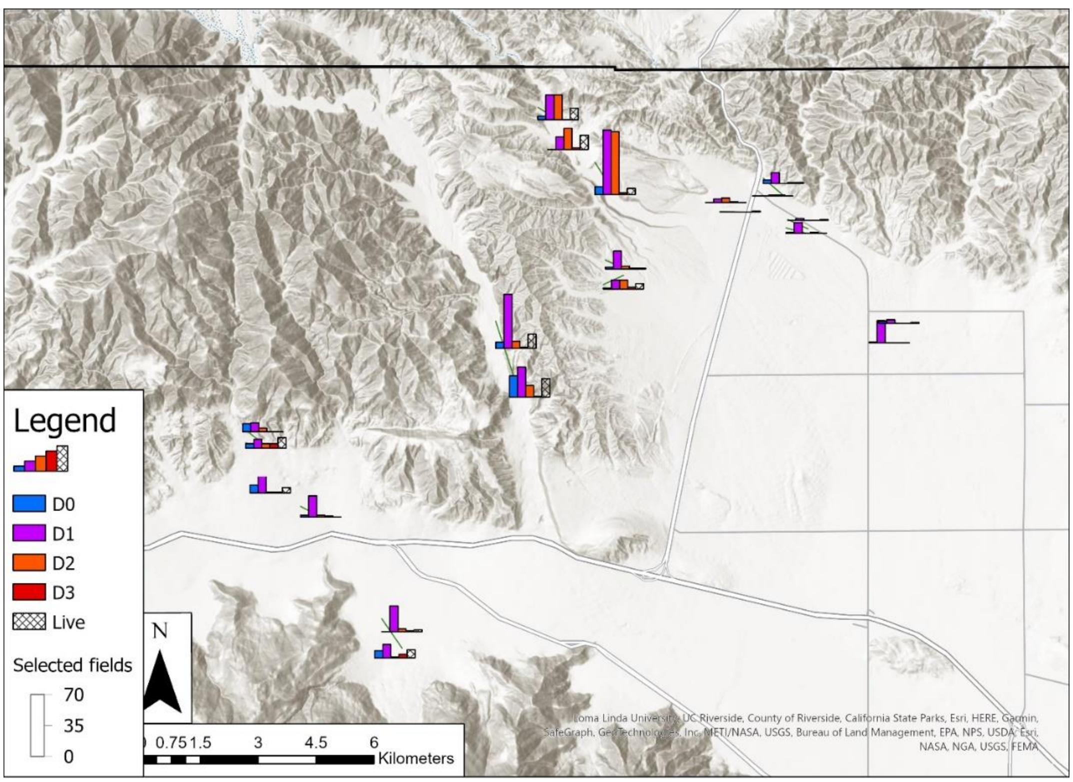

Figure 7. Map showing abundance of dead silver cholla, by death category, and live cholla per plot for western study sites.

Abiotic factors versus live silver cholla density

Of the 10 selected environmental variables chosen for simple regression analysis using the number of live silver cholla per plot as the response variable, all but one (average minimum monthly temperature, December to February, 1981-2010) produced significant regression coefficients (Fig. 8, A-J). The number of live cholla per plot changes in a predictable manner: plots experiencing relatively cool and wet conditions tend to harbor a higher density of live silver cholla. Also, silver cholla density appears to be positively correlated to proportion of clay and silt in the soil, indicating preferred soil composition may be comprised of less sand. However, even with highly significant regression coefficients, the adjusted r^2 values were always low, indicating that much of the variation present in the regression plots is not explainable by the predictor variable.

Only two plots showed evidence of fire: one in southwestern Desert Hot Springs near SR 62, and one in Devil's Garden. The former had no cholla live or dead, in spite of historic LeConte's Thrasher occurrences, and the former had only one live cholla in poor health, along with numerous dead.

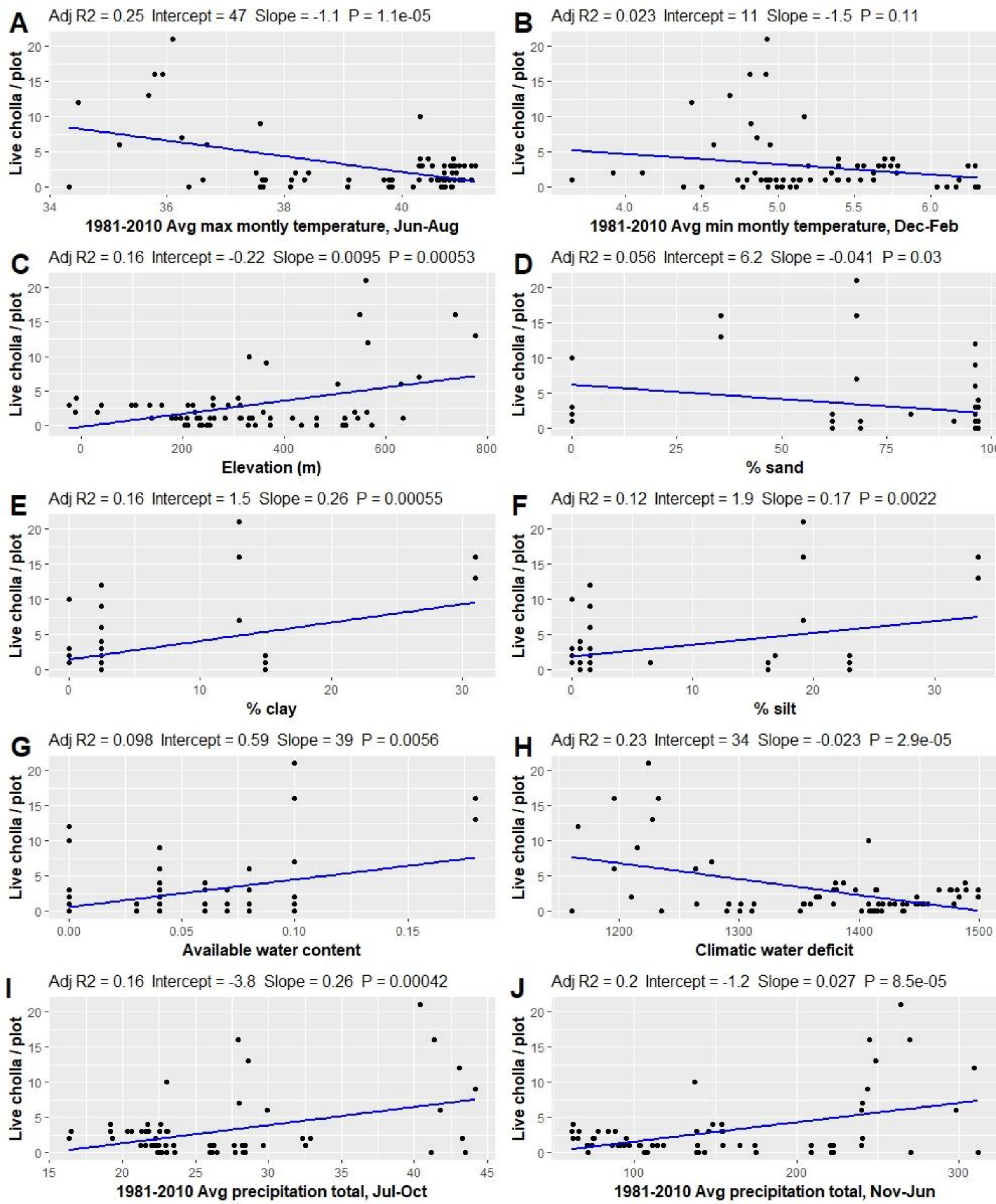

Figure 8. Results of simple linear regression relating abiotic variables to live silver cholla per plot as the response variable. A) Average maximum summer temperature; B) Average minimum winter temperature; C) elevation; D) percent of soil consisting of sand; E) percent of soil consisting of clay; F) percent of soil consisting of silt; G) available water content; H) Climatic water deficit; I) average summer precipitation total, July to October; J) average precipitation total, November to June.

4 Discussion

It widely known, but relatively poorly documented, that cholla are declining within many parts of the Coachella Valley. Early natural history records of the area seem to describe a notable density of cacti, including cholla which LeConte's Thrashers readily nested in (Stephens 1884, Gilman 1904, Grinnell 1904). However, more recent Valley-wide vegetation community mapping efforts, along with this study, indicate cholla in many areas are either sparse or locally extirpated. The primary goal of this study is to identify areas where silver cholla still thrive and to identify factors that may contribute to cholla decline in other areas.

The highest quality habitat for cholla persistence would be on undisturbed land with minimal fragmentation (highest in conserved lands) with other ecological processes intact and ideally these stands would exhibit a combination of large average size, high health, high density of live plants, and recruitment. Several promising sites were located among the canyons or related alluvial fans in the far west end of the valley: Stubbe Canyon, Snow Creek, Whitewater Canyon, and Mission Creek. These areas are the wettest, coolest, highest elevation sites visited during this study and may represent a climate refugia for this species. Along with the results of our regression analyses, this indicates that climate change, and associated hotter, drier conditions, are likely a major driver of local silver cholla mortality. We noted no seedling cholla during this study, however we recorded 13 relatively young plants from this area, likely germinated within approximately the last five years. We also found three young plants that had recently died. In order to make conclusions about demographic trends, we would need further information on the species, including average lifespan, in order to understand the replacement rate necessary for these stands.

Notably, this westernmost area is also the most likely to experience fire since it demonstrates the highest establishment of highly successful invasive grasses (Steers and Allen 2011). Studies in perennial plant succession throughout this area indicate short-lived perennials such as brittlebush (*Encelia farinosa*) colonize burn areas and maintain higher density than unburned landscapes, while other longer-lived perennial shrubs and cacti are reduced (Steers and Allen 2011). Risk of burn is an important factor that must be taken into consideration if exploring restoration here.

Another group of vigorous cholla occurs throughout Desert Edge, to the east of Desert Hot Springs and following the northwest margin of the Indio Hills. Some of these cholla were the largest and the individuals were morphologically densest (of branch tips) observed in this study, although they often showed signs of stress including desiccation and scarring of the trunk and stems (Fig. 9). The number of dead cholla here was low, indicating that this area has not shown recent high mortality. However, the low number of dead plants detected may also be due to variability in degradation and decomposition rates here, causing an underestimate of mortality. Regardless, this area seems to contain cholla that are ideal nesting hosts for LeConte's Thrasher. Unfortunately, Desert Edge is highly fragmented by roads and urban development and much of the land containing large cholla is privately owned, which will hamper conservation efforts.

Figure 9. Densely branching silver cholla at Desert Edge.

While many cholla species are well adapted to living in harsh desert conditions, it seems that many parts of the Coachella Valley are reaching environmental conditions at the limit of its physiological tolerance. McDonough (1965) documented a patch of teddy bear cholla at Boyd Deep Canyon Desert Research Center located in Palm Desert that had experienced considerable decline. Also at Deep Canyon, Bobich (2014) examined several cholla species and found that silver cholla suffered a 17.5% mortality during the drought period at the end of the 20th century and early 21st century – the second-highest mortality of four cholla species present, behind teddy bear cholla. In a 2003 survey, McCauliffe and Hamerlynck (2010) also noted two locations in nearby Joshua Tree National Park where over half the silver cholla had succumbed to drought. It is logical to assume that cholla mortality rates beyond replacement rates will continue into the future as climate change drives increases in temperature and drought severity/frequency (IPCC 2021).

5 MANAGEMENT RECOMMENDATIONS

There is a need for longer-term and a more systematic study to understand the patterns summarized here. Designating long-term study plants (individual cholla selected for regular study across an extended time frame) throughout the Coachella Valley will help provide clearer information about fates of these plants, including longevity, causes of death, rates of decay which can be used for more accurate estimates in the future. As well as add context to the life history of the species.

Areas noted in this study as containing vigorous cholla, namely the canyons and alluvial fans of the far-western Coachella Valley along with Desert Edge, should be investigated more closely to determine usefulness for restoration. Some factors not closely studied here, including ecological relationships, habitat fragmentation, proximity to urban areas and associated stressors (OHV activity, dumping, etc.), and fire history, may play critical roles in both cholla and LeConte's Thrasher success. Many LeConte's Thrasher researchers have noted the birds' shy nature around humans, so urban encroachment may play a significant role in determining habitat occupancy. Understanding the apparently healthy population at Desert Edge may help illuminate features of this area that are amenable to persistence of healthy stands elsewhere.

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APPENDIX VII: 2022 COACHELLA VALLEY MILKVETCH REPORT

Report begins on following page.

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

2021–2022 MONITORING RESULTS FOR THE COACHELLA VALLEY MILKVETCH (*ASTRAGALUS LENTIGINOSUS* VAR. *COACHELLAE*)

2021-2022 FINAL REPORT

<u>FINAL REPORT</u>

COACHELLA VALLEY MULTIPLE SPECIES HABITAT CONSERVATION PLAN 2021–2022 MONITORING RESULTS FOR THE COACHELLA VALLEY MILKVETCH (*ASTRAGALUS LENTIGINOSUS* VAR. *COACHELLAE*)

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1 INTRODUCTION

Coachella Valley Milkvetch (*Astragalus lentiginosus* (Douglas) Barneyby var. *coachellae*, hereafter CVMV; Figure 1) is federally endangered endemic plant 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 primarily 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 (Figure 2). This plant is usually an annual, but with sufficient resources it can survive multiple years; one robust specimen in Desert Hot Springs has survived for at least three years (UCR 2020).

Figure 1. Flowers of Coachella Valley milkvetch (*Astragalus lentiginosus* var. *coaechellae*). Near Windy Point, Coachella Valley, CA. Photo Scott Heacox, 2022.

The primary threat to CVMV has been identified as habitat destruction due to urban development and habitat conversion within the Coachella Valley (CVCC 2016). Much of the sand dunes that CVMV occupies as primary habitat have now been developed, stabilized, or fragmented by urbanization. Habitat that is not converted is at risk of sand depletion due to blocking or interrupting of sand transport into dune ecosystems. The species is also impacted by other threats including OHV use, trampling, and the introduction of invasive species, including Russian thistle (*Salsola tragus*) and Saharan mustard (*Brassica tournefortii*).

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). 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 worked to locate historic occurrence locations on public land for each species and document the existing populations through approximately 500m^2 vegetation relevé-style plots. For CVMV, five unique records were identified on public lands. Researchers found that of the five locations, CVMV occupied three of them (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 with adequate rainfall. As new occurrences are still being discovered for the species, an important goal remains to confirm any shift in its range by visiting and identifying range edge populations.

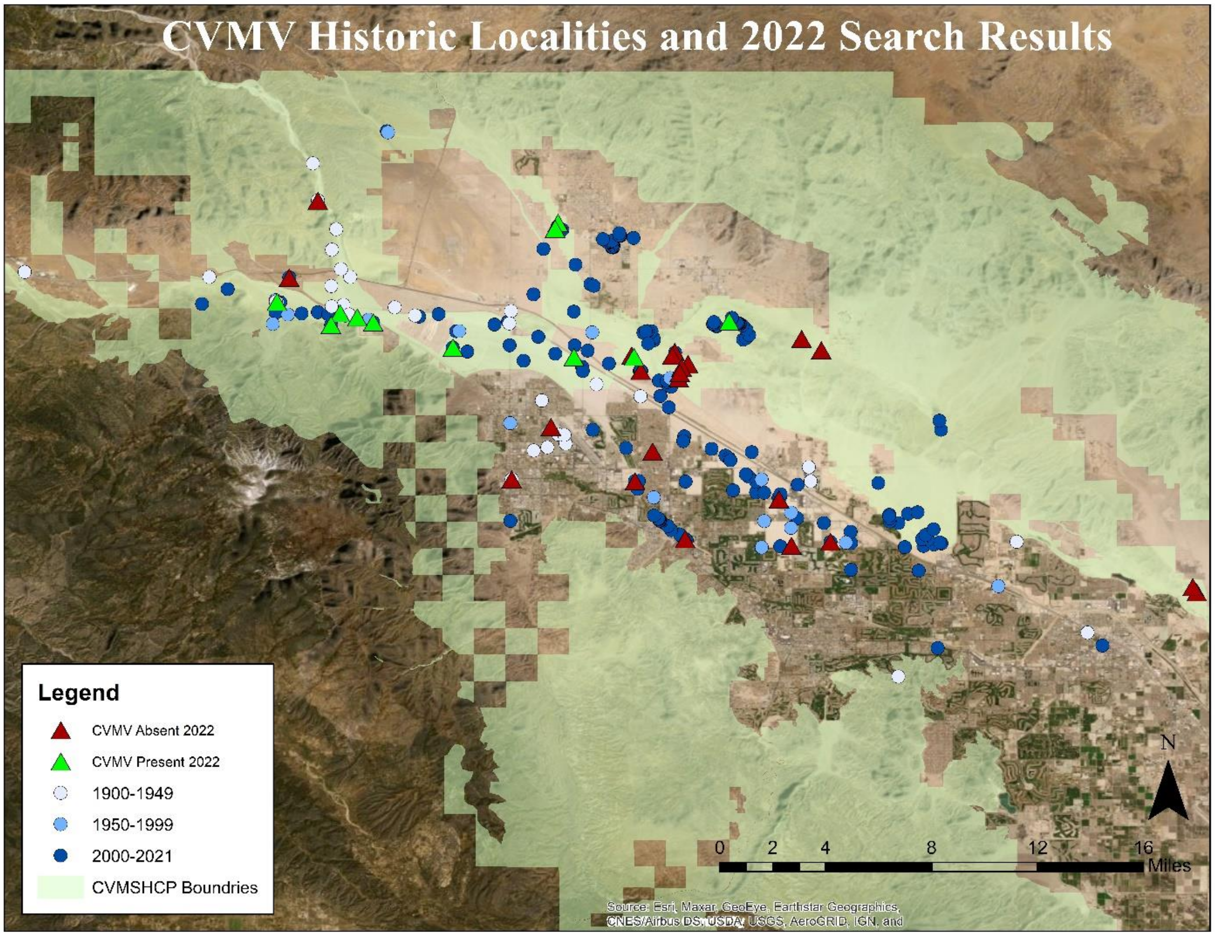

Figure 2. 2022 search and survey results overlaid on distribution of *Astragalus lentiginosus* var. *coachellae* records based on georeferenced records, color-coded by year. Occurrence points taken prior 1949 are georeferenced to the best of our ability using collection notations.

In accordance with our annual objectives for monitoring CVMV, we assembled an updated occurrence dataset from available online sources, created a current species distribution model (habitat suitability model), performed field surveys to investigate the edges of CVMV range within and outside of the Plan area, and recorded threats to the populations. We monitored the abundance of this species at our long-term aeolian community monitoring plots (Barrows *et al.* 2005) 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.

2 METHODS

2.1 DATABASE

To build upon the dataset that was created by UCR CCB in 2002, we obtained records from online sources including iNaturalist, California Natural Diversity Database, Global Biodiversity Information Facility, and California Consortium of Herbaria (Figure 2). Due to its status as federally endangered, records of the plant in some databases are obscured from the public. By vetting the information directly, we were able to compile a dataset of 302 observations with high precision, including outlier localities that needed to be ground-truthed. Our final dataset is submitted with this report.

2.2 SURVEYS

In spring 2021 we began visiting a subset of records from the database, however due to drought conditions and lack of germination, sites visited in 2021 were visited again in 2022, and we report solely on 2022 results here. We created the plot network by identifying records that were at the edges of the range-wide distribution of CVMV (Figure 2). We then chose records that at regular geographic intervals across the valley and not already captured by our annual aeolian monitoring plots (Sweet 2021), points within what appeared to be suitable habitat as viewed from aerial imagery but had not been confirmed recently, as well as those from the dataset that we identified as outliers (as above). Finally, we targeted points where the habitat type on the ground appeared to be suitable, i.e. sandy, but the area was isolated, such as sandy empty lots surrounded by urban development.

At each site we performed a truncated relevé protocol (CDFW-CNPS 2019). First, presence was determined; if it was not obviously present at the original locality, we spent at least five, and no more than 15, minutes per person searching the surrounding area and suitable habitat. If CVMV was not found at the initial record point, but found nearby, we moved the survey point to focus on the point that the plant occupied. In some cases, this may be due to error or lack of precision in the record; in others, it was due to changes in abundance at a fine scale, or local site occupancy. If it was not found at all, we recorded data at the original locality point. We also performed exploratory searches, or searches that were not associated with a record point, when we encountered CVMV while performing other surveys, or we were in an area that CVMV was anecdotally known to occur in. In this case we established the survey point at the estimated central point of the population.

At each point, whether or not CVMV was present, we took data on the dominant shrub community (species list and percent cover), UTM coordinates (NAD83 Zone 11N) using Avenza on a

Samsung Galaxy tablet (Avenza System Inc., Toronto, Canada; Samsung Group, Seoul, South Korea), and general site notes including documentation of invasive species, human disturbances, proximity to roads, sand flow, (see CDFW-CNPS 2019 Assessment Protocol for disturbance types) etc. We then paced out a 20 meter radius and counted all CVMV within the circular plot. For each plant we identified if it was a seedling, flowering, fruiting, or dead or dying. Since perennialized plants senesce prior to summer, it is not known whether all plants marked as dying were reflective of true mortality. However, efforts were made to perform the surveys in the appropriate season for detection, prior to annual senescence.

3 RESULTS

We visited a total of 33 sites between March 9, 2022 and April 28, 2022. Twenty-one of the sites were historic records or associated with historic records, and 12 were new additions from exploratory surveys (Figure 2). We confirmed presence of CVMV at 11 total sites, four of which were associated with a historic record, and seven were new additions. We did not find CVMV at 22 sites, 17 of which were historic records, and five were new additions. Points where CVMV was not found could not presumed to be extirpated from the site because of the low precipitation this and last year.

We documented a total of 1,067 CVMV (live and dead) within the 11 confirmed presence sites, resulting in presence at 33% of sites visited. Of the total individuals documented, 96.91% of them were vegetative or seedlings (non-reproductive), 2.81% were reproductive (had fruit or flower), and 0.28% were dead (Figure 3 & 4).

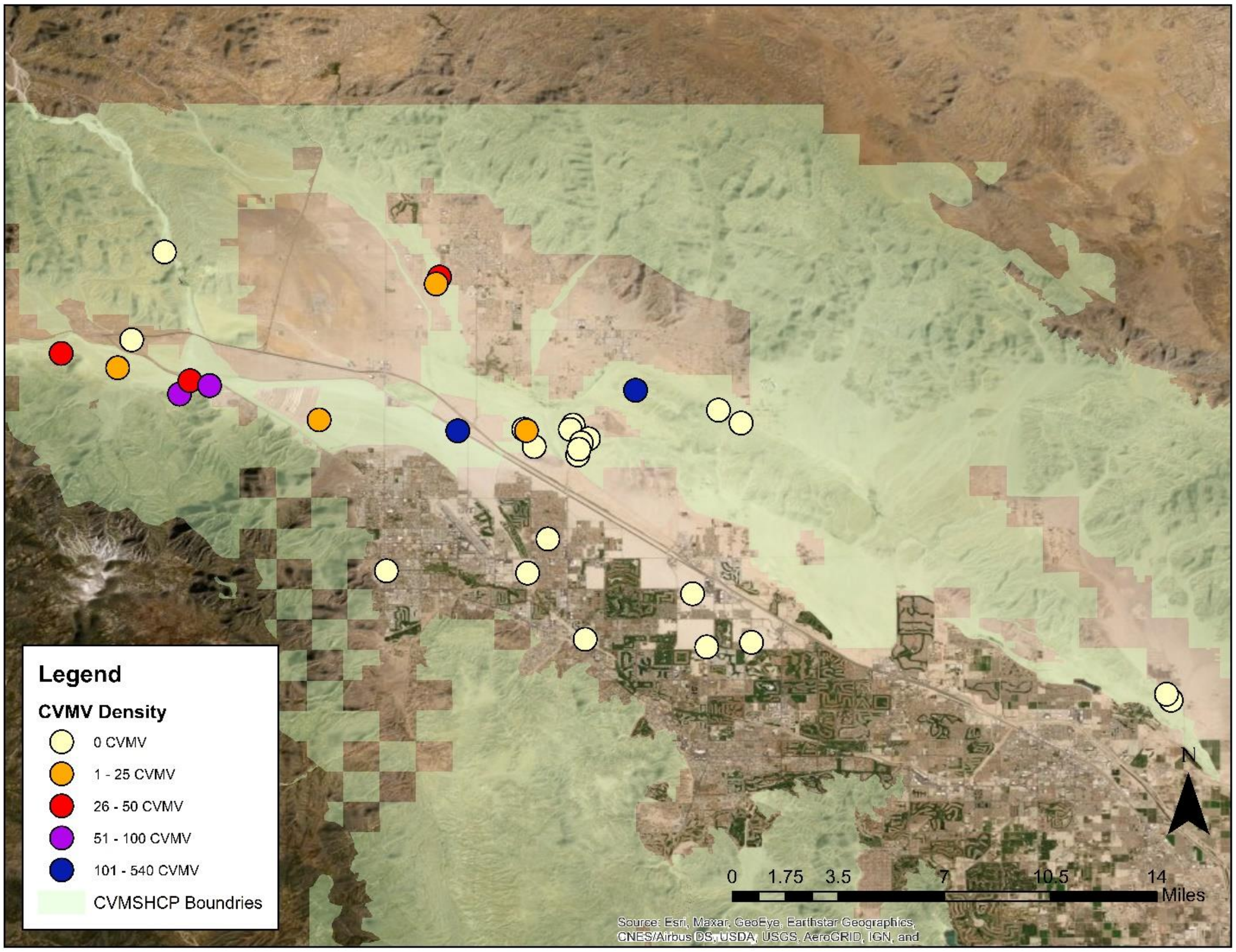

Figure 3. Map showing CVMV densities across all survey (absence and presence) locations visited in 2022.

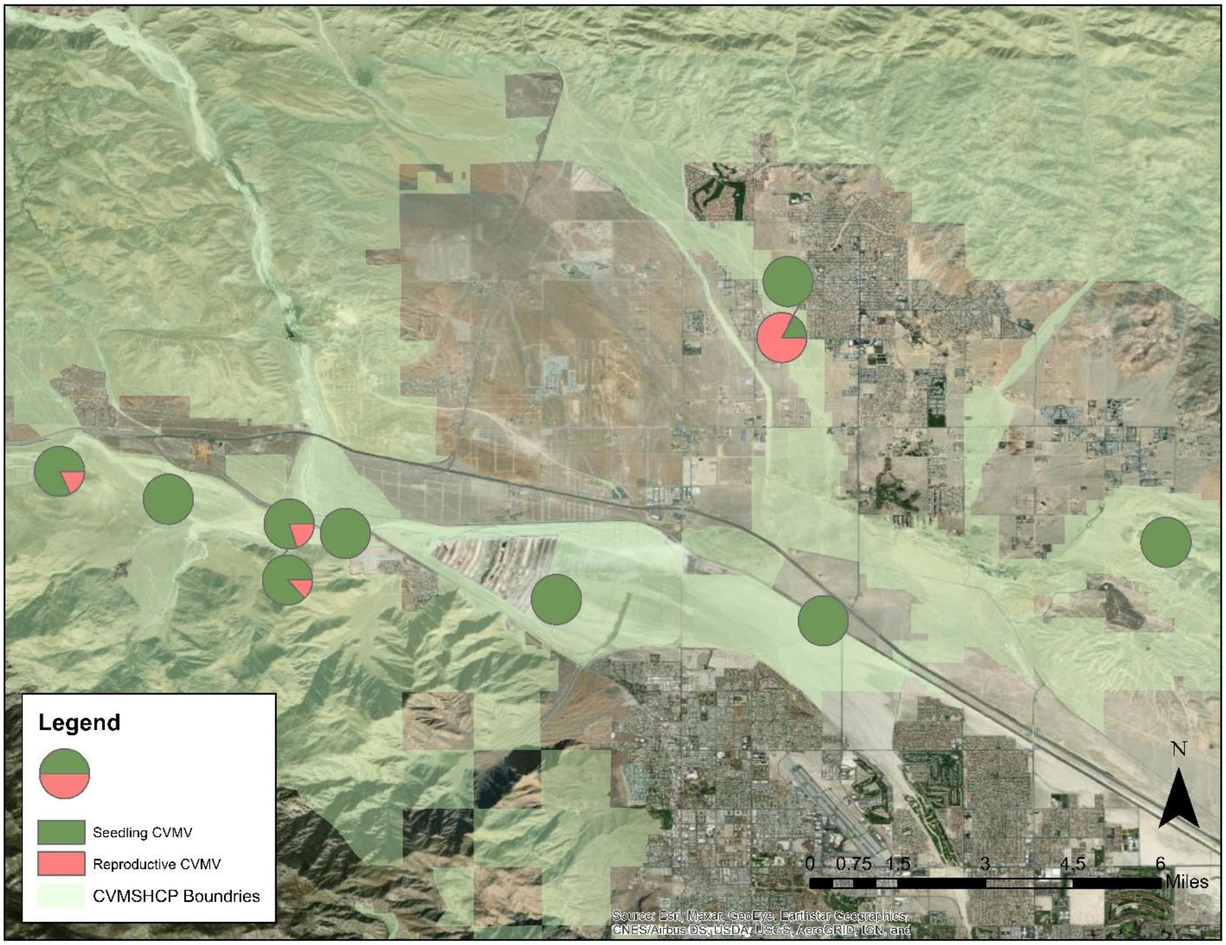

Figure 4. Map showing the ratio of nonreproductive (seedling/vegetative) to reproductive (flowering/fruiting) CVMV only at survey locations where CVMV was present.

3.1 THREATS

Threats may be grouped into the following five categories: ecosystem level impacts, direct human disturbance, eliminated or converted habitat, biotic threats, and no observed threats (Table 1). We define ecosystem level impacts to be threat impacts on the site that are specifically related to interrupted sand flow, or changes in the structural process and abundance of nutrients or resources. Sites that were determined to have ecosystem level impacts were sites that are islands, or partial islands (e.g. a sandy lot surrounded by suburbs), sites where the processes providing sand deposition are clearly impacted, or increased nitrogen deposition from car exhaust. We categorized direct human disturbance as direct impacts, such as OHV activity, dumping, or occurrence within 30m of a paved road, railroad, or wind turbines. These direct disturbances may impact individual plants (trampling or run over by OHV) or introduce invasive species to the habitat. We define converted habitat as historic habitat that has since been completely altered, such as graded, artificially stabilized, or completely developed. As one would expect, no CVMV was found at converted habitat sites because they had been completely cleared of all native vegetation and sand. All sites where we documented invasive species are categorized under biotic threats. Documented invasive species were primarily *Brassica tournefortii* (Sahara mustard, BRATOU), however *Salsola tragus* (Russian thistle), and *Schismus* species (Mediterranean grass) were also documented at lower densities. At sites where CVMV and BRATOU were present, BRATOU was always documented at less than 1% cover, and sites where CVMV was absent and BRATOU present, BRATOU was documented on average just over 1% cover. Finally, the last category is no observed threats. All sites we surveyed had some sort of quantifiable threat, and none were considered pristine habitat. Our plot network selection did favor historic occurrences along the urban/wildland interface, and thus sites with increased disturbance.

Table 1. Threats by presence vs absence sites. Most sites had multiple categories of disturbances, so totals do not sum to 100%.

	Ecosystem Level	Human Disturbance	Converted Habitat	Biotic Threats	No Observed threats
CVMV PRESENT (n=11)	6 (55%)	9 (82%)	0 (0%)	3 (27%)	0 (0%)
CVMV ABSENT (N=22)	17 (77%)	9 (41%)	4 (18%)	8 (36%)	0 (0%)

3.2 HABITAT MODEL

The habitat model was created in Maxent using 332 presence records and 10327 background points had an AUC from the training data of 0.95 (scale: a random prediction would score 0.5, and 1.0 is a perfect prediction) (Figure 5). Assessing the importance of each variable using permutation can provide insight into how important each variable is to the model's predictive gain; but this needs to be interpreted with caution when variables are correlated. The top predictors as assessed using this method were winter annual precipitation (45%), winter minimum temperature (33%), and summer annual precipitation (7%). Interestingly, final model was more heavily based on other variables, including sand (38%), winter annual precipitation (22%), summer precipitation (12%), closely followed by winter minimum temperature (11%). Urban development was mapped to illustrate the impact of human disturbance on this species, drawn from 2008 information from USGS. This approximation shows a significant area that has been developed coincident with CVMV habitat. As shown, the area of suitability appears to be an overestimate and further work should be done to refine the estimates, using reflectance similar to earlier models by Barrows and others in 2005.

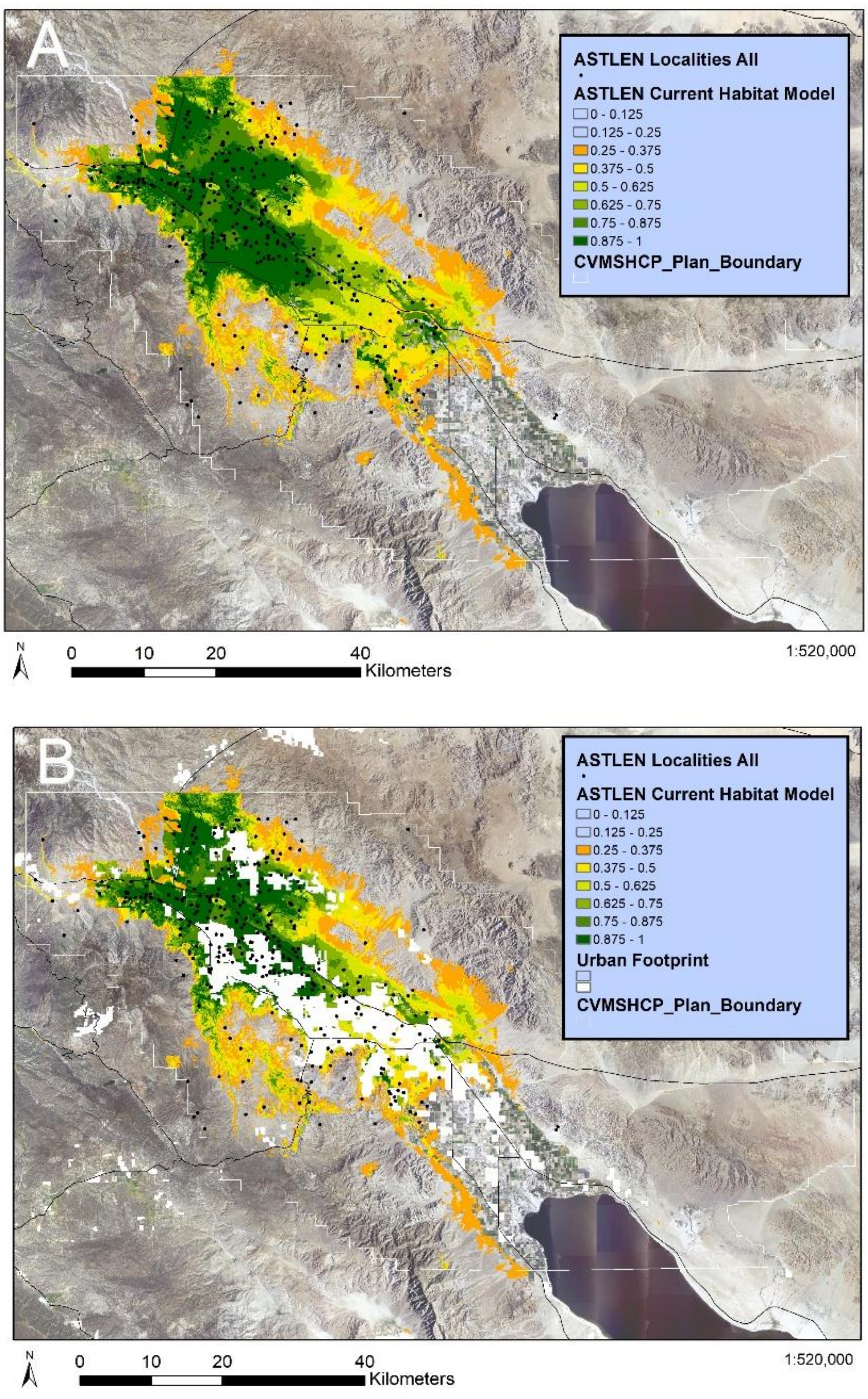

Figure 5. Habitat models created using Maxent for CVMV, showing current habitat suitability and future suitability in the Plan area. Modeled habitat suitability increases from a value of 0 to 1, and suitability is shown for the current time (A), and shown with approximate current development levels (B). Current locality data (training data) for the model is shown.

4 Discussion & Recommendations

4.1 Summary & Recommendations

As with last year, drought conditions are not ideal for monitoring CVMV. However, precipitation was higher in the western portion of the Coachella Valley than it was in 2021. As a result, there was enough moisture to facilitate the germination of CVMV along with other desert annual plants. This uneven precipitation, however, made true absence in the eastern side of the Coachella Valley impossible to determine. For example, at one of the 2022 points where CVMV was absent, it was recorded in some as present in 2020. These absences may be due to lack of germination and emergence due to precipitation, or the recorded individuals may have been fleeting or waif occurrences, leaving us with unconfirmed current presence/absence.

Where CVMV was present there was a higher percentage of sites with human disturbances, and a higher number of sites with ecosystem level disturbances where CVMV was absent. This is likely due to the fact that with ecosystem level threats the entirety of the habitat processes are jeopardized, as opposed to smaller acts of disturbance. Invasive plants occurred in low numbers this year (see 2022 Aeolian Sand Species report), however there was still enough BRATOU, both seedlings and skeletons from previous years, to document presence. It is clear that BRATOU occurs in stabilized, urban, and disturbed sites, and CVMV occurs in areas with more sand movement. Although BRATOU may assist in the stabilizing of dune habitat, a lack of sand input resulting from blocking of sand sources and sand transport corridors is likely a more significant factor, and the presence of BRATOU may not necessarily be correlated with the absence or low density of CVMV.

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 during the 2020-2021 season. This past season, 2021-2022 we visited these sites and were able to take habitat, disturbance, density, and phenology data at each site. However, due to uneven precipitation across the Coachella Valley, it is our recommendation that absence points are revisited after winter conditions have provided enough precipitation for adequate germination and emergence of CVMV in the central and eastern portions of the Coachella Valley, in order to get an accurate determination of the range of this species.

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APPENDIX VIII: 2022 LITTLE SAN BERNARDINO MOUNTAINS LINANTHUS REPORT

Report begins on following page.

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

2021–2022 MONITORING RESULTS FOR THE LITTLE SAN BERNARDINO MOUNTAINS LINANTHUS (*LINANTHUS MACULATUS* SSP. *MACULATUS*) WITHIN THE COACHELLA VALLEY

2021-2022 FINAL REPORT

FINAL REPORT

COACHELLA VALLEY MULTIPLE SPECIES HABITAT CONSERVATION PLAN & NATURAL COMMUNITY CONSERVATION PLAN 2021–2022 MONITORING RESULTS FOR THE LITTLE SAN BERNARDINO MOUNTAINS LINANTHUS (LINANTHUS MACULATUS SSP. MACULATUS) WITHIN THE COACHELLA VALLEY

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1 INTRODUCTION

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 (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 California Desert Conservation Area, and subsequently the Western Mojave Bioregional and the Desert Renewable Energy Conservation Plan Amendments (Fig. 2). Much of Linanthus range in San Bernardino County has been documented and archived in herbaria 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. The type locality may have been in Palm Springs (see Fig. 2), as indicated on the William Greenwood Wright holotype specimen label, at "Borders of the Colorado Desert, Agua Caliente," which would now be extirpated due to development (Magnaghi and Fong, 2022, *CAS Botany*). We propose that the record for this specimen may be imprecise; this locality is not near any of the currently known localities and this might more likely refer to a locality in San Diego County by the same name which is immediately proximate to known records for the other subspecies, *Linanthus maculatus* ssp. *emaculatus*, which does not occur in the Coachella Valley. Morphological (petal color) characters for distinguishing the two species would be difficult for a specimen this old. A specimen on the same herbarium sheet by Charlotte Wilder, dated 1907, may more likely be the first collection of this species, as it references the edges of the Whitewater River. Over the last few decades, more populations have been identified and Linanthus habitat has become better understood (Sanders 2006; UCR CCB 2015-2017, 2020-2021); however, because of the extreme inter-annual fluctuations in abundance, more information is needed in order to understand the habitat niche of this species, as well as threats to populations 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; however, many records were not precise enough for geo-referencing. A University of California, Riverside Center for Conservation Biology (UCR CCB) research team then worked to locate historic occurrence locations on public land for each species and document the existing populations through approximately $500m^2$ vegetation relevé-style plots. For Linanthus, only 2 unique historic records occurred on public lands. In 2003 no Linanthus were found on either plot, and 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. Since 2017, UCR CCB has documented more locations for the species, filling out the range and adding a few new edge locations, including in the Snow Creek area on Coachella Valley Conservation Commission land. An important goal remains to confirm any shift in the range of the species by visiting range edge populations frequently.

Figure 1. Linanthus maculatus ssp. maculatus plant in flower, March 1, 2022, Desert Hot Springs, Coachella Valley, CA. (Lynn Sweet photo)

The microhabitat in which Linanthus 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, however, 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 indigo bush (*Psorothamnus arborescens*), and the species may be coincident with a vegetation community association containing these species as dominants (Sweet *et al.* 2019).

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, and subsequently, the monitoring network was shifted in favor of adding more plots at locations where the species was present. These plots were used to facilitate more in-depth study on fine-scale relationships between Linanthus and invasive species and interannual abundance. Monitoring the status of Linanthus continues to be challenged by strong inter-annual fluctuations and the small, cryptic nature of the species.

Fine-scale work has uncovered some details about possible competition with invasive species, microhabitat preferences, substrate type, and species associations. Looking at 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. The density of native species similarly nearly doubled between the two years, while interestingly, the invasive grass, *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 there was a negative correlation in our plots between the cover of Linanthus and *S. barbatus* and vice versa, although the effect was weaker in 2017 when rainfall was higher.

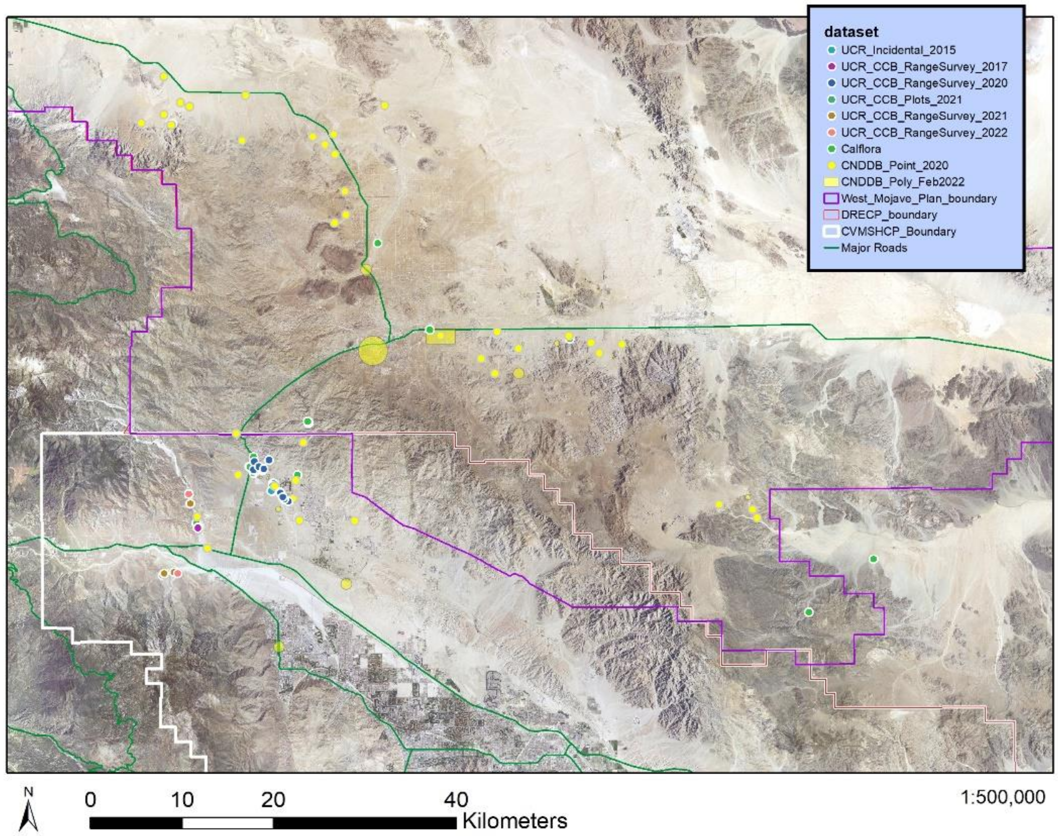


Figure 2. Distribution of Linanthus maculatus ssp. maculatus georeferenced records from UCR Surveys and available in Calflora and CNDDB, June 2022.

Although we found a negative correlation between abundance in the two species, we could not prove or disprove causality in whether *Schismus* may be impacting Linanthus. To further rule out microhabitat differences, we looked at the sampled mean particle size in the habitats dominated by each respective species. The sample particle ranges overlapped with similar means, so there was 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 and threats to this species, and it is reassuring that we have continued to find occurrences in known and new places in recent years within the Plan area. We continue to believe that some fine sheet flow may be necessary for species germination and persistence, although more work is needed to document the specific microhydrologic regime required since our study in 2021 was not successful in detecting overland water flow. 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 human foot traffic and OHV use; neither have been objectively quantified, however. 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 rockiness/ruggedness that is characteristic of Linanthus habitat also makes it particularly susceptible to foot traffic and OHV operators, as these are the same conditions that make a path of least resistance for off-trail travel. Therefore, there is an important question about whether this species is just coincident in space with disturbance, or there is a causal relationship that benefits the species. Even if so, there is certainly a threshold level of intensity of disturbance that would cause the decline of the species, and this is unknown. In recent years, fencing installed along some urban interfaces has reduced this traffic in some locations, but we have been unable to do a controlled observational study comparing protected vs. unprotected areas due to the highly variable interannual abundance of Linanthus.

Finally, most aspects of this species' biology, including mode of pollination, dispersal, germination requirements, and seed longevity, remain unknown (Patterson 1989). In 2020, we did photograph a putative pollinator, tentatively identified to the family Anthomyiidae (flower flies or root maggot flies; see UCR CCB Report 2020), however we were not able to definitively identify the insect or study its activity in depth. Most of these aspects of life history would require intensive effort to study, as the species' stature is so minute, and the plants are so ephemeral on the landscape. However, the most pressing question for this species, as with many others, is to understand the impacts of the current drought period, as well as climate change on the species.

1.1 Objectives

Research on Linanthus was carried out as part of research and monitoring for the CVMSHCP by the UC Riverside Center for Conservation Biology (CCB). Over-arching goals for species study include monitoring the current abundance and distribution for Linanthus populations, documenting habitat attributes and identifying 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. The objective of this year's study was to perform new habitat modeling for the species to better understand its geographic niche and use this information in concert with surveys to set up a more informative monitoring network to monitor population trends and threats to Linanthus.

2 Methods

2.1 Habitat Model

We assembled a revised list of localities from Calflora online, the California Natural Diversity Database (CNDDB), and locality information from recent UCR surveys not yet publicly available. We used all geolocated records with precision less than 2/5 mile (CNDDB), "High" accuracy (see Calflora data dictionary, 2022) and all UCR CCB records with accuracy within 20m. These data were also used as the basis for surveys. The climate and geographic predictor dataset was developed by UCR CCB, and the variables used (Appendix A) reflect available water, soil texture, precipitation, temperature and topography, all predicted to affect the suitability of habitat for this species. Variables were spatially downscaled or resampled from source data to 150m.

The habitat model was run in Maxent (version 3.4.1; Phillips et al. 2006) using default settings. The resulting model used 81 presence records for training, and the variable contribution was assessed via jacknife and by random permutation (see (difference in the model AUC when the variable is randomly changed; see Phillips et al. 2006 for explanation)). The two highest variables contributing to the model were selected for survey plot stratification. We used the following variables: available water; soil texture (percent for each of: clay, sand, and silt);

average monthly summer and winter precipitation; average winter minimum and summer maximum temperature; and terrain slope and ruggedness (see Appendix A for variable definitions).

2.2 Surveys

The preliminary long-term study plot selection was designed to distribute plots across a wider range of abiotic conditions than the former plot network. Extracting winter precipitation and average summer temperature from the abiotic and climate database (see Appendix A), plots were selected that spanned these gradients. The plot selection was non-random, and also considered were contemporary history of presence, coverage of geographic range-edge localities (spatial span), property ownership, and accessibility for monitoring.

We surveyed for Linanthus presence across this stratified selection of plots within the CVMSHCP area, from biological database locality information, as described above, performing a search within the vicinity of points by two individuals for at least 30 minutes per site. We visited sites in the Long Canyon, Mission Creek, Dry Morongo, Snow Creek and Whitewater River drainages. We also sought to confirm persistence for the species in several other locations, following up from the range-wide surveys in recent years, 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 submitted to CVCC and CNDDB.

3 Results

3.1 Habitat and Threats

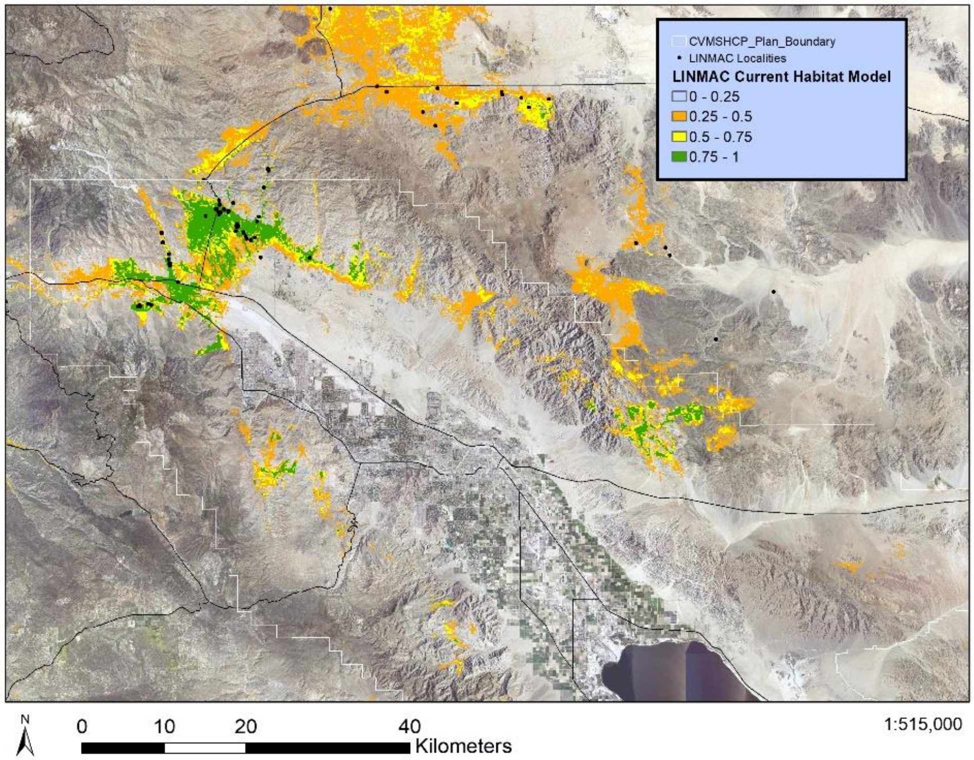
In all cases, Linanthus occurred in open, course-sandy microhabitats, generally beyond the dripline of large shrubs, threats noted included off-highway vehicle use, habitat conversion, silt deposition/sediment movement due to flooding, and invasive species. Off-highway vehicle use was noted near several localities in Desert Hot Springs and Snow Creek, although we did not observe vehicle tracks directly impacting occurrences. Invasive annual grasses were at low levels this year, and as in past years, and we did not detect the presence of a new local invasive threat, *Oncosiphon pilulifer* (stinknet) at the plots surveyed. Several older localities appeared to be either graded or transformed such that they would not support the species, including an older record just north of I-10 at the base of Whitewater Canyon (gravel extraction) and a record on CVCC land west of Little Morongo Rd, south of Mission Lakes that appeared to be either burned or graded in past years. Several sites continue to support Linanthus only where very fine gravel/sand is at least several inches deep and the site is not covered by recent deposition of silt. This includes several areas that have been flooded in the past 20 years within the Dry Morongo Drainage, as well as the Long Canyon locality. Often, however, silt covered a site in a heterogeneous manner, leaving some habitat intact either on a higher bench, or where a natural feature blocked the silt deposition. In all cases, anywhere that has been compacted, heavily vegetated, eroded or been subject to deposition of either medium gravel or fine silt was lacking the species.

3.2 EXTENT MAPPING AND PRESENCE/ABSENCE SURVEYS

Linanthus was detected at 12 out of 19 sites that we visited. Despite the dry year, no new extirpations were recorded and all presences that were confirmed this year were recorded to support the species recently, except one new location. The previously unrecorded locality/EO was found on the east side of Snow Creek on CVCC land, just beyond the occurrence found last year on BLM land to the west. This area was originally explored due to the similarity, on aerial imagery, with occupied areas. This area is characterized by the type of braided bajada washes that supports this species elsewhere, and the perennial vegetation contains the oft-co-occurring shrub *Psorothamnus arborescens*. However, on this east side of the bajada, stabilized benches predominate with deeply incised, rocky channels, and gentle, sandy flats are scarcer. This occurrence was located at the edge of a larger wash, opposite the base of the opposing hillside. Here and within the surrounding area, there are larger deposits of sand than seen elsewhere in Linanthus habitat.

3.3 HABITAT MODEL

The habitat model created in Maxent using 81 presence records and 10079 background points had an AUC from the training data of 0.97 (scale: a random prediction would score 0.5, and 1.0 is a perfect prediction) (Fig. 3). Assessing the importance of each variable using permutation can provide insight into how important each variable is to the model's predictive gain; but this needs to be interpreted with caution when variables are correlated. The top predictors as assessed using this method were maximum summer temperature (26%), winter annual precipitation (20%) and slope (31%), and the contribution of these to the final model used to predict habitat suitability were 29%, 24% and 10%, respectively. The model was used to project future suitable habitat at end of century, showing strong reductions in suitable habitat within the Plan area, spreading westward, and up in elevation, with increasing suitability in Joshua Tree National Park. Many of these areas are far from known current species localities.



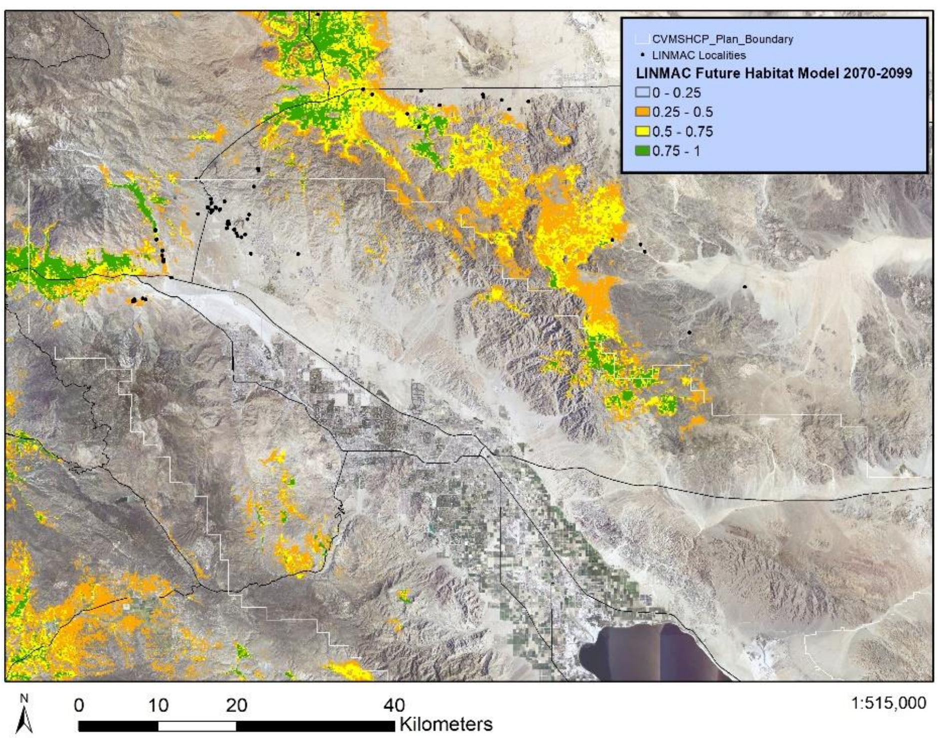


Figure 3. Habitat models created using Maxent for Linanthus, showing current habitat suitability and future suitability in the Plan area. Modeled habitat suitability increases from a value of 0 to 1, and suitability is shown for the current time (upper) and end-of-century (lower). Current locality data (training data) for the model is shown.

4 Discussion & Recommendations

4.1 Proposed Monitoring Network

From our habitat suitability modeling and field surveys, we propose a new monitoring network to measure responses of this species to abiotic factors known to influence occurrence. Of these plots surveyed, we propose a subset of plots that were shown in the field to be appropriate for annual monitoring and those that may persist as a suite of presence/absence survey locations in the future. Figure 4 shows the distribution of all database points for the species, as well as the older plot network, and the proposed plot network (survey plots) along two climate axes.

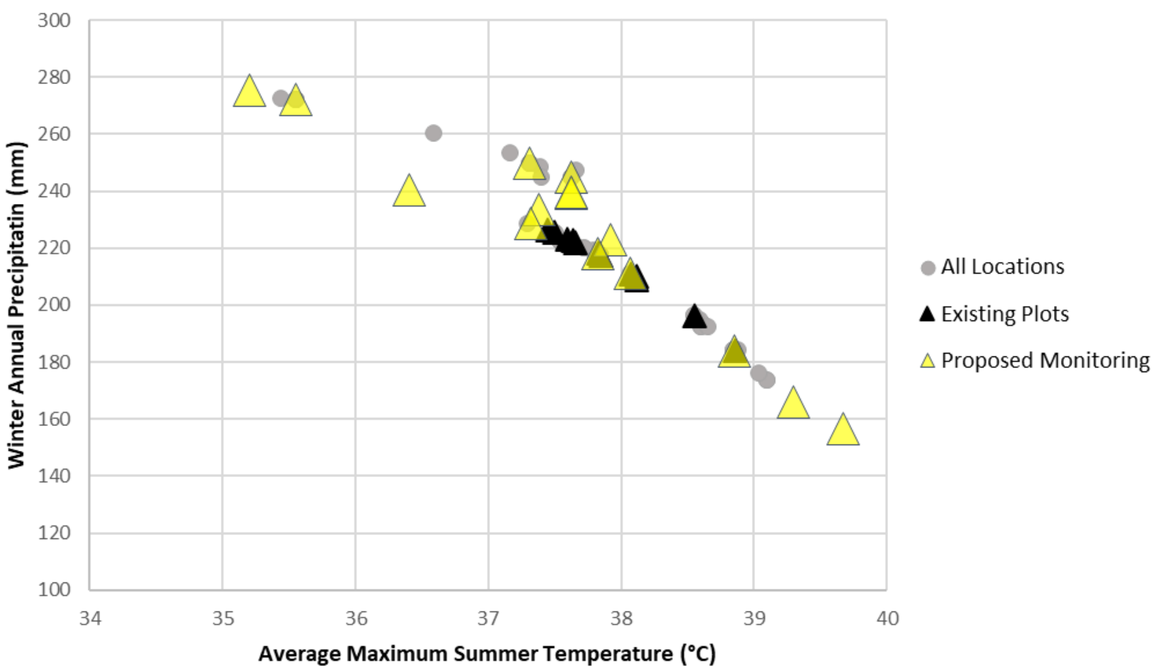


Figure 4. The distribution of all existing localities with respect to climate variables. Shown are the full locality database considered for the Plan Area (gray dots), the original monitoring plots based on known localities at the time (black triangles), and the proposed plot network (yellow triangles).

These plots also fall along a geographic span covering the range limits of the species within the CVMSHCP (Fig. 5). Proposed plots are non-randomly selected to span relevant climatological gradients, with considerations for access, and viability for the type of monitoring proposed. These are divided into intensive-study frequency plots, and presence/absence plots. Frequency plots are those proposed for nested frequency-frame monitoring (hereafter, frequency), similar to that used for long-term monitoring in Joshua Tree National Park (LaDoux, personal communication). This method is based on the frequency of presence in sample plots, and it is often used as a metric for commonness in the landscape in an efficient manner and is useful where richness and spatial abundance is more of interest than cover (Elzinga *et al.* 1998). Since Linanthus is diminutive, often showing <1% cover in frames, this method is more precise than cover estimates by observers at that scale, and more informative than total density counts, as the plants may be highly clumped within a classic 1x1m plot frame. The methodology is also highly repeatable and accurate in its simplicity. These frequency plots were selected for this more intensive study based on their conservation and land ownership, and year-to-year consistency in species presence.

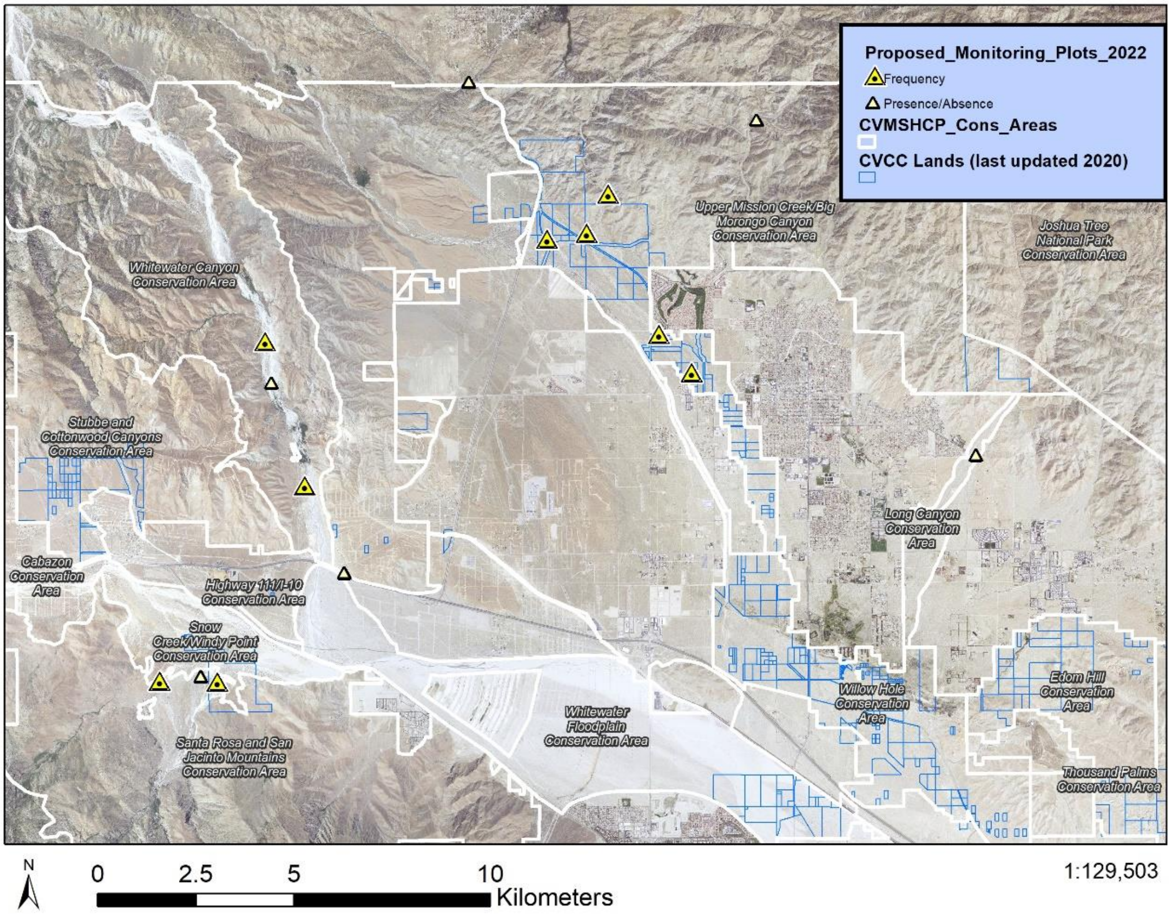


Figure 5. Proposed monitoring network containing 15 plots (9 in-depth frequency plots and 6 presence/absence localities) for Linanthus maculatus in the CVMHSCP Plan Area at the northwest end of the Coachella Valley, California.

Presence/absence plots are proposed here where there is limited access, or extirpation is suspected, but any occurrence at the site is important for regional conservation. For example, there are recent records at Long Canyon near the new Long Canyon Trail trailhead, but we were unable to locate the species this year. If present, this would be the easternmost occurrence of the species, and highly relevant to understanding of the species range. Similarly, the plot located at the top of Dry Morongo Canyon would be relevant to gene flow and population spread as a connection between the southern range in the Plan area and the northern extent of the range in San Bernardino County. At these plots, botanical searches would be proposed, following CDFW and CNPS guidelines for botanical surveys at the sites (CDFW 2015; Witham 2001). Observations of threats and other conservation-relevant information are recommended to be collected in both survey types to inform occurrence data for the CNDDB.

We recommend that the proposed monitoring should occur in years where Linanthus is detectable, and reference plots should be checked by a trained observer familiar with early-season morphology starting in late February in order to time surveys, which may be carried out from early March to early April, depending on the year. While we now know enough about the species' phenology and distribution to find plants even in dry years, surveys will not be informative if most sites have zero abundance, so it's recommended that the species surveys be carried out where there are likely to be enough plants to justify efforts. That said, the network may be flexible so that limited presence/absence surveys are done during dry years, to help understand precipitation thresholds for germination. As well, ongoing threats include OHV disturbance, invasive species competition and other factors may still warrant monitoring on a frequent basis. Thus, a flexible monitoring program is recommended to adapt to this, as seasons of adequate abundance may not be apparent prior to January or February of a given year, which may be late to plan a field campaign.

Overall, we propose a new framework with a wider distribution, including sites in the west end of the Coachella Valley, to overcome some of the challenges of studying this species, including 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 abundance. We hope that the new network will allow isolation of some factors involved in controlling species abundance, whether they are climatological, hydrological or otherwise. This method will also allow us to continue to monitor threats to the species including the abundance of co-occurring species including invasive plants.

Revisiting these plots and suitable microhabitats will allow researchers 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 the most effective for ongoing conservation of the species.

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APPENDIX IX: 2022 WESTERN YELLOW BAT REPORT

Report begins on following page.

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Surveys for Western Yellow Bat in the Coachella Valley

2022 Annual Report

February 8, 2023

Prepared For:

Coachella Valley Conservation Commission
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Cover Photograph: Western Yellow Bat captured at Thousand Palms Oasis. Photo taken May 16, 2022 by Kevin Clark.

Recommended citation:

Stokes, D., M. Combs, and K.B. Clark. 2023. Surveys for Western Yellow Bat in the Coachella Valley. 2022 Annual Report. February 8, 2023.

Introduction

In 2021 and 2022, the San Diego Natural History Museum (SDNHM) conducted surveys for the western yellow bat (*Lasiurus* (*Dasypterus*) *xanthinus*) in the Coachella Valley. Western yellow bats have been split from the southern yellow bat (*L. ega*) and are the only yellow bat species currently known to occur in California. The western yellow bat is a California Species of Special Concern and is strongly associated with the native California fan palm (*Washingtonia fillifera*, Figure 1), found abundantly in the Coachella Valley, and may depend on it for roosting (Stokes 2017). The Coachella Valley Multiple Species Habitat Conservation Plan (CVMSHCP) has identified the western yellow bat as a target for conservation and management. Western yellow bats were documented roosting in 33 of 41 palm groves surveyed in the Colorado Desert area by Ortiz and Barrows in 2012 (Ortiz and Barrows 2014). Our goal is to resurvey the 35 palm grove sites visited by Ortiz and Barrows located within the Coachella Valley, and assess the current population status of the western yellow bat by visual, acoustic, and capture techniques. At each palm grove we will also measure habitat features recorded by Ortiz and Barrows, including presence of open water, size of open water present, number of palm trees in the groves, levels of palm tree skirts available for roosting, and levels of disturbance such as recent fire, vandalism, and trash, and distance to other palm groves. This will allow for adaptive management based on monitoring of western yellow bat population trends concurrent with potential changes in measured habitat features.

Figure 1. Fan palm (*Washingtonia filifera*) grove at Deep Canyon.

Use of passive Anabat bat detectors allowed for nightly monitoring of western yellow bats, including the quantification and standardization of their activity levels that can be compared between palm groves and establishes baseline activity levels in the CVMSHCP for future monitoring and adaptive management. In addition to detection of western yellow bats, the entire community of bats in the palm groves were assessed based on anabat recordings. We recommended the use of mist-netting to capture western yellow bats so that the population demographics of the palm groves can be assessed. In 2011 and 2012, the San Diego Natural History Museum captured 24 western yellow bats in mist nets in Palm Canyon (south of Hermit's Bench) during the Grinnell resurvey of the San Jacinto Mountains; all but one were males, and the single female was non-reproductive. This suggests sexual segregation and roost selection is occurring among palm groves and this can only be documented by mist net capture. The presence of juvenile western yellow bats and verification of recruitment is also only possible by mist net capture. It is likely that breeding females are selecting for prime habitat conditions while males and non-reproductive females are likely using less favorable and perhaps marginal quality habitats. Documentation of the palm groves supporting breeding female western yellow bats and where recruitment of juveniles is occurring should be a high management and conservation priority for the CVMSHCP.

We proposed to survey the 35 palm groves over the course of the summer months May through September (over a two-year period) using the full complement of bat survey techniques outlined above to achieve the following clear objectives:

1. Document the presence of western yellow bats and inventory the entire community of bats in the 35 palm groves (assuming access).

2. Quantify western yellow bat (and other bat species) bat activity levels among the palm groves based on anabat bat detector recordings obtained on 3 consecutive, full nights of monitoring at each grove using passive anabat bat detectors.

3. Visually and acoustically verify western yellow bats as they exit from palm skirts in the groves providing a comparison of the results of the Ortiz and Barrows study.

4. Document the presence of breeding females and successfully recruited juveniles and identify the select palm groves in which they are occurring within the CVMSHCP. Knowledge of these select palm groves will be important to management and conservation of western yellow bats in the Coachella Valley.

5. Resample the landscape and vegetation metrics documented by Ortiz and Barrows to compare habitat selection models with the 2012 study.

Methods

All methods adhere to accepted standards of the American Society of Mammalogists. Multiple bat survey techniques were utilized to thoroughly document the presence of western yellow bats in addition to a diversity of bat species in the palm groves within the CVMSHCP. Research techniques include use of visual and active acoustic surveys, passive acoustic surveys, and mist netting as outlined below.

Passive acoustic surveys

Anabat 'express' electronic bat detectors were used to passively record bat echolocation calls in the palm groves. The passive anabats were set to begin recording at sunset and end recording at sunrise. From 2-6 passive detectors were used in each of the surveyed palm groves depending on the size of the grove. Larger groves required use of more detectors than smaller groves. The detectors were set up to record for a minimum of 3 consecutive nights per palm grove. The recorded calls were downloaded and identified to the species level when possible. Activity levels of western yellow bats and all identifiable bat species were quantified and standardized using number of batcall files per anabat per night. This allows for comparisons of western yellow bat activity levels between the various palm groves. This will also establish a baseline of western yellow bat activity levels at individual palm groves and in the CVMSHCP as a whole that can be used to observe future trends concurrent with monitoring of habitat quality and important ecological processes during long term monitoring for the purposes of adaptive management as outlined in the final Coachella Valley MSHCP, September 2007.

Mist netting

Mist nets were placed over suitable water sources and in vegetation flyways **(**e.g. among palm trees) to intercept and capture bats, including western yellow bats. Depending on available net sites, from 1-6 mist nets were placed in suitable locations and monitored continuously for 2-5 hours after sunset (Table 1). All captured bats were identified, measured, and photographed. The age class, gender, and reproductive condition was assessed and documented as well as the overall health and parasite load of captured bats. Any captured western yellow bats were recorded with an anabat bat detector upon hand release and the recorded file was placed into a western yellow bat reference call library.

Table 1. Mist netting sessions.

Date	Location	Start Time	Stop Time	Weather	Captures
May 2, 2022	Deep Canyon	1845	2245	Start: clear, s. wind 10 mph, 85°; end: clear, w. breeze 5-10 mph, 75°	None
May 3, 2022	Pushawalla Palms	1930	2230	Start: clear, w. breeze 5-10 mph, 85°; end: clear, w. breeze 5-10 mph, 75°	2 PAHE, 1 MYCA
May 4, 2022	Lakeshore Palms	1930	2310	Start: clear, w. breeze 5-10 mph, 85°; end: clear, w. breeze 5-10 mph, 75°	None

May 16, 2022	Thousand Palms	2000	2225	Start: clear, w. wind 5-10 mph, 99°; end: clear, n. wind 5-10 mph, 80°	1 LAXA, 1 PAHE
May 17, 2022	McCallum Palms	1940	2315	Start: clear, w. wind 5-10 mph, 95°; end: clear, w. wind 5-10 mph, 78°	None
June 27, 2022	Deep Canyon	1945	0040	Start: clear, w. wind 0-5 mph, 95°; end: clear, w. wind 0-5 mph, 85°	26 PAHE
June 28, 2022	Biskra Palms	1945	2240	Start: clear, w. wind 0-5 mph, 111°; end: clear, w. wind 0-5 mph, 99°	None
July 19, 2022	Thousand Palms	1945	2220	Start: clear, w. wind 10-15 mph, 95°; end: clear, w. wind 10-15 mph, 90°	None
July 20, 2022	McCallum Palms	1945	2315	Start: clear, w. wind 5-10 mph, 95°; end: clear, w. wind 5-10 mph, 90°	3 PAHE
October 11, 2022	Whitewater Delta	1900	2230	Start: clear, w. wind 5-10 mph, 85°; end: clear, w. wind 5-10 mph, 75°	None

Abbreviations: PAHE=*Parastrellus hesperus* (canyon bat); MYCA=*Myotis californicus* (California myotis); LAXA=*Lasiurus xanthinus* (western yellow bat);

Results

Species Assemblage

A total of fourteen bat species were recorded by anabat (Table 2). Bat species recorded ranged from as few as two species at sites such as Art Smith Trail I and McCallum Palms, to 11 species detected at Whitewater Delta, Lakeshore Palms, and Hidden Palms. Sites with higher bat diversity tended to also support more vegetation structure and habitat diversity while also supporting standing water.

Table 2. Anabat results.

Location	Canyon bat	California myotis	Western yellow bat^	Mexican free-tailed bat	Pocketed free-tailed bat^	Big brown bat	Yuma myotis	Myotis spp (40K)*	Pallid bat^	Western mastiff bat^	Townsend's big-eared bat^	Big free-tailed bat^	Hoary bat	Spotted bat^	*Total batcalls*	*Species*
Dead Indian Canyon Palms (April 2022)	839	735	259	49	22			45	7		12		5		1973	9
Ranch House Palms (June 2021)	1051	315	164	241	50		37		1	1	2		7		1869	10
Deep Canyon Golf Course Boundary (July 2022)	1393	37	37	76	35	6			5	7	4				1600	9
Whitewater Delta I (August 2021)	348	14	310	354	17	356	40		5	3	1			1	1449	11
Hunter Palms (July 2021)	832	300	47	96	10				6						1291	6
Living Desert (July 2022)	169	951	8	7	9	11					13				1168	7
Painted Canyon (October 2022)	106		17	438	472		34			22		58	11	1	1159	9
McCallum Palms (September 2021)	277	626	122	8	3	12	31		5	1	1				1086	10
Lakeshore Palms (August 2021)	247	146	474	43	29	2		48	75	1	13			1	1079	11
Deep Canyon Swimming Pool	957	7	10	9				2	22	3					1010	7
Whitewater Delta II (August 2021)	144	10	61	54	3	369	330		4		2				977	9
Dos Palmas (USFS) (April 2022)	186	49	6			6	111	579			3		2		942	8

Greenhill Palms (June 2021)	218	127	20	432	42		10		10						859	7
Deep Canyon Palms (May 2022)	236	15	459	30	2			4	16		1		2		765	9
Folgers Palms (June 2021)	447	122	58	13	5		14		11	4	1				675	9
San Andreas Palms (June 2021)	174	81	98	285	6		1		6				5		656	8
Vargas Palms (July 2021)	209	347		6		53		15			13				643	6
Cox Palms (July 2021)	79	391	12	52	2				3						539	6
Hidden Palms Mecca I (October 2021)	230	79	45	62	41		32		1	28		1			519	9
Deep Canyon pupfish pond (October 2021)	223	73	1	33	3		22		6			2	1		364	9
Art Smith Trail I (August 2022)	167	131	13	11	1	7		24	2		2				358	9
Deep Canyon Mouth (June 2022)	297	7	2	4					13						323	5
Pushawalla Palms (April 2022)	67	141	82	1			15		1						307	6
Macomber Palms (March 2022)	35	220	33												288	3
Dead Indian Canyon Palms (September 2022)	89	18	64	85	10				2		4		7	2	281	9

Thousand Palms (Sep 2021*2 nights only)	73	75	86	3	2		5						2		246	4
Lakeshore Palms (October 2022)	16	68	83	20	15		13	5	2	5	4		1		232	9
Hidden Palms Mecca II (June 2022)	118	58	25	2	12										215	5
Hidden Palms Indio II (September 2022)	84	26	89	2									4	6	211	11
Thousand Palms (June 2022)	12	130	36						3						181	4
Whitewater Delta I (November 2021)	7	10	6	71	16		16						4		130	7
McCallum Palms (June 2022)	123	1													124	2
Willis Palms (November 2021)	2	1	114	4	1										122	5
Deep Canyon Mouth (August 2022)	76	3	5	28	2			1	1	4	1				121	9
Art Smith Trail I (January 2022)	57	20		7	1		35								120	5
Biskra Palms (March 2022)	9	9	62												80	3
Willis Palms (August 2021)	68	6	2	1											77	6
Hidden Palms Indio I (July 2021)	38	11	3	1											53	4
Bogert Trail Palms (September 2021)	22	9	5	2	2		8		1				1		50	4

Macomber Palms (December 2022)	17		17	4	8										46	4
Biskra Palms (December 2022)	10		28	2	4										44	4
Willow Hole Palms (July 2021)	16	2	1	4	1				1						25	6
Indian Palms (July 2021)	18	4		1											23	3
Bogert Trail Palms (June 2022)	12		3	1	1				1						18	5
Pushawalla Palms (December 2022)	8	3	4												15	3
Art Smith Trail IIA (January 2022)	5	1	4												10	3
Art Smith Trail IIB (January 2022)	9		1												10	2
Willow Hole Palms (November 2021)	1				1		1								3	3
	9821	5379	2976	2542	828	822	755	723	210	79	77	61	52	2	24336	13

Species Abundance

Although we were not truly measuring bat abundance based on use of bat detectors and mist netting without mark and recapture, we can make inferences about the bats that were most common in the Coachella Valley study area. As measured by number of recorded bat calls and mist net captures, the canyon bat was the most commonly detected and captured species followed by the California myotis and western yellow bat. The former two species are ubiquitous in desert environments and it was surprising to see that the western yellow bat is also very common (i.e. active and widespread) throughout the area.

The pocketed free-tailed bat (*Nyctinomops femorosaccus*) was also found to be quite active and widespread in the study area, a cliff-roosting species whose life history is not well known in southern California based on published literature.

The rarest bats in the study area included the cliff-roosting big free-tailed bat (*Nyctinomops macrotis*), hoary bat (*Lasiurus (Aeorestes) cinereus*), and spotted bat (*Euderma maculatum*). The former two species are migratory and not expected year-round in the study area, the spotted bat has always been considered an extremely rare species throughout its range (Hoffmeister 1986).

Other significant species detections included the Townsend's big-eared bat (*Corynorhinus townsendii*), pallid bat (*Antrozous pallidus*), and western mastiff bat (*Eumops perotis*) all of which are California species of special concern and are regional and local conservation priorities.

The most notable species missed during our surveys was the California leaf-nosed bat (*Macrotus californicus*). This rare cave-roosting species is very difficult to detect acoustically and is most easily found by searching for cave roosts, a technique we did not employ.

Mist netting

A total of 34 bats were captured during the mist netting sessions, including one western yellow bat (Figure 2), 32 canyon bats (Figure 3), and one California myotis. High wind conditions limited captures during most sessions. Mist netting will be continued in spring and early summer 2023 to attempt to add to the western yellow bat capture numbers.

Figure 2. Western Yellow Bat captured at Thousand Palms Oasis. Photo taken May 16, 2022 by Kevin Clark.

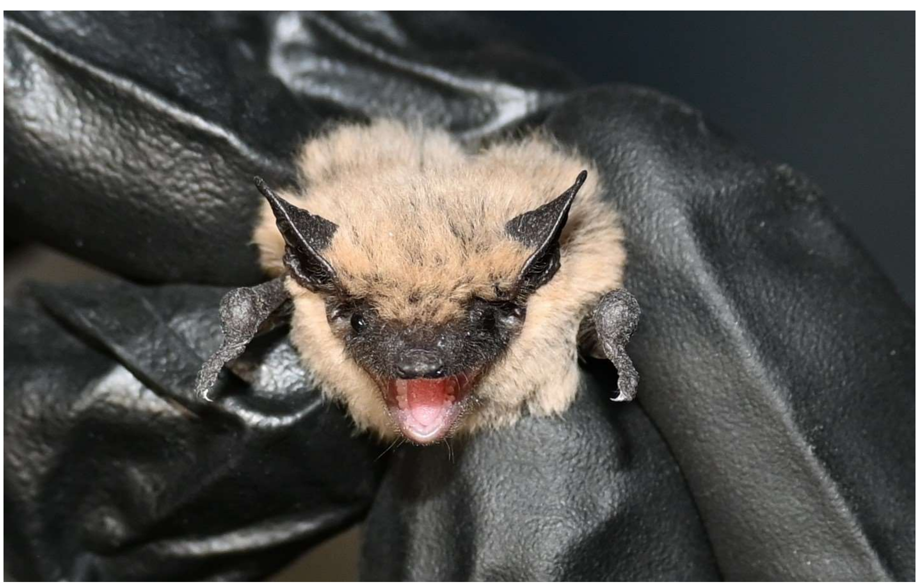

Figure 3. Canyon Bat (*Parastrellus hesperus*) captured at Thousand Palms Oasis. Photo taken May 16, 2022 by Kevin Clark.

Discussion and Recommendations

To be included in final report.

Literature Cited

Hoffmeister, D.F. 1986. Mammals of Arizona. University of Arizona Press.

Ortiz, D. D. and C. W. Barrows. 2014. Occupancy patterns of western yellow bats (*Lasiurus xanthinus*) in palm oases in the lower Colorado Desert. The Southwestern Naturalist, 59(3):381-388.

Stokes, D. 2017. Western yellow Bat, *Lasiurus xanthinus*. In Tremor, S., D. Stokes, W. Spencer, J. Diffendorfer, H. Thomas, S. Chivers, and P. Unitt, editors. San Diego County Mammal Atlas. Proceedings of the San Diego Society of Natural History 46.

APPENDIX X: PROPOSITION 1 - NORTH SHORE RANCH GRANT COMPLETION REPORT

Report begins on following page.

Proposition 1 Grant Completion Report: Wetlands Restoration: Tamarisk Control and Rail Habitat Enhancement at North Shore Ranch

Submitted by

Coachella Valley Conservation Commission

73710 Fred Waring Drive, Suite 200

Palm Desert, CA 92260

Submitted to:

Coachella Valley Mountains Conservancy
73710 Fred Waring Drive, Suite 112
Palm Desert, CA 92260

October 2022

EXECUTIVE SUMMARY

Beginning in September 2019, the Coachella Valley Conservation Commission (CVCC) received Proposition 1 funding from the Coachella Valley Mountains Conservancy (CVMC) with the purpose of restoring wetland habitat suitable for the endangered California Black Rail and the Yuma Clapper Rail listed under the Coachella Valley Multiple Species Habitat Conservation Plan (CVMSHCP). This was located at the North Shore Ranch property in the Coachella Valley Stormwater Channel and Delta Conservation Area. Restoring native wetland habitat included the removal of the non-native, invasive tamarisk vegetation as well as identifying the appropriate strategy for feasibly reintroducing the ephemeral wetlands of the Salton Sea region. The following deliverables were listed in the original application and more detail on their status will be provided in this report.

Deliverables

1. Progress reports documenting the removal of tamarisk and status of restoration plan.
2. Draft Restoration Plan.
3. Final restoration plan and final report

This initial phase provided CVCC the opportunity to develop a draft and final restoration plan. CVCC contracted two environmental consulting firms (Wood Environmental and GPA) to develop a feasibility study and restoration plan respectively. These plans identified challenges, opportunities, resources, and alternatives associated to complete our intended goals and objectives. Throughout this process, issues were identified regarding lack of access to surface water drains, discharging requirements, and groundwater usage. Understanding these complications meant CVCC had to shift design to accommodate environmental permitting requirements while still accommodating our species of interest.

Riparian vegetation enhancement of the area consisted of removing 8 acres of mature tamarisk along the edge of the ponds to help eliminate competition of native vegetation. The CVCC also planted native honey mesquite along the southern boundary of the pond to establish a viable seed source for new species recruitment.

At the end of this project, CVCC identified several challenges impacting the feasibility of the project. Low dissolved oxygen and high temperatures would result in algal blooms and species die-offs. To meet our dissolved oxygen and temperature goals within the wetlands, we would need consistent inflow and outflow to create the turnover needed to maintain a healthy ecosystem. The required inflow could be met by utilizing the groundwater source located on the site, however, these costs ($15,000/year) are not sustainable and there are concerns about long-term groundwater use given the current water shortages impacting the region. The required outflow of the wetland system would be about 7.29 acre-feet per year. The Coachella Valley Water District (CVWD) will not permit any new surface discharges into their drainages. CVWD would allow for tile drains to be used but this type of drainage system would not allow for our target oxygen and temperature goals. CVCC also explored the possibility of discharging onto a CVCC-owned parcel just south of the project site, however, this provides added complications given the in-lieu fee program that exists within the area. This program restricts use of those properties until it is determined that they are not needed for overall wetlands restoration under the U.S. Army Corps of Engineers credit system.

REPORTS AND/OR PRODUCTS

TASK	PROPOSED	COMPLETED
1	Document extent of invasive species, existing water levels, photograph conditions.	CVCC staff documented conditions at the site, and CVCC provided a report by Wood Environmental for the analysis of current water levels and in the February 2020 report. The analysis identified Pond 5 as the pond that would provide the best opportunity to enhance habitat for both Yuma Ridgeway's Rail and Black Rail.
2a	Establish contracts with tamarisk removal crew and a licensed applicator.	Contracts were established with Southern California Mountains Foundation in November 2019 for tamarisk removal in December 2019 and January 2020. A separate contract was established in February 2021 for tamarisk removal in early February 2021.
2b	Establish contract with a restoration plan consultant.	Contract was established with GPA consulting after RFP process was completed. Consultant has completed all deliverables by contract end period.
3a	Ongoing tamarisk removal.	Approximately 8 acres of tamarisk hedgerow on the western edge of Pond 1-4 as well the southern edge of Ponds 4 and 5 and southern and eastern sides of the Nesting Pond were removed by the UCC team and State Licensed Applicator between December 2019 and January 2020, and in February 2021 using the cut and treat method of removal. Trees were targeted closest to or on the berms as they had the highest likelihood of sending roots out into the ponds to sprout.
4a	Complete restoration plan.	A contract was established with GPA Consulting in January 2021 to provide a Draft Restoration Plan for Pond 5 including cost and feasibility analysis and determination on permitting requirements. The draft report was sent to CVMC in August 2021. CVCC distributed the report to North Shore Ranch and the Wildlife Agencies in September 2021 and again in May of 2022. No comments were received, and the plan was finalized in June of 2022.
4b	Pilot experimental restoration study	Selenium and Arsenic tests were taken of the groundwater well out of request. Both tests came back underneath their respective reporting limits.
5a	Install drop structures, pipeline from well to refuge pond.	Upgrades have been made to the drop structures on Pond 5. CVCC was notified in 2021 that the surface runoff coming from North Shore Ranch into the Johnson St drain and .5 drain would no longer be permitted by CVWD. CVCC then worked with North Shore Ranch to reduce runoff, better retain water on the property, eliminate surface runoff into the drains, and upgrade the tile drain system. The Restoration Plan calls for weir structures and drainage pipes to be upgraded and for a retention pond to be developed on the property to the south of Ponds 4 and 5 which CVCC owns. The process for the installation of this drainage pipe is still pending the ILF grading plans for the adjacent property to where the retention plan is proposed.
5b	Upgrade levees on some ponds.	Levees on Pond 5 and on the retention ponds to the south have been upgraded and recontoured.
6	Complete mesquite planting and watering.	On May 20th, 2022, seven mesquite trees (*Prosopis glandulosa v. torreyana*) were planted along the edges of Pond 5 using native soil.
7	Complete data analysis and report results to CVMC.	A complete restoration plan and feasibility study were submitted to CVMC at the end of the grant agreement. Challenges and opportunities were identified within both plans using data collected from the site.

COST AND DISPOSITION OF FUNDS INFORMATION

BUDGET CATEGORY	Project Budget	Year 1 – 1st Disb. Invoice # CVCC 20009-20	Year 2 – 2nd Disb. Invoice # CVCC 22006-21	Year 3 – 3rd Disb. Invoice # CVCC 23001-22	Year 3 – 4th Disb. Invoice # CVCC 23004-22	Grant Balance
Task 1 - Document invasive species, water levels (CVCC)	$0	$0	$0	$0	$0	$0
Task 2 - Establish contracts (CVCC)	$0	$0	$0	$0	$0	$0
Task 3 - Implement tamarisk removal	$0	$0	$0	$0	$0	$0
Task 3a - Restoration - tamarisk removal (400 hrs)	$42,000	$0	$6,465.00	$3,765.00	$6,157.50	$25,612.50
Task 3b - Conservation Corps Crew Rate -tamarisk removal	$47,824	$36,422.58	$10,500.64	$0	$0	$900.78
Task 3b - CA Licensed Applicator (160 hours @ $50/hour)	$8,000	$4,810.00	$2,080.00	$0	$0	$1,110.00
Task 4 - Develop restoration plan and Pilot Study	$85,000	$0	$53,665.13	$4,493.01	$0	$26,841.86
Task 5 - Upgrade water infrastructure (820 hrs)	$86,100	$0	$0	$2,762.66	$0	$83,337.34
Task 6 - Complete mesquite planting/watering (350 hrs)	$24,500	$0	$0	$537.80	$0	$ 23,962.20
Task 7 - Complete data analysis and final report (CVCC)	$0	$0	$0	$0	$0	$0
Contractor Services, Subtotal	***$293,424***	***$41,232.58***	***$72,710.77***	***$11,558.47***	***$6,157.50***	***$ 161,764.68***
Equipment						
Task 3 - Herbicide	$1,050	$659.33	$0	$0	$0	$ 390.67
Task 3 - Field supplies (loppers, shovels, prybars)	$1,500	$0	$0	$0	$0	$0
Operating and Equipment, Subtotal	$2,550	$0	$0	$0	$0	$2,159.33
TOTAL FUNDS REQUESTED	**$295,974**	***$41,891.91***	***$72,710.77***	***$11,558.47***	***$6,157.50***	***$163,924.01***

ADDITIONAL INFORMATION

Planned Schedule	Start Date	Completion Date
Document extent of invasive species and existing water levels and photograph conditions	July 2019	October 2019
Implement tamarisk removal	October 2019	February 2020
Develop restoration plan	September 2019	June 2020
Pilot experimental restoration study	June 2020	April 2022
Complete data analysis and report results to CVMC.	Annual report June 2020, 2021	Final report- June 2022

Actual Schedule	Start Date	Completion Date
Document extent of invasive species and existing water levels and photograph conditions	July 2019	October 2019
Implement tamarisk removal	October 2019	June 2022
Develop restoration plan	September 2019	September 2020
Pilot experimental restoration study	April 2021	June 2022
Complete data analysis and report results to CVMC.	Annual report June 2020, 2021	Final report- October 2022

APPENDIX XI: GPA POND 5 RESTORATION PLAN

Plan begins on following page.

Restoration Plan for Pond 5 at the North Shore Ranch

Creating Habitat for Yuma Ridgway's Rail and California Black Rail

June 24, 2022

Prepared for:

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Appendix A: Memo on Permitting and Definitions of Vegetation Communities
Appendix B: Water Supply and Availability Memo
Appendix C: Pond 5 Water Supply and Drain Schematic and Design Guidance Report
Appendix D: Overview of Proposed Pond 5 Instrumentation Report
Appendix E: Cost Estimate: Pond 5 Improvements for Rail Habitat

List of Preparers

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Section 1: Introduction

This plan was developed for the Coachella Valley Conservation Commission (CVCC) to guide the implementation of a pilot marsh restoration project on their North Shore Ranch property near Mecca, California (Figure 1-1). The restoration will occur in an approximately five-acre artificial wetland known as Pond 5 (Figure 1-2). Pond 5 is one of several ponds on the property that have been managed for duck hunting for the past several decades using water from an on-site well. The overarching goal of the restoration project is to assess the feasibility of altering hydrology and vegetation in Pond 5 in order to support secretive marsh birds, especially Yuma Ridgway's rail (*Rallus obsoletus yumanensis* = YRR*)* and California black rail (*Laterallus jamaicensis coturniculus* =CBR). If the restoration efforts in Pond 5 are successful, the template used for this pond could be expanded to other ponds on the property. This plan also provides guidance on establishing desert riparian habitat adjacent to Pond 5 and stabilizing the berms around the pond with native vegetation. This plan includes:

- Project goals and objectives
- Opportunities and constraints related to permitting, implementing, and managing the pilot project
- A basis of design for the restoration project that details the habitat requirements for California Black Rail (CBR) and Yuma Ridgway's Rail (YRR) related to topography, hydrology and vegetation and an analysis of the feasibility of creating that habitat in Pond 5
- An analysis of alternative restoration designs and a preferred restoration design for Pond 5
- Identification of restoration actions that will be necessary to create the target habitat in Pond 5 as well as mesquite and desert riparian habitat adjacent to the pond
- A monitoring and adaptive management plan and long-term maintenance plan
- Guidance on permitting
- Cost estimates for implementation and management

This restoration plan was developed based on the best available science. Information was drawn from peer reviewed literature, government publications and reports, and discussions with agency experts working with the target species throughout the region. Still, there remains considerable uncertainty related to how the restoration project will function once built. As such, this plan includes important recommendations for monitoring key parts of the restoration project to inform adaptive management and assess project success. Learning from the implementation of this pilot project could support the restoration of additional habitat on site and throughout the region.

1.1 Project Background

This plan to restore habitat for YRR and CBR fits into a much larger regional conservation framework. The YRR is federally endangered and considered threatened by the State of California. It also has special status in Nevada, Arizona and Mexico. The CBR is considered of migratory nongame bird of special concern by the US Fish and Wildlife Service (USFWS) and is considered threatened by the State of California. As such, both species are targets of conservation, management, and monitoring within the Coachella Valley Multiple Species Habitat Conservation Plan (CVMSHCP), which the CVCC is tasked with implementing. Restoration of appropriate marsh habitats will aid both species' recoveries and help CVCC implement the CVMSHCP.

Figure 1-1. Vicinity map show project site and nearby reference site.

1.1.1 The Coachella Valley Conservation Commission

The CVCC is a joint powers authority responsible for implementing the CVMSHCP for Local Permittees. The Local Permittees consist of the cities of Cathedral City, Coachella, Desert Hot Springs, Indian Wells, Indio, La Quinta, Palm Desert, Palm Springs, Rancho Mirage, the County of Riverside, the Riverside County Flood Control and Water Conservation District, the Riverside County Waste Resources Management District, the Riverside County Regional Parks and Open Space District, Coachella Valley Water District, Mission Springs Water District, and Imperial Irrigation District. State permittees include Caltrans, the Coachella Valley Mountains Conservancy, and California Department of Parks and Recreation. The Coachella Valley Association of Governments (CVAG) provides administrative support and staffing for the CVCC.

1.1.2 Coachella Valley Multiple Species Habitat Conservation Plan

The CVMSHCP is a regional landscape-scale plan which provides for conservation of biological diversity and ecosystem processes to meet the requirements of federal and state endangered species laws, while allowing for balanced growth and development. The CVMSHCP provides for conservation, monitoring and management of 27 species and 27 natural communities in an area of approximately 1.1 million acres in eastern Riverside County. The CVMSHCP is authorized by permits from the state and federal wildlife agencies including the California Department of Fish and Wildlife (CDFW) and U.S. Fish and Wildlife Service (USFWS). Protecting and restoring wetlands and the species that depend on them are important elements of the CVMSHCP.

Figure 1-2. Ponds of North Shore Ranch. Graphic from Wood 2019.

Section 9.7.1 of the CVMSHCP identifies several goals and objectives related to conserving existing habitat, preserving ecological processes, and restoring new habitat for YRR[1]. YRR are found in scattered locations on the lower Colorado River and some of its tributaries and around the Salton Sea in shallowly flooded marshes dominated by cattail (*Typha* spp.) and bulrush (*Schoenoplectus* spp.). Within the CVMSHCP they are found at the Dos Palmas Preserve, which is located about eight miles east of North Shore Ranch (Figure 1-1), in similar marsh habitats. YRR are year-round residents in the region, though some birds migrate south in the winter (Harrity and Conway 2020). They build nests in dense vegetation

[1] https://cvmshcp.org/PDFs_for_Website_Feb_28/CVMSHCP%20Plan%20Section%209.0%20-%20Major%20Amendment%20revision%20-%203-2014.pdf

above flooded areas and forage for aquatic vertebrates and invertebrates. The breeding season begins in late winter and continues through the summer. The primary threats to the species are predation by native and non-native species, loss of habitat, and fires during breeding season (BLM 2016).

Section 9.7.2.1 of the CVMSHCP identifies goals and objectives related to conservation of existing habitat and ecological processes and restoration of new areas of habitat, especially in the Coachella Valley Stormwater Channel and Delta Conservation Area (CVSCDCA), for CBR. CBR, which is the smallest rail in North America, were historically found in coastal marsh habitats in central and southern California and northern Baja California. They were first found around the Salton Sea in the mid 20th century and then a few decades later on the lower Colorado River. Within the CVMSHCP, they are currently known to occur at the Dos Palmas Preserve and within the CVSCDCA, probably in fairly low numbers. CBR prefer similar habitat to YRR but seem to avoid marshes with water more than a few inches deep. They are year-round residents in Salton Sea region. Breeding season extends from late winter into mid-summer. Nests are built in dense marsh vegetation in areas flooded to about one inch deep with only very minor fluctuations in water level (Flores and Eddleman 1993). CBR feed on aquatic and terrestrial invertebrates and bulrush seed (BLM 2016). Threats to CBR include predation by native and non-native species, water level fluctuations during nesting season, and loss of habitat due to lining of canals (BLM 2016). Selenium, which can be toxic to birds in high enough concentrations is found in agricultural runoff and in some groundwater in the Salton Sink and could potentially be a threat to both species as well.

The CVMSHCP also has conservation objectives related to protecting and restoring mesquite, cottonwood and willow habitat that provides breeding areas for several target passerine species including least Bell's vireo, southwestern willow flycatcher, crissal thrasher, yellow warbler, yellow-breasted chat, and summer tanager and small mammals such as the Coachella Valley round-tailed ground squirrel. This restoration plan also includes a pilot desert riparian habitat restoration component to help achieve these goals and objectives.

1.1.3 Coachella Valley Stormwater Channel and Delta Conservation Area.

The CVSCDCA includes Coachella Valley Conservation Commission land from Avenue 66 near Mecca to the Salton Sea. This Conservation Area contains suitable migration and breeding habitat for the riparian and wetland bird species covered by the CVMSHCP. CVCC has acquired several large parcels within this area, including the North Shore Ranch property, over the last few years as part of efforts to meet the acquisition objectives and requirements for this Conservation Area. Acquisition of these parcels has significantly connected existing conservation ownership in the Delta Area. The Coachella Valley Water District also owns land in the general area and is planning a habitat enhancement project for cottonwood/willow and mesquite habitat, to the south of the project site.

1.1.4 North Shore Ranch

In July, 2019 CVCC acquired approximately 143 acres of North Shore Ranch property near Mecca, California, for habitat conservation including restoration of natural communities. The CVCC will be managing the habitat for endangered species and other wildlife to help meet habitat conservation and restoration goals identified in the CVMSHCP.

North Shore Ranch is located in an unincorporated area of Riverside County near the Salton Sea, south of Mecca and Highway 111, between Avenue 68 to the north and Avenue 70 to the south, just west of Johnson Street (Figure 1-2). The property is composed of two parcels totaling 143 acres (Wood 2019). CVCC also owns the 142 acres directly south of the North Shore Ranch property (referred to as the "southern property" in this plan. As the Salton Sea has retreated, many native wetland-associated bird species have become reliant on artificial ponds in the Whitewater River Delta, including those on the

North Shore Ranch property. Prior to acquisition by CVCC, the ranch owner maintained the ponds as a private duck hunting reserve and encouraged game birds, especially ducks, to nest and frequent the area (Wood 2019). A Preliminary Site Assessment was prepared for the property in in 2019 (Wood 2019). This plan uses the guidance and background information provided in that assessment. Specifically, the site assessment identified the opportunity to alter management of the ponds to restore important ecological processes so they can support breeding populations of YRR and CBR.

1.2 Pond 5: Existing Conditions

Prior to the acquisition of North Shore Ranch by CVCC Pond 5 was managed for duck hunting. In general, it was flooded with water several inches deep during fall and winter months and then allowed to dry out over the summer (Wood 2019). Analysis of historic aerials shows that the pond was sparsely vegetated with some patches of what appears to be grass. The Preliminary Site Assessment for North Shore Ranch (Wood 2019) noted that swamp timothy (*Crypsis schoenoides*) and Bermuda grass (*Cynodon dactylon*) were common in many ponds. Since being acquired by CVCC, the management of water and vegetation in Pond 5 has changed and several native wetland species have established (presumably by natural colonization) by the time of our site visit in January 2021 (Figure 1-3). Keeping the pond flooded year-round over the last year or so has likely led to the colonization by these other species.

1.2.1 Vegetation Communities and Cover Class

Four vegetation communities and one cover class were identified during the site visit by GPA staff (Figure 1-4). Vegetation communities were classified based on the *Manual of California Vegetation* (Sawyer, Keeler-Wolf, & Evans, 2012). The communities are described below. None of the communities are considered rare by the California Department of Fish and Wildlife (CDFW) so altering the vegetation during restoration is not likely to trigger any regulatory hurdles. No special status plants were detected. Appendix A has further details.

1.2.1.1 American Bulrush and Cattail Marshes (Typha spp./Schoenoplectus americanus Herbaceous Alliance)

American Bulrush and Cattail Marshes within Pond 5 is co-dominated by cattail (*Typha* spp.) and American bulrush (*Schoenoplectus americanus*). This alliance is found throughout the pond. Associated species include alkali bulrush (*Bolboschoenus maritimus*), common threesquare (*Schoenoplectus pungens*), common spikerush (Eleocharis palustris), wire rush (*Juncus balticus*), and salt grass (*Distichlis spicata*). Approximately 1.67 acres of American Bulrush Marsh is present with in Pond 5.

1.2.1.2 Tamarisk Thickets (Tamarix ramosissima Shrubland Semi-Natural Alliance)

Tamarisk Thickets within Pond 5 is dominated by saltcedar (*Tamarix ramosissima*). This alliance is found along the margins of the pond. Associated species include arrowweed (*Pluchea sericea*), fourwing saltbush (*Atriplex canescens*) and salt bush (*Atriplex lentiformis*) with occasional patches of salt grass and salt crusts. Approximately 0.10 acre of Tamarisk Thickets is present within Pond 5.

1.2.1.3 Salt Grass Flats (Distichlis spicata Herbaceous Alliance)

Salt Grass Flats within Pond 5 is dominated by salt grass. This alliance is found along the pond edges, wetland-upland transition areas, and on the berms around Pond 5. Associated species include iodine bush (Allenrolfea occidentalis) and sprouting tamarisk. Approximately 1.24 acres of Salt Grass Flats is present within Pond 5.

1.2.1.4 Salt Grass Flats and Baltic Rush Marshes (Distichlis spicata – Juncus arcticus var. balticus Association)

Salt Grass Flats and Baltic Rush Marshes within Pond 5 are co-dominated by Baltic rush and salt grass. This association is found throughout the pond. Associated species include salt grass, common spikerush, and common three square. Approximately 1.82 acres of Salt Grass Flats and Baltic Rush Marshes is present within Pond 5.

1.2.1.5 Open Water

Open Water areas are permanently or temporarily flooded waterways or other water features that may support sparse emergent or submerged vegetation or may be unvegetated. This cover class is found throughout the pond. Approximately 0.43 acre of Open Water is present within Pond 5.

Figure 1-3. Pond 5 in January 2021. Cattail (center left), salt marsh bulrush (center right), and common spikerush (lower right) are the green marsh plants. Most of the brown vegetation is saltgrass and swamp timothy. Salt bush (at left) and arrow weed (at center) are the shrubs on the edge of the pond.

Figure 1-4. Vegetation communities in Pond 5 in January 2021.

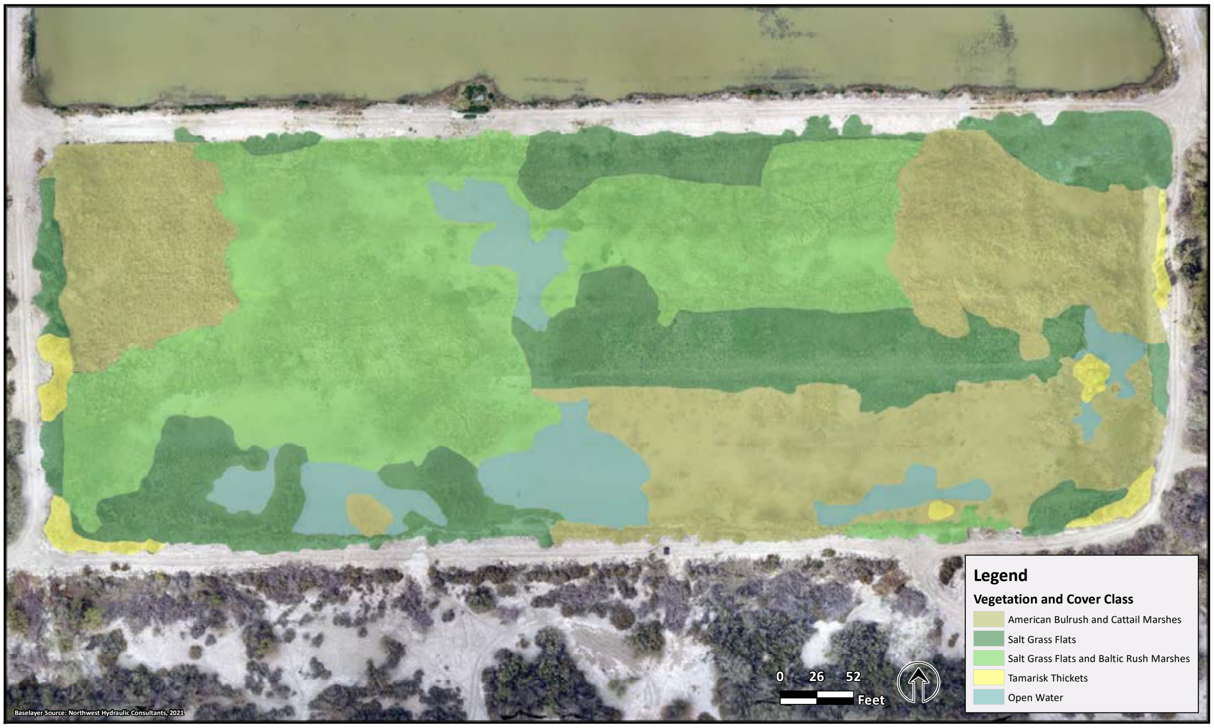

FIGURE 1.4 VEGETATION COMMUNTIES AND COVER CLASS
Pond 5 Restoration at the North Shore Ranch

Section 2: Project Goals and Objectives

Purpose of the project: Develop and test strategies for restoring habitat capable of supporting Yuma Ridgway's rail (YRR) and California black rail (CBR) in Pond 5 of the North Shore Ranch property.

1. **Develop a restoration plan for a pilot project in Pond 5 that can inform restoration planning and implementation for other ponds at North Shore Ranch**
    a. Develop restoration techniques and water and vegetation management strategies for Pond 5 that can feasibly be scaled up for restoration in other ponds
    b. Consider how complex-wide restoration will benefit the target species
2. **Develop a cost-effective strategy for establishing a hydrologic regime in Pond 5 that supports marsh habitats that are suitable for YRR and CBR breeding**
    a. Maintain shallow water depths (less than two inches) and saturated soil throughout the year in most of Pond 5
    b. Maintain sufficient water quantity and quality to support a healthy food web, especially for aquatic invertebrate (insects) and vertebrate (fish and amphibians) prey species
    c. Minimize well water use to the extent feasible
    d. Avoid discharging surface water to the Johnson Drain
    e. Assess strategies for beneficially using water discharges from Pond 5 to expand other marsh or riparian habitats on CVCC properties
3. **Develop re-vegetation and maintenance strategies to maximize habitat quality for YRR and CBR**
    a. Introduce desirable native species (bulrush) and control less-desirable native species (cattail) and invasive non-native species (saltcedar)
    b. Develop strategies to maintain target vegetation conditions in the marsh (periodically reduce thatch build-up) that are minimally disruptive to wildlife
    c. Expand native vegetation on berms, to provide high-water refugia and cover for birds moving between ponds, that is compatible with access needs
4. **Develop an adaptive management plan to guide implementation**
    a. Develop data collection protocols needed to monitor water depth
    b. Develop a water quality monitoring strategy that will inform water delivery strategies to Pond 5 (temperature, salinity, dissolved oxygen, etc.)
    c. Develop a strategy to monitor desirable (prey species) and undesirable (predators) vertebrates and invertebrates in Pond 5
    d. Monitor for YRR and CBR usage of the site in winter and during nesting season
    e. Identify other monitoring protocols that may be needed to successfully manage, maintain and learn from the pilot project

Section 3: Opportunities and Constraints

This section outlines significant opportunities and constraints for the project. The next section (basis of design) incorporates these opportunities and constraints to guide development of design alternatives. These opportunities and constraints will also be used to develop the long-term maintenance and management plan and an adaptive management plan for Pond 5.

3.1 Opportunities

Hydrologic/Hydraulic

- Clean water is available from existing well(s) with functioning delivery system
- Minimal percolation of surface water due to heavy soils
- Existing tile drain could be used to manage water quality (probably too inefficient)
- Deactivation of the tile drain or re-direction of its flows from the Johnson Drain would eliminate the need for a new discharge permit from CVWD
- Existing adjustable weir that drains to the south could be used
- A new water control structure could direct outflow to the Breeding Pond (directly east of Pond 5) or a new or existing pond on adjacent CVCC property to the south by gravity where it would support wetland habitat
- Outflow from Pond 5 could be used to irrigate/support restoration of riparian habitats to the south (downhill)
- A solar-powered pump could be used to recycle water through an aerator or bubbler to help maintain water quality and reduce water use/cost
- Outflow from Pond 5 could be kept on CVCC property and used to support other habitats
- Other ponds can be connected hydrologically to Pond 5 by gravity flow
- Shallow ground water could be an alternative source of water though heavy soils and high salinity may make it impractical
- Using a large water storage device (tank or adjacent pond) would allow continual slow flow of water into Pond 5 without continual pumping

Topography/Soil

- Soil has high silt and clay content and readily ponds water
- Existing topography in Pond 5 may need only minor adjustments to support target habitats

Ecology

- Some existing native wetland vegetation is already present in the pond
- Target plant species are easy to establish and spread quickly
- Target plant species occur on the property and could be sources of seeds or propagules
- Outflow from Pond 5 could support restoration of other habitats
- There are nearby CBR and YRR populations so natural colonization of the site is possible
- The restored pond (and associated restored habitats) could support other species of concern in the CVMSHCP
- Native riparian trees can survive in the long-term once their roots reach the shallow groundwater (several examples on site)

Infrastructure

- Existing irrigation system along levees (likely needs repairs)

- Existing pipe to Pond 5 with valve from well
- Existing adjustable weir
- Existing tile drain could be remediated to help increase flow through the pond

Human Interaction

- Levee system could be used for trails
- Interpretive signs could enhance the visitor experience
- Reestablishment of saltgrass on berms could act as a desirable trail surface

Regulatory/Permitting

- Likely no special status species on site currently
- Likely no federal waters or wetlands in the project area
- No National Pollution Discharge Elimination System (NPDES) or CVWD permit needed if there is no water discharge from the CVCC properties

3.2 Constraints

Hydrologic/Hydraulic

- Well water is likely the only source of water and its cost (currently $66 per acre-foot plus pumping costs) will likely rise in the future
- Shallow ground water is salty and may be difficult to pump due to heavy soils
- Pumping shallow groundwater would likely require a new well pump
- High evaporation rate in the summer will require regular pumping to maintain steady water levels unless a large water storage system is developed
- High summer temperatures will warm water and increase evaporation, which could lead to declines in water quality (e.g., lower DO and higher salinity)
- Maintenance of good water quality and target water depths will likely require a flow-through system that may require a more or less constant flow of water
- Burrowing mammals can breach berms and drain the pond

Topography/Soil

- Potentially sodic soil conditions may be leading to water turbidity
- Soil in all planting areas may need to be amended to reduce sodic conditions (gypsum) or add structure and nutrients (mulch or biosolids)

Ecology

- Both target species require shallow water or saturated soil with only minor depth fluctuations, especially in the breeding season
- Potential non-native predators such as bullfrogs and crayfish are known to occur nearby
- Potential native predators such as coyote and raccoon are likely present
- Aquatic invertebrate communities (prey) may be slow to develop on their own
- Disruptions to water supply in the summer could lead to drying of the pond and extirpation of aquatic species
- Cattails are likely to establish from nearby seed sources and could outcompete more desirable bulrush species without control
- Saltcedar seed sources are abundant (CVCC currently working to eradicate on their property)
- Establishment of riparian trees will require at least short-term irrigation

- Pond 5 may be too small of a habitat patch to support both target species because YRR have larger home ranges than CBR
- Colonization of the site by YRR and CBR is not assured even when suitable habitat is present

Infrastructure

- May need backup water source in case primary feed from the well becomes temporarily inoperable
- There is no electricity source near Pond 5
- Signage and other infrastructure would likely need to be upgraded if public access is increased

Human Interaction

- Human use could disturb target species, especially during nesting season

Regulatory/Permitting

- Existing tile drain outflow to the Johnson Drain is not currently permitted
- Colonization of the site by special status species could limit management actions
- Investigate feasibility of a safe harbor agreement
- Consultation with CDFW and RWQCB will be needed to assess need for 1600 permit and/or Porter-Cologne Act permit

Section 4: Basis of Design for Restoration of Pond 5

There is a fairly wide range of possible approaches for restoring habitats that could support YRR and CBR in Pond 5. The previous three chapters of this plan provide a general framework for designing the restoration project. The project's overall Goals and Objectives and the site-specific Opportunities and Constraints help set limits to the potential actions. Principles of ecological restoration, lessons learned from other successful projects, site-specific studies, and current conditions are then used to develop potential designs alternatives. This section of the plan outlines the basis of design that supported the development of the restoration alternatives and preferred alternative presented in the next chapters. The principles laid out in this chapter should also be used for other restoration projects within the North Shore Ranch focused on YRR and CBR in the future. The basis of design provides a model for achieving restoration success for different habitats in different areas.

The basis of design identifies how to restore the important ecosystem processes that are essential for establishing target habitats. To do this, the target habitats must first be defined. This is done primarily by hydrological regime and plant species composition. Successfully establishing and maintaining the different habitats requires restoration of important ecosystem processes. The most important processes of the basis of design are those related to hydrology, landform, and food web dynamics.

Using this approach for restoration planning provides a clear rationale for success. It is important to acknowledge that at this stage of the planning process, that there are still important data gaps. As these gaps in the basis for design are filled in the next stages of planning, the preferred alternative can be refined. After the project is built, further refinement in designs and management will need to be identified within an adaptive management framework.

4.1 Target Habitats

The pilot restoration project will focus on modifications to Pond 5 to create suitable habitat for YRR and CBR. There is generally broad overlap in habitat requirements for YRR and CBR on the lower Colorado River and in the Salton Sink. The two species are often found in the same areas; however, they are likely utilizing different microhabitats for foraging and nesting and are likely exploiting different food resources. Observational studies, primarily conducted on the lower Colorado River, indicate that while both species can tolerate a wide range of conditions, there are certain aspects related to vegetation structure and composition that are likely critical for supporting each species. Restoring beneficial habitat for YRR and CBR in Pond 5 will require, at a minimum, altering vegetation and hydrology to provide these conditions.

Additional revegetation efforts will include establishment of riparian trees adjacent to Pond 5 and expansion of saltgrass (*Distichlis spicata*) on the berms surrounding Pond 5. Outflow from Pond 5 into a receiving basin could allow the establishment of different wetland habitats.

4.1.1 Pond 5 Marsh Habitat

Nadeau et al. (2011) found both species of rail most commonly associated with marshes dominated by tall (> 6 ft.) chairmaker's bulrush (*Schoenoplectus americanus*) or early succession cattail (*Typha* spp.)[2]. Both of these species grow in year-round or seasonally flooded or saturated soils.

[2] Previous studies suggested CBR preferred shorter marsh species or grasses (Repking and Ohmart 1977), though Nadeau et al. (2011) found a negative association with common three square (*Schoenoplectus pungens*), a bulrush that grows to only about 3-feet tall.

Chairmaker's bulrush has higher tolerance to salinity/alkalinity than cattail, provides food (seeds) for CBR (Eddleman et al. 1994, Eddleman et al. 2020), and was found to be the dominant species at CBR nest sites along the Colorado River (Flores and Eddleman 1993), so it is considered the best species for vegetating Pond 5. Assuring chairmaker's bulrush is the dominant species in Pond 5 will require planting rhizomes and weeding of other species (saltcedar and cattail) early in the revegetation effort. Cattail, which is native and wide spread in other wetlands at North Shore Ranch, produces huge amounts of seed that travel by wind and germinate readily on wet soils. As such, cattail can become invasive and take over wetlands that have moist soils (seedlings do not establish in flooded areas). Weeding cattail seedlings will be especially important in the early phase of restoration when there are large areas of bare, wet soil; once charimaker's bulrush has established a dense stand, cattail will be less likely to invade. Some amount of cattail may be desirable as it may be an important nesting material for CBR (Flores and Eddleman 1993). Increased concentration of salts in the system (e.g., through evaporation or by using water sources other than well water) would favor chairmaker's bulrush over cattail (Baeza et al. 2013). Salinity would need to be maintained in the range of 7-12 parts per thousand (ppt) in order for this to be effective. Higher water salinities would decrease the vigor of target species and favor other species such as salt marsh bulrush (*Bolboschoenus maritimus*).

High density of decadent cattail and/or bulrush stems in marshes is negatively associated with both CBR (Conway and Nadeau 2005) and YRR (Conway et al. 2010) presence. Decadent biomass builds up each year as stems senesce. It is thought that this buildup decreases the productivity of the marsh by shading the water or soil and making nutrients unavailable; it may also make movement more difficult for rails (Conway and Nadeau 2010). Periodic prescribed burns have been used to remove the dead (and living) biomass to decrease shading and release nutrients. After burning, marsh species quickly re-sprout from rhizomes and marshes can recover within a few months (Conway and Nadeau 2010). In large marsh systems on the lower Colorado River, where birds can easily move to adjacent non-burned marshlands, there does not seem to be a negative effect on rails (Conway et al. 2010) and over the longer term, periodic burns may increase the number of YRR in a marsh (Conway and Nadeau 2010).

In a small system like Pond 5, with relatively limited adjacent habitat for the rails to move to, the effects of fire on birds that are present is difficult to predict. It may be feasible to burn relatively small areas of the marsh in rotation to leave significant unburned areas each year. This however might require burning more or less every year, which may become expensive. Mowing and raking sections of the marsh in rotation may be more cost effective; though removing biomass would not have the same benefits to nutrient cycling as burning. The feasibility of using controlled grazing by goats could also be investigated. This might be less disruptive to resident rails and might have similar benefits to burning. Non-fire approaches would have less impact on air quality and would likely not need special permitting.

Some habitat diversity is probably desirable for both YRR and CBR. Including a range of water depths and areas with saturated soil (i.e., not flooded) will allow the habitat to support a wider range of plant and prey species. Establishing dense vegetation around the edges of Pond 5 that are too dry for chairmaker's bulrush will also be desirable. Dense cover of species such as saltgrass, Cooper's rush (*Juncus cooperi*), spiny rush (*Juncus acutus*), arrowweed (*Pluchea sericea*), or common threesquare (*Schoenoplectus pungens*) would help limit establishment of undesirable species such as saltcedar and cattail in these areas. Finally, since CBR appear to not use chairmaker's bulrush to construct their nests (Flores and Eddleman 1993), planting other species such as spikerush (*Eleocharis macrostachya* and *E. palustris*) may be worthwhile.

4.1.2 Desert Riparian Habitats

Establishing desert riparian habitats on the North Shore Ranch property would potentially benefit a wide range of special status species (especially birds). Several Fremont cottonwoods (*Populus fremontii*) have been planted on the property and appear to be thriving without supplemental irrigation (though irrigation was used during establishment). There is a small Fremont cottonwood on the edge of Pond 5 that apparently established naturally. This suggests that the shallow water table at the site is both close enough to the surface and low enough in salts to support at least this species at the site. Other typical riparian trees such as black willow (*Salix gooddingii*), honey mesquite (*Prosopis glandulosa*), screwbean mesquite (*Prosopis pubescens*), ironwood (*Olneya tesota*), and palo verde (*Parkinsonia florida*) and understory species such as narrowleaf willow (*Salix exigua*), salt bush (*Atriplex lentiformis*), and arrowweed could all likely be established from nursery stock with irrigation for the first year or so after planting.

There are two potential sources of irrigation water for riparian plantings; the existing irrigation lines along the berms and outflow from Pond 5. The irrigation lines that follow most of the berms at North Shore Ranch were used in the past to sustain saltgrass on the berms. The system has not been used in many years and will require inspection and repairs and an additional line to the pilot riparian planting area. Alternatively (or additionally), outflow from Pond 5 could be directed towards the riparian planting area to occasionally flood irrigate the plantings. This would likely require the construction of small berms to divert flows towards the plantings. Trees and understory species should be installed from nursery stock in late winter and irrigated through at least the first summer and fall. Irrigating with occasional deep soaks will help encourage deep root growth and eventual tapping of the shallow groundwater. Using a broad suite of species in the pilot planting project will help inform planting palettes for future planting efforts in other areas.

4.1.3 Berm Revegetation

As discussed in Section 4.1.1 above, the berm edges within Pond 5 should be planted with wetland associated species that can handle these somewhat drier conditions. The berm tops could also be revegetated with salt grass. This would require irrigation and planting of nursery stock. The saltgrass would help stabilize the soil on the berms and provide some cover if rails decide to move between ponds. Saltgrass can handle moderate trampling and occasional driving without harm.

4.1.4 Receiving Basin Habitats

Outflows from Pond 5 may be used occasionally for irrigating riparian plantings, but the majority of the time, the flows will need to go into a receiving basin. The retention basin would be likely to support salt panne habitat or vegetated marsh depending on size of basin and other factors.

4.1.5 Saltcedar Control

Maintaining the above habitats will require considerable control efforts targeting saltcedar (*Tamarix* spp.). CVCC's ongoing efforts to eliminate saltcedar from their properties will need to continue. As long as there are mature trees in the area, all wet areas will need to be monitored for seedlings on an ongoing basis. Removal of small newly established plants is easy compared to more mature plants with deep roots. Saltcedar primarily produces short-lived seeds throughout the summer, but seedlings can appear in almost any season where there is wet soil. Permanently flooded habitats are much less likely to be invaded than areas with wet soil.

Any wet but not flooded areas in Pond 5 will be highly prone to invasion. The dense vegetation may eventually make invasion less likely. The pilot riparian area will also be especially prone to invasion in the first year or so when it is being irrigated as will the berms if irrigated. The effort required to monitor and weed saltcedar seedlings will decrease as control efforts of mature trees on the property proceed.

4.2 Hydrology and Hydraulics

Water management will be a crucial aspect to restoring habitat for the YRR and CBR in Pond 5. There is no natural water source that can support wetland habitat at the site so water must be delivered to the site by artificial means. The water will need to be delivered consistently to Pond 5 to maintain acceptable water quality and offset losses due to evaporation and transpiration and to maintain water quality.

Appendix B includes further details on water sources and volumes needed. It is estimated that loss of water to seepage will be relatively low (4.38 acre-feet per year). Losses through the existing tile drain and to evapotranspiration will be much greater (29.04 acre-feet per year). Additional water will need to flow through the site in order to maintain stable water levels and good water quality. We estimate that the amount of annual outflow, called turnover, that will be required is about 17.5 inches or 7.29 acre-feet per year. This estimate is based on values developed for the Created Marsh at the Dos Palmas Preserve (GEI Consultants 2020). A lower amount of turnover may be sufficient, but monitoring and adaptive management will be needed to determine this. Based on these estimates, the annual amount of water required to sustain rail habitat in pond five will be 36.33 acre-feet (with an additional 8.09 acre-feet needed in the first year to fill the pond and saturate the soil profile).

4.2.1 Water source

The preferred water source for Pond 5 will be the current well, which can deliver 700 gallons per minute (gpm) and has a supply line leading to Pond 5 (and most of the other ponds on the property). The water is from a fairly deep aquifer and is reportedly cool with very low salinity, but may have limited DO. The annual cost of using this water source is estimated to be in the range of \$3,000 - \$4,000 per year at 2020 water and electricity rates (*see* Appendix B).

4.2.2 Water depths

CBR have narrow requirements for water depth within marshes where they occur[3]. They are most commonly found in marshes that have either saturated soil or are flooded to less than about 1.5 inches deep (Nadeau et al. 2011) though others have suggested depths to 2.5 inches are suitable (*see* Dodge 2019). YRR can tolerate much deeper water (they can swim) but Nadeau et al. (2011) found them most commonly in areas of marsh flooded to less than about 2.5 in (and only rarely in areas that were not flooded). Several investigators have also noted the need for stable water levels (Repking and Ohmart 1977, Evans et al. 1991, and Flores and Eddlemen 1995), though more recent studies have questioned this assumption (Nadeau et al. 2011 and Dodge 2019).

Given the preferences of the two target species, the majority of Pond 5 should be flooded to less than about two inches year-round. Some proportion of the pond should have deeper water, which could act as refugia for aquatic species if there are temporary disruptions to water delivery that cause water

[3] CBR are also found in tidal marshes on the California coast, but this discussion is focused on conditions in non-tidal systems

levels to drop. Fluctuations in water depths of two or more inches (deeper or shallower) should be avoided, especially March through July, the CBR nesting season[4].

4.2.3 Water quality

Maintaining good water quality in Pond 5 will be crucial for supporting YRR and CBR. Several different water quality parameters will be important to monitor. Section 8 of this plan includes targets and thresholds for these parameters. The well water that will be used for Pond 5 is not expected to have water quality issues, but problems would likely develop if water just sits in the pond and evaporates. Keeping water flowing through the pond will help avoid water quality problems. In any case, the well water should be sampled and analyzed by a lab so that concerns can be addressed before final design and construction.

Dissolved oxygen (DO) levels need to remain high enough to support aquatic animal species. Even short-term drops in DO can lead to die-offs of fish, amphibians, and invertebrates (prey items for YRR and CBR). The most effective approach to maintaining acceptable DO levels is to keep the water temperature in the pond as low as possible (cooler water can hold more oxygen) and to avoid algal blooms (see below).

Elevated phosphorus levels in freshwater wetlands can lead to algal blooms. When the algae produced in the blooms eventually dies, decomposition by microorganisms (which use oxygen) can cause DO levels to crash. Cyanobacteria blooms can create toxins, which may be harmful to wildlife. It is expected that the well water will be very low in phosphorous, however it could build up over time from atmospheric deposition and wildlife.

Total dissolved solids (TDS) is a measure of the amount of minerals, salts, metals, and other ions dissolved in water. When water evaporates, these materials are left behind and their concentrations can rise to levels that negatively affect plants and animals. While the well water is expected to have low TDS, the high evaporation rates and alkaline shallow groundwater at the project site mean that TDS could become a problem. The primary target plant species for the pond, chairmaker’s bulrush, can handle (and may prefer) relatively high salt concentrations (Howard 1995). Elevated salt concentrations in the range of 6 – 12 parts per thousand (ppt) may also discourage establishment of less desirable species such as cattail (Baeza et al. 2013). However, lower salt concentrations may be needed for some invertebrate and vertebrate species such as amphibians.

It is presumed that the well water has a pH of about 7 (neutral), which is desirable for most wetland plants and animals. The alkaline soils and shallow groundwater at the site could lead to an increase in pH in Pond 5. Increased pH could have negative effects on some aquatic species.

The very fine (and possibly sodic) soils at the project site could tend to become suspended in the water column, leading to high levels of turbidity. The other ponds at North Shore Ranch appeared turbid during a January 2021 site visit. Analysis of historical aerial photos show the ponds often have a grey-green color, which could be simply micro algae blooms or a combination of suspended soil particles and algae. A densely vegetated pond would be expected to be less turbid as the effect of wind moving water and stirring up soil would be greatly reduced. Elevated turbidity would likely limit the productivity and the types of prey in the pond and reduce the ability of YRR and CBR to catch prey (they are primarily visual hunters).

Selenium can cause mortality and impaired reproduction in aquatic birds (Hoffman 2002). Selenium is found naturally in ground water but in the Salton Sea area, it is found in higher concentrations

[4] CBR nests tend to be located a few inches above water about one inch deep (Flores and Eddleman 1993). Water level fluctuations greater than a few inches can cause eggs to float out of nests.

in agricultural tail waters and tile waters (Ricca et al. 2022, Saiki et al. 2010). Concentrations at or above 5.5 *u*g/L in tail waters feeding wetlands constructed as secretive marsh bird habitat in the southern Salton Sea are considered a concern (Ricca et al. 2022). The concentration of Selenium in the well water at North Shore Ranch was tested in May 2022 and found to be <0.02mg/L (or < 20*u*g/L). While these results are encouraging, groundwater in the Coachella Valley can have non-toxic levels of Selenium (i.e., lower than the minimum threshold of the current testing method) that could nevertheless bioaccumulate in Pond 5 over time even at lower input concentrations (*see* Ricca et al. 2022). Therefore, Selenium should be monitored in surface waters and perhaps in tissue samples from organisms in Pond 5.

4.2.4 Pond 5 Outflows

There are a range of opportunities to beneficially use the outflows from Pond 5 to support other wetland and riparian habitats on the North Shore Ranch and adjoining CVCC-owned property. Outflow could go east into the 7.2-acre nesting pond, which is a foot or two lower than Pond 5. The amount of outflow would probably not be sufficient to flood the entire nesting pond even in winter. The lower parts of the pond that are closer to the inflow point would become wetland habitats. The year-round flows would likely support marsh habitat if a tile drain were added to the pond. This marsh could be additional rail habitat. If water was simply allowed to evaporate, flooded parts of the nesting pond would eventually become seasonally flooded salt flats. Salt flats could provide valuable shorebird habitat in the winter and potential nesting habitat for western snowy plover in the spring and summer. Outflows could also be directed south into an existing or new basin on CVCC's neighboring property where the same habitats could be created.

Outflows could be used to occasionally irrigate riparian planting in the pilot riparian planting area and in the arroyos on the neighboring property in the future. Minor grading would be needed to direct flows to planted areas, which are all at lower elevations than Pond 5. It is probably more feasible to use outflow water for this type of irrigation occasionally as opposed to it being a continual flow.

4.3 Landform and Soils

It is expected that there will need to be minor grading in Pond 5 in order to optimize rail habitat. The current understanding of the topography in the basin is based on Lidar, which does not appear to have captured the small-scale topographic features in the pond. The pond was flooded during our site visit (January 2021) so we have limited first-hand observations of the basin bottom, however, there appeared to be raised areas through the middle of the pond that were not flooded and had different vegetation. Aerial photos clearly show this higher ground (Figure 4-1). We estimate that the area is likely on the order of 4-10 inches higher than the rest of the basin, which otherwise appears to be fairly flat-bottomed.

Soils at the site seemed uniform in texture with high silt and clay content. The non-flooded areas around Pond 5 had abundant sodium or calcium carbonate visible on the surface, likely due to the shallow salty groundwater and high summer evaporation rates at the site. The alkaline soils will probably not impact revegetation if appropriate species and sufficient irrigation with fresh water is used.

4.3.1 Pond 5 Topography

At least minor grading will be needed in Pond 5 to create a more desirable range of water depths. In general, gentle slopes within the wetland will allow different areas to be shallowly flooded or saturated as water levels very slightly so birds can move to areas with appropriate depths (*see* Dodge 2019). These slopes could occur in a uniform way (i.e., a shallower end and a deeper end of the pond) or as part of a more complex mosaic (i.e., broad shallow depressions and/or low mounds in some sort of mosaic). The latter approach would provide more habitat edges, which have been associated with higher bird usage for both species (Marty and Unnasch 2015a and 2015b). Areas designed to be flooded to one inch would likely provide preferred nesting locations for CBR (Flores and Eddleman 1993). Broad wetland-upland transition zones may also be beneficial (Flores and Eddleman 1995). Having deeper areas (up to about 10" deep) would provide refugia for aquatic species if water levels dropped for an extended time due to problems with the water delivery system.

The soil in Pond 5 may not need amending. The pond currently supports native wetland vegetation, an indicator that it will support the target vegetation community. If grading removes the current topsoil, the post-grading topsoil should be tested and consideration should be given to adding biosolids to add structure and nutrients that will help plants grow. Gypsum could be added to counter sodic conditions as well. The high clay content of the soil limits water loss due to seepage which will mean less water needs to be added to the pond.

Figure 4-1. Aerial photo of Pond 5 showing higher topography around some edges and down the middle of the basin. The pilot riparian planting area should be located within the orange rectangle (CVCC is in the process of removing the saltcedar seen in this image). Image taken December 2019.

4.3.2 Berms

The berms around Pond 5 are currently in good condition. There will need to be a plan in place to maintain the current berms and repair damage as it occurs. The North Shore Ranch manager reports that gophers and muskrats can burrow into and through the berms, causing ponds to drain within a day or less. Irrigation and planting on the berms would likely increase the presence of gophers. Some soil amendments (biosolids and gypsum) may be desirable on the berms to create better soil structure and counter sodic soils.

4.3.3 Riparian Habitats

The pilot riparian planting area (Figure 4-1) is in a low-lying area that was formerly dominated by saltcedar. It may be desirable to make small scale changes in the landform to make flood irrigation more efficient (i.e., adding small check dams or removing higher ground between lower areas to let water flow to all plantings). If outflow from Pond 5 is used for irrigation, a small channel will need to be constructed between the outfall and the planting area. As with the berms, some soil amendments (biosolids and gypsum) may be desirable to create better soil structure and counter sodic soils.

4.4 Food Web Dynamics

Restoration of appropriate vegetation, hydrology, and water quality for YRR and CBR in Pond 5 could lead to the natural development of a food web that will support these birds. However, this should not be taken for granted. Eddleman et al. (1994 and 2020) list a range of prey species for both birds, but little is known about the relative importance of different species or functional groups for either bird.

Assuring there is sufficient prey will probably be most important for YRR, which feed primarily on aquatic vertebrates and invertebrates, including small fish and amphibians (Eddleman 1989). It will be crucial to assure the water quality and hydrology of Pond 5 is appropriate for support these types of species by including areas flooded year-round. Introductions of some prey species may be warranted.

The smaller invertebrates that CBR feed on (Eddleman et al. 1994, Eddleman et al. 2020) will likely colonize the site on their own or may already be present. Planting bulrush in the pond will provide seed for CBR to eat. Monitoring of all these prey species and water quality will be important after the pilot project is built.

4.4.1 Predation

Both species of rails are vulnerable to predation by other birds, mesopredators, cats, and bull frogs (Eddleman 1989 and Marty and Unnasch 2015a and 2015b) at all life stages. Crayfish may prey on CBR, especially immature birds (Inman et al. 1998). Bullfrogs and crayfish are both reportedly present in at least the bass pond (and therefore are likely to be in the refuge pond as well). Pond 5 will need to be monitored regularly for these species. If either species colonizes Pond 5, it may have to be drained temporarily to remove them. Source populations of both species may need to be controlled. Both rail species are generally protected from other predators such as coyote, cats, and other birds by dense vegetation (Flores and Eddleman 1993) so encouraging dense bulrush will be important. It may be useful to install one or more motion-activated wildlife cameras near Pond 5 to understand what predators are using the site with what frequency.

Section 5. Design Alternatives

The purpose of generating alternatives for Pond 5 is to analyze the feasibility of different approaches to attaining the project's goals and objectives. Different approaches to grading, water delivery, and using water outflows can lead to designs that attain different goals and objectives to greater or lesser degrees. Some of these approaches were considered and rejected because they were either not feasible, not cost-effective, or did not sufficiently meet the goals and objectives. Seven alternatives were carried forward for further analysis. The alternatives are grouped into three themes: topography, water delivery, and water outflow.

The alternatives were sketched out in order to better communicate them to CVCC staff, other stakeholders, and readers of this plan. This section of the plan includes the sketches and brief analyses of each alternative's pros and cons. Analysis of these alternatives will lead to the choosing of a preferred alternative, which will be developed by mixing and matching an alternative from each theme.

5.1 Theme 1: Topography

Based on field observations and an analysis of Google Earth aerial photos from the last 15 or so years, it was determined that the existing topography in Pond 5 would not allow a majority of the pond to be flooded to 1-2 inches. This is due to the fact that significant areas within the pond are at least several inches higher and lower than other areas. While topographic surveys were not conducted for this study, Figure 4-1 presents a rough depiction of this topographic variability. It was concluded that some limited grading would need to occur to optimize the area of the pond flooded to 1-2 inches. Several alternatives for grading we considered and two were analyzed[5]. Each alternative would support chairmaker's bulrush throughout Pond 5.

5.1.1 Designs Considered and Rejected

Three different grading designs were considered and rejected. The "flat" design featured an essentially flat basin bottom that would allow for uniform water depths across the whole pond. This design lacked deeper water refugia for aquatic species so was not carried forward. A "channel" design featured a flat bottom bisected by a channel leading roughly from the water input point to the main outlet point. This design was not carried forward because the deeper water might restrict the movement of CBR (especially chicks) to one side of the channel or the other and therefore limit foraging areas. The "moat" design featured deeper water around just the edges of the pond. This design was rejected because any breach in a berm (by a gopher for example) would allow the pond to drain more or less entirely (i.e., no deeper water refugia would exist in that case).

5.1.2 Topographic Alternative 1: Gently Sloping

This alternative would require minor grading of Pond 5 to create a gentle slope to the basin bottom with the majority of the site flooded to two inches deep or less (Figure 5-1). This would likely be somewhat easier to construct versus Topographic Alternative 2. Cut and fill could likely be balanced within the pond. This alternative would provide a single larger deeper water refuge for aquatic species, which may be more effective at maintaining aquatic habitat during water supply interruptions than having the multiple smaller refugia in Topographic Alternative 2.

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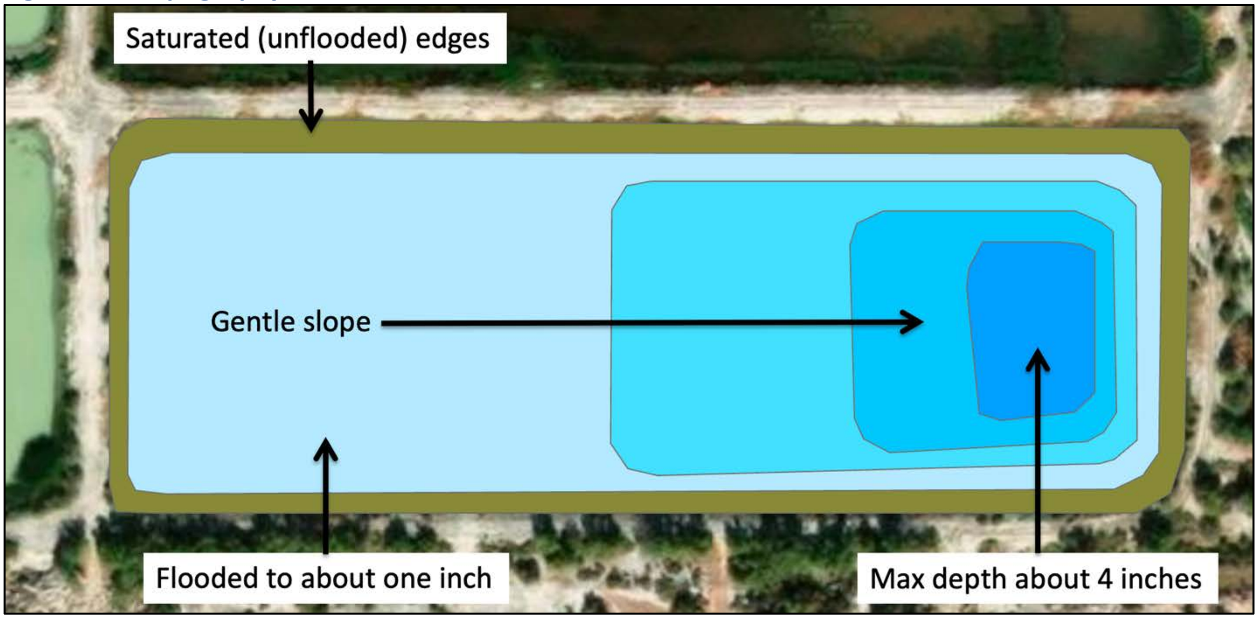
[5] The highly conceptual grading designs presented in this section to not account for other grading that may be needed, especially around inflow and outflow structures.

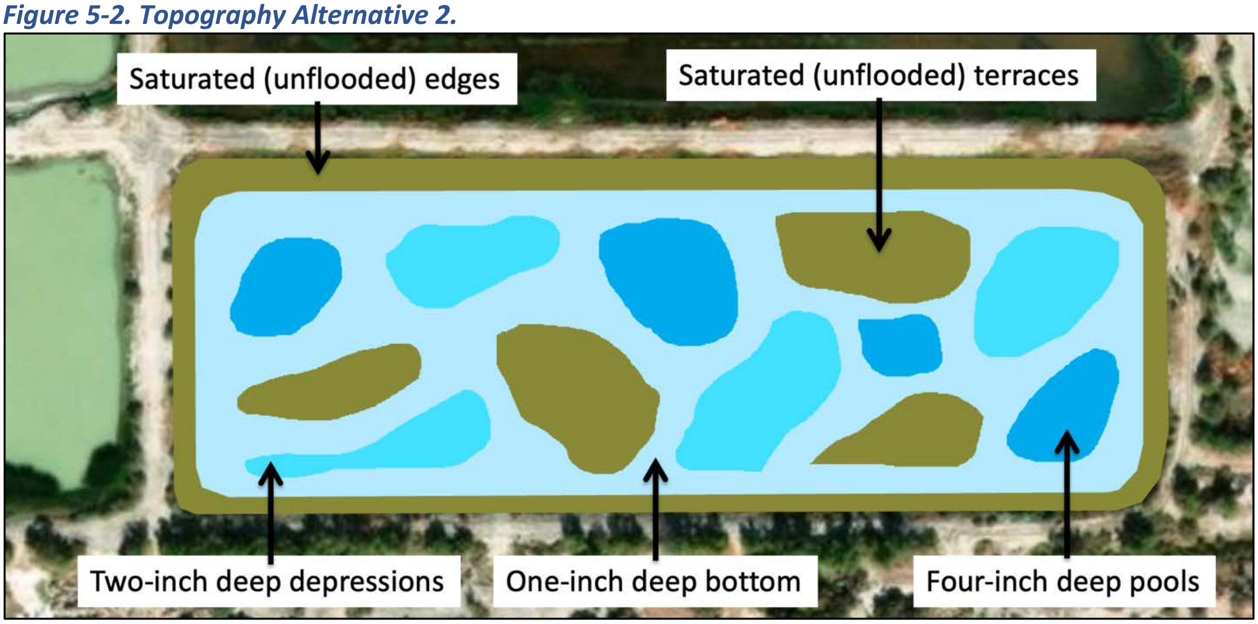
Figure 5-1. Topography Alternative 1.



5.1.3 Topographic Alternative 2: Microtopography

This alternative would require minor grading to create a mosaic of shallow depression, deeper pools, and raised terraces with the remaining area flooded to about one inch deep (Figure 5-2). There are many options for different sizes and total area of these different features; Figure 5-2 shows fairly large features covering a maximal area. This alternative would likely be slightly more labor intensive to construct than Topographic Alternative 1, though cut and fill could likely be balanced with this design as well. This design is probably ecologically superior to Topographic Alternative 1 as increased habitat heterogeneity might be expected to support a wider range of prey species throughout the pond.

Figure 5-2. Topography Alternative 2.



5.2 Theme 2: Water Delivery

A Water Supply Availability Evaluation (Appendix B) determined that the preferred source of water for Pond 5 is the existing well on the North Shore Ranch site. That evaluation also determined that the constant inflow and outflow through the system was most desirable to maintain constant water levels and acceptable water quality. To achieve this, it was determined that water from the well would need to be occasionally pumped into a holding structure and then slowly released into Pond 5 over time. It is probably most desirable to have enough storage capacity to limit pumping to once a day or less in the summer. All of these alternatives would need some sort of devices to control inflow rates and allow for seasonal increases and decreases in inflow. Three different alternatives were developed for storing and dispensing water to Pond 5.

5.2.1 Designs Considered and Rejected

Multiple alternative water sources were considered (*see* Appendix B). These included pumping shallow groundwater with a new well, using Colorado River Canal water, and diverting flows from the Johnson Drain. These were considered infeasible due to water quality and/or cost considerations.

Using the existing well and plumbing to pump water as-needed directly into Pond 5 is feasible, but is not being considered. This is due to the fact that it would lead to too much variability in water level or a need to cycle the well pump more often than desired. This approach would also necessitate fairly complicated controls over turning the well on and off or daily monitoring and manual control of pumping on a more or less daily basis by ranch staff.

5.2.2 Inflow Alternative 1: Sub-basin Storage in Pond 5

This alternative would require the construction of a sub-basin within Pond 5 that would receive water from the well and act as a storage structure, releasing water as needed into the pond to maintain target outflow (Figure 5-3). The sub-basin would be built by constructing a new berm across the northwest corner of the pond. The dimensions of the storage pond have not yet been determined, but the sub-basin would be probably be flooded one to two feet deep. Further analysis will refine needs for total storage volume and hydraulic head. The berms around the sub-basin would need to be designed to discourage burrowing by small mammals and could be raised slightly higher than the existing berms. The sub-basin would be sized to minimize well cycling while keeping the residence time as low as possible to assure cool water is discharged into the habitat area of Pond 5. The sub-basin could be covered to decrease evaporation and help keep the water cool (this would be the most water-efficient of all the alternatives). The cover would need to be designed to hold up to the elements, especially high winds. If not covered, the sub-basin would be densely vegetated with cattails to discourage water fowl use and decrease the chances of introducing pathogens to the system. This approach would necessitate a larger sub-basin since the vegetation would decrease the total water storage compared to an unvegetated basin. This alternative would provide less rail habitat than the other Inflow Alternatives due to the sub-basin area likely not supporting at least CBR.

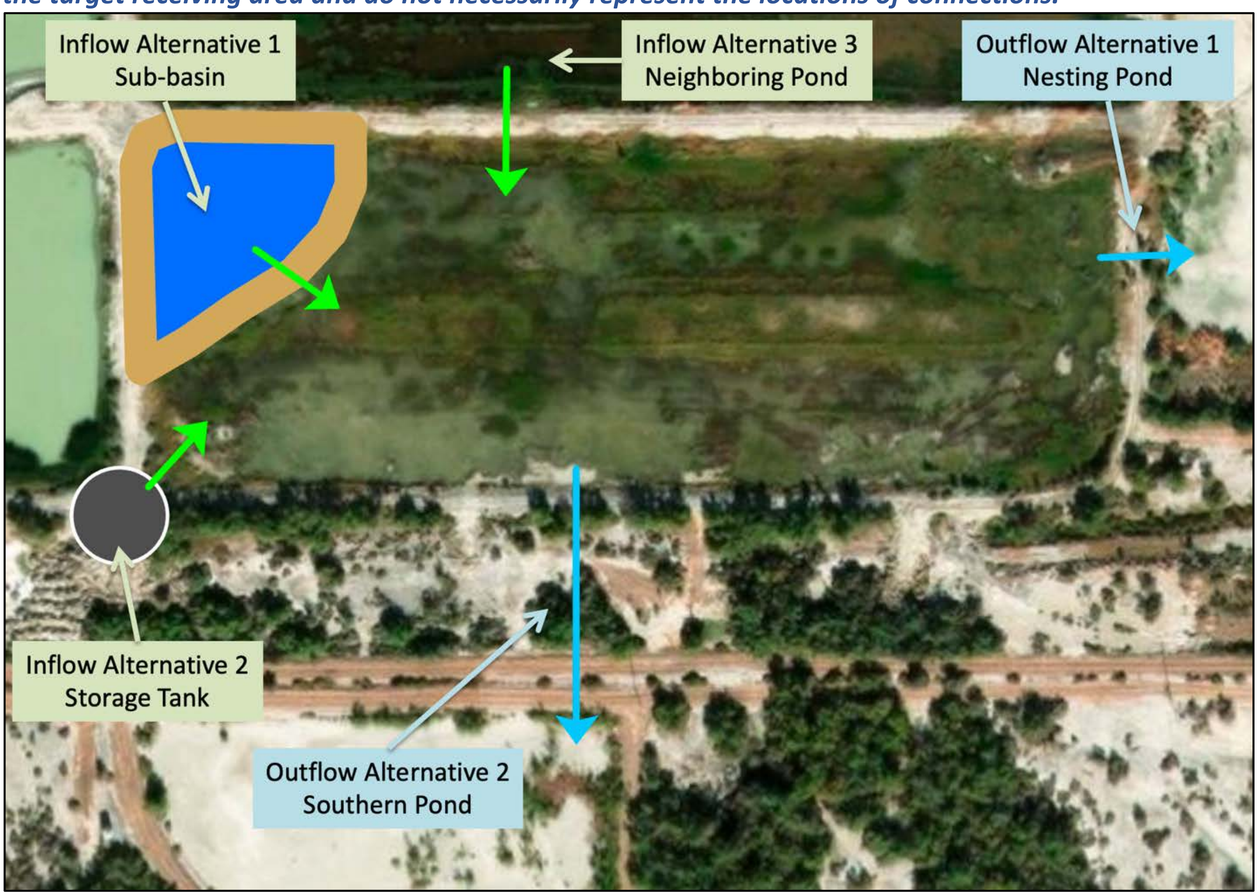
5.2.3 Inflow Alternative 2: Storage Tank

This alternative would require purchasing and installing a storage tank that would be filled by the well. A delivery system would release water at the desired rate into Pond 5 (Figure 5-3). There are several options for different size tanks, however the smaller the tank, the more often the well would need to cycle. For example, a 58,000-gallon tank would be needed to store a 24-hour supply of water at peak demand in July. A smaller tank or tanks are feasible but would require multiple rounds of pumping each day, at least in summer. Using a tank could make controlling inflow rates more challenging due to the large differences in water pressure coming out of a full tank versus a nearly empty tank (due to the difference in hydraulic head). The tank could be located directly adjacent to Pond 5 as shown in Figure 5-3 or closer to the well. This alternative would use about the same amount of water as Inflow Alternative 1 (assuming a covered sub-basin) and much less than Inflow Alternative 3 and have an intermediate area of appropriate habitat for the target birds.

5.2.4 Inflow Alternative 3: Adjacent Pond

This alternative would use the adjacent uphill Pond 6, which is 12.3 acres in size, to store water and then slowly release it to Pond 5. This approach is similar to that used at the Dos Palmas Created Marsh, where water cascades through three constructed ponds, each of which provides habitat for secretive marsh birds. Depending on how water inflows are managed, Pond 6 could also provide habitat for YRR and CBR, however this might involve fairly frequent pumping to maintain shallow stable water levels. Flooding Pond 6 more deeply (less frequent pumping) would mean deeper water and habitat likely not suitable for at least CBR. With any approach, Pond 6 would be vegetated with bulrush and/or cattails to discourage water fowl use and decrease the chances of introducing pathogens to the system. This alternative would increase habitat area, but would greatly increase the amount of water needed due to the expanded area of marsh and associated extra losses to evapotranspiration, seepage, and the tile drain.

Figure 5-3. Inflow and Outflow Alternatives. Arrows represent direction of flows from their source to the target receiving area and do not necessarily represent the locations of connections.



5.3 Theme 3: Water Outflow

As discussed in Section 4, in order to maintain acceptable water quality in Pond 5, there will need to be continuous inflow and outflow through the system. It was determined that the best option is to use the outflow to support other habitats. Due to the extreme evaporation rates and alkaline soils at the site, the habitats created with the outflow will be salt-affected. Without enough sub-surface drainage of water, salts would eventually build up enough to preclude vegetation and the result would be unvegetated salt flat or salt panne habitats. With enhanced sub-surface drainage marsh habitats dominated by salt-tolerant species such as salt marsh bulrush (*Bolboschoenus maritimus*), Parrish's glasswort (*Arthrocnemum subterminale*), iodine bush (*Allenrolfea occidentalis*), salt grass, and bush seepweed (*Suaeda nigra*) could be created. Either option would provide valuable wildlife habitat.

5.3.1 Designs Considered and Rejected

Two alternatives that sent outflow to the Johnson Drain via either surface discharge or a new, larger tile drain were rejected due to potential costs and feasibility of permitting and an overall desire to beneficially use outflow to support other habitats. Recirculation of all outflows using a sump and pump system was rejected because it was decided that this approach would not be sufficient for maintaining good water quality in the pond year-round.

5.3.2 Outflow Alternative 1: Nesting Pond

The Nesting Pond (7.2 acres in area) appears to be about one to two feet lower than Pond 5. Outflow from Pond 5 could flow by gravity into that pond, which is only the width of the berm away to the east (Figure 5-3). The Nesting Pond currently has a considerable amount of saltcedar in it that would need to be removed. The outflows would support wetland habitat in some fraction of the pond area.

5.3.3 Outflow Alternative 2: Southern Pond

A smaller (about 1.6 acre) pond lies about 200 feet south of Pond 5 and appears to be about one to two feet lower than Pond 5. Outflows from Pond 5 could be directed to this pond with a pipe, though more careful elevation measurements will be needed to assure the pipe has a sufficient gradient to efficiently convey flows.

5.4 Other Design Options

Other potential design options that could work with any of the alternatives were deemed worthy of consideration. These options could be built with the initial construction effort or added later with fairly minor modifications.

5.4.1 Recirculation and Aeration

Keeping the level of dissolved oxygen (DO) sufficiently high to support a range of aquatic species may be a challenge, especially in the summer as the water in Pond 5 warms. The well water is expected to be fairly low in DO, but there are opportunities to aerate it in the process of delivering it to Pond 5. Additionally, outflow from Pond 5 could be collected in a sump and pumped back into the Pond 5 through an aerator. This would not cool the water appreciably, but could help keep DO levels higher. This option might decrease the amount of well water needed (i.e., less flow through might be needed to maintain water quality).

5.4.2 Flood Irrigation of Restored Riparian Areas

The outflow from Pond 5 could be diverted to downslope areas and used to flood-irrigate restored riparian habitats. These would be occasional diversions during the establishment phase. Salt build-up could become a problem if used too often. Diverting the water would likely require a combination of control valves and pipes and minor grading to assure the water can flow to all the plantings without causing excessive erosion. This approach could be tested at the pilot riparian planting area south of Pond 5. If it proves effective, the approach could be used for further plantings in the arroyos on the southern property.

5.5 Comparing the Alternatives

Within the three themes, the alternatives were compared to each other as to the extent they achieve the project's goals and objectives (*see* Section 2) and other factors such as implementation cost, permitting complexity, ongoing water costs, and frequency of maintenance needs. Discussions with CVCC staff established the relative importance of these different factors. CVCC staff made the final decisions in order to settle on a Preferred Alternative for Pond 5.

Section 6. The Preferred Alternative

The alternatives presented in Section 5 were reviewed by CVCC staff and a rail expert from the CDFW[6]. Based on this input, the preferred alternative was based on Topography Alternative 2, Water Delivery Alternative 1, and Outflow Alternative 2. In general, the preferred alternative includes a fairly flat basin bottom with abundant microtopography with a sub-basin in the northwest corner to control water inflows (Figure 6-1). Outflows will flow downhill to a pond on CVCC's southern property.

It was decided that microtopography is important for rails as it would tend to increase habitat heterogeneity, which probably allows for more niches for foraging and nesting. The sub-basin was chosen as it was deemed to be the most cost-effective method for controlling water delivery while maintaining good water quality. Using the basin to the south to receive outflow was preferred due to its more ideal size for the assumed flows it would receive.

6.1 Final Design Considerations

The design for the preferred alternative includes a range of features explored in the alternative analysis in Section 5 though the details of the design have been fine-tuned compared to those conceptual designs. First, in regards to the microtopography design, the mounds that would have been saturated (un-flooded) areas throughout the pond have been eliminated due to the fact that they would be likely areas for saltcedar to invade. Flooded areas will be considerably less prone to invasion. Saturated habitat will occur around the edges of the pond where monitoring for and removing saltcedar seedlings will be much easier. Also, the depressions in the final design are smaller in area and have a larger range of depths (2-6 inches deep).

Second, the sub-basin was deliberately designed and sized to optimize the amount of water stored. The berms around the sub-basin will be 4-feet higher than the pond bottom elevation. The new diagonal berm will cut off the northwestern corner of the pond and have a 6-foot wide top with 3:1 slopes on both sides. The existing berms may need to be raised slightly to match the 4-foot elevation. The well pump will be used to fill the sub-basin to 3-feet deep and then be shut off. The amount of water flow out of the sub-basin will be controlled depending on season (higher in summer). The pump will re-fill the basin once the water level drops to 1-foot deep. The lower foot of the water column would not be used so that there will always be sufficient head to drive flows by gravity into the pond. A range of sizes and volumes were considered (Table 6-1) for the sub-basin. Different sized structures have different advantages and disadvantages. A larger sub-basin would require less pump cycling and a greater back up reservoir if there is a problem with water delivery. However, the larger basin would also mean longer residency time which could lead to water quality degradation, more evaporative loss due to the larger surface area, more earthmoving and higher construction cost, and less area of target habitat in the pond itself. It was determined that a new berm 50-100 feet long would best optimize the tradeoffs.

Third, slightly deeper areas are included around the water input and outflow points. The former acts as a "plunge pool" to accept inflows without causing erosion or turbidity. The latter allows the pond to be drained more easily if needed.

And finally, the outfall structure was located near the southeastern corner as opposed to north of the receiving basin. This was done to help assure better water circulation by locating the outfall as far

[6] Samantha Przeklasa, nee Haynes, CDFW Environmental Scientist – Salton Sea Program

from in inflow point as feasible. The northeast corner of the pond may have poorer circulation than other areas so water quality monitoring in different areas of the pond may be warranted (*see* Section 8).

Figure 6-1. Schematic of the preferred alternative for Pond 5. The size of the sub-basin and the optimum location for the outflow pipe will need to be determined in future planning steps following more site-specific data collection on soils, elevations, etc.

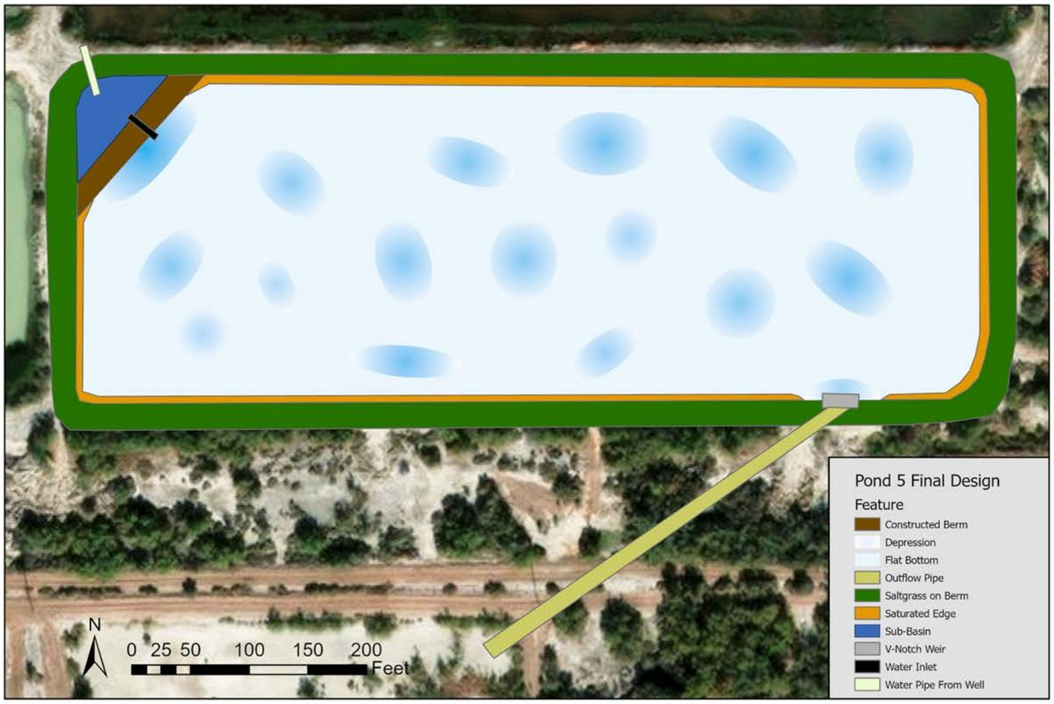


Table 6-1. Size, volume, and pumping frequency of differently sized sub-basins. Daily water requirements in December (minimum) and July (maximum) are 1,446 and 6,407 cubic feet respectively.

Sub-basin Berm Length* (feet)	Basin Area** (acres)	Usable Volume from 1-3 feet (cubic feet)	Hours Between Pump Cycles in July (hours)	Hours Between Pump Cycles in December (hours)
20	0.005	228	1	4
40	0.018	1,301	5	22
60	0.041	3,173	12	53
80	0.073	5,846	22	97
100	0.115	9,319	35	155
150	0.258	21,500	81	357
200	0.459	38,682	145	642

* = The berm will cut off the northwest corner of Pond 5 and have equidistant legs along the existing berms

** = Approximate

Section 7. Implementation Guidelines

This plan does not include detailed engineering or grading plans for the restoration of Pond 5. It is recommended that a "design build" approach be employed using the guidance in this section for the pond bottom. Design drawings will need to be developed in the next stage of planning for the new berms and water control and distribution structures.

Revegetation of the pond and berms will be required after grading and installation of water control structures. This will be accomplished through a combination of seeding and planting. The riparian pilot planting area will also need plants installed and an irrigation strategy.

This guidance in this section is not intended to be exhaustive and is not intended to supplant formal engineering design (if needed) or development of construction plans. It does, however, highlight various considerations relevant to achieving the habitat objectives and allows for construction costs to be estimated.

7.1 Grading and Construction

Prior to the beginning of grading, the pond should be allowed to dry out sufficiently so that heavy equipment can operate easily without sinking in the mud. Grading could occur in any month, but spring and summer should be avoided due to the possibility of bird nesting in the pond. Grading in the winter would raise the small risk of activities being interrupted by rain and muddy conditions. Plants will establish best in the spring and summer so late fall or winter are the preferred times to grade the site. If grading occurs in the fall or early winter, planting and water delivery to the pond could be put on hold until about March.

Some existing wetland plants could be salvaged prior to grading, though it may not be cost effective versus seeding. If plants are salvaged, the priority species would be chairmaker's bulrush and spikerush. Plugs with rhizomes could be dug up by hand and potted or larger chunks could be dug up with a back hoe and put into plastic kiddie pools. Salvaging healthy rhizomes for these species will probably require removing the top 6 inches of soil for spikerush and 8-12 inches for bulrush. Whether in pots or in pools, the plants will need to be kept wet until re-planting occurs.

Grading will include three main tasks: 1) re-contouring the basin bottom, 2) constructing berms to create the sub-basin, and 3) installing water control structures. More detailed guidance on these tasks is included below.

7.1.1 Grading the Basin Bottom

Prior to grading, the vegetation in the pond will need to be largely removed (the existing small cottonwood tree should be protected). Ideally, vegetation should be mowed and the biomass removed from the pond. Ripping and/or disking would break up roots. The goal would be to break up the plant material so that equipment doesn't drag around large chunks of vegetation and interfere with final grading. Following ripping and/or disking, the pond should be graded to a flat surface. Given the goal of keeping the majority of the pond flooded to only about one inch, this flat surface will need to be precisely graded to within an inch of perfectly flat. The absolute elevation of the flat surface is not specified. The edges of the pond should slope very gently towards the existing berms; 2 – 3 inches of elevation gain over about 8 feet. This will provide some un-flooded but saturated habitat areas and keep any berm failures (e.g., due to burrowing mammals) from draining the pond.

Simple percolation tests should then be conducted to see if more compaction of the soil is needed. However, given the high silt and clay content of the soils, extensive compaction will probably not be necessary in order to make the basin pond water. During grading, the existing tile drain should be eliminated.

Once flattened and smoothed, a gannon box can be used to create depressions that are 1 – 4 inches deep. The scale of the depressions should can be determined by what is easy based on the size of the equipment being used, but they should be on the scale of 500 – 1,000 square feet each. The depressions should be spaced apart by at least 40 – 50 feet. The depressions should have very gradual slopes from the basin bottom elevation to their deepest point.

Finally, the areas around the inlets and the outlet should be graded so they are 4-6 inches deep. This will help maintain water circulation and water quality. As with the other depressions, the slopes should be gentle and the features should be sized roughly as shown in Figure 6-1.

7.1.2 Water Delivery and Control Structures

The existing water supply and weir structures in Pond 5 will not be sufficient to maintain desired water levels in Pond 5. The following sections outline the changes that are recommended to meet the stringent water level goals outlined in Section 4.

7.1.2.1 Water Supply

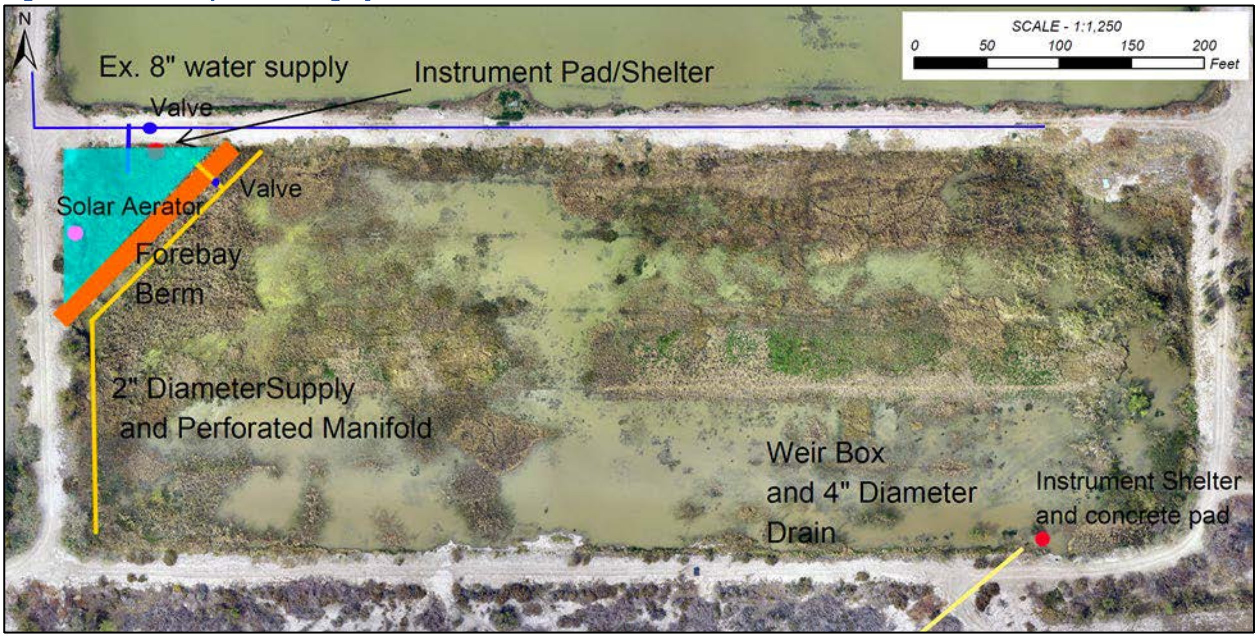
The existing water supply to Pond 5 consists of an 8-inch diameter supply line from a well which is stated as having a capacity of 700 gpm (Wood 2019). A supply line empties into the northwest corner of the pond. The projected water demand for the pond, consisting of the volume required to initially fill it, and to offset evapotranspiration and supply a desired annual total turnover of 17.5 area-inches/year, is detailed in Appendix B.

As presently configured using the 700 gpm pump as the supply would require the installation of a number of new valves to restrict the discharge from the pump solely to Pond 5. Operations staff at the North Shore Ranch have indicated that the 700 gpm pump typically is used to fill multiple ponds simultaneously and that limiting the discharge to a single pond is infeasible because of excessive pressure generated when the discharge is limited to just one pond. It may be possible to develop a scheme to divert water to other ponds while filling the Pond 5 sub-basin in a beneficial way, though this would increase the overall amount of water used in most scenarios. An alternate supply scheme could consist of using the 400 gpm “Bass Pond” pump as the primary supply. Either a new dedicated supply line would be constructed from the pump to Pond 5, or a tie-in to the existing supply line would be required. Either way, water from one well or the other will be used to fill the Pond 5 sub-basin.

The operating scheme is to have the sub-basin serve as a small supply reservoir, shown in Figure 7-1. The pump would fill the sub-basin and water will exit it via a pond supply pipe connected to a perforated manifold. The maximum depth of water within the sub-basin will be 3 feet. The minimum depth will be one foot so as to provide sufficient head for water to flow out through the pond supply manifold at the required rate. Once the water level drops to one-foot, automated controls would immediately activate the pump and it will refill the sub-basin. Water will exit the pond near the southeast corner through a v-notch weir and flow through a drain line to a cell on the south side of 70th Avenue, see Figure 6-1.

Water will exit the sub-basin through the sub-basin berm via a 2” PVC Schedule 80 line. The invert should be located an inch off the bottom and equipped with a 90-degree non-cemented slip fitting 6” long to prevent sediment from entering the pipe. The fitting can be removed to drain the sub-basin. A seep collar should be installed at a position within the horizontal portion of the berm. A manual or automatic valve will be installed on the pond side of the berm. This manifold valve is required to adjust the outflow in order to match evapotranspiration rate as it changes throughout the year. From there, water discharges into the outlet manifold, which consists of a perforated 2" or 3" diameter pipe. The manifold should be elevated 1-2" and rest on a layer of drain rock and must be horizontal to perform as intended.

Figure 7-1. Conceptual design for sub-basin and water control structures in Pond 5.



7.1.2.2 Outlet Weir and Drain

The outlet will be comprised of a weir box to control the water level and a drainpipe. Typically, a weir box is equipped with flash boards that are used to control the pond water level. In this application, however, it is critical that the weir function as a highly accurate flow measuring device. This requires use of a steel or aluminum top "board" of angle iron equipped with sharply beveled surface with the bevel facing the drain[7]. Knowing the depth of water flowing through the weir allows for use of a standard weir formula to compute the flow rate out of the pond.

The average discharge required to attain the target "turnover" of 7.3 acre-feet/year is 0.01 cubic feet/second (cfs). This flow rate is so small that even for just a one-foot-wide weir, the depth of water spilling over the weir would be only 0.02 feet, which is the error range for many water level sensors. We therefore recommend a "90-degree V-notch" weir plate be installed which is far more accurate at low discharge rates. The disadvantage is that they can be more easily affected by debris and changes in discharge more directly affect the water level in the pond. For 0.01 cfs the flow depth at the weir for a 90-degree V-notch is 0.11 feet.

Examples of a commercially available weir box can be seen in Appendix C. The bottom of the V-notch would be installed 0.11 feet below the desired normal water level. To accommodate the risk of settlement and to provide for flexibility should there be a need to raise or lower the target pond water

[7] https://cclynch.com/criteria-for-proper-weir-design

level, the weir plate need only extend a few inches below the notch, with the remainder of the water column blocked by boards or aluminum channel or bars of a thickness representative of the magnitude of anticipated adjustments. Leakage can be addressed by covering with plastic or caulking. The entrance and exit to the drainpipe should be covered with a coarse wire mesh.

An accessible instrument shelter should be installed several feet within the pond to house the water level measurement and communication equipment. A 6'x6' concrete pad should extend out from the weir box to prevent vegetation from fouling the weir plate or interfering with the weir hydraulics and it may be necessary to construct a mesh screen around the pad to prevent vegetation from getting caught in the weir.

Because of the soft soils, settlement of the weir is a concern since it will increase the depth of water flowing over the weir. For this reason, the weir frame elevation should be checked in comparison to a reliable benchmark, at least four times the first year and annually thereafter. A staff gauge should also be installed on the same pad as the weir box to avoid confusion caused by differential settling. It should be located well to the side of the weir notch and should be installed to read the total depth of the water at the pond, and not set at the bottom of the V-notch. The water level sensor should also be located near the bottom of the water column away from the V-notch.

A 4" diameter drain will convey the "turnover" water to the discharge location across 70th Avenue. The pipe should be PVC 2729 or have similar rigidity. Appendix C includes the approximate cross-section for the alignment which connects Pond 5 to the northern most cell across 70th Avenue. There is ample fall (approximately 1.5 feet) for the drain to function but installation of the drain would result in filling in the two drainage ditches it crosses. The pipe should have a minimum of one foot of cover. Inspection of the County of Riverside Transportation Department "County Maintained Road Book," page 234, shows that 70th Avenue between Lincoln and Johnson Streets is not dedicated nor maintained by the county which should allow for the installation of the drain, assuming the project owner is the landowner. Filling of the ditches could create a drainage problem, though these ditches are likely locations for restoration of riparian habitats so any changes in drainage can be addressed as those restoration projects are designed and implemented.

The design 17.5 inches of annual turnover water exiting Pond 5 is equivalent to 7.3 acre-feet of water discharged to the cell across 70th Avenue. That cell has an approximate area of 1.75 acres. Based on the mean annual water balance for the site, the discharge location will evaporate 10.2 acre-feet/year, approximately 40 percent greater than the amount discharged to it each year. Thus, the discharge point is expected to fill with some water during the cooler months but, on average, has the capacity to evaporate all the water discharged to it. Nonetheless, it would be prudent to install a weir box on the downslope berm to pass water into another cell if for any reason the pump failed to shut-off for an extended period or heavy rain increased flows.

7.1.3 Building the Berm to Create the Sub-basin

A new berm will need to be constructed to form the sub-basin. It should be placed such that it intersects the sides of the sub-basin at a 45-degree angle. In cross-section, the berm shall be at least 4 feet high, with an 8-foot top width and 3(H):1(V) sides. A 6-foot top width is sufficient but the 8-foot width is more convenient for construction of the keyway (see below).

The soil at the site is given as a silty clay loam[8]. Its rating for "embankments, dikes, and levees" by the Natural Resources Conservation Service is given as "somewhat limited." The silt content for this

[8] https://websoilsurvey.sc.egov.usda.gov

texture can range from 60-72 percent silt, which affects its bearing strength and can make compaction particularly sensitive to the amount of soil moisture. This could be problematic, especially given the shallow surface water table. Given the known bearing strength limitation and the need for compaction tests, prior to development of construction plans, a soils engineer should be consulted to assess the suitability of the soil for this application and supply recommendations as to the depth and treatment of subgrade, its compaction, and berm construction methods. Likewise, the firm should supply recommendations on thickness and type of foundation for instrument shelters and the weir to prevent settling. Moisture-density laboratory tests of subgrade and proposed berm materials should be conducted to derive compaction curves and provide allowable moisture limits. Since the volume of material required to construct the berm is not yet known, there may be a need to import material, which would again warrant consultation with a soils engineer to assess its suitability. If the material is borrowed from on-site, the top 8 inches should first be removed to avoid the high salt content at the surface.

The following measures represent typical berm construction techniques which may be suitable for construction of the berm but should be confirmed by a soils engineer. They are provided only to illustrate the level of effort typically required to construct a low levee. The footprint of the berm should be excavated to a depth of one foot. The subgrade should then be ripped, moisture conditioned as required and compacted to greater than 90 percent relative compaction. The berm should then be formed through placement of loose lifts not to exceed 8 inches thick and compacted. The ends of the berm shall extend a minimum of three feet into the existing roads on each end. The existing berms that will form the other two sides of the sub-basin should be examined by a geotechnical engineer to assess whether they need to be reinforced or re-built.

A keyway should be excavated on the berm centerline to a depth 18” below the original grade. The width of the keyway will depend on the method used to prevent burrowing animals from breeching the berm. The keyway could consist of either; 1) concrete, 2) sheet piling, or 3) a well prepared and compacted admix of clay, gravel, and drain rock.

The exact size of the sub-basin is somewhat flexible. There is a direct trade-off between the sub-basin size and the number of pump start/stop cycles, which adds wear and tear on the pump. A larger sub-basin reduces net habitat area, but also increases evaporation losses from the sub-basin and increases wave action. For example, if the sub-basin berm were 50 feet long, the active storage would be approximately 2,140 cubic feet. During the warmest period of the year, July and August, the pump would typically have to run 3 times/day. During December, it would require somewhat less than once per day. If the sub-basin berm were 70 feet long, the active volume increases to 4,410 cubic feet, requiring, on average, 1.5 pump cycles/day in July and August, and once every 3 days in December (see Table 6-1 for comparisons to other sizes). A berm length between 50 and 100 feet is probably ideal. There is a direct trade-off between wear on the pump (small sub-basin and more cycling) and initial construction cost (longer berm but less pump cycling).

The interior surface of the berm should be protected from erosion. To avoid the use of a geotextile, the interior face should be first covered with 1-2” of crushed gravel, and then have a single rock layer of drain rock, in the range of 1.5-3” applied over the gravel. The sides of the sub-basin should be evaluated to assess their erosion potential and potential need for a similar treatment. They may be prone to sloughing given the constantly fluctuating water level in the sub-basin. The pond side of the berm should either be faced with gravel or planted with a ground cover that can prevent erosion.

In order to prevent the berm from being breached should the pump fail to shut off, several 8” diameter pipes should be installed at an elevation 1-2 inches above the 3-foot water level limit. The pipes will need to extend down to the pond surface and have rock protection at their outlet. Their combined capacity should be 2 cfs or greater.

The sub-basin will need to have an instrument pad installed to house the water level measuring and communication equipment. At the pond supply valve access should be improved to allow for easy access.

7.3 Instrumentation

Appendix D includes much of the detail needed to help CVCC with the installation of the necessary instrumentation on Pond 5 to automate the delivery of water to the sub-basin and to establish a system to record the water level in the pond and compute and report the discharge rate and total volume of water exiting the pond over any period of interest. This instrumentation is needed to maintain a shallow water level in the pond with a nearly constant outflow rate as described in Section 4 of this plan.

7.3.1 Pump Controls

In concept, the pump control is straight forward; switches are installed at the 1-foot and 3-foot water levels in the sub-basin. When the water level drops below one foot, the switch is activated and a signal is sent to the pump to activate it. Once the sub-basin is filled to a depth of three feet, the high-water-level switch is activated and a signal is sent to the pump to shut it off.

There are two approaches available in installing such a system. One consists of purchasing and installing water level monitoring and communication hardware from specialized vendors such as Stevens Water or Campbell Scientific, among others. Here, a water level sensor in the sub-basin will provide continuous readings stored in a data logger which can then transmit the readings to an internet, cloud-based software system, which would then transmit an “alarm” at the one foot and three-foot water levels to activate and shut off the pump. There are a number of options for the water level instrument, including pressure transducers, ultrasonic sensors, and bubblers. Appendix D gives two examples of such systems. It may be possible that Ranch personnel could set up and operate the equipment at the sub-basin. However, the system still requires installation of equipment at the pump itself to receive and translate the alarm to the pump relay, which, in turn, requires use of personnel with expertise in communications and electrical controls. Such a system may be overkill for the relatively simple needs of the proposed design though.

The second, and simpler, approach would be to construct a dedicated system from standard components. Appendix D includes a description of such a system. The approach uses direct (wired) communication between the sub-basin and the pump to avoid risks of interruption associated with loss of cell phone communication.

In either case, installation of the equipment at the pump is especially critical. It must be “upstream” of any safeguard shut-offs used to protect the pump. Additionally, because of the large amperage needed to operate the pump additional considerations are required. More details can be found in Appendix D.

7.3.2 Outflow Weir Water Level

A water level recorder is required to compute and report the discharge from the pond. This instrument is the basis for determining if the manual manifold valve needs to be adjusted. This instrument consists of several components; an instrument to measure the water level, a data logger, software to record the readings and translate them into discharge rates and outflow volumes, and a modem to transmit the data. Since this instrumentation does not control equipment but merely reports data used in adjusting the manifold valve, an off-the-shelf system is more appropriate. These systems typically allow for multiple inputs into the data logger. Here it might be useful to consider also installing a dissolved oxygen probe in order to assess if anaerobic conditions develop in the pond. Appendix D includes brochures and price quotes for two different systems that could work. Both of these systems allow for the issuance of an alarm to be transmitted. This could serve to alert Ranch personnel that the manifold valve requires immediate adjustment. The water level data can be converted by the data logger via input of the V-notch weir formula to report out the discharge at any time frequency. Typically, the stored data can be downloaded to a spreadsheet. This will be extremely useful in seeing how the pond water level fluctuates in response to the draining and refilling of the sub-basin and the diurnal fluctuation in evaporation rate, and, of course, in reporting the total volume discharged to assess if it matches the target turnover rate.

As stated above, these systems allow for the use of different instruments to measure the water level. The most common three are ultrasonic, pressure transducer, and bubbler. Ultrasonic sensors and pressure transducers typically have an accuracy of +/- 0.02 feet. Ultrasonic sensors do not work well in windy conditions, which can lead to false alarms. Pressure transducers require a vent tube to account for changes in atmospheric pressure and these can be problematic in some circumstances with condensation in the vent tube. They may also be subject to drift if algae or any bio-film accumulates on the pressure plate. In any case, an accuracy of +/- 0.02 feet is insufficient for this application. At the target discharge rate, the stage on the V-notch weir is only 0.11 feet. The range in discharge for that range in stage is 40-50 percent. As a result, these sensors would be inappropriate. The Stevens system quoted uses a pressure transducer to measure the water level and is, therefore, not preferred for use at the weir. Our initial quote for the ISCO recorder was based on an ultrasonic water level sensor, we subsequently received a quote on a bubbler system which is recommended for use here.

A bubbler sensor is the most accurate and can be highly reliable since they typically program a high-pressure purge of the water line to prevent the entry of sediment or the build-up of algae. Most data loggers can accept other brands of water level sensors. For the ISCO system, the reported accuracy for the bubbler is +/- 0.007 feet.

7.4 Revegetation

Once the grading is completed and all the water control structures are installed, the site will need to be revegetated. A combination of direct seeding and planting from nursery stock will be the most desirable approach. Seed could be collected locally for species such as chairmaker's bulrush. Rhizomes could be salvaged or collected on-site and transplanted. Seed and container stock could also be purchased from a nursery that specializes in native plants[9]. Cultivars or horticultural hybrids should be avoided. Nurseries that can provide the location where the source seed was collected are highly preferred in order to help assure plants are indeed wild types. In general, seed should be sourced from collections in the Coachella Valley or greater Salton Sea region to help assure they come from populations adapted to local conditions. This is less important for wetland species such as chairmaker's bulrush, which has seeds that are moved around widely by migrating birds, is unlikely to have any local adaptations due to the constant gene flow from throughout North America.

7.4.1 Pond 5

The goal of the restoration effort is to establish chairmaker's bulrush as the dominant species throughout Pond 5. Introducing this species is best done by seed, though limited plantings of nursery stock or salvaged material could be done. For seeding, directions from the seed supplier should be followed regarding seeding rate and seed treatment (e.g., stratification or pre-soaking). Cold stratification may be important for this species (*see* Marty 2016). In general, expect to seed at a rate of 5-10 lbs./acre. The seed

[9] The California Native Plant Society maintains a list of native plant nurseries here: https://calscape.org/plant_nursery.php

should cost approximately $50 per pound, for an overall seed cost of approximately $1,250 - $2,500. Seed should be distributed by hand throughout the shallowly ponded pond (after treating it as recommended).

The edges of the pond that will be drier than the basin itself should be planted with species such as spikerush, saltgrass, Cooper's rush, spiny rush, and arrowweed. Spikerush and saltgrass could be planted by rhizomes or salvaged material. The other species are best introduced from nursery stock. The goal will be to have dense vegetation on the edges of the pond to discourage invasion by cattail and saltcedar, so dense initial planting may be desirable. The total area of this edge is expected to be between 0.25 and 0.5 acres. If plants were installed on 2-foot centers, this would mean 3,000 to 6,000 plants would be needed (if 3-foot centers were used, the number of plants would be less than half). Wholesale pricing for 1-gallon pots for the target species should cost about $5 each (though some species may cost more than others). Therefore, plant acquisition costs could range from about $6,500 - $30,000 depending on planting density and the actual final area of pond edge habitat that is constructed.

7.4.2 Saltgrass on Berms

Establishing saltgrass on the berms surrounding Pond 5 will help control erosion and likely help decrease turbidity in the pond. The lower edges of the berms inside the pond will be wet enough to support saltgrass. Irrigation will be needed to establish this species higher on the berms and on top of the berms. The existing irrigation system along the berms at the site were historically used to support saltgrass all along the berms. This system could be repaired around Pond 5 or a new system could be installed. Saltgrass is highly resistant to trampling and can handle occasional driving.

Saltgrass spreads somewhat aggressively, mostly via rhizomes. In time, existing patches will spread into irrigated areas, though this could take a few years or more to achieve full cover (~100% absolute cover). Planting can be done from nursery stock or by digging up sections of rhizomes from other areas on site and directly planting into the new areas. Not all plantings using the latter method will establish, but it can be a cost-effective strategy. Seeding and irrigating is also an effective strategy. Seed could be collected on site or purchased. Recommended seeding rates range from 4-10 lbs./acre and commercial seed would cost about $50 per pound. Total cost would be dependent on the total area of berms to be planted or seeded.

7.4.3 Desert Riparian Pilot Project

Riparian trees and understory species can likely be established around the wetland basins using short-term (1-2 years) irrigation. Fremont's cottonwood occurs already on site. Other desert riparian trees such as black willow, honey mesquite, screwbean mesquite, ironwood, and palo verde could also likely be introduced. Understory species such as narrowleaf willow, salt bush, and arrowweed could also potentially be established. All of these species could be introduced from nursery stock in 1-gallon or larger pots. The short-term survival of plantings would be dependent upon irrigation from a sprinkler system, outflow from Pond 5, or both. It would be crucial that a reliable water delivery system is in place prior to planting. Pre-soaking the planting area might help leach some salts out of the soil prior to planting. The trees should be planted in late winter or early spring and watered regularly through at least late fall. At that point, less frequent deep soaks should be used to help encourage deep root growth. Plantings would ideally be weaned off of irrigation by summer, though they would need to be monitored for signs of stress and watered deeply as needed.

7.5 Future Refinements

The design and implementation strategies presented in this section will need to be fine-tuned as data gaps are filled and agencies are consulted about permits. As discussed above, water quality testing on the source water from the well should be carried out. This would identify potential problems that could change the design of the project somewhat. For instance, very low DO levels might mean a bubbler will be necessary to aerate the water. Other factors such as selenium and nutrient levels will help inform the need for different monitoring approaches or the need to use a different water source. Additionally, a soils engineer should be consulted to assess the suitability of the soil on site for construction of the new berm. If, for instance, the soil is not suitable for a 5-foot-high berm, the specs for the sub-basin could be altered so that the soil is usable (i.e., a lower berm and smaller volume of water in the sub-basin). Consultation with regulatory agencies may drive slight changes to the design. For instance, if refinements can lead to less complicated permitting, they may be desirable.

7.6 Implementation Monitoring

A range of things should be monitored during the construction and early establishment phases of the restoration project (the first 6-12 months after breaking ground). After this early phase of monitoring, longer-term monitoring to support adaptive management will phase in (see Section 8). Checking of final grades and water control devices will be needed in order to assure the project meets the specifications laid out in the final construction plans. Having as-built drawings prepared will document any changes between the initial plans and the post-construction conditions.

While vegetation is establishing, the site will require invasive plant species control (see Section 7.4). It will benefit from contingencies for re-seeding if re-vegetation is not successful in all areas. Water delivery and control structures will need fine-tuning to optimize performance during this phase as well. The water control infrastructure may settle over this altering pond depth and turnover rates so its components should be surveyed regularly. A detailed implementation and monitoring plan will need to be developed when the design is finalized.

Section 8. Monitoring and Adaptive Management Framework

Once the implementation phase is completed, the site should be on a good trajectory towards success. To assure the project is successful in the long term, we recommend using an adaptive management approach. Adaptive management is a tool for achieving success where there is uncertainty as to what actions will be needed to accomplish specific goals. Ecological restoration is inherently uncertain. There are usually variables that cannot be controlled or predicted. Designing and implementing the project using an adaptive management approach will lead to better outcomes and help the project meet its goals.

The hallmark of the adaptive management approach is a reliance on streams of data that are regularly analyzed and used to assess progress towards the achievement of performance criteria. Performance criteria related to the project goals (see Section 2) will need to be developed (e.g., percent cover of native species, water depth, use by target species, etc.). Some provisional criteria and an overview of how to develop other criteria are included below. Once the final project design is complete, a Monitoring and Adaptive Management Plan will need to be prepared that identifies success criteria, monitoring protocols to assess progress towards those criteria, and triggers for changing management if progress is not being made.

8.1 Water Monitoring

Assuring that the target hydrologic conditions are met will require monitoring of key components. Water depth needs to be constant and flowthrough needs to be optimized to assure water quality remains good while minimizing the amount of water used overall. The following sub-sections identify preliminary criteria for water levels and water quality based on the Basis of Design (see Section 4) and values from the literature and the consulting teams experience. Management actions should be considered when water level or water quality parameters are outside the target ranges (see Table 8-1). The actions might include repairs, adjustments to water delivery rates, aeration of water in the sub-basin, etc.

Table 8-1. Preliminary water quality parameters with targets and limits.

Water Quality Parameter	Target	Limit	Source
Dissolved Oxygen	> 4 mg/l	0.5 mg/l	EPA 1986
Phosphorus	< 40 *ug*/l	60 *ug*/l	Walker and Havens 1995
Total Dissolved Solids (TDS) (salinity/alkalinity)	< 6 ppt	12 ppt	Howard 1995
pH	~7	6 to 8	McKean & Nagpal 1991
Temperature	< 25 C	35 C	
Turbidity	< 30 NTU	100 NTU	
Selenium	< 1 *ug*/l	2 *ug*/l	CDFW[10]

[10] https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiarpuJnq7wAhXWJTQIHULnBnIQFjALegQIBBAD&url=https%3A%2F%2Fnrm.dfg.ca.gov%2FFileHandler.ashx%3FDocumentID%3D9094&usg=AOvVaw1e3BFKThLeifdDiOp0cvHu

8.1.1 Water Level and Flow Rates

Appropriate pond depth and steady water levels are a crucial aspect of this project. Assuring the target depths are met will require careful monitoring of pond water levels (see Section 7 for the recommended strategy). The initial target for water level should be design depth. Adjustments should be made to the outflow structure if the ponding depth is more than 0.5 inches from the target. Water level fluctuations should also be monitored (water level should be steady). The water delivery design should be adjusted if water levels fluctuate by more than plus or minus one inch from design depth in any one-week period.

The outflow rate should be a constant 0.01 cfs. To maintain this year-round, inflow rates will have to be altered throughout the year to offset extra evapotranspiration in the warm months. Outflow should be monitored using water level data and a data logger as described in Section 7. A camera that uploads images via a modem could also be pointed at the weir, allowing confirmation of the discharge calculated by the water level data logger.

8.1.2 Water Quality

Assuring good water quality is maintained in Pond 5 will be key to it supporting the target species. We recommend a three-part strategy for tracking water quality at the project site: 1) data logger collection, 2) regular field sampling, and 3) annual sampling requiring laboratory analysis. In general, the more data collected the more opportunities there will be to identify problems and use adaptive management to correct them. The following discussion lays out a strategy that balances this desire with the level of effort and cost needed to collect the data. Preliminary target and threshold criteria for the seven most important parameters are included in Table 8-1.

1) Data Logger Collection. The data logger system that will be needed to monitor water depths and flowthrough could also be used for tracking some water quality parameters. A sensor for DO will probably be most important because this parameter usually fluctuates throughout the day and night. Higher DO levels during the day are often due to algae photosynthesizing (and releasing oxygen into the water). Decomposition and respiration reduce DO levels at night. Understanding the fluctuations will be key to managing water delivery to keep DO high enough to support aquatic animals. Monitoring water temperature is not as crucial, but it would be valuable because it has a direct relation to DO (warmer water holds less oxygen). Knowing the temperature of the water would therefore allow for a calculation of percent saturation, which is more useful to know when troubleshooting a potential cause of low DO.

2) Regular Field Sampling. Other important water quality parameters are not as variable on a day to day basis as DO and temperature. Most of these can be measured with handheld instruments. It may be desirable to measure levels in the sub-basin and in multiple locations within Pond 5. If different locations are strongly correlated after the first year of monitoring, the number of locations could be reduced. Recommended parameters include: pH, conductivity/salinity, turbidity, and total phosphates. Routine monitoring should occur monthly from November-March and twice weekly or weekly the remainder of the first year. The data set should be continuously updated and values checked against target criteria. If data loggers are not used, it will be important to standardize the water quality sampling time of day for parameters that vary strongly diurnally (mainly DO, temperature, and pH). To fully characterize the diurnal fluctuation in these parameters during the height of the summer, we recommend monitoring several times in a 24-hour period to capture the diurnal fluctuation. Samples should be taken at standard times, for instance, at midnight, daybreak, noon, and dusk. This information will be useful in understanding how data collected during standard monitoring relates to the daily extremes at the most stressful time of year.

3) Annual Monitoring. Annual monitoring for a larger range of water quality parameters (requiring laboratory analysis) will be important to understand a broader range of potential contaminant and water chemistry issues. Selenium will be the most important of these other constituents because it is harmful to birds and is a known issue in the region. Other constituents might include various potentially toxic chemicals or pathogens. In the first year of the project, this sampling should be done quarterly to identify any issues early on. If there are no issues in the first year, sampling could move to annually and should be done in the summer to be most applicable to conditions for breeding birds (an important life history stage).

8.2 Vegetation Monitoring

A primary goal of this project is to establish vegetation in Pond 5 that will provide breeding and over-wintering habitat for YRR and CBR. Success criteria related to vegetation composition, structure, and cover will need to be developed to ascertain progress towards achieving that goal. We recommend the use of reference sites to develop the success criteria. Sites in the Salton Sea area that support one or, preferably, both species, such as the Dos Palmas Preserve (Figure 8-1), should be used. Data should be collected in areas that are being used for nesting. Data collection should occur in late summer or fall after nesting season but before plants senesce for the winter.

Figure 8-1. One of the constructed basins in the Managed Marsh at the Dos Palmas Preserve. Chairmaker's bulrush is the dominant species in the marsh. Cooper's rush and saltgrass occur along the unflooded edges of the basin.

Examples of the types of data that should be collected include percent cover by species, live and dead stem density by species, stature, species richness, and percent cover of open water and bare ground. The vegetation at reference sites and in Pond 5 should be characterized along randomly located transects and compared to each other. Successful re-vegetation in Pond 5 would mean that the important characteristics are statistically similar to the reference sites. Coordinating this monitoring with managers of the reference sites will be important and the data collected would be of benefit to all managers working on restoring habitat for secretive marsh birds in the region.

After success criteria are met, longer term vegetation monitoring will be important to assure the same vegetation mix is persisting. Eventually, there will be challenges with the build-up of dead plant material. Assessment of dead plant biomass will not be needed in the first few years, but managers should also track this aspect of pond condition to maintain optimum habitat for CBR and YRR.

Vegetation monitoring in restored riparian areas should also be carried out. Having data on survival and growth rates of plantings will help inform future restoration efforts. It also may be useful to develop an experimental approach to irrigating different zones to test the effects of different watering strategies (e.g., less frequent deep soaks versus more frequent shallower watering). Again, this will help with future efforts to restore riparian habitats on the site.

8.3 Vertebrate and Invertebrate Monitoring

We recommend three general types of monitoring for animals. Abundance and diversity of aquatic vertebrates and invertebrates that are potential prey items for YRR and CBR, presence of potential predators on the birds, and monitoring for the birds themselves.

8.3.1 Prey Items

Annual or seasonal surveys of aquatic invertebrates and vertebrates at Pond 5 and reference sites will be useful in assessing project success. Ideally target levels should be developed from several reference sites that currently support breeding CBR and/or YRR. Pond 5 should be monitored using the same protocols. Understanding the changes over time in the abundance and diversity of aquatic prey items post-restoration could help inform management of the site (i.e., should species be introduced?). Further, if the target bird species don’t colonize the restored pond, having data on prey availability could help provide an explanation.

8.3.2 Predators

There is limited information on the predators of/predation rates on CBR and YRR, for adults, eggs, and unfledged chicks. Potential threats include both native and non-native predators. Managers should be concerned with potential predation from terrestrial species due to the relatively small area of the restoration sites (with a high ratio of edge to core). Wildlife cameras within the marsh and on one or more berms may be useful in monitoring predators at the site. Aquatic non-native species such as crayfish and bullfrogs could be a threat, especially to chicks, if they colonize Pond 5. Their presence should be revealed when monitoring prey items, but visual checks for these species could be carried out more regularly. The pond may need to be temporarily drained if either species colonizes.

8.3.3 Monitoring for YRR and CBR

Assessing use by the target species will of course be important. At a minimum, the presence or absence of both species should be monitored throughout the year by a qualified biologist. Ideally, more detailed monitoring of nesting and fledging would be carried out as well. These more intensive efforts would likely need to be coordinated with agency personnel and could also involve academics.

8.4 Future Management Plan

All of the above factors related to water levels, water quality, vegetation, prey, and predators will have direct and indirect effects on the number of birds, nesting attempts, and nesting success and failures in Pond 5. Understanding how these other factors relate to successes and failures will be key for managing Pond 5 into the future. This plan presents a restoration strategy that gives the managers considerable control over water delivery and outlines a robust strategy for monitoring parameters that will be important to habitat suitability. In the early years of the project, it will be important to learn and document how different management actions are changing conditions in the pond for better or for worse. These lessons should eventually be developed into a management plan for Pond 5.

Development of this management plan will be critical to the Pond 5 restoration becoming an effective pilot project. The plan will help CVCC assess the feasibility of future restoration, estimate the benefits to the target birds and other species, and provide guidance for how to restore and manage other ponds at North Shore Ranch for secretive marsh birds.

Section 9. Cost Estimates

The cost estimates presented in Table 9-1 are conceptual and meant for general planning and budgeting purposes. More precise estimates can be developed after the project design is refined and detailed implementation and monitoring plans are competed. These estimates assume CVCC will hire an outside firm to do the work. Some tasks could be implemented more cheaply by using CVCC staff or the Urban Conservation Corp. Costs related to managing the water delivery system are not included in this estimate; CVCC has indicated that its staff at the ranch will do the day-to-day work of monitoring water levels and outflow and adjusting the inflow rate as needed.

Table 9-1. Conceptual cost estimates for constructing and maintaining the Pond 5 restoration project

Task	**Cost Estimate**
Final design and permitting	$50,000 - $75,000
Construction – earthmoving*	$90,000 - $95,000
Construction – revegetation	$10,000 - $40,000
Instrumentation and pump controls	$30,000 - $40,000
5-year maintenance and monitoring	$35,000 - $75,000
Pond 5 management plan	$20,00 - $40,000
Ongoing Costs	**Annual Cost Estimate**
Water (Pond 5 plus riparian & saltgrass irrigation)	$3,000 - $7,000
Weeding (Pond 5 and riparian areas)	$1,000 - $5,000
On-going monitoring	$5,000 - $15,000

* = See Appendix E for a detailed breakdown

Section 10. Environmental Review and Permitting

The restoration projects outlined in this plan will all have clear ecological benefits. The riparian and saltgrass planting projects will not need any environmental review or permits, but the restoration of Pond 5 could. The following is an overview of the potential environmental permitting needs. A more detailed discussion of potential needs related to environmental review and permitting is included in Appendix A.

10.1 Environmental Review

It is expected that the Pond 5 restoration will be categorically exempt from the California Environmental Quality Act (CEQA) as a "Small Habitat Restoration Projects". CVCC would only need to file the appropriate categorical exemption form and file it with the State Clearinghouse. The project will not trigger any type of review under the National Environmental Policy Act (NEPA).

10.2 Federal Permits

A Section 7 permit from the US Fish and Wildlife Service (USFWS) would not be needed as there are no species currently on site covered by the Endangered Species Act. Under current U.S. Army Corp of Engineers guidance, the habitats in Pond 5 are likely not federal wetland waters or waters of the U.S. and a Clean Waters Act Section 404 permit would not be required. While it is expected federal permits would not be needed, it is recommended that CVCC begin consultation with the USFWS regarding a safe harbor agreement. Such an agreement would allow for additional types of ongoing management of Pond 5 and the rest of the property if YRR or other federally protected species colonize the site.

10.3 State Permits

Pond 5 is likely under the jurisdiction of the California Department of Fish and Wildlife (CDFW) so a Section 1600 Lake or Streambed Alteration Agreement may be needed. It is recommended that CVCC conduct an informal consultation with CDFW early in the next phase of planning to better assess whether a permit under Section 1600 will be required. Alternatively, the project may qualify under CDFW's Habitat Restoration and Enhancement Act (HREA) which is a streamlined permitting process for restoration projects that avoids the need for a Section 1600 permit. Appendix E has more details on this program. In addition, no species listed under the California Endangered Species Act were detected in Pond 5; therefore, an Incidental Take Permit from CDFW would not be required. However, listed species have been observed elsewhere on North Shore Ranch so informal consultation with CDFW is warranted. A safe harbor agreement with CDFW is also recommended.

The project is not expected to need any permits from the State Water Resources Control Board (SWRCB). The project will not discharge water into federal waters so a National Pollution Discharge Elimination System permit (which are issued by the SWRCB in California) would not be required. The wetland areas of Pond 5 are likely under the jurisdiction of the SWRCB as Waters of the State so a Waste Discharge Requirements permit may be needed. Since the project would result in enhanced habitat and areas under SWRCB would increase, a permit may not be required. Again, early informal consultation with SWRCB staff is recommended.

10.4 Other Permits

There is potential that a county grading permit for the earthmoving would be required for the Pond 5 restoration. These permits are not always needed for small restoration projects with minimal earthmoving so the project may be exempt from this type of permit. Since the project will not discharge any water off of CVCC properties, it will not need any other type of discharge permit from the Coachella Valley Water District or other local entities. No other potential permitting needs were identified.

10.5 Burn Permits

As discussed in Section 5, it may be desirable to periodically burn off dead vegetation in Pond 5. Burn Permits within Riverside County are typically obtained for waste materials produced entirely from agricultural operations. Only tumbleweeds may be burned, and no other material is allowed, unless required by Fire Agencies through written notice. For prescribed burns used for promoting a healthier environment for plant or animal species or to re-establish native species there are two potential ways to obtain permits to do this burning. The first approach is through a cooperative agreement or contract between CVCC and the fire protection agency. The second approach for burning dead biomass is to utilize California's Vegetation Management Program (VMP). The VMP allows private landowners to enter into a contract with CAL FIRE to use prescribed fire to accomplish a combination of fire protection and resource management goals. The projects which fit within a CAL FIRE unit's priority area (e.g., those identified through the Fire Plan) and are considered to be of most value to the unit and will be a priority. The Unit VMP Coordinator will make the determination as to the suitability of a project for funding through the VMP. When approved as a VMP project, CAL FIRE assumes the liability for conducting the prescribed burn.

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Appendix A

Memo on Permitting and Definitions of Vegetation Communities
From GPA

North Shore Ranch Pond 5 Restoration

Draft Potential Permitting

July 2021

CEQA

The project is eligible for a categorical exemption under Title 14, California Code of Regulations, Division 6 Chapter3, Guidelines for Implementation of the California Environmental Quality Act (CEQA), Article 19, section 15333, "Small Habitat Restoration Projects." The appropriate Categorical Exemption form should be completed and an Notice of Exemption filed with the State Clearinghouse.

Section 1600 Lake or Streambed Alteration Agreement:

Section 1602 of the California Fish and Game Code requires submittal of a Lake or Streambed Alteration Notification to the California Department of Fish and Wildlife (CDFW) for any activity that may substantially divert or obstruct the natural flow or substantially change the bed, channel, or bank of any river, stream, or lake. Streams (and rivers) are defined by the presence of a channel bed and banks and at least an intermittent flow of water; therefore, the project may fall under CDFW jurisdiction.

The CDFW typically requires notification for activities that will be conducted within jurisdictional areas. If a Lake or Streambed Alteration Notification package is needed, a notification package should be submitted to the CDFW. The notification should include a brief description of the project and the ecological reference, an assessment of the projected net increase in aquatic resource functions and services, and other pertinent project information, as required by the CDFW. If warranted, a site visit should be coordinated with the CDFW and other regulatory agencies to facilitate the process. It is important to plan for sufficient time to complete all the necessary consultations and regulatory processes, typically 3 to 6 months.

HREA

The Habitat Restoration and Enhancement Act (HREA) of 2014 (Fish & G. Code §§ 1650-1657) established a permitting process with CDFW for landowners, state and local governments, and conservation organizations seeking to implement small-scale, voluntary habitat restoration projects throughout California. Restoration and enhancement projects approved by CDFW, pursuant to HREA, do not require additional permits from CDFW, such as a Lake and Streambed Alteration agreement or California Endangered Species Act permit. To qualify, HREA projects must meet the eligibility requirements for the state Water Resources Control board's Order for Clean Water Act General Water Quality certification for Small Habitat Restoration Projects (401 SHRP Certification). Eligibility for coverage under this Order would need to meet the following criteria:

- The project is eligible for a categorical exemption.
- The project size will not exceed five acres of a total of 500 linear feet.

- Pre-project authorization by the State Water Board and/or appropriate Regional Water Board
- The project is not a compensatory mitigation project.
- The primary project purpose is habitat restoration.
- The construction period does will not exceed five years.

If the project is required to be permitted by CDFW, there are two permitting pathways defined in the Fish and Game Code:

- Section 1652 is appropriate for projects that have not received 401 SHRP certification. CDFW has 60 days to determine if a 1652 request is complete and eligible for coverage under the HREA.
- Section 1653 - This pathway is appropriate for projects that have received 401 SHRP certification. CDFW has 30 days to determine if a 1653 request is complete and eligible for coverage under the HREA.

This project would qualify under Section 1652 since a 401 Water quality certification would not be required for the project.

Vegetation Management Program for Prescribed Burning

Burn Permits within Riverside County are typically obtained for waste materials produced entirely from agricultural operations. Only tumbleweeds may be burned, and no other material is allowed, unless required by Fire Agencies through written notice. To perform vegetation burning within the project area, a Vegetation Management Program (VMP) is recommended. The VMP is a cost-sharing program that focuses on the use of prescribed fire, and some mechanical means, for addressing wildland fire fuel hazards and other resource management issues on State Responsibility Area (SRA) lands.

The VMP is derived from Senate Bill 1704, authored by then Senator Barry Keene, and ultimately signed by Governor Edmund G. Brown Jr. on July 16, 1980. The original legislation established the basic processes and procedures consistent with the need to manage chaparral-covered and associated lands within California. The laws enacted in support of this program are found in Title 14, California Code of Regulations, Chapter 9.8 Chaparral Management, Sections 1560 to 1569.6. The program is further defined in the Public Resources Code Sections 4461 to 4473, 4475 to 4480 and 4491 to 4494.

VMP allows private landowners to enter into a contract with CAL FIRE to use prescribed fire to accomplish a combination of fire protection and resource management goals. The projects which fit within a CAL FIRE unit’s priority area (e.g., those identified through the Fire Plan) and are considered to be of most value to the unit and will be a priority. The Vegetation Management Program has been in existence since 1982 and has averaged approximately 25,000 acres per year since its inception.

The Unit VMP Coordinator will make the determination as to the suitability of a project for funding through the VMP. When approved as a VMP project, CAL FIRE assumes the liability for conducting the prescribed burn.

Grading

Grading permits are typically required when grading is completed for the construction of buildings and structures. An exemption may be possible for habitat restoration.

Vegetation

Cattail Marsh (*Typha* [*angustifolia, domingensis, latifolia*] Alliance)

Cattail Marshes are dominated by cattail (*Typha domingensis, Typha latifolia* and *Typha angustifolia*). Cattails are an emergent perennial hydrophyte growing up to 1.5 meters tall. This species commonly hybridize when they grow in mixed stands. Cattail is an emergent perennial hydrophyte with a persistent seed bank that allows for rapid colonization of disturbed sites and is most commonly found in semi-permanently flooded freshwater or brackish marshes. Within the project area this community is found within the Pond 5 basin and intermixes with the American bulrush community.

American bulrush Marsh (*Schoenoplectus americanus* Herbaceous Alliance)

California Bulrush Marsh is dominated by American bulrush (*Schoenoplectus americanus*). This community is found in brackish to freshwater marshes, shores, bars and river mouth estuaries. This community appears to dominate edges of marshes adjacent to open water. Within the project area, this community is within the Pond 5 basin and intermixes with the Cattail Marsh community.

Tamarisk Thickets (*Tamarix* spp. Shrubland Semi-Natural Alliance)

Tamarisk thickets are dominated by tamarisk species (*Tamarix* spp.). This community is found along arroyo and lake margins, ditches, washes, rivers, and other watercourses. Emergent trees may be present at low cover, including *Fremont cottonwood* or *Salix* spp. This community is characterized by shrubs less than 26 feet tall. Additional characteristics of this community include a continuous or open canopy, and a sparse herbaceous layer. Within the project area this community is found on the southern and eastern berm surrounding Pond 5.

Salt Grass Flats (*Distichlis spicata* Herbaceous Alliance)

Salt Grass Flats are dominated by salt grass (*Distichlis spicata*). This community is found in coastal marshes and in inland habitats including swales, playas, and terraces along washes that are typically intermittently flooded. Soils are alkaline, often deep, and have an impermeable layer making them poorly drained. Ground surfaces often have salt accumulations when the soil is dry. This community is found on the berm slopes and wetland-upland transition areas surrounding Pond 5.

Appendix B

Water Supply Availability Evaluation Draft Report Version 1

northwest hydraulic consultants

February 26, 2021

NHC Reference 5006291

Coachella Valley Conservation Commission
73-710 Fred Waring Drive, Suite 110
Palm Desert, CA 92260

Attention: **Kathleen (Katie) Brundige, Conservation Program Manager**
Copy to: **Sheri Mayta, Senior Biologist/Restoration Ecologist, GPA Consulting**
Via email: kbrundige@cvag.org

Re: **Development of Draft Restoration Plan for Enhancement of Wetlands Habitat Water Supply Availability Evaluation Draft Report Version 1**

Dear Ms. Brundige:

1 Introduction

This letter provides an initial assessment of water supply needs, reviews water supply options and calculates a cost estimate for water use in the Pilot Study.

2 Water Supply Needs

NHC developed a monthly water balance model to estimate water needs at the site. Given the low target water levels in the proposed wetland, it will have to be modified to a weekly or even daily time-step to be used in assessing operational needs for water delivery.

Based on monthly mean data for precipitation and potential evapotranspiration, and the visual estimate of the discharge rate from the tile drains, 29.04 acre-feet of water would be needed in a typical year to maintain a constant water level in the created wetland. That value includes an annual total of 0.516 inches of seepage loss, equivalent to 4.38 acre-feet.

For the initial year, there would be an additional draw to saturate the soil column and to bring the water level to its target mean depth, which would require an additional 8.09 acre-feet, bringing the first-year water demand to 37.13 acre-feet.

There will likely be rapid accumulation of salts in the proposed wetland because of the average of 72 inches of evaporation/year. In order to maintain an acceptable level of salinity in the wetland, and for other water quality considerations, additional water will be required to replace the salt laden water in the wetland with “fresh” water. Based on the Dos Palmas Refuge Water Monitoring Report (Wood Environment, 2019), they have an objective of having 17.5 inches of “flow through” for the entire wetland complex. While the precise amount of “flow-through,” “replenishment,” or “turn-over” water will likely only be known through monitoring and adaptive management, based on the Dos Palmas figure, there would be an additional draw of 7.29 acre-feet/year required to maintain water quality in the wetland. This information is summarized below in Table 2.1.

Table 2.1 Average Yearly Water Supply Needs for Pilot Project

Average Yearly Water Supply Needs for Pilot Project	Water Balance +Seepage	Turnover or Flow Through	Saturate Soil Column	Initial Fill	Total (per Year)
Initial Year (acre-ft)	29.04	7.29	7	1.09	44.42
Subsequent Years (acre-ft)	29.04	7.29			36.33

Additional water will be required in dry years. It is reasonable to expect that under severe drought conditions that potential evapotranspiration might increase from 72 to 80 inches, and mean precipitation drop from 2.6 to 0.6 inches, yielding an additional net 10 inches of water demand, equivalent to 4.2 acre-feet.

For comparison, if the site used the 10 acre-ft per acre per year estimated for the nearby IID Rail Habitat site (Wood Environment, 2019), the water needs for the site would be 50 acre-ft. This value can be used as a high end bound for water supply needs and cost estimations.

3 Water Supply Options

During discussions with the team and client, four potential options were identified for water supply: (1) Wells, (2) Groundwater, (3) Agricultural Drains and (4) Colorado River Water from CVWD. The following section looks at the viability and costs associated with these options.

3.1 Wells

The North Shore Ranch facility has three wells on site. The 700 gpm well is currently being used to supply the site and will be available for continued use. The other wells are being used for the nesting pond or are currently out of commission. The preliminary study (Wood Environment, 2019) stated that both of these pumps could potentially be used for the project if necessary and that one of them (the sprinkler well) could be rehabilitated to provide up to 400 gpm of additional capacity.

North Shore Ranch (NSR) provided utility bills from CVWD (RAC) and Imperial Irrigation District (electricity) for a period between 2019 and 2020. NSR pays a $66 per acre-ft RAC fee for pumping of the well. The RAC fee is used by CVWD to fund groundwater replenishment projects in the valley. The cost of electricity (assuming the entire bill was for the well) equates to an average of $15.5 per acre-ft. The total cost per acre-ft of water for use of the existing 700gpm well is then currently $81.5. This figure will vary with the depth to the water table and it would be useful to consider trends in that depth when assessing future pumping costs, along with some estimate of increasing electricity rates. No additional infrastructure is needed at this time to support the well.

3.2 Groundwater

The surface aquifer in this region is high, making it reasonably accessible to provide or supplement water supply. We were informed that the previous landowner (NSR) had tried using groundwater to fill the ponds and had run into issues with water quality, specifically with salinity. There is a potential that the groundwater could be used in a ratio with a clean water supply (irrigation or well) to dilute and supplement. This would be a secondary option if supply becomes a limiting factor. It is unclear if infrastructure is currently in place to access near-surface groundwater at the site. Due to previous issues with salinity, groundwater was not considered a viable alternative at this time.

3.3 Agricultural Drains

Agricultural drains flank the site, with the 0.5 Drain to the South and the Johnson Drain to the West. Through discussions with CVCC it was noted that the drains are environmentally sensitive with endangered pup fish inhabiting drains in this region. Additionally, the drains are not ideal sources for water supply due to potential quality concerns from agricultural runoff and the inability to control availability. The use of the drains as a water source was eliminated from consideration.

3.4 Colorado River Canal Water

NHC explored the option of getting water from a CVWD irrigation lateral. Currently, there is no lateral to the site, with Irrigation Lateral 94.2, approximately 0.75miles to the north of the parcel being the closest source (see attached map from CVWD). CVWD appears to have available capacity for the expected range of water needs. However, verification would be required from a professional engineer.

A new meter, valve and pipeline extension would need to be installed, along with securing easements for access from the northern properties. The extension of the pipeline requires going through tribal land which will need to be coordinated with the tribe and Bureau of Indian Affairs (BIA). An installation agreement would need to be executed with CVWD and coordination with additional landowners and CVWD departments would be required prior to water delivery. All of these items must be paid for by the end water user.

The water use would qualify as a "Class 2" user and the parcel will require an Irrigation Water Availability Assessment (IWAA) charge. As a Class 2 user the water would be subject to the Irrigation Water Commodity Charge ($34.32) plus a Water Supply Surcharge ($67.80) for a total of $102.12 per acre foot (CVWD, 2017). The IWAA charge is based on acreage of the site and would be around $650. A copy of the rate sheet is attached.

Since the cost per acre-ft is higher than for the existing well (see Section 4) and would require a significant investment in time, money and coordination, it was determined that this would not be pursued any further at this time.

3.5 Recommendation

It is recommended that the 700 gpm well pump is continued to be used on the site. If the project expands to additional acreage and water needs surpass the availability of the pump, then other options could be revisited. Repairing the existing pumps is likely the most economical choice at that time, given the high capital costs of extending the lateral.

A quick check to determine the adequacy of the 700 gpm pump was performed to see how many hours a day the pump would have to operate, on average, to provide the water needed. The pump would need to run on average 1.04 hours/day to offset the potential evaporation (9.06 inches) during the most intense time of the year (July). This demonstrates that the pump has plenty of additional capacity to service the pilot project.

4 Cost Estimate

A preliminary cost estimate was performed using the preferred water supply from the existing wells, which has a rate of $81.5 per acre-ft. The estimated water costs for the high end (using IID acre-ft estimates) would be $4,075. Using our water balance analysis, the preliminary estimates are $3,620 for the initial year, and $2,961 for subsequent years.

DISCLAIMER

This report has been prepared by **Northwest Hydraulic Consultants Ltd.** for the benefit of **Coachella Valley Conservation Commission** for specific application to the **Development of Draft Restoration Plan for Enhancement of Wetlands Habitat**. The information and data contained herein represent **Northwest Hydraulic Consultants Ltd.** best professional judgment in light of the knowledge and information available to **Northwest Hydraulic Consultants Ltd.** at the time of preparation and was prepared in accordance with generally accepted engineering and geoscience practices.

This document has been prepared by **Northwest Hydraulic Consultants Inc.** in accordance with generally accepted engineering practices and is intended for the exclusive use and benefit of Coachella Valley Conservation Commission and their authorized representatives for specific application to the North Shore Ranch Project near Thermal, CA USA. The contents of this document are not to be relied upon or used, in whole or in part, by or for the benefit of others without specific written authorization

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Senior Hydrologist

Report reviewed by:

UNSIGNED DRAFT BY

Name, Designation(s)
Job Title
Area of Responsibility

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Name, Designation(s)
Job Title
Area of Responsibility

5 Bibliography

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Wood Environment. (2019). *Rail Habitat for CVCC at North Shore Ranch.* Prepared for CVCC.

Coachella Valley Water District's
Canal Water Rates & Charges

(effective July 1, 2017)

Consumptive Rates			
Type of user	**Description**	**Irrigation Water Commodity Charge***	**Water Supply Surcharge***
Class 1	All canal water customers who use Colorado River (canal) water for commercial agricultural activities – i.e., customers who use canal water for the production of agricultural commodities for commercial purposes, including growing crops and raising animals for the commercial production/sale of food, fiber, fuel and other products.	$34.32	$0
Class 2	All other canal customers – i.e., customers who use canal water for: groundwater replenishment, including the District Replenishment Fund; drinking water production; landscape irrigation; recreation; and other activities, including, but not limited to, golf courses, hunting clubs, polo fields and the District Nonpotable Water Fund.	$34.32	$67.80
Construction	Temporary use for construction purposes	$47.41	$67.80

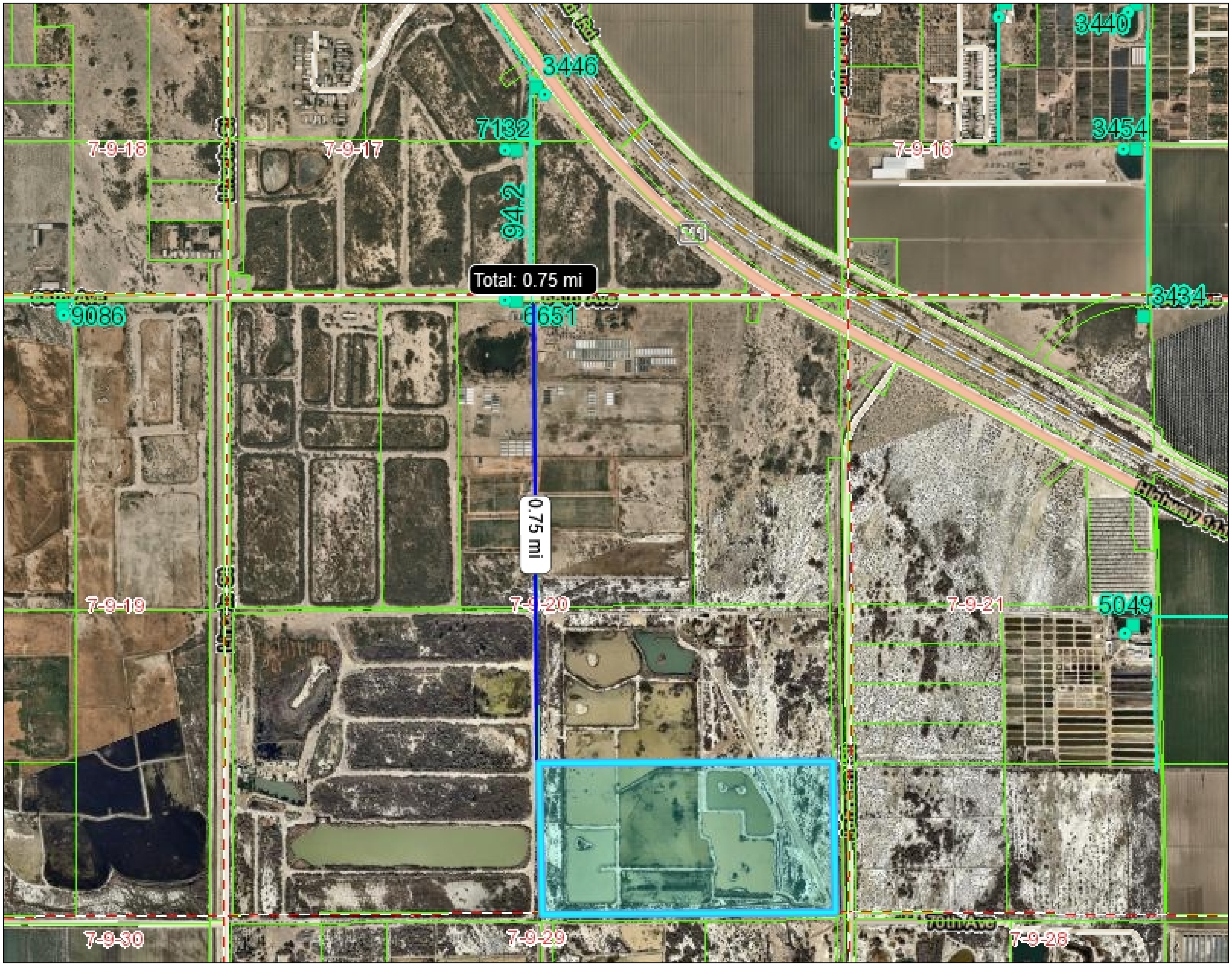
*Rates are per acre-foot, which is equal to 325,850 gallons

Other Consumptive & Miscellaneous Charges	
Quagga mussel mitigation surcharge	$2.78 per acre-foot
Scheduled gate orders	$16.66 per occurence
Unscheduled gate orders	$33.32 per occurence
Surcharge for deliveries outside the boundaries of Improvement District 1	$3.69 per acre per month
Irrigation Water Availability Assessment	3.8 x IWCC x number of acres in the parcel
Account Establishment Fee	$30
Return payment charge	$25

Other restrictions and rates apply where required, and may include a hold harmless agreement and/or various applications where necessary. Fees, charges and services are non-refundable. These rates are subject to rules and regulations as adopted and amended by the Coachella Valley Water District Board of Directors.

Coachella Valley Water District
PO Box 1058, Coachella, CA 92236
(760) 391-9600
www.cvwd.org

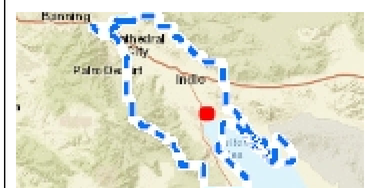
Coachella Valley Conservation Commission



Legend

- Irrigation Delivery Point
- Irrigation Meter
- Irrigation Lateral
- CVWD Boundary
- Township and Range
- Sections
- Riverside Parcels
- Imperial Parcels

Location



Notes

APN 729-040-013

Water Availability from Irrigation Lateral 94.2

Coachella Valley Water District

P.O. Box 1058
Coachella, CA 92236
www.cvwd.org

2505 0 1252 2505

Feet

1: 15,028

N

This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Appendix C

Pond 5 Water Supply and Drain Schematic and Design Guidance Report

northwest hydraulic consultants

June 11, 2021

NHC Reference 5006291

Coachella Valley Conservation Commission
73-710 Fred Waring Drive, Suite 110
Palm Desert, CA 92260

Attention: **Kathleen (Katie) Brundige, Conservation Program Manager**
Copy to: **Sheri Mayta, Senior Biologist/Restoration Ecologist, GPA Consulting**
Via email: kbrundige@cvag.org

Re: **Pond 5 Water Supply and Drain Schematic and Design Guidance**
Report Version 1

Dear Ms. Brundige:

1 Introduction and Overview

NHC, Inc. is providing the following schematic of water supply and drainage features to be considered for incorporation into plans for creation of Rail habitat in Pond 5. This guidance is not intended to be exhaustive and is not intended to supplant formal engineering design and development of construction plans for Pond 5 or the specification and performance of instrumentation. It does, however, highlight various considerations relevant to achieving the habitat objectives.

2 Water Supply

Pond 5 has an existing water supply consisting of an 8-inch diameter supply line from a well which is stated as having a capacity of 700 gpm ("Rail Habitat for CVCC at North Shore Ranch," Wood Environment and Infrastructure Solutions 2019). A supply line empties into the northwest corner of the pond. NHC has previously submitted the projected water demand for the pond, consisting of the volume required to initially fill it, and to offset evapotranspiration and supply a desired annual total turnover of 17.5 area-inches/year.

As presently configured using the 700 gpm pump as the supply would require the installation of a number of new valves to restrict the discharge from the pump solely to Pond 5. Operations staff at the North Shore Ranch have indicated that the 700 gpm pump typically is used to fill multiple ponds simultaneously and that limiting the discharge to a single pond is infeasible because of excessive pressure generated when the discharge is limited to just one pond. An alternate supply scheme could consist of using the 400 gpm "Bass Pond" pump as the primary supply. Either a new dedicated supply line would be constructed from the pump to Pond 5, or a tie-in to the existing supply line would be required.

A berm will be constructed across the northwest corner of the pond which will form a forebay from which water will flow into the pond via gravity. The size of the forebay will be determined by the project owners. In our opinion a forebay in the range of 50-70 foot sides may represent a reasonable tradeoff in terms of construction costs versus the frequency of pump on/off cycles and wear-and-tear on the pump.

The operating scheme is to have the forebay serve as a small supply reservoir, shown in Figure 2.1. The pump would fill the forebay and water will exit it via a pond supply pipe connected to a perforated manifold. The maximum depth of water within the forebay will be 3 feet. The minimum depth will be one foot so as to provide sufficient head for water to flow out through the pond supply manifold at the required rate. Once the water level drops to one-foot, automated controls would activate the pump and it will refill the forebay. Water will exit the pond near the southeast corner through a v-notch weir and flow through a drain line to a cell on the south side of 70th Avenue, see Figure 2.2.

For the system to function, if the existing supply line is used, all laterals from the existing supply line will need to be equipped with valves, and a valve will have to be installed on the other side of the lateral to the forebay to prevent flows into the nesting pond. Obviously, all valves must remain closed to prevent unintended delivery of water to the other ponds.

Water will exit the forebay through the forebay berm via a 2” PVC Schedule 80 line. The invert should be located an inch off the bottom and equipped with a 90-degree non-cemented slip fitting 6” long to prevent sediment from entering the pipe. The fitting can be removed to drain the forebay. A seep collar should be installed at a position within the horizontal portion of the berm. A manual or automatic valve will be installed on the pond side of the berm. This manifold valve is required to adjust the outflow in order to match evapotranspiration rate as it changes throughout the year. From there, water discharges into the outlet manifold, which consists of a perforated 2” or 3” diameter pipe. The manifold should be elevated 1-2” and rest on a layer of drain rock and must be horizontal to perform as intended.

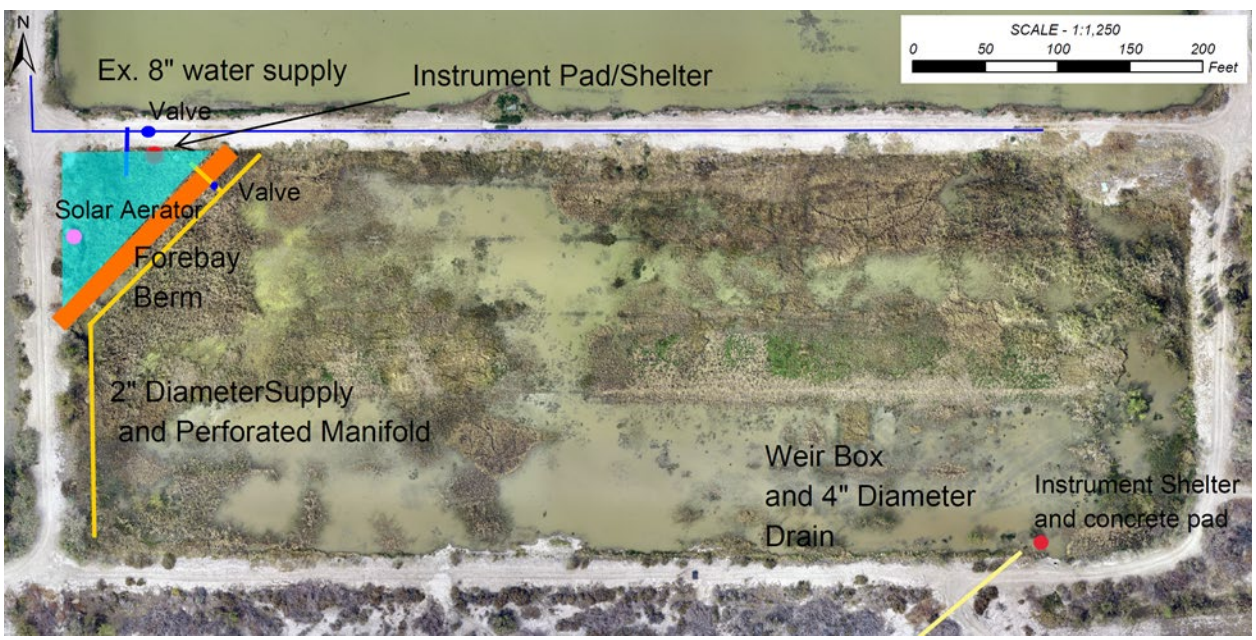


Figure 2.1 Water Supply and Drainage Schematic

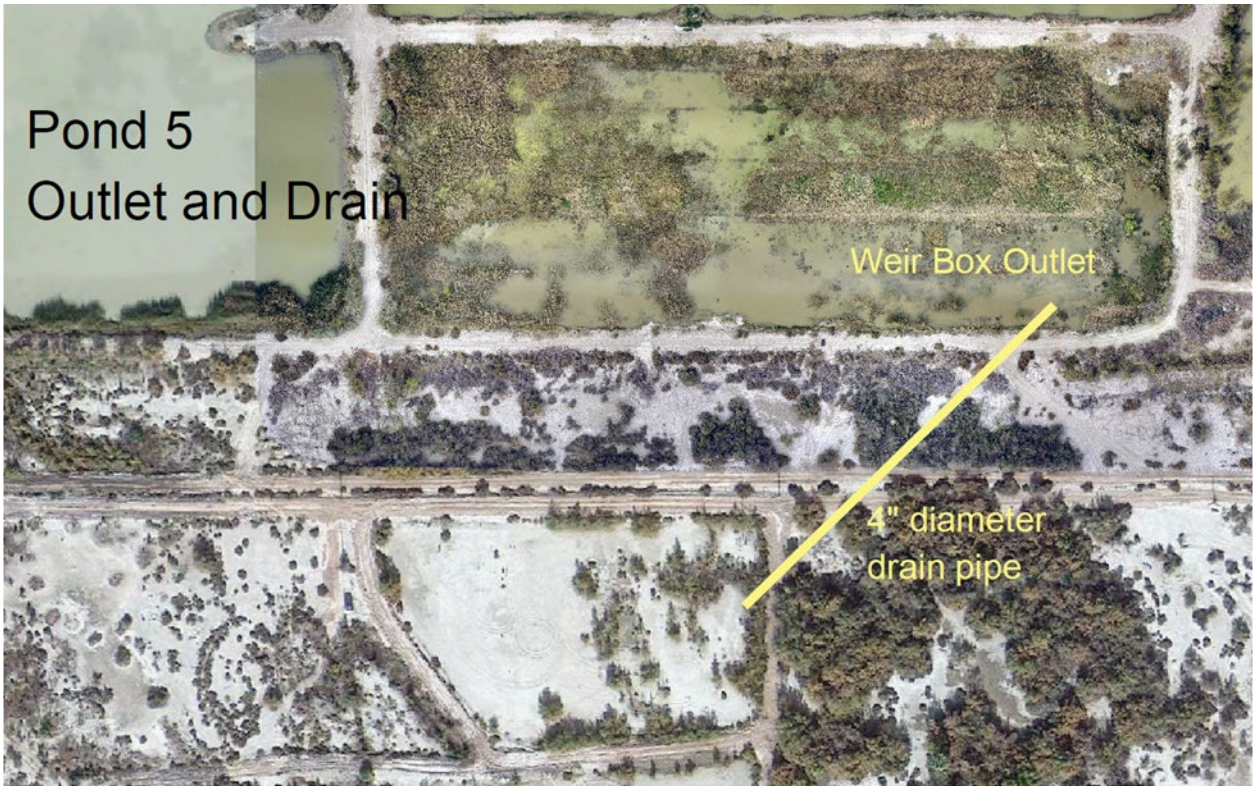


Figure 2.2 Drain Alignment

3 Controls

It is recommended that the supply line to Pond 5 should be equipped with a totalizing volume meter (aka Sparling meter). At the outlet weir, a water level recorder should be installed. Instruments are available which automatically compute and report the total volume of water exiting the pond. Only the water level recorder is needed to compute the total volume of water exiting the pond. However, it may be useful to assess how much water was supplied to assess the degree to which the estimated required annual average water supply conforms to what was actually supplied to the pond.

From an operational perspective, the water level recorder will be used to assess if the water level in the pond is at the level equivalent to achieving the target discharge rate. A staff gauge should be set at the weir such that the water level is at an even 0.01-foot mark when the water level at the weir is level with the top of the weir plate. The weir can be equipped with an instrument to transmit the water level to the internet such that the pond water level is always remotely available. A camera linked to the internet aimed at the staff gauge could also be installed to verify the water level. The manifold valve can then be adjusted accordingly. This computation and adjustment should be performed at least weekly, and we anticipate that daily adjustments may be needed initially to assess the sensitivity of the valve and the degree of water level fluctuation resulting from the constantly changing evaporation and inflow rates. Alternately, a calibrated automated manifold valve could be networked with water level recorder to adjust the valve automatically.

The other required set of controls is to automatically start and stop the pump, based on the maximum water level in the forebay of three feet and the minimum water level of one foot. A concrete pad should be installed on the side of the forebay to locate the instruments. It is critical that the pad not be subject to settling as that will directly impact the water levels which control the pump. A 24-inch diameter culvert mounted on the pad could serve to house the water level switches. A stage gauge set to read 1.00 feet at the low water switch should be installed on the culvert. A platform and shelter mounted over the top of the culvert can house the instrumentation. Redundant high and low water switches should be installed, or a backup alarm could be installed if the water levels exceeded the 1–3-foot bounds. Additionally, at the outlet weir, maximum and minimum water levels within the pond would be specified. Exceedances of those levels would initiate an alarm (e.g., text message) transmitted to the Ranch manager via text message. This would aid in alerting the need to adjust the manifold valve. It could also serve as a further backup alarm to indicate a malfunction in the pump, the pump controls, or the presence of debris caught on the discharge weir. A further backup to prevent the pump from overfilling and breaching the forebay should the normal control mechanism fail to function might consist of a timer to automatically shut off the pump after a given amount of run time.

Flow control will be complex because of the target small continuous discharge into the pond with a low tolerance for water level fluctuations in a setting where there is a 10X range in evaporation rates over the year and a continuously variable supply rate into the pond. A manual supply valve will require considerable time and dedication of Ranch staff to check the water level at the weir (this can be done remotely) and make perhaps iterative fine-tune valve adjustments to achieve the target outflow rate. A motorized supply valve in communication with the weir would, in theory, eliminate much of the personnel time required to maintain the system. However, programming the valve will require a complex algorithm that changes throughout the year. The controlling program must prevent over-correction with respect to the target water level but also be aggressive enough to prevent under-correcting such that the release rate never catches up to the evaporation rate.

Based on conversation with the project owners and the Ranch operations manager on May 27, 2021, they have opted to operate the manifold valve manually. Based on this decision the suggested instrumentation will consist of the following:

- The pump control system
- The pond water level recorder and alarm system
- A totalizing meter on the Pond 5 supply line (optional)

We expect that installation of the instrumentation would be performed by a firm specializing in automated controls of field equipment and that some further commitment might be required to fine tune the control software and monitor its performance. Depending on the system installed, an annual subscription may also be needed to access and download the data from the water level recorder at the weir. Specific information on instrumentation and vendors is provided separately.

4 Forebay Berm

The berm shall be placed such that it intersects the sides of the forebay at a 45-degree angle. In cross-section, the berm shall be at least 4 feet high, with an 8-foot top width and 3(H):1(V) sides. A six foot top width is sufficient but the 8-foot width is more convenient for construction of the keyway (see below).

The soil at the site is given as a silty clay loam (https://websoilsurvey.sc.egov.usda.gov). Its rating for "embankments, dikes, and levees" by the Natural Resources Conservation Service is given as "somewhat limited." The silt content for this texture can range from 60-72 percent silt, which affects its bearing strength and can make compaction particularly sensitive to the amount of soil moisture. This could be problematic, especially given the shallow surface water table. Given the known bearing strength limitation and the need for compaction tests, prior to development of construction plans, a soils engineer should be consulted to assess the suitability of the soil for this application and supply recommendations as to the depth and treatment of subgrade, its compaction, and berm construction methods. Likewise, the firm should supply recommendations on thickness and type of foundation for instrument shelters and the weir to prevent settling. Moisture-density laboratory tests of subgrade and proposed berm materials should be conducted derive compaction curves and provide allowable moisture limits. Since the volume of material required to construct the berm is not yet known, there may be a need to import material, which would again warrant consultation with a soils engineer to assess its suitability. If the material is borrowed from on-site, the top 8 inches should first be removed to avoid the high salt content at the surface.

The following measures represent typical berm construction techniques which may be suitable for construction of the berm but should be confirmed by a soils engineer. They are provided only to illustrate the level of effort typically required to construct a low levee. The footprint of the berm should be excavated to a depth of one foot. The subgrade should then be ripped, moisture conditioned as required and compacted to greater than 90 percent relative compaction. The berm should then be formed through placement of loose lifts not to exceed 8 inches thick and compacted. The ends of the berm shall extend a minimum of three feet into the existing roads on each end.

A keyway should be excavated on the berm centerline to a depth 18" below the original grade. The width of the keyway will depend on the method used to prevent burrowing animals from breeching the berm. The keyway could consist of either; 1) concrete, 2) sheet piling, or 3) a well prepared and compacted admix of clay, gravel, and drain rock.

The size of the forebay shall be determined by the project owners. There is a direct trade-off between the forebay size and the number of pump start/stop cycles, which adds wear and tear on the pump. A larger forebay provides reduces net habitat area, but also increases evaporation losses from the forebay and increases wave action. For example, if the forebay sides were 50 feet long, the active storage would be approximately 2,140 cubic feet. During the warmest period of the year, July and August, the pump would typically have to run 3 times/day. During December, it would require somewhat less than once per day. If the forebay sides were 70 feet long, the active volume increases to 4,410 cubic feet, requiring, on average, 1.5 pump cycles/day in July and August, and once every 3 days in December.

The interior surface of the berm should be protected from erosion. To avoid the use of a geotextile, the interior face should be first covered with 1-2" of crushed gravel, and then have a single rock layer of drain rock, in the range of 1.5-3" applied over the gravel. The sides of the forebay should be evaluated to assess their erosion potential and potential need for a similar treatment. They may be prone to sloughing given the constantly fluctuating water level in the forebay. The pond side of the berm should either be faced with gravel or planted with a ground cover that can prevent erosion.

In order to prevent the berm from being breached should the pump fail to shut off, several 8" diameter pipes should be installed at an elevation 1-2 inches above the 3-foot water level limit. The pipes will need to extend down to the pond surface and have rock protection at their outlet. Their combined capacity should be 2 cfs or greater.

The forebay will need to have an instrument pad installed to house the water level measuring and communication equipment. At the pond supply valve access should be improved to allow for easy access.

5 Outlet Weir and Drain

The outlet will be comprised of a weir box to control the water level and a drainpipe. Typically, a weir box is equipped with flash boards that are used to control the pond water level. In this application, however, it is critical that the weir function as a highly accurate flow measuring device. This requires use of a steel or aluminum top "board" of angle iron equipped with sharply beveled surface with the bevel facing the drain (https://cclynch.com/criteria-for-proper-weir-design). Knowing the depth of water flowing through the weir allows for use of a standard weir formula to compute the flow rate out of the pond.

The discharge required to attain the target "turnover" of 7.3 acre-feet/year is 0.01 cubic feet/second (cfs). This flow rate is so small that even for just a one-foot-wide weir, the depth of water spilling over the weir would be only 0.02 feet, which is the error range for many water level sensors. We therefore recommend a "90-degree V-notch" weir plate be installed which is far more accurate at low discharge rates. The disadvantage is that they can be more easily affected by debris and changes in discharge more directly affect the water level in the pond. For 0.01 cfs the flow depth at the weir for a 90-degree V-notch is 0.11 feet.

Examples of a commercially available weir box is attached. The bottom of the V-notch would be installed 0.11 feet below the desired normal water level. To accommodate the risk of settlement and to provide for flexibility should there be a need to raise or lower the target pond water level, the weir plate need only extend a few inches below the notch, with the remainder of the water column blocked by boards or aluminum channel or bars of a thickness representative of the magnitude of anticipated adjustments. Leakage can be addressed by covering with plastic or caulking. The entrance and exit to the drainpipe should be covered with a coarse wire mesh.

An accessible instrument shelter should be installed several feet within the pond to house the water level measurement and communication equipment. A 6'x6' concrete pad should extend out from the weir box to prevent vegetation from fouling the weir plate or interfering with the weir hydraulics and it may be necessary to construct a mesh screen around the pad to prevent vegetation from getting caught in the weir.

Because of the soft soils, settlement of the weir is a concern since it will increase the depth of water flowing over the weir. For this reason, the weir frame elevation should be checked in comparison to a reliable benchmark, at least four times the first year and annually thereafter. A staff gauge should also be installed on the same pad as the weir box to avoid confusion caused by differential settling. It should be located well to the side of the weir notch and should be installed to read the total depth of the water at the pond, and not set at the bottom of the V-notch. The water level sensor should also be located near the bottom of the water column away from the V-notch.

A 4” diameter drain will convey the “turnover” water to the discharge location across 70th Avenue. The pipe should be PVC 2729 or have similar rigidity. Figure 5.1 shows the approximate cross-section for the alignment which connects Pond 5 to the northern most cell across 70th Avenue. There is ample fall for the drain to function but, as can be seen from the figure, installation of the drain would result in filling in the two drainage ditches it crosses. The pipe should have a minimum of one foot of cover. Inspection of the County of Riverside Transportation Department “County Maintained Road Book,” page 234, shows that 70th Avenue between Lincoln and Johnson Streets is not dedicated nor maintained by the county which should allow for the installation of the drain, assuming the project owner is the landowner. Additionally, since the location where it crosses the road appears to be at or near a high point relative to Johnson and Lincoln streets, filling of the ditch should not create a drainage problem.

The design 17.5 inches of turnover water exiting Pond 5 is equivalent to 7.3 acre-feet of water discharged to the cell across 70th Avenue. That cell has an approximate area of 1.75 acres. Based on the mean annual water balance for the site, the discharge location will evaporate 10.2 acre-feet/year, approximately 40 percent greater than the amount discharged to it each year. Thus, the discharge point is expected to fill with some water during the cooler months but, on average, has the capacity to evaporate all the water discharged to it. Nonetheless, it would be prudent to install a weir box on the downslope berm to pass water into that cell if for any reason the pump failed to shut-off for an extended period.

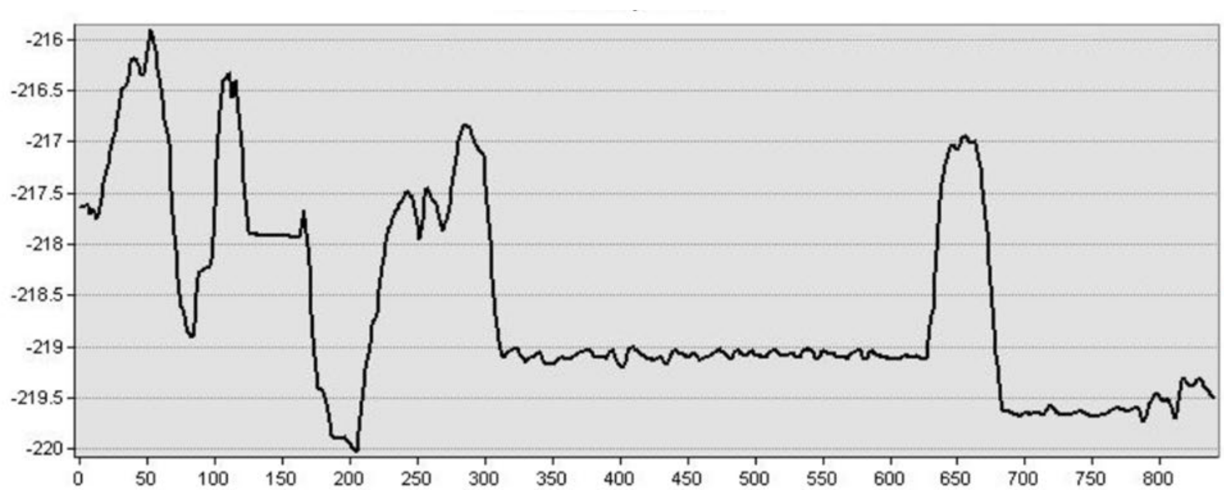


Figure 5.1 Cross-section of drain alignment exiting to northern most cell south of 70th Avenue.

6 Water Quality

Given the low pond depths and high temperatures during much of the year, maintaining acceptable dissolved oxygen levels is expected to be a challenge. It is recommended that the forebay be equipped with a solar powered aerator to increase dissolved oxygen levels of water released to the pond. However, it should operate by pumping and releasing air through tubes at the bottom of the forebay, as opposed to creating a fountain or spray which will vastly increase evaporation losses. Dissolved oxygen and turbidity sensors can be added to the water level measurement instrumentation at the weir and programmed to issue an alarm if levels exceed acceptable ranges.

7 Cost Estimate

A cost estimate for installation of the forebay and associated infrastructure is provided on a separate spreadsheet. It is an estimate only. Labor rates are approximate Davis-Bacon wage rates and equipment rates are based CALTRANS equipment rental rates for 2021. We envision that construction of the infrastructure and installation of the control equipment would be two separate contracts. The cost estimate is for a berm length of 72 feet, associated with forebay sides of 50 feet. If the sides were increased to 70 feet, the berm length would increase to 100 feet and the estimated infrastructure cost would increase by approximately 39 percent.

The cost estimate assumes no soil or equipment limitations, or lowered construction productivity associated with the silty clay loam soils. However, the cost estimate was intended to be conservative, and includes a 20 percent contingency for unanticipated or under-estimated costs, as well as a 30 percent profit margin for the contractor. Hopefully, the “multiplier-effects” of these two items results in a substantial over-estimation of construction costs.

For the instrumentation, we have gotten some initial cost estimates from instrumentation suppliers and, in one case, cost of full installation of the pump controls. That cost estimate is included in the separate document regarding instrumentation and controls. The Ranch personnel may be able to install and operate “off-the-shelf” systems which are appropriate at the weir and possibly within the forebay but consultation with a hydrologist familiar with field instrumentation is advised. An electrical engineer will be required to design and install the controls at the pump.

DISCLAIMER

This report has been prepared by **Northwest Hydraulic Consultants Ltd.** for the benefit of **Coachella Valley Conservation Commission** for specific application to the **Pond 5 Water Supply and Drain Schematic and Design Guidance**. The information and data contained herein represent **Northwest Hydraulic Consultants Ltd.** best professional judgment in light of the knowledge and information available to **Northwest Hydraulic Consultants Ltd.** at the time of preparation and was prepared in accordance with generally accepted engineering and geoscience practices.

This document has been prepared by **Northwest Hydraulic Consultants Inc.** in accordance with generally accepted engineering practices and is intended for the exclusive use and benefit of Coachella Valley Conservation Commission and their authorized representatives for specific application to the North Shore Ranch Project near Thermal, CA USA. The contents of this document are not to be relied upon or used, in whole or in part, by or for the benefit of others without specific written authorization

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Flashboard Riser 24" W x 24" H

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Appendix D

Overview of Proposed Pond 5 Instrumentation Report

northwest hydraulic consultants

June 11, 2021

NHC Reference 5006291

Coachella Valley Conservation Commission
73-710 Fred Waring Drive, Suite 110
Palm Desert, CA 92260

Attention: **Kathleen (Katie) Brundige, Conservation Program Manager**
Copy to: **Sheri Mayta, Senior Biologist/Restoration Ecologist, GPA Consulting**
Via email: kbrundige@cvag.org

Re: **Overview of Proposed Pond 5 Instrumentation**
Report Version 1

Dear Ms. Brundige:

1 Introduction and Overview

This document is intended to aid the Coachella Valley Conservation Commission in its need to install instrumentation on Pond 5 of the North Shore Ranch to automate the delivery of water to the forebay and to establish a system to record the water level in the pond and compute and report the discharge rate and total volume of water exiting the pond over any period of interest. This instrumentation is needed to maintain a shallow water level in the pond with a nearly constant outflow rate in order to establish habitat for endangered rails.

This document tiers from "Pond 5 Water Supply and Drain Schematic and Design Guidance" (NHC, Inc., June, 2021), which describes how the water delivery and drain infrastructure is designed to function and details what controls are required. A manual valve will control the rate of outflow from the forebay into the pond (manifold valve). Water to the forebay will be supplied by one of the Ranch pumps. Inflow into the forebay will be controlled by an automated pump control to maintain the active storage depth in the forebay from 1-3 feet. The pump will fill the forebay to a depth of three feet, and water will drain by gravity into the pond, as moderated by the manual valve. Once the water level in the forebay recedes to a depth of one foot, the pump is switched on and the forebay is refilled. A V-notch weir will be installed at the outlet. The outflow through the weir will be passive such that water level in the pond will be controlled solely through a manual manifold valve located on the pond side of the forebay berm. Because there on no active controls at the pond itself, line power is not required and solar panels can be used to power the instrumentation.

We obtained product information and price quotes for the instrumentation described below from Stevens and Teledyne ISCO. Unfortunately, the price quotes are security protected and we must forward them directly to you via e-mail. We obtained the services of an electrical engineer to design a system to control the pump. It appears likely that the Stevens instrumentation (or equivalent from another vendor) could serve to transmit water level information from the forebay to the pump, however, further investigation would be required and, in any case, an electrical engineer would be needed to design the communication and control equipment at the pump itself.

Contact Information

- For weir flow meter: Craig Johnson, Clipper Controls, Craig@ClipperControls.com, (844) 880-AHOY x101
- For forebay instrumentation: Fred Holloway, fholloway@stevenswater.com, 800-452-5272
- Forebay and pump controls: David Brach, P.E., brachd@msn.com

2 Pump Controls

In concept, the pump control is straight forward; switches are installed at the one foot and three foot water levels. When the water level drops below one foot, the switch is activated and a signal is sent to the pump to activate it. Once the forebay is filled to a depth of three feet, the high water level switch is activated and a signal is sent to the pump to shut it off.

There are two approaches available in installing such a system. One consists of purchasing and installing water level monitoring and communication hardware from specialized vendors such as Stevens Water, or Campbell Scientific, among others. Here, a water level sensor in the forebay will provide continuous readings stored in a data logger which can then transmit the readings to an internet, cloud-based software system, which would then transmit an "alarm" at the one foot and three-foot water levels to activate and shut off the pump. There are a number of options for the water level instrument, including pressure transducers, ultrasonic sensors, and bubblers. Attached is a brochure obtained from Stevens Water illustrating the product and price using a pressure transducer to measure the water level (2 complete systems are quoted).

It may be possible that Ranch personnel could set up and operate the equipment at the forebay. However, the system still requires installation of equipment at the pump itself to receive and translate the alarm to the pump relay, which, in turn, requires use of personnel with expertise in communications and electrical controls. We have not solicited any quotes on instrumenting solely the pump itself. In general, these forebay systems, in our estimate, provide more capability and flexibility than is required, since the sole objective here is to automate activation and shut-off of the pump. This can be done with simple water level switches commonly used to control the water level in tanks. Furthermore, these systems appear to be cloud-based such that interruption of cell phone service for any reason could disrupt pumping into the forebay.

The second approach would be to construct a dedicated system from standard components. We enlisted the aid of an electrical engineer, David Brach, P.E., with experience in developing automated systems to perform an initial design and provide an estimate of the total cost required to acquire/configure/install and test such a system. Attached is a depiction of the system. Mr. Brach's design utilizes direct communication between the forebay and the pump to avoid risks of interruption associated with loss of cell phone communication. Installation of the equipment at the pump is especially critical. It must be “upstream” of any safeguard shut-offs used to protect the pump. Additionally, because of the large amperage needed to operate the pump additional considerations are required. Mr. Brach states:

On my block diagram you can see that our pump controls are “electrically isolated” from the pump itself. This is important in that large, three-phase AC motors pulling lots of current make for very large EMI/RFI fields and ugly “ground loops” in control systems. We need to avoid those difficulties by not actually “electrically” connecting to the pump. Instead, the system will use Z-wave to give us the air-gap that solves all these issues.

3 Weir Water Level

A water level recorder is required to compute and report the discharge from the pond. This instrument is the basis for determining if the manual manifold valve needs to be adjusted. This instrument consists of several components; an instrument to measure the water level, a data logger and software to record the readings and translate them into discharge rates and outflow volumes, and a modem to transmit the data. Since this instrumentation does not control equipment but merely reports data used in adjusting the manifold valve, an off-the-shelf system is more appropriate. These systems typically allow for multiple inputs into the data logger. Here it might be useful to consider also installing a dissolved oxygen probe in order to assess if anaerobic conditions develop in the pond.

The brochure and price quote from Stevens is applicable. Note that we obtained a quote to use the same system at the forebay and the weir. We have attached an additional quote and brochure for an ISCO flow meter equipped with a bubbler water level sensor. Both of these systems allow for the issuance of an alarm to be transmitted. This could serve to alert Ranch personnel that the manifold valve requires immediate adjustment. The water level data can be converted by the data logger via input of the V-notch weir formula to report out the discharge at any time frequency. Typically, the stored data can be downloaded to a spreadsheet. This will be extremely useful in seeing how the pond water level fluctuates in response to the draining and refilling of the forebay and the diurnal fluctuation in evaporation rate, and, of course, in reporting the total volume discharged to assess if it matches the target turnover rate.

As stated above, these systems allow the use of different instruments to measure the water level. The most common are ultrasonic, pressure transducer, or bubbler. Ultrasonic sensors and pressure transducers typically have an accuracy of +/- 0.02 feet. Ultrasonic sensors do not work well in windy conditions, which can lead to false alarms. Pressure transducers require a vent tube to account for changes in atmospheric pressure and these can be problematic in some circumstances with condensation in the vent tube. They may also be subject to drift if algae or any bio-film accumulates on the pressure plate. In any case, an accuracy of +/- 0.02 feet is insufficient for this application. At the target discharge rate, the stage on the V-notch weir is only 0.11 feet. The range in discharge for that range in stage is 40-50 percent. As a result, these sensors would be inappropriate. The Stevens system quoted uses a pressure transducer to measure the water level and is, therefore, not preferred for use at the weir. Our initial quote for the ISCO recorder was based on an ultrasonic water level sensor, we subsequently received a quote on a bubbler system which is recommended for use here.

A bubbler sensor is the most accurate and can be highly reliable since they typically program a high pressure purge of the water line to prevent the entry of sediment or the build up of algae. Most data loggers can accept other brands of water level sensors. For the ISCO system, the reported accuracy for the bubbler is +/- 0.007 feet.

4 Cost Estimate

All the estimates include the cost of solar panels to power the equipment at the forebay and weir. An estimate to equip and install all instrumentation at the forebay and pump, along with the required equipment at the weir (not installed) is $23,605. This is the sum of the weir water level recorder at the weir, and the complete forebay-pump turn-key controls as provided in the preliminary design by David Brach. The Stevens estimate only applies to the forebay equipment and does not include costs for the communication and switching equipment at the pump nor any installation costs. Further investigation would be needed to determine the total cost for the pump controls if the Stevens system were installed in the forebay. As noted above, the estimate for the design supplied by Mr. Brach does not rely on uninterrupted cell phone service, as appears to be the case with the Stevens equipment.

Table 4.1 Cost Estimate

Item	Cost
Weir water level recorder, w/ bubbler, ISCO	$7,000 (approx. installation not included)
Pump Controls, David Brach, P.E	$16,605 (includes installation and testing)
Forebay water level transmission, Stevens	$3,370 (installation not included)

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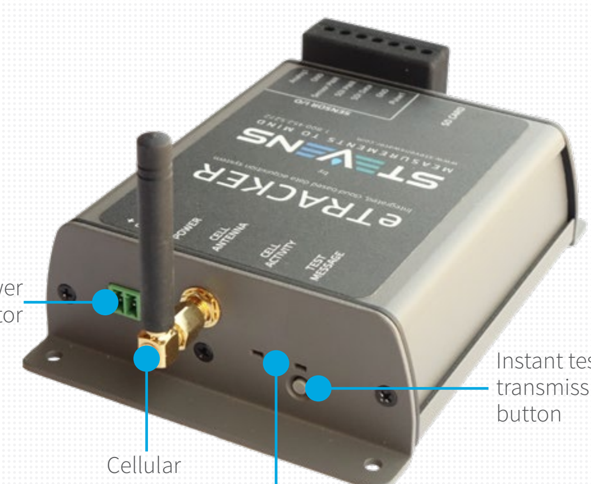
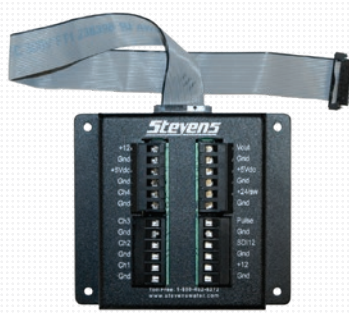
- **Direct data access options**: Third-party programs can access data using REST API or HTTP post.





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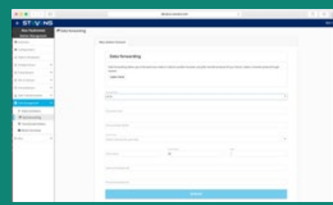
Stevens-Connect provides web-based station management, data access and data processing.

Drag-and-Drop Customizable Dashboard

Configure what data to show and how with dashboard widgets. Place them where you want and stretch to resize. Choose high-visibility single data values, line graphs, bar charts, fuel-gauge style graphs, or 360° directional graphs, for any parameter.

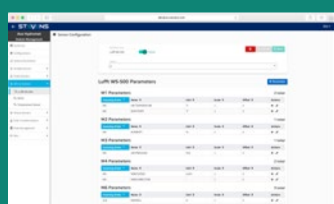


Forward Data to 3rd-Party Software

Stevens-Connect is an easy to use and easily accessible reporting and analysis tool for visualizing your data. However, if you prefer to use other software, data can be automatically formatted and forwarded to an external destination.

Remotely Configure etracker

Configure all aspects of the station including logging and reporting intervals and all analog, pulse and SD-12 sensors. Make changes at any time, from any device.

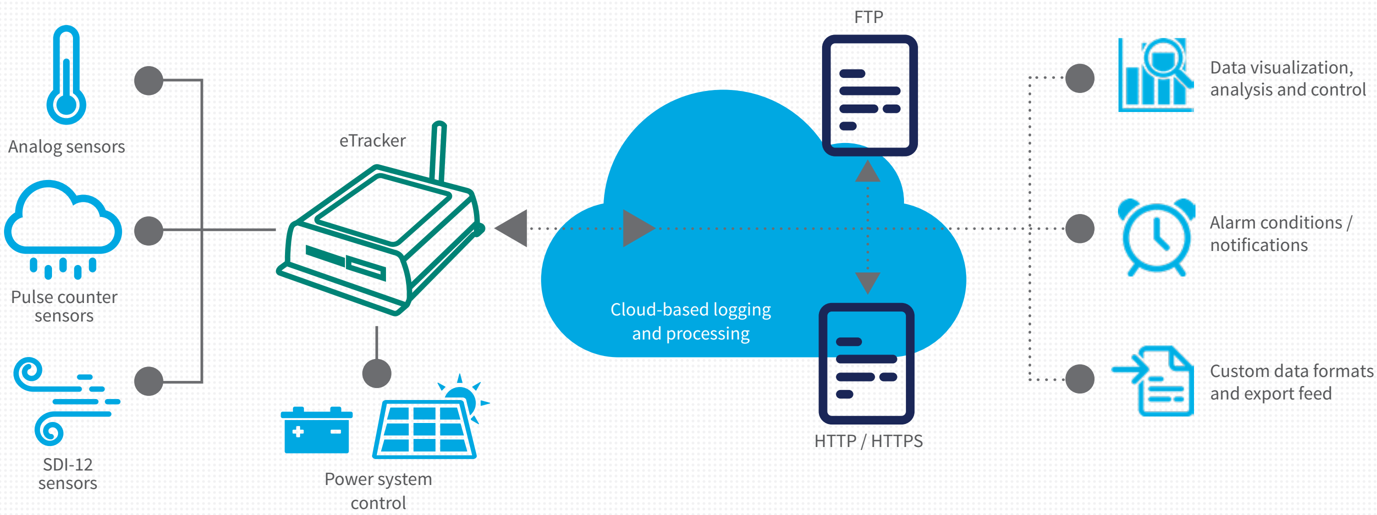


Custom Calculations and Data Transformations

Use the visual formula builder to create simple to complex math functions using any sensor data as variables. Create a “virtual sensor” from this data to create new graphs or serve as inputs to other calculations.

Simple stations.

Interact with your system and data from anywhere.



3 steps to set up your station in minutes.

1 Set up eTracker on Stevens-Connect*

This step can be done anywhere, with any device.

2 Connect sensors

3 Connect power source

TECHNICAL SPECIFICATIONS

GENERAL

Data storage	Removable 2 GB SD memory card (FAT 32)
Logging interval	1 seconds to 12 hours (sensor dependent)
Reporting interval	2 minutes to 12 hours
Cellular antenna	External SMA
Cellular communications	**80060-70A1** (Verizon CDMA) • CDMA band 800, 1900 MHz **80060-70B1** (4G LTE) • LTE bands 700 (B17), 850 (B5), 1700 (B4), • 1900 (B2) MHz • GSM Quad band 700, 850, 1700, 1900 MHz • UMTS/HSPA+ band 850 (B5), 1900 (B2) MHz • GSM | GPRS | EDGE bands 850, 1900 MHz

POWER

Input voltage	10 to 18 VDC (reverse polarity protection)

SENSOR INPUT

Analog input	Up to 4 analog channels, single-ended **Input type**: 2 wire, 0-2.5 V or 4-20 mA current loop (accessible DIP switch) **Sensor power**: 24 VDC switched (under firmware control) **Analog to digital (0-2.5 VDC)**: 21-bit resolution
Pulse input	Up to 4 channels[1] **Continuity or TTL**: 0 V to 2.2 V - 5 V **Maximum rate**: 10 pulses per second
SDI-12 input	**Number of sensors**: up to 62 **Sensor power**: 12 VDC switched, during measurement

ENVIRONMENTAL

Operating temperature	-30°C to 60°C (-22°F to 140°F).
Storage temperature	-40°C to 85°C (SIM Card selection may limit this range for GSM version)
Lightning protection	AC transient voltage suppressor (TVS) on each sensor port input

PHYSICAL

Dimensions	1 3/8" (3.5 cm) x 5 1/8" (13 cm) x 3 3/4" (9.7 cm)
Weight	10.78 oz (305.6 g)

PORTS

Cellular antenna	SMA
Sensor module interface	30-pin connector

INCLUDED

Power cable with flying leads, dipole dual-band cellular antenna.

[1] Sensor capacity is driven by the power model for your system. Sensor power consumption profile in combination with high transmission and logging intervals may require larger solar panels.

eTracker:

A cloud-based management experience

All configuration, data logging, data storage, custom algebraic equations, custom data formats and forwarding, control, analysis, alarm notifications, data visualization, and reporting is **done in the cloud.**

ORDERING INFORMATION

PART #	DESCRIPTION
80060-70B1	eTracker for 4G LTE
80060-70A1	eTracker for Verizon CDMA
80060-502	Mini sensor interface box
80060-505	Full sensor interface box
93777	Antenna, dual-band 900/1900 MHz, 5dB gain, Omni with N female
92824-002	Cable assembly, cell modem to bulkhead, N to SMA, 2 ft.
92845-010	LMR400, N-to-N, antenna cable length per 10 feet
93772	Antenna, 900 Mhz, 70 MHz BW, 11DB, Yagi with N female
93950-108	Antenna, 700-2500 MHz wideband, high gain, log periodic with N female

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SDX

Analog Pressure Transducer

The Stevens SDX (Submersible Depth Transmitter) is a pressure sensor that delivers accurate results while still remaining very affordable for a wide range of level measurement applications.

High impact, corrosion-resistant PVC Type II housing and potted electronics make the SDX extremely durable for most water and hostile fluid environments. The SDX is also an excellent choice for level measurement application that may put more expensive sensors at risk for damage.

The SDX comes equipped with user specified vented cable lengths. The vent provides an atmospheric reference for the sensor, which is necessary for ensuring the highest possible accuracy when making a level measurement.

The SDX features one 4-20 mA analog output signal that corresponds linearly to range. Compatible with existing power and data logging instruments, the SDX can easily be deployed for data collection at remote monitoring sites.

The sensor housing integrates pipe threads for securely mounting the SDX into pipes, tanks, or other applications.

STEVENS

MEASUREMENTS TO MIND

FEATURES

- Rugged housing and fully potted electronics—not damaged by freezing water
- Compact size
- Accuracy of ± 0.25% full span
- Analog output (4-20 mA)
- Vented cable, 2 wire, with drain
- Weighted copper nose cone

APPLICATIONS

- Well Monitoring
- Ground water monitoring
- Surface water monitoring
- Tank level monitoring
- Soil & ground water remediation
- Lake, river, and wetland studies
- Environmental impact and research studies
- Water level for flow calculations

OPTIONAL DESICCANT CARTRIDGE

The SDX is a “Wet-Wet” device. While it is important to keep the SDX cable’s vent tube unobstructed for barometric pressure compensation, neither the pressure transducer nor internal electronics are damaged by condensation or moisture entering the vent tube. For best results, Stevens recommends the desiccant cartridge with vent tube adapter.

TECHNICAL SPECIFICATIONS

Power requirements	9 - 26 VDC
Output	4-20 mA current signal, linearly corresponding to range
Operating temperature	-40° F to 185° F (-40° C to 85° C)
Compensated temperature	32° F to 122° F (0° C to 50° C)
Linearity	0-2.5 ft range: 0.2% max. 0-5 ft range: 0.2% max. 0-10 ft range: 0.2% max. 0-35 ft range: 0.3% max. 0-50 ft range: 0.3% max. (0.1% typical for all ranges)
Repeatability & hysteresis	Typical: ± 0.2% span
Reverse polarity protection	Built into sensor
Overpressure	0-2.5 ft: 20 psi max. (46 ft.) 0-5 ft: 20 psi max. (46 ft.) 0-10 ft: 20 psi max. (46 ft.) 0-35 ft: 45 psi max. (103 ft.) 0-50 ft: 45 psi max. (103 ft.)
Shock	Qualification tested to 150 g
Pipe threading	1/2-14 straight pipe thread (back of sensor housing near cable) 3/8-18 straight pipe thread (under removable copper nose-cone)
Dimensions	4.00” L x 0.84” ∅ (101.6 mm L x 21.33 mm ∅)
Weight	Probe: 2.37 oz (61.19 g) Cable: 0.43 oz (12.19 g) per foot (.4 g per cm) (weights are approximate)

ORDERING INFORMATION

PART #	DESCRIPTION
93720-102	SDX Pressure Transducer, 0-2.5 ft range w/o cable
93720-105	SDX Pressure Transducer, 0-5 ft range w/o cable
93720-110	SDX Pressure Transducer, 0-10 ft range w/o cable
93720-135	SDX Pressure Transducer, 0-35 ft range w/o cable
93720-150	SDX Pressure Transducer, 0-50 ft range w/o cable
44049	Vented cable, 2 wire, with drain
93030-010	Desiccant cartridge with vent tube adapter, 3.9” (10 cm) length
93030-001	Desiccant cartridge with vent tube adapter, 7.8” (20 cm) length

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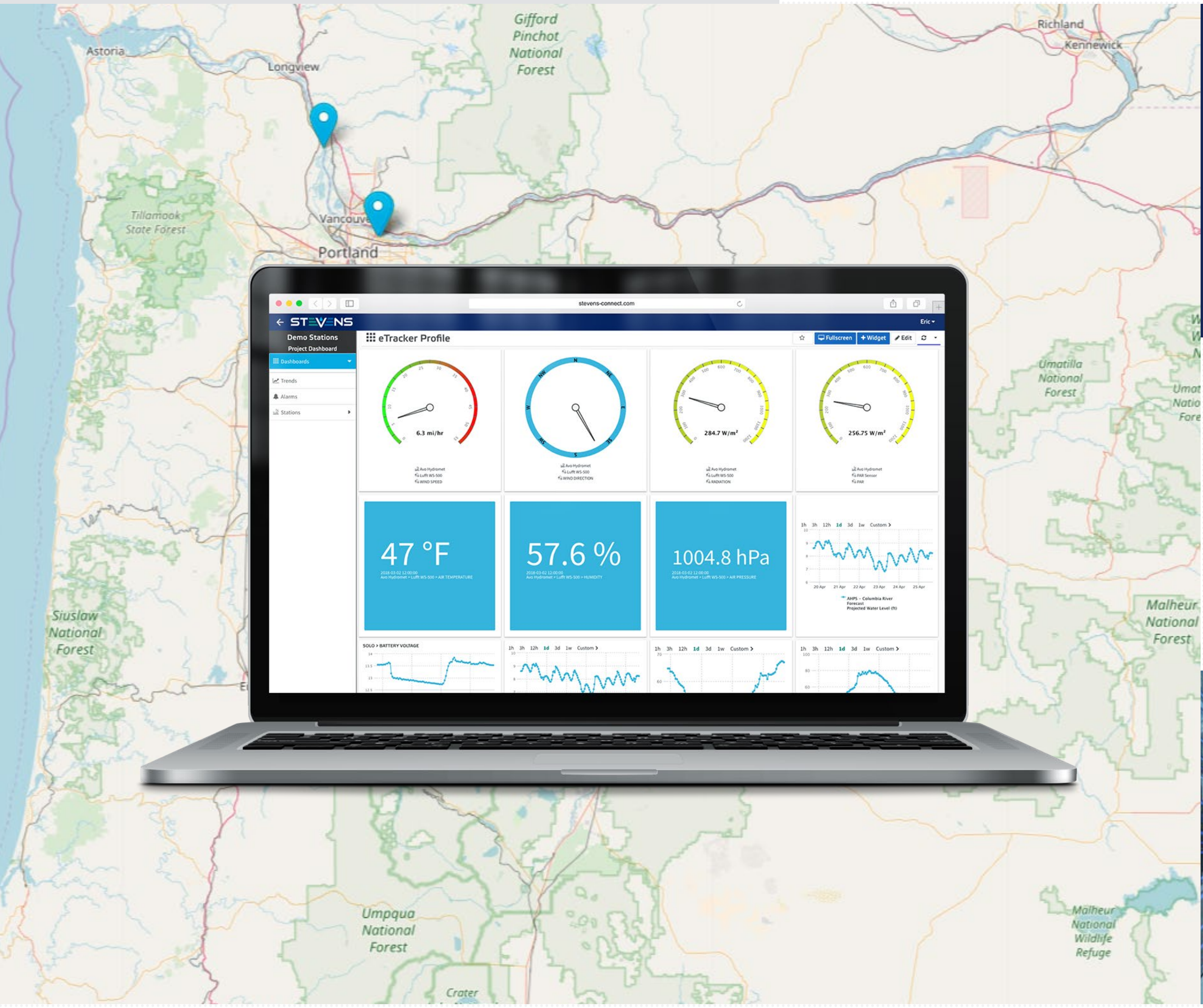
STEVENS CONNECT

STEVENS
MEASUREMENTS TO MIND

Efficient access to remote data anytime, anywhere.



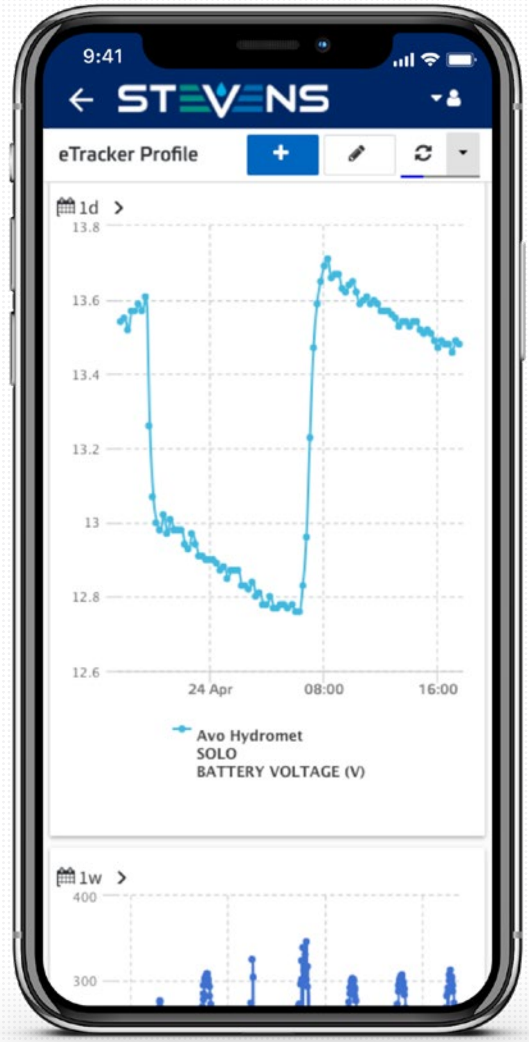
Stevens-Connect is a cloud-based data acquisition and management software system that enables the collection, analysis, reporting, and storage of data from remote monitoring locations. As cloud-based software-as-a-service (SaaS), Stevens-Connect streamlines the data management process and can be accessed from any computer or smartphone with Internet connectivity.

Stevens-Connect manages data from multiple locations and reduces the need for a localized data management software and data collection hardware.

Turn Your Data into Useful Information

Our cloud-based data hub is incredibly powerful and incredibly intuitive. It's used to configure your sensors' logging and reporting settings. It stores and analyzes your data, notifies your smartphone when conditions are met, allows you to visually create custom calculations and "virtual sensors", and it can receive and/or forward data from/to 3rd-party systems.

- Immediate access to data, anywhere, any device.
- Reduced IT requirements: no need for upgrades, transfer to other PCs, uptime maintenance, security.
- No special hardware required, other than a modem at each monitoring location.
- No software to install or reinstall.
- Easily scalable: add additional station data collection when needed. Access data from any number of computers, even simultaneously.
- Data received via cellular (CDMA and GSM) or satellite communications (GOES, Iridium, Inmarsat)
- Custom math functions and calculations
- Selectable calculations
- Data output in XML, Excel, .CSV and other formats
- Alarms
- Map view and integration of external data feeds
- Integrated Report Writers
- REST API supports integration with 3rd-party apps



Stevens-Connect is a cloud-based application that is as much at home on your smartphone as it is on your laptop. You don't need to install an app, just go to stevens-connect.com.

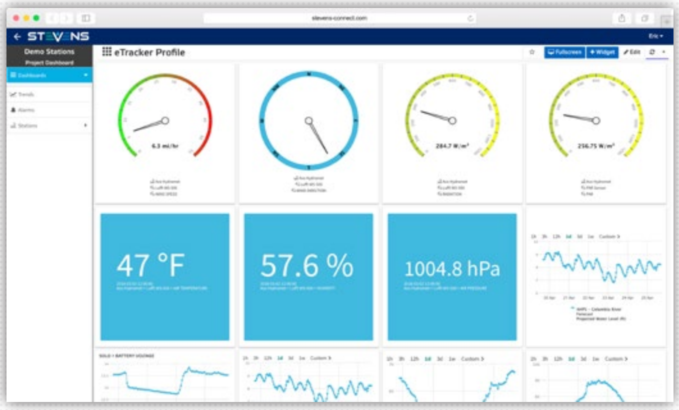
KISTERS

AQUATIC INFORMATICS™

Forward Data to Any 3rd-Party Software

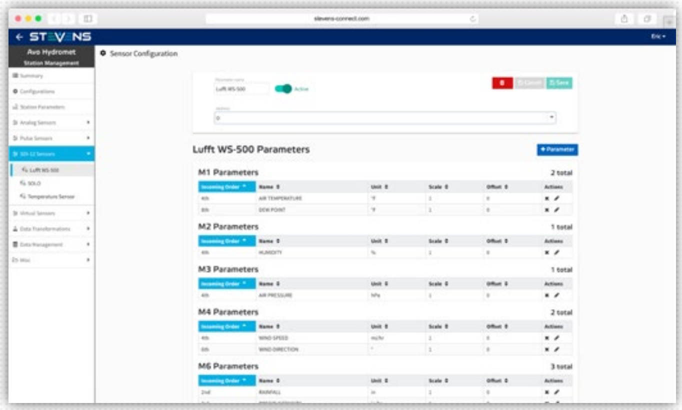
Stevens-Connect is an easy to use and easily accessible reporting and analysis tool, ideal for visualizing your remote data. However, if you prefer to use other software like Aquarius or WISKI, that's no problem: data can be forwarded to another online destination via FTP ot HTTP for use in your software, or you can choose to export the data to work with it in Microsoft Excel.

Cloud-based logging, analysis, reporting, and storage of data from remote monitoring locations.



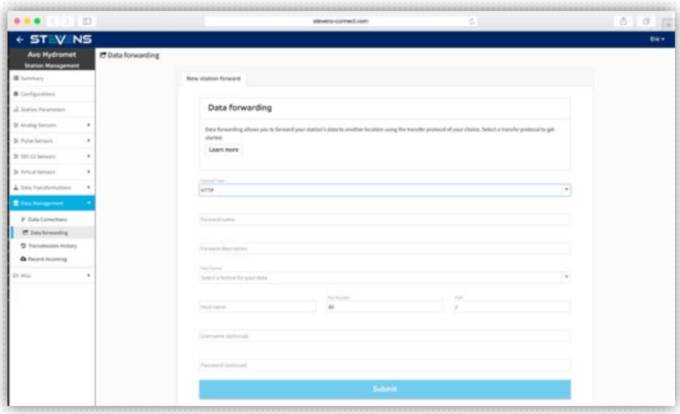
Drag-and-Drop Customizable Dashboard

Configure what data to show and how with dashboard widgets. Place them where you want and stretch to resize. Choose high-visibility single data values, line graphs, bar charts, fuel-gauge style graphs, or 360° directional graphs, for any parameter.



Remotely Configure Remote Avo or eTracker

Configure all aspects of the station including logging and reporting intervals and all analog, pulse and SD-12 sensors. Make changes at any time, from any device. Make changes at any time, even if the station is in low-power (sleep) mode—all changes made will be synced to the remote station when it next connects.



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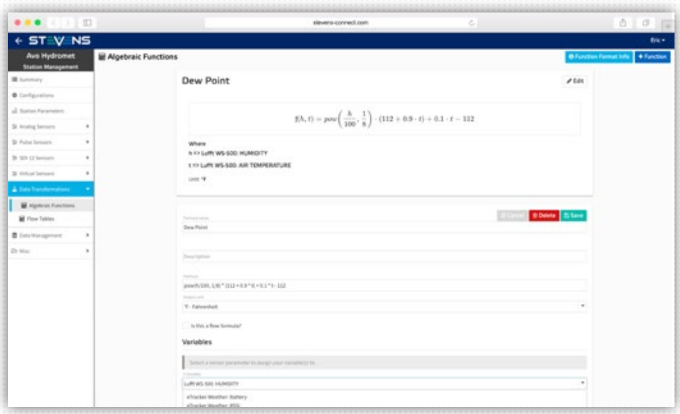

Custom Calculations and Data Transformations

Use the visual formula builder to create simple to complex math functions using any sensor data as variables. Create a "virtual sensor" from this data to create new graphs or serve as inputs to other calculations.

Unique Features

- **True cloud data service**. Data via cellular or satellite networks is sent directly and securely to the Amazon cloud service. No back-end database hosting and web server controlled by Stevens in which data flow takes a detour to the cloud.
- **Web services**. Integrate third party web services for enhance data analysis.
- **Custom Math Functions**. Ability to set up simple to complex algebraic math functions and logic “if” statements using any of the sensor measurements as variables and display the resulting calculate data as separate graphs and data tables.
- **Selectable calculations**. min/max, average, totalization, evapotranspiration, flow, dew point, wind chill, and conversion of raw data.
- **Direct data access options**. Third-party programs can access data using REST, API or HTTP post.
- **Data format flexibility**. Forward data in various formats for 3rd party software platforms, like Aqaurius or WISKI, or in other formats such as pseudo-binary, SHEF, and more.
- **Data output** available in an XML, Excel, .CSV, and many other popular data formats.
- **Automated updates**: Software updates and new features are automatically installed.
- **Alarms**: Automatic alerts from user defined alarm condition for any measurement or calculation can be sent via email or SMS.
- **Security**: Three user access levels for configurations, data management interface, and visualization. Data is stored on the secured and redundant Amazon Cloud service and can be export to other servers using HTTPS (optional FTP).

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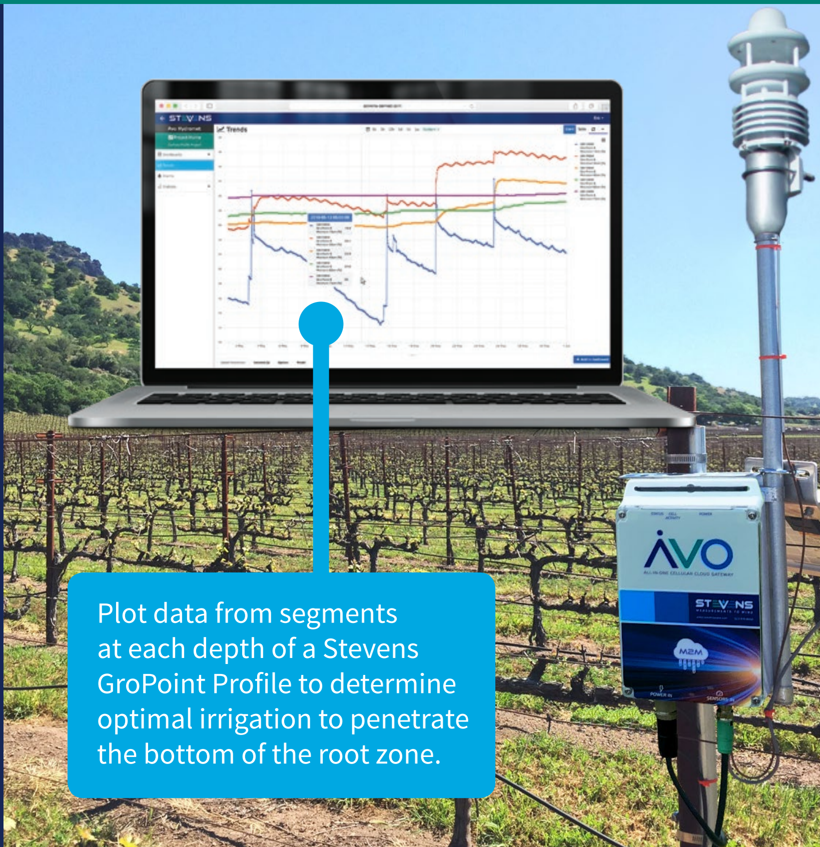
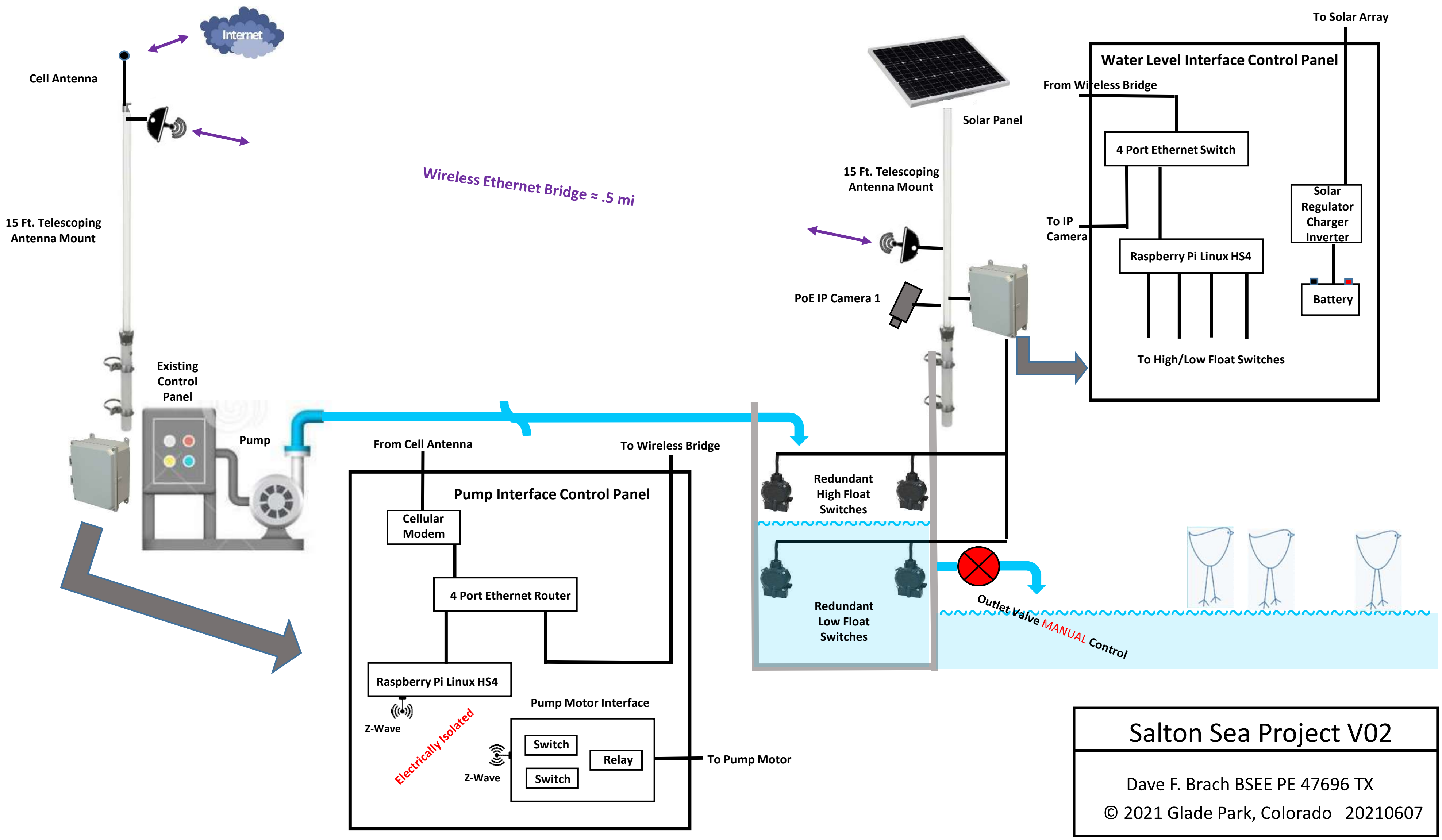




Internet
Cell Antenna
15 Ft. Telescoping Antenna Mount
Existing Control Panel
Pump
Wireless Ethernet Bridge ≈ .5 mi
From Cell Antenna
To Wireless Bridge
Pump Interface Control Panel
Cellular Modem
4 Port Ethernet Router
Raspberry Pi Linux HS4
Z-Wave
Electrically Isolated
Pump Motor Interface
Switch
Relay
Switch
Z-Wave
To Pump Motor
Solar Panel
15 Ft. Telescoping Antenna Mount
PoE IP Camera 1
Redundant High Float Switches
Redundant Low Float Switches
Outlet Valve MANUAL Control
To Solar Array
Water Level Interface Control Panel
From Wireless Bridge
4 Port Ethernet Switch
To IP Camera
Raspberry Pi Linux HS4
Solar Regulator Charger Inverter
Battery
To High/Low Float Switches
Salton Sea Project V02
Dave F. Brach BSEE PE 47696 TX
© 2021 Glade Park, Colorado 20210607

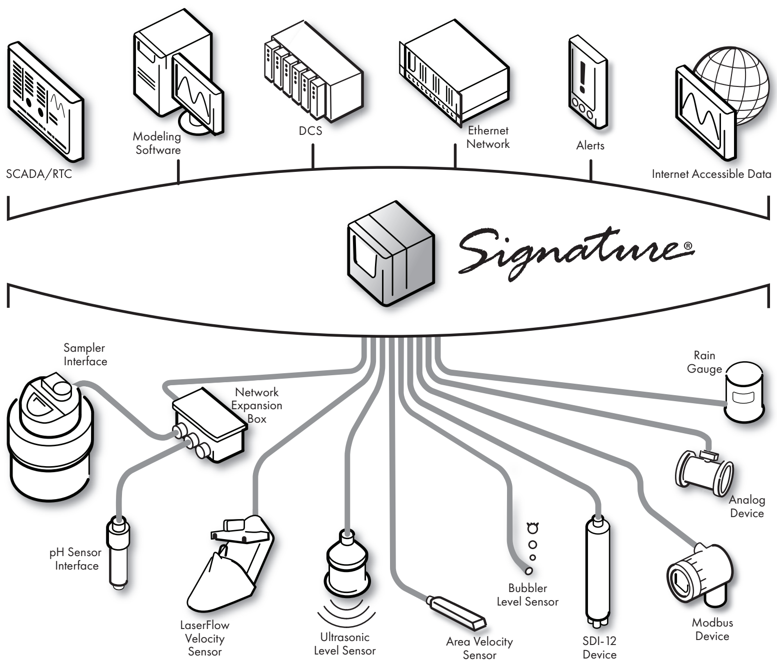
Signature®
Flowmeter

The Signature flowmeter is designed for open channel flow monitoring applications. It supports flow measurement technologies including bubbler, non-contact laser area velocity, submerged Doppler ultrasonic area velocity, and ultrasonic.

A highly flexible monitoring platform, adapting right along with your current need and any future changes in your monitoring requirements.

The meter can calculate flow using standard open channel level-to-flow and area velocity conversions, as well as user defined equations, level to area data points, or level to flow data points, depending on the application needed.

The Signature flowmeter has unique features to verify data integrity. It logs key events such as changes in calibration and power outages to validate data accuracy. Data can be easily reviewed to detect any type of data alteration. With multiple smart interface options and multi-parameter logging (such as pH), the Signature flowmeter provides a common platform for control, action, reporting, and communication.



Signature®

Applications:

- Industrial pretreatment compliance
- Shallow flow measurement in large and small pipes
- Permit enforcement
- Wastewater treatment plants
- Outfall
- Stormwater monitoring

Standard Features

- Multiple parameter data logging
- Program and summary reports
- Triggering, sampler enabling
- Compatibility with Flowlink® software
- Load calculation
- Add, subtract average multiple inputs

Data Collection

Flowlink® Data Analysis
Teledyne ISCO Flowlink® software is a powerful tool for analyzing flow and water quality data. It provides site setup and data retrieval/analysis, as well as advanced reporting and graphing. Flowlink software also gives you the ability to generate site data graphing and reports.

Remote Communication
Remote communication options allow meter configuration and data/report retrieval from remote locations. They also enable the transfer of data to a dedicated server running Flowlink Pro software.

USB Connectivity
With a USB flash drive attached, you can quickly update firmware in the Signature flowmeter and connected TIENet® devices, and download data files for use with Flowlink software. In addition, the USB port provides direct serial connection with a computer running Flowlink software.

Data Integrity
Data Integrity is ensured by logging event data types that can be verified, thereby producing confidence with verifiable data including; Summary, Diagnostic, Program, History and Verify Report files.

Signature Flow Meter

Size (HxWxD):	8.88 x 12.22 x 8.22 in (with mounting bracket) 16.74 x 13.58 x 10.48 in (with stand)
Materials:	PPO Polyphenylene Oxide
Enclosure:	IP66 (self-certified)
Power Required:	100 to 240 VAC 50/60 Hz 12V DC, Lead Acid Battery 12V DC (current consumption varies depending upon configuration)
Cable Entry:	Standard: ¾" NPT conduit Optional: ¾" NPT cord grips
Flow Measurement Technologies:	Ultrasonic (TIENet 310) Bubbler (TIENet 330) Area Velocity (TIENet 350, 360)
Inputs:	Two SDI-12, Two MODBUS ASCII/RTU, pH Measurement (TIENet 301) Analog In (TIENet 307), Rain In
Setup:	Front Panel Keypad-Flowlink Software with serial USB, remote cellular, or Ethernet
Flow Conversions:	Area Velocity, Weir, Flume, British Flume, Metering Insert, Manning Formula, Equation, Level to Flow Data, Points, Level to Area Data Points
Data Storage:	Non-volatile flash; retains stored data during program updates. Capacity: 8M Interval: 15 or 30 seconds; 1, 2, 5, 15, or 30 minutes; or 1, 2, 4, 12, or 24 hours Capacity: 180 days with 5 parameters logged at 1 minute intervals, reports once per day
Data Retrieval:	USB drive, Flowlink Software–with serial USB, remote cellular, or Ethernet
Outputs:	MODBUS ASCII/RTU, Analog (TIENet 308), Contact Output (TIENet 304), SMS Alarm
Sampler Interface:	TIENet 306

Input Options

- Multiple simultaneous flow technologies
- pH and temperature
- SDI-12
- RS-485 Modbus
- Rain gauge
- Analog (optional TIENet® 307 card)

Output Options

- RS-485 Modbus
- Analog (optional TIENet® 308 card)
- Contact (optional TIENet® 304 card)

Available Measurement Technologies

- Bubbler and Ultrasonic
- Non-Contact Laser Velocity
- Continuous Wave Area Velocity

Teledyne ISCO
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Teledyne ISCO is continually improving its products and reserves the right to change product specifications, replacement parts, schematics, and instructions without notice.

L-2151 Rev 2.0
9/18

Appendix E

Cost Estimate: Pond 5 Improvements for Rail Habitat

COST ESTIMATE: POND 5 IMPROVEMENTS FOR RAIL HABITAT

prepared by: Toby Hanes, Northwest Hydraulic Consultants   3-Jun-21

Notes: labor costs are approximate Davis-Bacon wage rates. Equipment rates are approximate from CALTRANS equipment rental rates.
Costs for berm and outlet construction include a 20% contingency and a 30% profit allowance.

Cost estimate for berm construction is for a forebay with 50' sides. The estimated volume and cost associated with 70' sides (100' long berm versus 72' berm is 39% greater than as given below

Hours by Activity by Labor and Operated Equipment

Activities	Laborer	Water Truck	Backhoe	Loader	613 scraper	0 10-yd dump	Roller	Dozer	Excavatc	Tractor	Finish Roller	Grader	Lump
Mobilization,													$3,000
Demobilization													$3,000
Instrument pads, 2	5											4	
Intall Sparling meter with sump box			1										
Link bass pond supply line			3										
Berm, subex 86 yds		3					1	2				1	
On site borrow, 226 yds								4					
Berm placement and compaction 72 ft long, 312 yds		16			16		16	16			12		
supply line, valve and manifold	8								1				
Keyway	8								4				
Spread gravel	12	2						2				1	
Spread drainrock	6							2					
Install weir box	2												
Install drain	12							2	8				
construct instrument shelters	8												
pond grading	16	8						4		24			
Total Hours	77	29	4	0	16	0	17	32	13	24	0	0	

Labor, and Labor Operated Equipment	Hours	Equip Rate	Labor Rate	Total/hr	Lump Sum	Cost
Mobilization					3000	3000
Demobilization					3000	3000
Laborers	77		$58	$58		$4,466
Welders	19		$70	$70		$1,330
Foreman/ with PU	32	$35	$90	$125		$4,000
Grade checker	24		$68	$68		$1,632
Water Trucks	29	$60	$65	$125		$3,625
Rototiller	8	$60	$63	$123		$984
Backhoe	4	$65	$82	$147		$588
D-4 Dozer	32	$65	$82	$147		$4,704
613 Scraper	16	$87	$82	$169		$2,704
Excavator	13	$65	$82	$147		$1,911
Roller	17	$60	$82	$142		$2,414
Finish Grader - gannon box	24	$55	$82	$137		$3,288
					Labor Total	$37,646

Delivered Materials	Quantity	Units	$/unit	Lump Sum	Cost		with optional items
8" Valves?	9	each	$530.00		$4,770		
8" PVC	150	lineal ft	$2.00		$300		
8" Sparling flow meter (Badger via Grainger) (optional)	1			$8,050.00	(optional)		$8,050
2" Sch 80 PVC pipe	40	lineal ft	$2.35		$94		
3" perf pipe	300	lineal ft	$1.20		$360		
2" valve	1	each		$50.00	$50		
Solar powered aerator	1	each		$4,000.00	$4,000		
Forebay instrument shelter	1	misl.		$300.00	$300		
4" rigid sewer pipe	460	lineal ft	$2.00		$920		
Weir Box, Briggs, 24"x24"	1	each		$500.00	$500		
Outlet cement pad	1	each		$250.00	$250		
Outlet equipment shelter	1	each		$300.00	$300		
Sand/cement slurry for keyway	7	cu. Yds.	$97.00		$679		
allowance for standby or pumping				$1,500.00	$1,500		
Concrete for pad	2	cu. Yds.	$120.00		$240		
Gravel facing, 2" thick	16	cu. Yds.	$30.00		$480		
Drain rock for forebay berm face	11	cu. Yds.	$30.00		$330		
Weir angle Iron fabrication and boards	1	each		$120.00	$120		
					Materials	$15,193	$23,243
					Total	$52,839	$60,889
					20% contingency	$10,568	$12,178
					Project Total	$63,407	$73,067
					30 % profit	$19,022	$21,920
				Expected Bid		$82,429	$94,987

APPENDIX XII: DESERT TORTOISE MORTALITY STUDY

Study begins on following page.

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https://doi.org/10.3354/esr01215

ENDANGERED SPECIES RESEARCH
Endang Species Res

Published January 5

High female desert tortoise mortality in the western Sonoran Desert during California's epic 2012–2016 drought

Jeffrey E. Lovich[1,*], Shellie R. Puffer[1], Kristy Cummings[1], Terence R. Arundel[1], Michael S. Vamstad[2], Kathleen D. Brundige[3]

[1]US Geological Survey, Southwest Biological Science Center, Flagstaff, Arizona 86001, USA
[2]National Park Service, Joshua Tree National Park, Twentynine Palms, California 92277, USA
[3]Coachella Valley Conservation Commission, Palm Desert, California 92260, USA

ABSTRACT: We conducted population surveys for desert tortoises *Gopherus agassizii* at 2 nearby sites in the western Sonoran Desert of California, USA, from 2015–2018, during the driest ongoing 22 yr period (2000–2021) in the southwestern USA in over 1200 yr. We hypothesized that drought-induced mortality would be female-biased due to water and energy losses attributable to egg production during protracted periods of resource limitation. At the higher-elevation, cooler, wetter Cottonwood site from 2015–2016, the sex ratio of live adult tortoises was biased toward males and the sex ratio of tortoises estimated to have died during the intensified drought conditions from 2012–2016 was essentially even. At the lower-elevation, warmer, drier Orocopia site from 2017–2018, the sex ratio of live adult tortoises was biased toward males and the sex ratio of tortoises with estimated times of death from 2012–2016 was biased toward females. High female mortality at the Orocopia site may have resulted from the interaction of drought effects and the bet-hedging reproductive strategy of tortoises wherein they continue to produce clutches of eggs in drought years. Annual reproductive output results in an estimated loss of up to 13.5% of female tortoise body mass including over 0.20 l of water. Combined with dehydration during severe droughts, these losses may compromise their ability to survive droughts lasting more than 2 yr. The low tortoise density and high mortality of females observed may reflect reduced survival of tortoises near the southern edge of their range due to climate change, including protracted and intensified droughts.

KEY WORDS: Climate · Drought · *Gopherus agassizii* · Mortality · Sex ratio · Bet-hedging

1. INTRODUCTION

The desert southwest region of North America continues to experience significant and protracted drought. Analysis of soil moisture deficits from tree ring data suggest that the interval from 2000–2021 was the driest 22 yr period in ≈1200 yr (Williams et al. 2022). The ongoing multi-decadal drought is thought to be driven by both natural variability in soil moisture and anthropogenic warming (Diffenbaugh et al. 2015, Williams et al. 2020, 2022). Aridity in the region intensified in California, USA, from 2012–2016, with record-setting low measures of precipitation, high annual temperatures, and the most extreme drought indicators on record (Griffin & Anchukaitis 2014, Diffenbaugh et al. 2015). The years 2012–2016 were essentially a more severe drought within an ongoing multi-decadal megadrought.

Even without the current drought conditions, the Mojave and Sonoran Deserts are the most arid eco-

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systems in North America. Organisms living there have varying degrees and types of behavioral and physiological adaptations (Schmidt-Nielsen 1964, Ezcurra et al. 2014) to the spatially and temporally unpredictable seasonal and interannual water availability characterizing deserts (Noy-Meir 1973). Survival under such extreme environmental conditions is difficult without the additional challenges created by protracted severe droughts that the region is currently experiencing.

The effects of drought on the survival of desert plants and animals vary among species due to differences in their adaptations to resource scarcity and competition (Prugh et al. 2018, Riddell et al. 2021). For example, severe mortality was observed in drought-deciduous shrubs, especially those in the genus *Ambrosia*, in portions of both deserts in 2003, early in the ongoing drought cycle (McAuliffe & Hamerlynck 2010) but following a year with extreme precipitation deficits. Drought has also been implicated in the collapse of the bird community in the Mojave Desert since the early 20th century, with sites losing an average of 43% of their species (Iknayan & Beissinger 2018). In contrast, small mammal communities remained relatively stable during the same time period, perhaps due to burrowing behavior and nocturnal activity (Walsberg 2000) that buffers them against environmental extremes (Riddell et al. 2021). Regionally, Landsat data show large decreases in vegetation cover in the Sonoran Desert of California from 1984–2017 attributable to decreased precipitation and warming summer temperatures (Hantson et al. 2021). Additional environmental impacts of severe drought include increased wildfire risk (Littell et al. 2016) as well as reduced carbon uptake by plants (Schwalm et al. 2012).

Agassiz's desert tortoise *Gopherus agassizii* is a conservation-reliant (Averill-Murray et al. 2012), flagship species that lives in portions of both the Mojave and Sonoran Deserts (Berry & Murphy 2019). Although populations north and west of the Colorado River are protected under the US Endangered Species Act of 1990, the species exhibited significant declines throughout its range from 2004–2014 (Allison & McLuckie 2018), attributable to drought and other factors. Other long-term threats to the continued survival of desert tortoises include habitat destruction and fragmentation, invasive plant species, predation from subsidized predators, fire, and road mortality (Ernst & Lovich 2009, Berry & Murphy 2019). A more recent threat is habitat destruction associated with a buildup of utility-scale wind (Lovich & Ennen 2013) and solar (Lovich & Ennen 2011, Agha et al. 2020) energy development in the desert southwest. The additive and interactive effects of these threats (e.g. drought and fire) can have particularly negative consequences for wildlife populations in the arid southwest region of North America (Lovich et al. 2017).

We studied the demography and reproductive ecology of desert tortoises (hereafter used interchangeably with 'tortoises') in Shavers Valley, California, from 2015–2018 as part of surveys supporting the research and monitoring requirements of the Coachella Valley Multiple Species Habitat Conservation Plan (www.cvmshcp.org/). We were particularly interested in documenting trends in mortality and how they affected population structure, including adult (≥180 mm carapace length, Berry & Murphy 2019) sex ratios.

Several field studies support the importance of drought as a mortality factor in *G. agassizii* populations throughout their range in California and Nevada, including the eastern, central, and western Mojave Desert (Peterson 1994, Berry et al. 2002, Longshore et al. 2003), and the western Sonoran Desert (Lovich et al. 2014a). Protracted drought kills desert tortoises directly through the effects of extreme dehydration (Berry et al. 2002), or indirectly through the phenomenon of 'prey switching'. The latter occurs when desert carnivore prey populations, typically rabbits and rodents, decline during droughts, and predators like coyotes *Canis latrans* shift their diets to include desert tortoises that are not typically preferred (see review by Lovich et al. 2014a). In addition, modeling predicts that suitable desert tortoise habitat will be reduced by as much as 88% in the western Sonoran Desert portion of Joshua Tree National Park (JTNP) under a warming, drying climate scenario (Barrows 2011), further emphasizing the negative effects of drought on survival of the species.

Previous studies have not fully examined the possible differential effects of drought on mortality of male and female desert tortoises, although Esque et al. (2010) observed that females were more likely than males to be killed by coyotes during drought. Similarly, other studies involving translocation of desert tortoises found that females were more likely to die than males, but the cause of sex-biased mortality was unknown (Field et al. 2007, Germano et al. 2017). Increasing global temperatures can disrupt population sex ratios in species that have environmental sex determination (Hulin et al. 2009), like the desert tortoise (Lewis-Winokur and Winokur 1995). Biased hatchling sex ratios can lead to mate shortages, reduced population growth, and increased extinction risk, especially when ratios are male-biased (Lovich 1996, Edmands 2021).

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We have conducted field studies on desert tortoises at various locations in the western Sonoran Desert of California for 25 yr (e.g. Cummings et al. 2020, Lovich et al. 1999, 2014a, 2015, 2018, 2020). More recently, we noticed differential mortality of adult male and female desert tortoises that we hypothesized was attributed to drought effects described as 'extraordinary' (Swain et al. 2014) or 'epic' (Berg & Hall 2017) that occurred from 2012–2016, during the ongoing multi-decadal megadrought (Williams et al. 2022). Because some previous studies suggested that female mortality was higher, we hypothesized that in our samples the sex ratio of living adult tortoises would be statistically biased toward males and that the sex ratio of adults estimated to have died during the epic drought of 2012–2016 would be statistically biased toward females. We further hypothesized that drought-induced mortality of females could be caused by water and energy losses attributable to egg production during protracted periods of extreme resource limitation.

2. MATERIALS AND METHODS

2.1. Study sites

Research was conducted at 2 study sites in Shavers Valley, between the Cottonwood and Orocopia Mountains, about 70 km east–southeast of Palm Springs, Riverside County, California. Both sites are part of the hydrographic Salton Trough, a large, low-elevation, tectonic basin (Lovich et al. 2020). Vegetation in the region is typical of the Sonoran Desert ecosystem in southeastern California, as described in more detail elsewhere (Lovich et al. 2018, 2020, Cummings et al. 2020), but general site summaries are provided below. The study sites are approximately 4–5 km apart and separated by Interstate 10, thus isolating the tortoise populations from the possibility of intermingling during our study. Despite their proximity, local differences in topography and their concomitant effects on precipitation, even during the drought, resulted in variation in limited germination of winter annual food plants necessary for desert tortoise survival (Jennings & Berry 2015).

The Cottonwood study site (CoSS) is located in the southernmost portion of JTNP, in an area drained by Shavers Wash, north of Interstate 10 (Fig. 1). The site is characterized by the steep, boulder-strewn, southern versant of the Cottonwood Mountains that meets sloping bajadas (tilted outwash plains at the base of mountain slopes) and arroyos (ephemeral stream channels) running southward toward Interstate 10. The area surveyed encompassed approximately 5.75 km^2. Tortoises occupied elevations from 530 to 780 m. Details of the perennial vegetation are described in the citations in the previous paragraph but included scattered ironwood *Olneya tesota* and blue palo verde *Parkinsonia florida* trees as well as ocotillos *Fouquieria splendens*.

The lower-elevation Orocopia study site (OrSS) is located on the northern versant of the Orocopia Mountains, south of Interstate 10 and JTNP, and to the west of Chiriaco Summit, California. The area is bounded by the Orocopia Mountains to the south, with a total area surveyed for tortoises of about 21 km^2 (Fig. 1). Most of this land is managed by the Bureau of Land Management. The area was heavily impacted by WWII military training activities during the early 1940s associated with the former existence of Camp Young (Lathrop 1983, Prose 1985, Prose & Metzger 1985, Henley 2000). Tank and jeep tracks are still visible throughout the study site, resulting in long-lasting negative changes to soil conditions and plant communities that are still detectable almost 80 yr later (Lovich & Bainbridge 1999). The effects of these enduring habitat impacts on modern tortoise populations are unknown.

The site is dominated by gently sloping bajadas and arroyos running northward to Interstate 10 and Maniobra Wash. These bajadas rise to meet the Orocopia Mountains to the south. Elevations of known tortoise locations at OrSS ranged from approximately 480 to 620 m. Ironwood, blue palo verde, and ocotillo plants were less abundant than at CoSS. See Cummings et al. (2020) for a more detailed site description.

2.2. Field techniques

Surveys similar to those described by Lovich et al. (2014a) were conducted to locate live tortoises and additional tortoise sign such as burrows, carcasses, and scat. Transects were conducted throughout the areas of interest with 10–25 m spacing between 2 or more observers. During each year, surveys were conducted over 2 or 3 d periods 2–3 times every month from February through July. Additional surveys were conducted once per month while radio-tracking tortoises (see below) from August through January. Live tortoises were notched with a unique combination of marginal scutes using a triangular file for future identification (Cagle 1939). Body sizes of live tortoises and carcasses were measured using straight-line carapace

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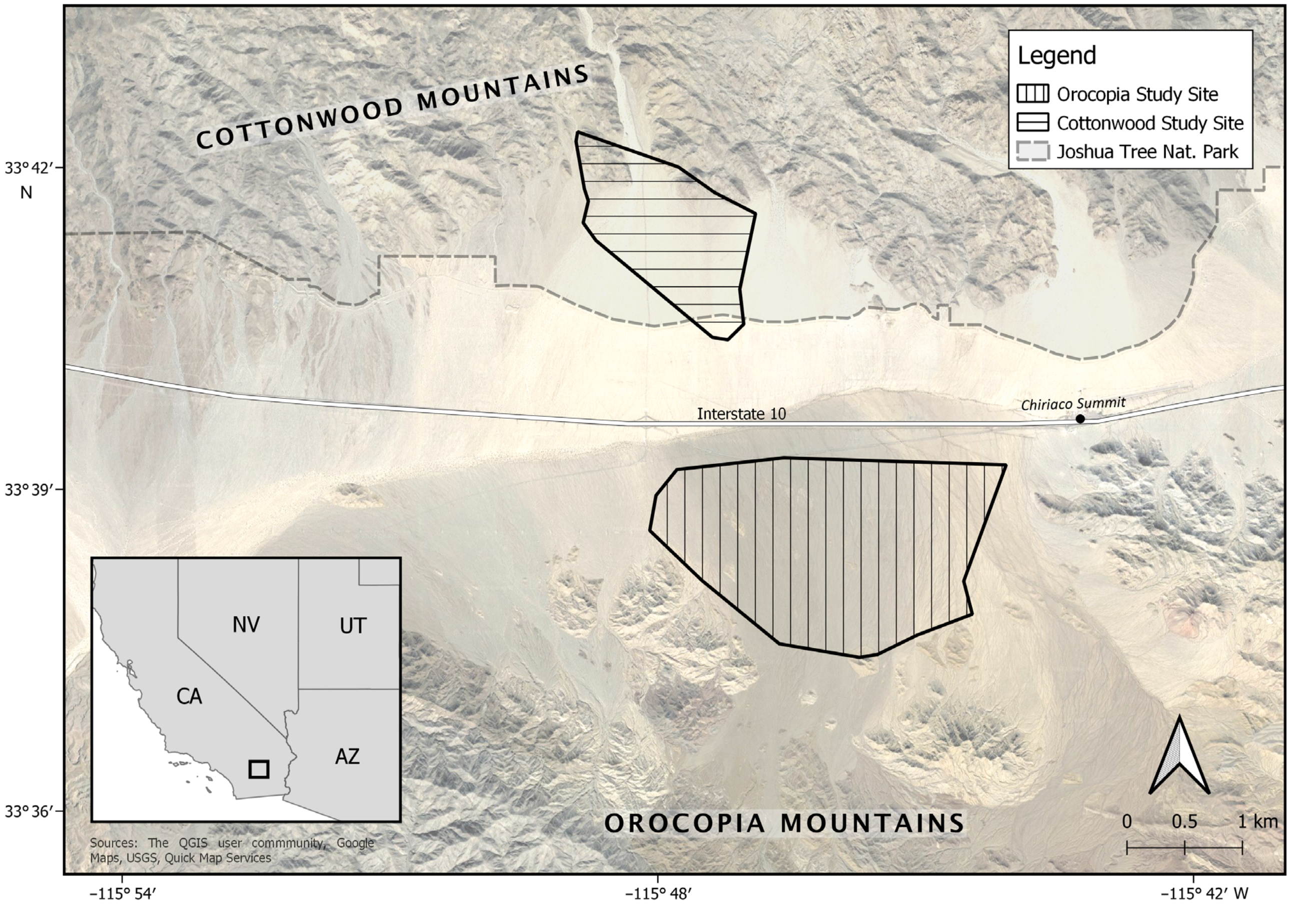

Fig. 1. Locations of the 2 study sites in California (USA) in relation to Joshua Tree National Park. Polygons circumscribe the general areas surveyed for desert tortoises and carcasses at each site. CA: California, NV: Nevada, UT: Utah, AZ: Arizona

length with tree calipers (±1 mm) when possible. Sex was determined using characteristics described by Ernst & Lovich (2009). Some carcasses were highly weathered and disarticulated, making it difficult or impossible to determine their sex. When possible, we rearticulated those carcasses to determine sex and measure carapace length. GPS locations were recorded using a Garmin Oregon 550T. When whole shells or shell fragments of dead tortoises were located, detailed notes were recorded on the state of the remains and photographs were usually taken to estimate their time of death (see Section 2.3).

A subsample of tortoises was outfitted with radio transmitters at both sites (Advanced Telemetry Systems models R1850, R1860; or Wildlife Materials reptile transmitters with replaceable batteries). At CoSS, 12 tortoises (4 males and 8 females) were fitted with transmitters but 2 malfunctioned early in the study (1 male and 1 female) leaving 10 to monitor. Ten tortoises (6 males and 4 females) were radioed at OrSS. Not all radioed tortoises were monitored in both years at our 2 study sites due to radio malfunctions in Year 1 and finding and affixing transmitters to new tortoises in Year 2. During the tortoise activity season from March to July, all radio-transmittered tortoises were located approximately every 10–14 d, and once per month for the remainder of the year. Radio transmitters were initially deployed on tortoises at CoSS in March 2015 and at OrSS in February 2017. As the conclusion of the studies neared, radio transmitters were removed from tortoises, with the final transmitter removed in July 2016 at CoSS and August 2018 at OrSS.

X-radiography was used to quantify reproductive output. Females with radio transmitters (CoSS n = 8; OrSS n = 4) were X-radiographed from April to July. The period from April to July overlaps known earliest and latest dates of the production of shelled eggs in JTNP (Lovich et al. 1999, 2018). X-radiographs were obtained in the field using a digital X-ray generator (model TR80; Min-X-ray) connected to a custom Canon X-radiography system. Exposures were taken

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using the settings described by Lovich et al. (2015) at doses that are considered safe for tortoises (Hinton et al. 1997).

2.3. Estimating time of death from carcasses

We estimated time of death for tortoise carcasses and remains found during our surveys as detailed below. Our analyses focused on remains estimated to have died during the time period from 2012−2016, for 2 reasons. First, even though the megadrought has so far persisted from 2000−2021 (and continues), drought conditions intensified in California from 2012−2016, compounding the effects of the preceding drought. Second, it is difficult to accurately estimate time of death based on carcass condition after about 4 yr. However, the time of death in tortoises can be estimated in the first few years post mortem based on stages of carcass deterioration. Several factors have to be considered relative to deterioration rates, including the size of the tortoise and the condition of the scutes and bones at the time of death, especially the amount of predation or scavenging that may have been inflicted on the carcass. Predation or scavenging can remove scutes and separate bones, allowing increased exposure to areas that may not be exposed initially. Shell surfaces that are exposed to sunlight or precipitation may disarticulate at different rates than those that are not (e.g. those that are shaded by shrubs). Smaller-sized tortoises (e.g. juveniles) degrade at a faster rate due to the light, thin nature of their small scutes and incomplete ossification of their skeletons (Berry 1984).

According to Dodd (1995), the shells of 6 different turtle species in Florida disintegrate in a relatively predictable pattern. Generally, the keratinized scutes covering the bony shell begin to exhibit dullness and curling, followed by peeling from the larger vertebral scutes down to the marginal scutes around the periphery of the shell. The marginal scutes are usually the last to be exfoliated. Underlying shell bones (post-scute deterioration) also go through stages as they age post mortem. Skeletal shell bones begin either white to dirty brown in color (if the scutes have recently exfoliated) and have a solid, fresh appearance without cracks, pits, or peeling. As the bones are exposed to the elements, they progress to a cracking, peeling, pitted, or disarticulated state as scavenging and environmental factors cause further deterioration (Dodd 1995). The rate of decomposition is slower in arid environments (Berry 1984) but follows a similar general progression of stages.

All carcasses located at both study sites were assessed and placed into 1 of 7 categories of decomposition according to specific criteria (Table 1, Fig. 2), which included analyzing the overall intactness of the carcass, scute condition, and bone condition. The categories are derived from a classification system based on a compilation of previous schemes used by Dodd (1995) and Berry (1984: Appendices 6 & 7, cited by Berry 1986 and used by Lovich et al. 2014a). Carcasses were examined for recency of death by first looking for the presence of soft tissue within the shell. Scutes, when present, were then assessed for any fading, peeling, shrinkage, and attachment to the underlying bone. Next, shell bones were examined (where exposed) for color, strength, cracking, chalkiness, or separations. Carcasses were assessed for structural rigidity by determining whether the bones were intact (with or without suture separation or minor predation/scavenging damage) or completely or partially disarticulated. Signs of predation or scavenging, particularly tooth marks or breakage that did not correspond to sutures, were also noted, since this can influence deterioration rates (Fig. 3). In recognition of the differences in ossification between juvenile and adult shells that may cause variation in decomposition rate, we report data on juvenile carcasses (<180 mm) scored using our decomposition classification system but did not include those data in our statistical analyses.

Estimated time since death was assigned from categories summarized in Table 1. The first category (A) is for a fresh carcass dead for only a couple of weeks. The shell appears fully intact with no disarticulations (unless damaged with breaks away from sutures caused by a predator or scavenger). Scutes are fully intact and appear shiny and fresh, and abundant tissue is still present inside the shell.

The second category (B) (Table 1, Fig. 2) includes carcasses that died over a period of up to 2 yr prior to discovery, which would include deaths at both study sites during the 2012–2016 drought conditions described above. This category could also include carcasses that died immediately post-drought at OrSS, depending on the year of discovery. In this stage, the external surface still has the same fresh appearance of a live tortoise, but internal tissues are dried up and/or have been consumed by predators or scavengers. The scutes have a smooth surface and are not yet peeling or fading. The bone (if exposed) is a solid, non-chalky white or brown color without pits or cracks.

The third category (C) (Table 1, Fig. 2) includes carcasses that died during the period 2–4 yr prior to

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Table 1. Classification system we used for estimating time since death of *Gopherus agassizii* carcasses, including summary of decomposition descriptions. Table adapted from criteria described by Berry (1984) and Dodd (1995). Estimating time since death after 4 yr is difficult or impossible under variable conditions. Although categories D–G have the same estimated time since death, we assumed that they represent sequentially older remains because of their progressing stages of decomposition

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

discovery and can include tortoises that died during the 2012–2016 drought, depending on the year the carcass was discovered. As decomposition progresses, scutes begin to fade, causing a dullness on the scute surface, and they may start to peel away from the bone. However, there is still greater than 50% area of the shell with scutes attached. The bone begins to show signs of wear (surface cracking or dullness) where it is exposed. This category represents a liberal estimate for tortoise mortality at CoSS that occurred during the severe drought period 2012–2016. If a carcass at CoSS was placed into this category, it is possible that the tortoise died either during the drought (up to 3 yr prior to discovery), including during the first year of the drought in 2012 before the drought effects intensified, or just before (4 yr prior). This is a liberal estimate because we included any tortoises at CoSS that fell into this category in our count of tortoise deaths during the drought since we cannot determine with certainty the exact year of death. Carcasses in this category located at OrSS died during the 2012–2016 drought.

Category D (Table 1, Fig. 2) represents the first category encompassing an estimated time since death of >4 yr. Carcasses in this category have <50% of scutes covering the shell, and the remaining scutes are peeling, shrinking, curling, loose, or brittle. The bone shows signs of aging at this point, including pitting, porous texture, and possible development of suture cracks along the margins. Carcasses in this category located at CoSS died prior to the beginning of the 2012–2016 drought. This is a liberal estimate of tortoises that died at OrSS during the epic drought because it would include tortoises that died during the first year of the drought in 2012 before the drought effects intensified.

Category E (Table 1, Fig. 2) also includes carcasses that died more than 4 yr prior to discovery, but in this stage, there are few to no scutes remaining on the shell although scutes may still be present on the ground surrounding the carcass. The bone is white and chalky with suture cracks widening, but the carcass is still intact. Carcasses at both study sites placed into this category, or either of the categories listed below, died prior to the beginning of the epic drought.

Category F (Table 1, Fig. 2) is the next stage of decomposition also encompassing an estimated time since death of >4 yr. Sutures are separated, and the carcass is mostly disarticulated, with a few large pieces still connected at suture margins. Scutes may or may not be visible on the ground. The bone is brittle and white or pink colored.

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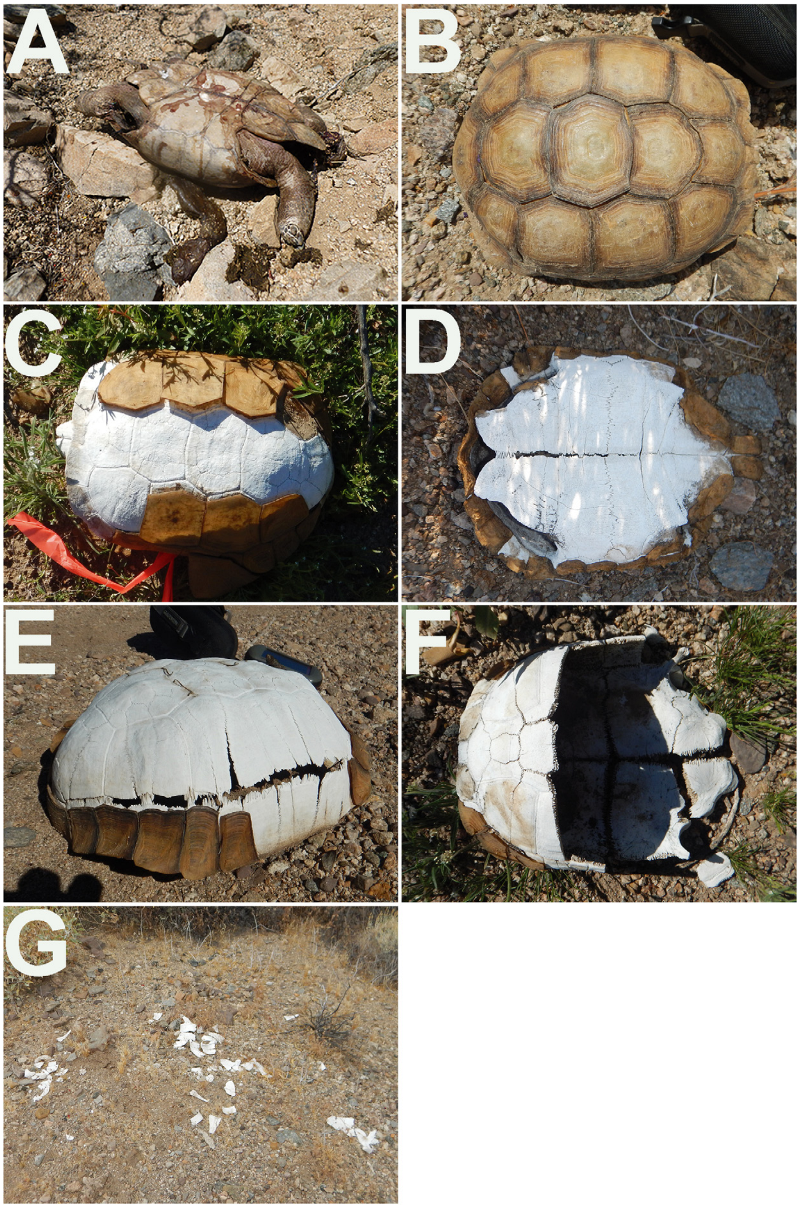

Fig. 2. Carcasses exemplifying assigned categories of decomposition and disintegration based on combined criteria for aging tortoise remains as given by Dodd (1995) and Berry (1984) (see Table 1 for decomposition category descriptions). Photos are assigned to categories as follows: category A: dead for only a couple of weeks, fresh carcass with viscera and scutes still attached as they would be on a live tortoise; category B: dead <1–2 yr, shell intact, scutes attached; category C: dead 2–4 yr, shell intact, more than 50% scutes still attached; category D: dead >4 yr, bone developing suture separation; category E: dead >4 yr, suture separations widening; category F: dead >4 yr, shell is disarticulating, partially intact; category G: dead >4 yr, shell is completely disarticulated and bone is weathered

The final category including carcasses that died over 4 yr since discovery is category G, which is also the last stage of decomposition (Table 1, Fig. 2). This category includes carcasses that are completely disarticulated into pieces scattered on the ground. Sex is usually indiscernible, scutes are rarely present, and bones are bleached white.

All of these categories apply to general time periods, since many variables affect rates of decomposition as discussed above, and this makes exact aging impossible. The decomposition study by Berry (1984) was performed in a similar environment to that of our study — both were within California deserts with comparable climates — which makes the study by Berry (1984) the best candidate for approximations of time since death. However, age studies were not included in that study for tortoises thought to have died more than 4 yr prior to discovery. We assumed that categories E–G represent sequentially older remains than category D because of their increased stages of decomposition. We considered carcasses both with and without signs of potential predation that were estimated to have died between 2012 and 2016 to be victims of the epic drought. This is due to recognition that one of the effects of drought in the California deserts is prey switching, described in Section 1. As noted by Lovich et al. (2014a, p. 221): '… we cannot determine with certainty if all tortoise remains with carnivore tooth marks, missing limbs and broken shells were predated or scavenged after dying from some other cause (drought, disease, etc.). However, our experience radio tracking live tortoises at [Joshua Tree National Park] from 1997–1999 (Lovich et al. 1999) confirmed that some tortoises were alive and well one week and then killed and partially or almost completely consumed by coyotes (that left their hair on the tortoise carcass) the next week.' In addition, suspected badger *Taxidea taxus* predation on a large male desert tortoise was reported at CoSS in 2015 (Smith et al. 2016).

2.4. Statistical techniques

We assumed that the probability of finding male or female tortoises (carcasses or alive) did not differ. While live male tortoises may have higher detection

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Fig. 3. Example of a carcass that was assigned to the 'death during drought' category that had evidence of biting and chewing from predation and/or scavenging. Even if death occurred as a result of predation during the drought, it was still scored as a drought-induced mortality due to the effect of 'prey switching' that occurs during droughts (Lovich et al. 2014a). This carcass was found at the Orocopia study site on 10 May 2017 and was scored category C (see Fig. 2)

probabilities than female tortoises within short survey periods (Mitchell et al. 2021), this difference dissipates when within-year capture data are pooled (Freilich et al. 2000). Thus, our data pooled over 2 yr are less likely to be affected by any differences in detectability between male and female tortoises.

We used a 2 × 2 Fisher's exact test calculator (https://www.omnicalculator.com/statistics/fishers-exact-test) to compare the number of adult male and female carcasses to the number of living adult male and female tortoises at each site. Since previous studies suggested that females are more likely than males to die for various reasons, our tests were 1-tailed. We set alpha at 0.05 to test for the significance of association between status (living or dead) and sex ratios (male or female). Adult sex ratio indices were calculated using the method of Lovich & Gibbons (1992) and Lovich et al. (2014b).

2.5. Weather data

We estimated mean air temperatures and precipitation data for the time periods during our tortoise surveys with the WestMap Climate Analysis Tool (www.cefa.dri.edu/Westmap/Westmap_home.php) using a pixel point near the center of each study site (Table 2). Following Ennen et al. (2017), data were collected according to wet season (1 October–30 March) and dry season (1 April–30 September) estimated amounts. Mean temperatures (overall means, mean high and low temperatures) were also estimated for each study site over the period of the study. Wet season (winter) precipitation influences annual tortoise food plant productivity in the spring (Beatley 1974, Bowers 2005). Dry season precipitation can trigger summer annual plant germination. When dry season precipitation fell at our study sites, the result was dense fields of chinchweed *Pectis papposa*, but this species is rare in the diet of desert tortoises (Esque 1994). Long-term data on climate at each study site were also estimated using WestMap by looking at means for precipitation and temperatures over the 25 yr period from 1993–2018, an amount of time equivalent to the approximate generation time of desert tortoises (USFWS 2011, Edwards et al. 2004), according to winter wet season and summer dry season. Event timing, including survey dates and overall drought conditions, are summarized in Fig. 4.

3. RESULTS

3.1. Adult sex ratios and body sizes

At CoSS, we located an almost equal number of carcasses (4 males and 3 females) with a known (see Smith et al. 2016) or estimated time of death during the severe drought period 2012–2016. We found only 1 freshly dead tortoise at CoSS and none at OrSS (Table 1, Fig. 2; see Smith et al. 2016 for details). The sex ratio of living tortoises at CoSS was 22 males and 9 females (Table 3). Despite the strongly biased live tortoise sex ratio, a 1-tailed 2 × 2 Fisher's exact test comparing the number of adult male and female carcasses to the number of living adult male and female tortoises yielded a probability of 0.385. This suggests that sex was independent of status (dead vs. living) at CoSS. However, a chi-squared test comparing just the number of living males and females was significantly biased toward males (χ^2 = 5.45, df = 1, p = 0.020).

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Table 2. Estimated climate data for 2 study sites at the eastern end of the Coachella Valley Multiple Species Habitat Conservation Plan area: Cottonwood (CoSS) and Orocopia (OrSS). Data for each study site were obtained using the pixel function of WestMap, with the point location chosen near the center of each site. Location of pixel at the Cottonwood study site was 33.697°N, 115.803°W. Location of pixel at the Orocopia study site was 33.645°N, 115.763°W. Data were calculated according to patterns of the estimated total winter wet season (1 October–30 March) and summer dry season (1 April–30 September) precipitation

Study site	Year	Season	Est. mean min temp (°C)	Est. mean max temp (°C)	Est. mean temp (°C)	Est. precipitation (cm)
Cottonwood	2014–2015	Dry	16.4	32.8	24.6	4.2
		Wet	7.3	21.6	14.4	5.1
Cottonwood	2015–2016	Dry	16.1	32.4	24.2	2.8
		Wet[a]	5.8	20.3	13.1	4.9
Cottonwood	2016	Dry	16.4	32.8	24.6	5.0
Cottonwood	1993–2018[b]	Dry	15.4	32.6	24.0	3.6
		Wet	5.3	19.4	12.4	8.1
Orocopia	2016–2017	Dry	18.6	34.8	26.7	3.7
		Wet	8.1	22.2	15.2	11.6
Orocopia	2017–2018	Dry	18.8	35.1	26.9	1.9
		Wet	7.8	23.1	15.4	1.3
Orocopia	2018	Dry	19.5	35.6	27.6	0.3
Orocopia	1993 – 2018[b]	Dry	17.9	34.5	26.2	3.1
		Wet	6.8	21.3	14.0	7.5

[a]El Niño conditions were observed; [b]25 yr period in which averages across the entire time span were calculated

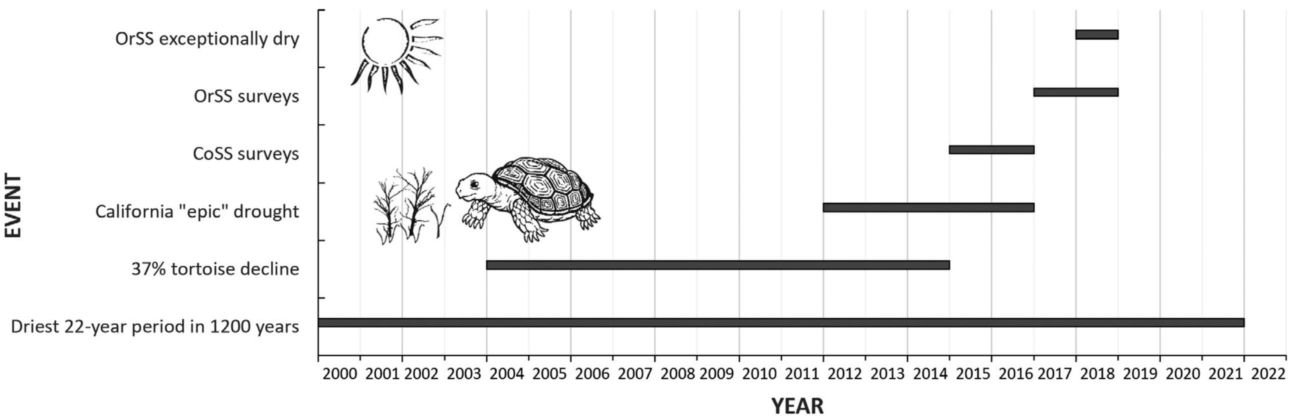

Fig. 4. Timing of surveys and drought conditions discussed in the text. CoSS: Cottonwood study site; OrSS: Orocopia study site

In contrast, at OrSS, the sex ratio of carcasses was decidedly female biased with 4 males and 15 females estimated to have died during the intensified drought period. Similar to, but more biased than, CoSS, living males outnumbered living females 16 to 5 at OrSS (Table 3). The one-tailed 2 × 2 Fisher's exact test probability of 0.0006 suggests that sex was not independent of status (dead vs. living) at OrSS. The upright posture and location of many of the carcasses outside of burrows is consistent with the behavior of tortoises dying from dehydration and starvation (Berry et al. 2002).

Other than the non-transmittered male that appeared to have been killed by a badger (Smith et al. 2016), we are unaware of any mortalities of our marked or transmittered tortoises during the period of study. In addition, the cause of a radio malfunction involving another small male at CoSS could not be determined since he was never relocated despite multiple attempts to do so. It is conceivable that a large predator such as a coyote carried him away, but it is also possible that the radio stopped sending a signal.

At CoSS, mean carapace length of living females ≥180 mm (221 mm, n = 9) was smaller than that of liv-

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Table 3. Summary of all desert tortoise carcasses and live tortoises located during 2015–2016 at the Cottonwood study site (CoSS) and 2017–2018 at the Orocopia study site (OrSS). Numerals in parentheses represent tortoises or carcasses per km^2. Carcasses were assessed for approximate time of death according to their state of decomposition and deterioration (see Table 1 and Section 2.3 for descriptions of decomposition categories). Carcasses were broken down into 2 categories: death pre-drought (died prior to the beginning of the 2012–2016 epic drought) and death during drought (died sometime during the 2012–2016 epic drought)

Sex	Cottonwood				Orocopia			
	Death pre-drought	Death during drought	Total carcasses	Live tortoises	Death pre-drought	Death during drought	Total carcasses	Live tortoises
Male	1 (0.17)	4 (0.70)	5[a] (0.87)	22[a] (3.83)	13 (0.62)	4 (0.19)	17 (0.81)	16 (0.76)
Female	2 (0.35)	3 (0.52)	5 (0.87)	9 (1.57)	10 (0.48)	15 (0.71)	25 (1.19)	5 (0.24)
Juvenile[b]	2 (0.35)	1 (0.17)	3 (0.52)	3 (0.52)	1 (0.05)	–	2 (0.10)	1 (0.05)
Unknown	2 (0.35)	1 (0.17)	3 (0.52)	–	15 (0.71)	2 (0.10)	16 (0.76)	–
Total	7 (1.22)	9 (1.57)	16[a] (2.78)	34[a] (5.91)	39 (1.86)	21 (1.00)	60 (2.86)	22 (1.05)

[a]These numbers include 1 adult male tortoise that was initially located alive and healthy on 1 April 2015 but was subsequently found freshly predated on 13 April 2015 (see Smith et al. 2016 for additional information). This tortoise is also included in the carcass count

[b]Numbers for juveniles were scored using the same classification system as adults and are reported here; however, we recognize that differences in ossification between adult and juvenile shells may cause differences in decomposition rates

ing males in the same size range (268 mm, n = 22), and the differences were statistically significant (2-sample *t*-test, $t = -5.30$, df = 29, $p < 0.001$). In contrast, at OrSS, mean size of living females (234 mm, n = 5) was not statistically different from the mean size of living males (263 mm, n = 16) (2-sample *t*-test, $t = -1.77$, df = 19, p = 0.09).

3.2. Reproductive output

Females reproduced during the 2012–2016 drought and afterwards in the exceptionally dry year of 2018. At CoSS, 7 of 8 monitored females produced at least 1 clutch of eggs during 2015–2016. Not every female was monitored during both years due to radio failure and location of new individuals during the second year of study. A single female did not produce eggs in either 2015 or 2016. One female monitored only during 2016 produced a single clutch of one egg. Four females monitored during both years produced 2 clutches each year, and 3 females that were monitored for a single year (1 in 2015, 2 in 2016) each produced 2 clutches during the year they were monitored (Lovich et al. 2018).

At OrSS, at least 1 small female did not reproduce in the exceptionally dry conditions of 2018, although we only had a single year of data for her, so we cannot definitively say that she was capable of reproducing. Two females produced 2 clutches each in 2017, and then each produced only a single clutch in 2018. A fourth female produced at least 1 clutch in 2017 while none was observed in 2018. However, we were unable to handle and X-radiograph this tortoise on sequential captures during the reproductive season, so it is possible that the appearance and disappearance of other clutches were missed in both years.

3.3. Weather data

Despite severe drought conditions, some germination of winter annual food plants for tortoises was observed at CoSS in 2015. The winter of 2015–2016 was characterized by a strong El Niño event in terms of the amount of warming that occurred, and although that did not result in higher-than-average precipitation in California, the precipitation at CoSS was adequate to again support limited germination of tortoise food plants (see Table 2). In contrast, the OrSS had limited germination in 2017 following higher precipitation totals during the winter of 2016–2017, but a complete lack of winter annual plant germination for the duration of our study in 2018. A single rainfall event during the winter of 2017–2018 was inadequate to prevent severe drought conditions at OrSS the following spring. The lower-elevation OrSS has a climate that is warmer and drier than that of the neighboring CoSS. During the 25 yr period 1993–2018, both the winter wet season (October–March) and summer dry season (April–September) had higher average precipitation and lower averages for maximum, minimum, and mean temperatures at CoSS than at OrSS (based on estimated temperatures and precipitation calculated using WestMap; Table 2).

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4. DISCUSSION

Our data suggest that adult tortoise mortality in the western Sonoran Desert during the epic drought conditions of 2012–2016 appears to be statistically biased toward females at the lower elevation OrSS. Conversely, the sex ratio of living adult tortoises at OrSS was biased toward males, consistent with the hypothesis that female mortality may have been higher than that of males. This is particularly interesting since studies elsewhere suggest that annual survival of females is generally greater than survival of males (Berry et al. 2020). The number of tortoises that were estimated to have died during the epic drought at OrSS (n = 21) is almost equal to the number of live tortoises located at the site (n = 22), suggesting a significant mortality event for such a long-lived species (Germano 1992). Although the biases above were not statistically significant for the 1-tailed 2 × 2 Fisher's exact test at the higher-elevation, wetter CoSS (Table 2), the number of live males (n = 22) greatly exceeded the number of live females (n = 9), a finding that is generally consistent with our hypothesis of greater adult female mortality. However, we found 4 male and 3 female carcasses estimated to have died during the epic drought at CoSS, but these figures should be interpreted with caution due to the small sample size.

Independent support for our hypothesis was provided in 2017 when the US Fish and Wildlife Service conducted tortoise surveys within the much larger Chuckwalla Tortoise Conservation Area (that includes OrSS and areas to the southeast) with a different survey technique: line distance sampling (Allison & McLuckie 2018). Their numbers also suggested a male-biased sex ratio of live tortoises as well as a greater number of female carcasses. They located 39 live adult females and 50 males, as well as the carcasses of 16 adult females and 12 adult males (L. Allison pers. comm.). Estimates of the time of death were not recorded during their surveys.

The high mortality rate we observed at OrSS was mirrored by earlier data collected in the footprint of a large, proposed development located less than 10 km to the west of OrSS. Tortoise surveys there in 2000, reported in an unpublished environmental compliance document, noted a small number of live tortoises (n = 10) compared to a very large number of tortoise carcasses (n = 123) in various stages of deterioration in April and May 2003 over an area of approximately 27 km^2 (Psomas 2003). Sex was determined for only a small fraction of the carcasses located but was not significantly different from 1:1 (16 males, 14 females). The surveyors used a system to assign categories of shell deterioration but did not estimate times of death (Psomas 2003). Most carcasses were disarticulated, suggesting death 4 or more years prior (according to our classification system).

Similarly, high rates of mortality were reported based on 2014 surveys just over 20 km to the north of CoSS and OrSS in the Pinto Basin of JTNP. A large number of carcasses (n = 64) were found, compared to a small number of live tortoises (n = 14) during surveys in 2012 that only noted sex ratios of live tortoises (Lovich et al. 2014a). Live tortoise sex ratios in 13 surveys between 1978 and 2012 ranged from 1:1, to male-biased, to female-biased with no trend in any one direction. The die-off in the Pinto Basin was attributed to the effects of drought and prey switching by predators, with estimated survival rates being coincident with 3 yr moving average precipitation trends. The strong adult female-biased mortality we observed at OrSS is of interest, since many females appear to have died during the recent epic drought in California (2012–2016). However, the effects of the ongoing megadrought on long-lived species like tortoises imposed stresses to survival that extended both before and after the intensified 2012–2016 drought. For example, tortoise population declines in the larger Sonoran Desert region of California (often referred to as the Colorado Desert) suggest a loss of 37 578 (±11 006 SE) adults from 2004–2014 (Allison & McLuckie 2018).

Sex ratios in turtle populations vary due to the effects of 5 factors (Lovich & Gibbons 1990, Lovich 1996). First, sampling bias can result in the perception of skewed adult sex ratios. Given the fact that line distance sampling transects conducted by the US Fish and Wildlife Service in the Chuckwalla Tortoise Conservation Area (including our OrSS) observed an adult female carcass bias (see above) as we did, we believe that it is unlikely that our results were affected by sampling bias.

Second, desert tortoises, like many turtles, have environmental sex determination with high incubation temperatures producing more female hatchlings and low incubation temperatures producing more males (Ewert et al. 1994, Spotila et al. 1994). Given concerns about global warming, some authors have suggested that turtle and tortoise populations may face extinction due to a strong sex ratio bias (Janzen 1994, Hulin et al. 2009). However, in the case of desert tortoises, warming would potentially lead to a sex ratio bias opposite to that which we observed (i.e. the number of live tortoises in a population would be female-biased).

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The third possible explanation is differential age of maturity of the sexes, or bimaturism (Lovich et al. 2014b). Simply stated, the sex that matures earlier predominates in adult sex ratios assuming all other factors have little influence. Age of maturity largely determines adult size, with little evidence for additional growth (Congdon et al. 2018), although adult tortoises appear to exhibit some growth after maturity (Nafus 2015). Adult male tortoises tend to be slightly larger than females, but sexual size dimorphism of populations, when present, is not pronounced as it is in other species of turtles (e.g. Lovich & Gibbons 1990). Male and female tortoises mature at approximately the same age, so it is unlikely that bimaturism would be a significant factor. Indeed, the mean sex ratio of desert tortoises in 22 populations (Berry & Murphy 2019) was almost exactly 1:1, with a sex ratio index of 0.003 (Lovich & Gibbons 1992, Lovich et al. 2014b).

The fourth reason adult sex ratios can be biased is the possible effect of differential immigration or emigration of one sex or the other. Since desert tortoises are not migratory animals and typically have relatively small home ranges (Ernst & Lovich 2009), it is unlikely that this affected our results.

The fifth, and we believe most likely, reason for the female-biased carcass sex ratio we observed at OrSS is due to differential mortality. For some reason, it appears that females were more likely to die during the drought of 2012–2016 than males, whether by dehydration and starvation or by predation via prey switching as detailed by Lovich et al. (2014a). If so, the question remains, why? As stated above, adult female tortoises tend to be somewhat smaller, on average, than males, so it is possible that they are more vulnerable to predation than males as suggested by Esque et al. (2010). However, mean carapace length of live males was not significantly greater than that of live females at OrSS, where the sex ratio of dead tortoises was most biased toward females. It is worth reiterating that we could not determine if carcasses that bore marks from teeth of carnivores were a result of predation, scavenging, or both. It is also possible that females are more susceptible to death by drought and starvation due to their smaller size in some populations, therefore reducing their ability to store water and nutrients. The upright orientation and location of many of the carcasses we found outside of burrows is consistent with the behavior of tortoises dying from dehydration and starvation (Berry et al. 2002, Lovich et al. 2014a), although alternative explanations are possible (e.g. sex-biased mortality from disease: see Wendland et al. 2010). However, we found no evidence of shell disease, previously reported nearby (Jacobson et al. 1994), or obvious symptoms of upper respiratory tract disease (URTD) (Jacobson et al. 2014) such as mucus exudate from the nares.

URTD was previously reported from tortoises in JTNP (Homer et al. 1998), so it may have played a role at our study sites since it may also be exacerbated by drought (Lederle et al. 1997). It is also worth noting that clinical signs of URTD are not always present in tortoises that are seropositive for exposure to the pathogen (Schumacher et al. 1997). If URTD was a factor in the mortality of tortoises at our study sites, that still does not explain why females were disproportionately affected. The likelihood of testing positive for antibodies after exposure to the URTD pathogen does not appear to differ between the sexes (Lederle et al. 1997).

A possible mechanism for the sex-biased mortality we observed as a result of drought relates to female reproductive strategy. We hypothesized that drought-induced mortality would be female-biased due to water and energy losses attributable to egg production during protracted periods of resource limitation. Female desert tortoises have a 'bet-hedging' reproductive strategy whereby they make a small reproductive 'wager' every year (Ennen et al. 2017). Bet-hedging theory predicts that, if juvenile survival is low and unpredictable, organisms should consistently reduce short-term reproductive output to minimize the risk of reproductive failure in the long term (Lovich et al. 2015). By producing relatively small single or multiple clutches that are spatially and temporally isolated (Lovich et al. 2014c), female tortoises reduce the risk of reproductive failure in any one year. Since female tortoises cannot predict the environmental conditions that hatchlings will encounter when they hatch 74–100 d after oviposition (Ennen et al. 2012), females further hedge their bets by rarely skipping even bad years to reproduce, including drought years (Henen 1997, Averill-Murray et al. 2014, Lovich et al. 2015).

Reproducing in bad years has consequences on reserves of energy necessary for growth, storage, and maintenance (Congdon 1989), as well as on osmotic condition. Desert tortoise eggs range in mass from about 31 to 42 g (Turner et al. 1984), with an estimated median of 36.5 g. Mean clutch size of first and second clutches in the region is about 4.3 eggs, and females produce 1.78 clutches per annum (Lovich et al. 2018). In addition, females lose about 10 g of uterine fluid with each clutch during oviposition (Turner et al. 1984). Assuming a grand mean

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female mass of about 2469 g at our study sites (J. Lovich et al. unpubl. data) yields the following estimate of the percentage of mass lost to a typical female annually by ovipositing 2 clutches of eggs in a year:

(4.3 eggs × 36.5 g × 2 clutches) + (2 clutches × 10 g uterine fluid) / 2469 g body mass × 100 = 13.5% of body mass lost

If desert tortoise eggs have a mean water content of 65.26%, like the congeneric *Gopherus polyphemus* (Congdon & Gibbons 1985), then females at our study sites that produce 2 average-sized clutches lose an estimated 218 g of water annually to reproduction, or over 0.20 l, before accounting for additional losses due to the effects of drought. Females that produce only a single clutch lose an estimated 7.7% of body mass, including 109 g of water, or over 0.10 l, still a substantial loss during drought.

Desert tortoises have remarkable adaptations or exaptations (Bradshaw 1988) to survive short-term droughts. They do so by relaxing control of energy and water homeostasis to withstand wide physiological fluctuations via anhomeostasis. For example, during times of drought, tortoise body mass may decrease 40%, and their total body water content may decline to 60% or less of their body mass (Peterson 1996). In addition, females have the ability to reduce their field metabolic rates 70–90% during a drought, and these adaptations partially contribute to their ability to produce a few eggs under adverse conditions (Henen 1997, 2002). Henen (2004, p. 65) noted that even with these capabilities, tortoises have their limits: 'Although relaxing homeostasis facilitates survival and reproduction, desert tortoises are vulnerable in particularly dry periods.' Droughts lasting more than 2 yr reduce the survivorship of tortoise populations (Lovich et al. 2014a), and the 2012–2016 epic drought lasted 5 yr with no sign of letting up as of 2022 as part of the ongoing megadrought that started in 2000. It is possible that bet-hedging female tortoises exhausted stored resources necessary for their own survival during the epic drought by producing clutches of eggs almost every year. At OrSS, some females produced eggs in both 2017 and 2018 despite the return to extreme drought conditions in 2018.

This scenario of higher adult female mortality due to reproductive output is not unprecedented in turtles. In a study of over 1100 marked individuals of the freshwater turtle *Mauremys reevesii* on an island in Japan, the estimated sex ratio of younger age class turtles was essentially equal, but slightly skewed toward males in intermediate age classes, and significantly male biased in older age classes. Carcass surveys found a significantly female-biased sex ratio of dead, mostly adult, turtles (Takenaka & Hasegawa 2001), similar to our results. Since there were no native mammalian predators on the island capable of killing turtles, the authors concluded that some females were unable to recover nutritionally from energetically costly reproductive output before becoming inactive for the winter. This in turn, led to increased mortality of females but not males at their overwintering sites.

Modeling shows that population growth of desert tortoises is sensitive to the survival of large adult females (Doak et al. 1994, Berry et al. 2020). Given the high mortality (especially adult females) and low density of living tortoises that we and others (e.g. Psomas 2003, Lovich et al. 2014a, L. Allison pers. comm.) observed at or near our study sites, the viability of these southernmost populations is not necessarily assured. The location of a single live juvenile (approximately 4 yr old) and 1 live subadult male indicate that some recruitment has occurred at OrSS during the last several years, but further monitoring would be required to determine if there is enough recruitment occurring to offset mortality in the population.

5. CONCLUSION

A preponderance of evidence from our research (e.g. male-biased living adult sex ratios at both study sites, female-biased mortality at OrSS) points to the conclusion that drought is causing female-biased mortality of tortoises at these study sites, especially at OrSS. We suggest that declines of tortoise populations, especially females, in the Sonoran Desert of California are exacerbated by increasing climatic extremes in low, hot, and dry areas like OrSS that are near the southern edge of the range for desert tortoises (Berry & Murphy 2019), as predicted by Barrows (2011) and supported by the previous findings of Lovich et al. (2014a). With climatic extremes becoming more prevalent (Cayan 2010), extended periods of protracted drought are expected to continue to affect tortoise sex ratios, survival, reproduction, and recruitment in the region. Sex ratio bias can be an overlooked threat to population persistence, especially in populations of long-lived organisms (Grayson et al. 2014), like Agassiz's desert tortoise.

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APPENDIX XIII: OROCOPIA SAGE RANGE EXTENSION AND POPULATION DECLINE STUDY

Study begins on following page.

RANGE EXTENSIONS AND POPULATION DECLINE OF THE ENDEMIC DESERT PERENNIAL OROCOPIA SAGE (SALVIA GREATAE [LAMIACEAE]) IN THE MECCA HILLS AND OROCOPIA MOUNTAINS, CALIFORNIA

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RANGE EXTENSIONS AND POPULATION DECLINE OF THE ENDEMIC DESERT PERENNIAL OROCOPIA SAGE (*SALVIA GREATAE* [LAMIACEAE]) IN THE MECCA HILLS AND OROCOPIA MOUNTAINS, CALIFORNIA

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ABSTRACT

Orocopia Sage, *Salvia greatae* Brandegee (Lamiaceae), is an endemic shrub restricted to the Orocopia and Chocolate Mountains within the Colorado Desert of Riverside and Imperial Counties, California. Very little has been published on this species' demographics, distribution, range, ecology, or threats. Generally, habitat for *S. greatae* has been described as alluvial fans, slopes, and washes between 30–450 m elevation. Our study was designed to focus specifically on documenting threats and describing the demographic patterns of *S. greatae* populations, as well as establishing a set of baseline data for long-term monitoring. Our surveys, performed in fall and winter of 2019–2020, revealed patterns that differed from the previously documented distribution for this species; we found denser, more expansive populations, and lower mortality rates at even higher elevations, up to 1011 m on steep slopes and rugged terrain. Populations at mid-elevations, 200 to 500 m, had higher mortality rates than high elevation sites. For populations previously considered to be within 'core habitat' at elevations below 200 m and within bajadas and alluvial fans, we relocated very few of the populations recorded in the early 1900s, and observed high mortality within those that persisted. Over the gradient studied, we found that the condition of plants significantly increased with elevation, with the highest proportion of vigorous individuals found at higher elevations. Our data indicate that either this species is shifting to higher elevations, or the previously described habitat of *S. greatae* was biased toward the lower, easily accessible populations, and may have been composed of waifs, as opposed to stable upland populations. Declines noted in mid- and lower-elevation populations are consistent with the effects of drying due to anthropogenic climate change.

Key Words: California endemic plants, climate change, conservation, desert shrubs, Orocopia Mountains, rare species, *Salvia*.

Orocopia Sage, *Salvia greatae* Brandegee (Lamiaceae) is a shrub endemic to the Orocopia and Chocolate mountains within the Colorado Desert of Riverside and Imperial Counties, traditional territory of Cahuilla, Xawiłł kwñchawaay (Cocopah), and Nuwuvi (Southern Paiute) tribes, in southern California (Averett 2012; Native Land Digital 2021). *Salvia greatae* is <1 m to 1.5 m tall, with branching, white, tomentose stems, lavender flowers, and fragrant, ovate-lanceolate persistent (Averett 2012) or opportunistically-drought-deciduous leaves (Davis et al. unpublished) with two to seven pairs of spines on leaf margins and one at the tip, generally flowering March through April (Brandegee 1906; Averett 2012) (Fig. 1). *Saliva greatae* was described by T.S. Brandegee (1906) and early specimens were collected near what is now the Dos Palmas Preserve and the Salt Creek watershed, which is contained within the Bureau of Land Management (BLM)-administered Dos Palmas Area of Critical Environmental Concern (ACEC) and surroundings (Fig. 2) (GBIF 2019). This species has no status under the State of California or Federal Endangered Species Acts. However, *S. greatae* has been assigned a California Rare Plant Rank of 1B.3 (threatened or endangered in California, with <20% of occurrences threatened/low degree and immediacy of threat or no current threats known), it has a State Rank of S2S3, a Global Rank of G2G3 (Imperiled/vulnerable and at medium to high risk due to restricted range), and it is protected under the Coachella Valley Multiple Species Habitat Conservation Plan (CVMSHCP) (Allen et al. 2005; CNPS 2020). Core habitat of *S. greatae* has been described as alluvial fans, slopes, and washes between 30–450 m, although CNPS reports it as occurring in a wider elevational range, from 40 m below sea level up to 825 m elevation (Munz and Keck 1965; Averett 2012; CNPS 2020). Questions regarding distribution, substrate tolerances, range, and ecology of *S. greatae* have not been previously addressed. Given this species' narrow distribution within one of the hottest and most arid regions of the southern California deserts (Weiss and Overpeck 2005; Schoenherr 2017), there is a critical knowledge gap of the impact of anthropogenic activities, including the current and potential impacts of climate change.

Deserts are one of the most sensitive bioregions to increased temperature and climatic changes, where increased drying is both expected and already observed (Seager et al. 2007; Woodhouse et al. 2010; Gonzalez et al. 2018). Considering the strong influence of climate on the distribution of vegetation (Schimper et al. 1903) and evidence of recent shifts in

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FIG. 1. Illustration of *Salvia greatae* by Melanie Davis, 2021.

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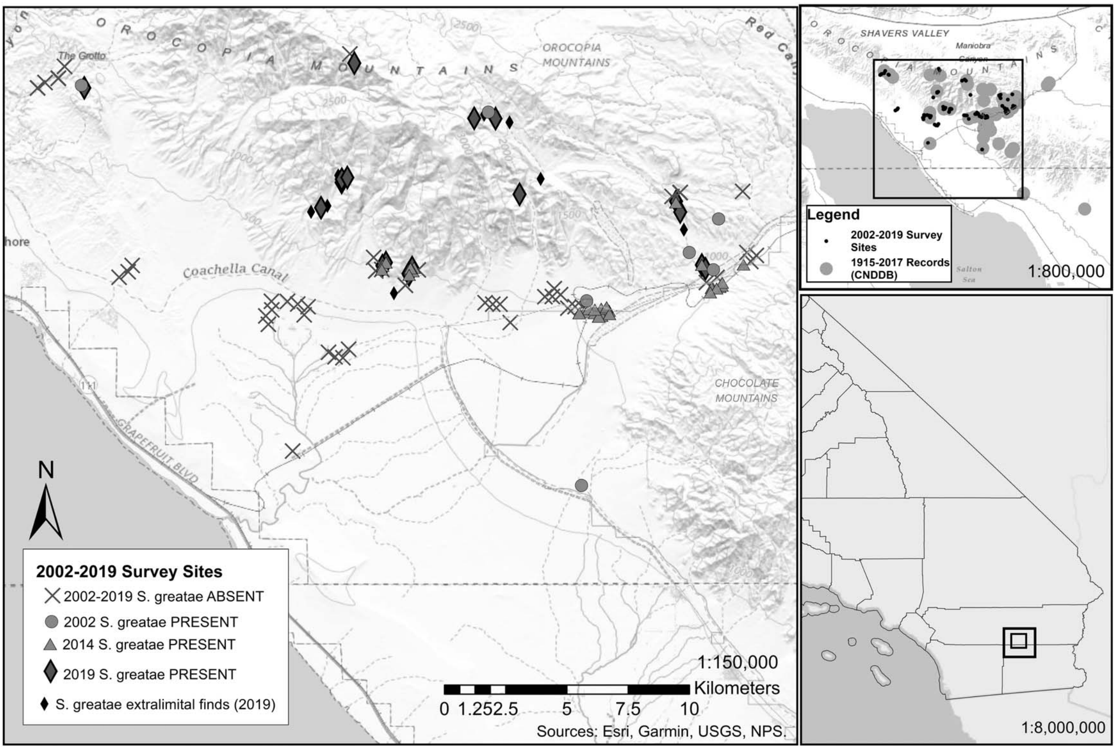

FIG. 2. Map of Orocopia Mountains, *Salvia greatae* historical records, and study plots.

the abundance of other regional species at their low elevation, warm range edges (Kelly and Goulden 2008; Sweet et al. 2019a), we may expect *S. greatae* to be vulnerable across its already small range. Along with climate change, potential threats and challenges to the persistence and successful conservation of *S. greatae* include invasive plant species, urbanization, and off-highway vehicle recreation, which were intentionally not addressed in this study. Specifically, invasive plant species may increase resource competition and limit *S. greatae* seed germination or seedling survival. In terms of other disturbances, while there are several popular off-highway vehicle trails in the area, the rugged terrain and restricted land use of the Orocopia and Chocolate Mountain ranges help to protect *S. greatae* from access of off-highway vehicles; those restrictions also limit the threat of urbanization (CVCC 2016).

Threats to *S. greatae* cannot be appropriately evaluated without baseline information about distribution and abundance, and questions remain about the range, and population dynamics of this rare and endemic species. One aspect of this research was to determine whether *S. greatae* individuals and putative populations within lower-elevation bajadas and washes represent the plant's described core habitat, or if they were initially established as waifs from higher elevational populations, which generally do not persist for more than a few generations (Baldwin et al. 2012). Due to the rugged terrain, higher elevation populations could have been under-represented in previous range assessments, resulting in an access or observer bias of *S. greatae* habitat.

Our objectives for this study were to better understand the population characteristics across elevational gradients, as well as to understand the stressors causing populations to disappear from some historical localities. In the process, we established a series of long-term study plots that will provide an opportunity to better understand abundance, range, and threats, as well as capture demographics, distribution, and density of *S. greatae*. This type of information is key to appropriately managing populations of rare plants, even when they occur primarily on conservation lands.

METHODS

Study Area

To define the climate of this region of the Colorado Desert, we used climate data collected from September 1905 to June 2016 at the nearest weather station (MECCA 2 SE, N 33.569631 E –116.073132, –54 m elev.), located approximately 25 km West from the Orocopia Mountains (14 km to 38 km [nearest/furthest] from study plots) in Mecca, CA. This data records that the area receives 79 mm in mean annual precipitation, primarily in winter

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months, and summer and winter mean temperatures are 32.2°C and 13.8°C, respectively (Western Regional Climate Center 2018). *Salvia greatae* local populations (groups of plants or portions of the whole population that occupy patches surrounded by unsuitable habitat, *sensu* Chesson [2001], hereafter, "populations") occur in the remote southern portions of the Orocopia Mountains Wilderness (CNPS 2020) on land currently owned and managed by the BLM, and in the western portions of the Chocolate Mountains on land currently owned and managed by the Department of Defense (Chocolate Mountains Aerial Gunnery Range, CMAGR) (Fig. 2). On the southwest end of the Orocopia Mountains lies the Salton Sea, and to the north, the foothills of the Eagle Mountains within Joshua Tree National Park. As characterized by the regional vegetation maps for the Mecca Hills and Orocopia Mountains (Sweet et al. 2015), and the Dos Palmas Preserve area (Sweet et al. 2019b), the plant community of the upper elevations and mid-slopes of the area is characterized by Creosote Bush scrub (*Larrea tridentata* [DC.] Coville), along with the Schott's Indigo Bush scrub (provisional alliance, Sweet et al. 2015; *Psorothamnus schottii* [Torr.] Barneby) and with Blue Palo Verde - Ironwood woodland (*Parkinsonia florida* [Benth. ex A.Gray] S.Watson type) throughout bajadas, and a variety of Colorado desert scrub types including those defined by Creosote Bush, Burro Bush and Brittle Bush (*Ambrosia dumosa* [A.Gray] W.W.Payne and *Encelia farinosa* A.Gray ex Torr.) occurring on canyon slopes (Sawyer et al. 2009), interspersed with areas of non-vegetated land (<2% perennial cover). At lower elevations, at and below the previous shoreline of the historical Lake Cahuilla, halophytes comprising of Fourwing Saltbush scrub (*Atriplex canescens* [Pursh] Nutt) and Iodine Bush scrub (*Allenrolfea occidentalis* [S.Watson] Kuntze) dominate, also containing large areas of non-vegetated land. The geology of the area is characterized as an intersection of Mecca Hills Sandstone and Orocopia Schist, topped by gneiss, and sedimentary mixed alluvial fan descending and depositing into Salt Creek, bounded to the west by the San Andreas Fault and the Salton Sea (Jacobson et al. 2007). The elevation ranges from –69 m at the Salton Sea to 1117 m at the peak of the Orocopia Mountains.

Range Study

We conducted *Salvia greatae* surveys from October 2019 to February 2020, with the goal of establishing the current range extent of the species in the Orocopia Mountains. We acquired data from previous *S. greatae* surveys conducted in 2002 and 2014, vegetation mapping data collected in 2015, and both historical and recent locality data (records from 1905 to 2017) from California Natural Diversity Database (CNDDB) (Allen et al. 2005; UCR 2014, 2015; CNDDB 2019).

The 2014 research team found that *S. greatae* was absent in Dos Palmas Preserve and Salt Creek, and we report here presence/absence at the locations visited for vegetation mapping of Dos Palmas Preserve by University of California, Riverside Center for Conservation Biology (UCR CCB) in 2018–2019. As *S. greatae* was not found in these extensive searches, nor has it been documented in the vicinity within the last 20 years, we did not conduct any additional surveys in those areas in 2019 and 2020. Additionally, in 2014, UCR CCB documented the extent of a well-known and large *S. greatae* population along the Bradshaw Trail. Although we did revisit several of the established survey points in this area, most of this population is located on land that is part of the CMAGR (outside the boundary of the CVMSHCP and located on land under the jurisdiction of the Department of Defense), and therefore we were unable to access it for this study or to verify presence or absence.

Plot Selection

Our plot surveys were aimed at resurveying established *S. greatae* survey plots (as above), and establishing additional study plots within the Orocopia Mountains. We established 30 study plots non-randomly; 15 plots were selected from general survey locations conducted in 2014, six were locations where *S. greatae* was identified as present during vegetation mapping in 2015, and the remaining nine plots were established in the field during investigative searches using CNDDB localities. To place the center point of the plot, we either used the pre-established 2014 center point (which was generally located at an individual *S. greatae*), or we placed it deliberately at the individual plant (when present) assessed to be at the center of the stand. Overall, plots were biased only towards spanning the elevational gradient and covering the geographic extent of the species. We accessed nearly all known occurrences within Riverside County and outside of DoD lands including CNDDB locations with <100 m accuracy (Fig. 2). We were unable to stratify equally across elevation. Therefore, our description of trends for generally low, medium, and high elevational plots are not analyzed statistically by category; and are included here as descriptive terms for each plot. Ten plots were established as 'absence plots', where no *S. greatae* was present, but within the range of *S. greatae* and adjacent to plots where it occurred and within the presumed dispersal area, within 100 m as well as up and down slope of populations. We used these absence plots to help characterize what habitat attributes may be intolerable for *S. greatae*. At each absence plot, all the same data were collected, except that we did not do additional belt transects adjacent to these plots. It should be noted that these surveys were coincident with a related study of the Mecca Aster (*Xylorhiza cognata* [H.M.Hall] T.J.Watson) of which required

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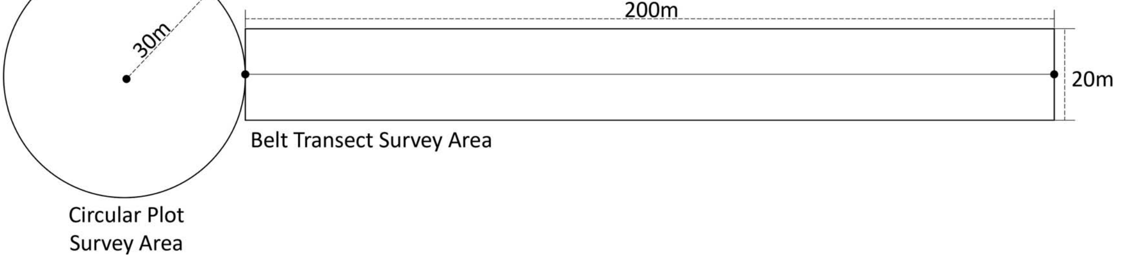

FIG. 3. Diagram of a 30 m radius survey plot and a 20 × 200 m belt transect plot.

searches within the Mecca Hills. During these searches we confirmed absence of *S. greatae* throughout many areas of the Mecca Hills except for the location detailed here.

Data Collection

We carried out a two-part survey protocol: a 30 m radius circular plot (area of 2827 m^2), and a 20 × 200 m (4000 m^2) belt transect survey (Fig. 3) (CDFG 2018). We developed the circular plot survey method to obtain a standardized density at each plot. We only implemented the belt transect survey in broad bajadas to determine how *S. greatae* plants or groupings are distributed across this landscape type.

We located the survey plots by using a Samsung Galaxy Tab Active 2 tablet (Samsung Group, Seoul, South Korea) running a georeferenced PDF map created using ArcMap ArcGIS Desktop, version 10.9 (Esri, Redlands, CA) on Avenza Maps (Avenza System Inc., Toronto, Canada). We cross-referenced coordinates using a Trimble Juno 3B GPS unit (Trimble Inc., Sunnyvale, CA). We accessed plots by foot and at the specified coordinates we spent at least ten minutes between two researchers searching the plot area for *S. greatae*. Once the location of the survey point was established, we marked the center point for the 30 m radius circular survey plot with a 12-in. galvanized iron stake with a washer and numbered tag attached. We recorded basic plot data at the center point, including UTM coordinates (NAD 83 UTM Zone 11S), the tag number, photos of the plot, and identity of any shrub comprising 1% or more cover to assign a vegetation classification at the alliance level, or "dominant perennial plant community", regardless of whether *S. greatae* was present, alive, or dead. When we encountered *S. greatae* individuals or populations outside of plots we recorded them as extralimital occurrences and noted population sizes, UTM coordinates, and the perennial plant community.

Within the circular plot we counted all *S. greatae* individuals rooted within the circle and categorized the ("health") condition of each one, where 'Dead' represented 0% of crown alive, Low (1–25% alive), Medium (26–50% alive), High (51–75% alive), and Very High (76–100% alive). Observer bias was calibrated by having the same two surveyors conduct and agree upon the assessment together for every plot. We observed that *S. greatae* drops its leaves during drought years, making it difficult to determine condition based on presence of leaves, and so we identified live individuals and crown sections by searching for small leaf buds and observing stem color. We made a distinction between adults and juveniles, defining juvenile plants as being <20 cm tall and with no evidence of reproductive maturity (flowering). We did not otherwise measure plants or attempt to distinguish age classes. We used both the Samsung tablet and a Hilti PD-42 laser rangefinder (Hilti Corporation, Schaan, Liechtenstein) to identify *S. greatae* plants within 30 m of the center point. If the terrain was too fragile or rugged to access individual plants, we used the laser rangefinder and binoculars to determine distance and condition of individuals. To evaluate the substrate and terrain type at each plot, we noted the steepness and ruggedness as an observational qualitative assessment, used plot location photos, and calculated slope with the slope tool in the spatial analysis toolbox in ArcMap ArcGIS Desktop using the national elevation dataset (NED) (USGS 2017).

We recorded important quantifiable disturbances within the 30 m radius. These disturbances are OHV activity, erosion, invasive species, trampling due to foot traffic or social trails, and dumping or littering. These were evaluated on the following scale: 'Light' indicated that less than 33% of the plot area was impacted by the specific disturbance, 'Moderate' was 33–66% plot area impacted, and 'High' was greater than 66% of the plot area impacted by the disturbance. We identified invasive plant species, and made notes about significant terrain, geology, or unique attributes of the area.

To estimate density and distribution of *S. greatae* occurring in bajadas, we performed belt transect surveys. These transects bisected the broad bajadas, starting on the outer perimeter of the circular plot (Fig. 3). Using line-distance survey methodology to survey the belt, two researchers traversed the transect on foot, using a compass and georeferenced PDF maps to correct our walking line. We counted plants within 10 m on either side of the line (rooted within the 20 m belt), measured the distance of *S. greatae*

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TABLE 1. MEAN ELEVATION FOR THE OCCURRENCE OF SAGR PLANTS ASSIGNED TO EACH CONDITION CLASS. Superscripts show the statistical differences between each group in pairwise comparisons.

Condition class	Mean elevation (m)	n
Dead[a]	210	37
Low[b]	350	31
Med[bc]	429	72
High[c]	496	107
Very High[d]	629	86

individuals from the transect line by using the laser rangefinder, recorded the UTM coordinates, and conducted a condition assessment as described above. Transect length spanned a maximum of 200 m or until we reached the edge of the bajada.

Statistical differences between the mean elevation for the occurrence of plants between health condition category (dead, low, medium, high and very high) were tested using the Kruskal-Wallis test followed by the Wilcoxon rank sum test with continuity correction in R (version 4.0.3, R Foundation for Statistical Computing, Vienna, Austria) to make multiple pairwise comparisons between each category (Bonferroni correction applied) since the data violated normality assumptions under the Shapiro-Wilk test ($W = 0.9144$, $P < 0.001$). We used ordinal logistic regression using the *MASS* package (version 7.3-53.1; Venables and Ripley 2002) to assess the log-odds of each condition class by plant across the elevational gradient for the plants within plots. Since the belt transects were biased toward mid-elevation and focused on spatial patterning on a micro-topographic scale, they were not included in this analysis. We produced spline plots and a display of the model predicted probabilities by condition class across elevation using *ggplot2* in R (version 3.3.3; Wickham 2016) for n = 333 plants. To approximately test model significance, we compared the t-value against the standard normal distribution and obtained confidence intervals for the parameter estimates by profiling the likelihood function.

RESULTS

We documented a total of 296 live *Salvia greatae* and 37 dead individuals in 18 of the 20 established circular presence plots, and 13 *S. greatae* individuals (11 live and two dead) in three of seven belt transect surveys. In the belt transects, we found that *S. greatae* was not evenly distributed across the large bajadas, but was restricted to the braided washes cut along the sides and within the bajadas. at a density of 0.00092 live *S. greatae*/m^2 in transects where it was present. Populations were present in plots across the sampled elevational gradient, 135–1011 m elevation: we found populations in five of the 13 lower elevation plots (<200 m), 10 of the 13 at mid elevation plots (200–500 m) and three of the four at higher elevation plots (>500 m). Mean elevation differed by condition class per individual *S. greatae* (Table 1) and number of individuals in each class by elevation (Fig. 4).

Dead individuals were present regardless of elevation, but were most common at low elevation plots, and were statistically more likely to be found at lower elevations (Fig. 5). Overall, the higher the condition class, the more likely they were to be found at increasingly higher elevations, which was significant as evaluated by the likelihood function (model AIC 926.9; overall estimate 0.004; 95% CI = 0.0032–0.0050; $P < 0.001$). From the modeled log-odds coefficients, most classes, generally Dead and Low condition class plants decreased in probability as

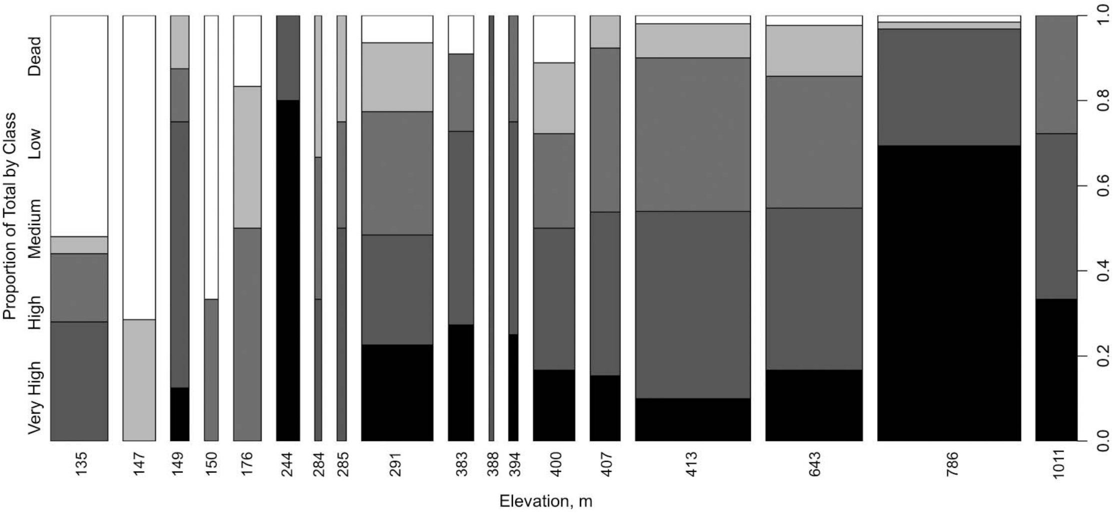

FIG. 4. The proportion of total *Salvia greatae* plants per site for each condition class across elevation. Bar width varies with the density of samples at that elevation. Condition classes are as follow: Dead (0% live); Low (1–25% live); Medium (26–50% live); High (51–75% live) and Very High (76–100% live).

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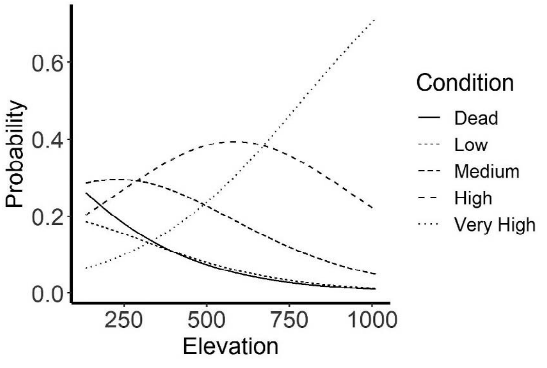

FIG. 5. Predicted probabilities (from model coefficients) of *Salvia greatae* plants within the respective conditions across elevation (m). Condition classes are as follow: Dead (0% live); Low (1–25% live); Medium (26–50% live); High (51–75% live) and Very High (76–100% live).

elevation increased; and Medium and High condition plants increased as elevation increased, with the probability of Very High condition plants continuing to increase through the highest elevations and being over three times more likely than the next-lowest class to be found with increasing elevation (Fig. 5).

High elevation plots (within the upper third of the elevational gradient) had the highest density per plot (with 18 individuals at the highest plot and 62 individuals at the second-highest plot). Comparing substrate and terrain types of the plots sampled (which do not represent a random sampling of the range), high elevation populations occurred on steep slopes and rugged terrain with an overall higher density of *S. greatae* per plot, with a mean of 18.5 *S. greatae* per plot with sloped or rugged terrain (wash plots and bajadas had 9 and 12.5 mean *S. greatae* per plot, respectively) (Table 2). We established a plot at the highest recorded population (1011 m elevation). This plot consisted of 18 plants scattered along a steep, south facing slope with 13 of the plants in the High and Very High condition classes (Table 2). The population extended down the southern slope, distributed along drainages. We also confirmed and surveyed the most western occurrence of *S. greatae* in the Mecca Hills Wilderness. This population (244 m elevation) contained the only recorded juvenile individuals within our circular plots, had a high proportion of plants in the Very High condition class (eight out of 10, five of those being juveniles), and

TABLE 2. TOTAL *S. GREATAE* INDIVIDUALS BY TERRAIN TYPE.

Terrain type	Plots with live *S. greatae*	Total live *S. greatae*	Mean live *S. greatae* per plot
Bajada	3	37	12.3
Wash	2	18	9
Rugged Slopes	13	241	18.5
Total	18	296	16.4

occurred exclusively on an isolated patch of Orocopia Schist, as mapped by C.W. Jennings (1967) for the California Division of Mines and Geology and verified in the field.

Overall, recorded human activity and disturbances within *S. greatae* range such as off-highway vehicles, trampling, and dumping occurred at very low rates. Invasive and non-native plants that we documented within *S. greatae* plots were *Brassica tournefortii* Gouan and *Schismus sp.* P.Beauv. Both taxa occurred in very low numbers. *B. tournefortii* was present in four plots with low occurrence rates (following the same rating system used to document disturbances), *Schismus sp.* in 17 plots, 16 with low and one plot with medium occurrence rates. In the plot where *Schismus sp.* was Moderate, no *S. greatae* was present, however this plot was established in the Mecca Hills sandstone substrate to check for the occurrence of *S. greatae* within that substrate type and therefore cannot be used as an indicator of stress caused by the presence of *Schismus sp.*

DISCUSSION

This study characterized *Salvia greatae* populations across much of the known range of the plant, including a range extension, with a goal of documenting the species range and habitat conditions, as well as detecting any geographical or population level trends in abundance or condition of the species, as follow-on study from earlier unpublished surveys. Considering the findings from previous surveys noting the absence of the *S. greatae* at low elevation plots, *S. greatae* mortalities in mid- and lower-elevation populations are consistent with drying due to anthropogenic climate change and reflect the findings of Kelly and Goulden (2008) where upward shifts in desert shrub density were observed. However, definitive attribution of the cause of these declines due to these factors cannot be determined with the current approach and this warrants further investigation and continued monitoring of the species.

There are some alternative explanations for the observed absence of plants at previously documented localities, however. The differences between the previously described habitat and the presently observed locations of populations of *S. greatae* could indicate a possible bias towards accessibility and an under-representation of higher-elevation populations in past surveys and records. Another possibility is natural population dynamics, similar to those described by Bowers et al. (1997) on plant succession within in the Grand Canyon. Lower bajada and wash populations within these areas may have been established waifs originating by debris flow from higher and more rugged populations, which then re-establish periodically, but fail to form self-sustaining populations. Other than older historical records, we are aware of no observations of this species within the last 20 years in the Dos Palmas Preserve vicinity,

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along Salt Creek, and along the Coachella Canal. Vegetation mapping surveys performed in 2014 and 2018 found that *S. greatae* was no longer present in Dos Palmas Preserve (–35 m elev.), along Salt Creek (–42 to –52 m elev.), and south of the Coachella Canal (2 to 12 m elev.); the lowest elevations where *S. greatae* had been recorded (Fig. 2).

Another possibility is that these local populations may have disappeared due to anthropogenic means—these groups of waifs may have been extirpated after the construction of the Coachella Canal, which increased soil salinity and blocked the natural watershed drainage patterns, diverting natural flash flood flows from the Orocopia Mountains. Seed distribution and fresh alluvial deposits created by flash flooding has been documented as a facilitator of desert plant succession (Zedler 1981; Bowers et al. 1997). Already infrequent flash flooding events may become more variable with increased effects of climate change, thus making continued waif succession even more infrequent after periodic drought related die off. The diversions created by the construction of the Coachella Canal already channels natural flash flood flows into very few siphon crossings, thus changing natural distributary patterns of seed dispersal and debris flow into the Dos Palmas Preserve (Letey 2000; CVCC 2016). The construction of the Coachella Canal was completed in 1948, however it was unlined, resulting in extensive water seepage into the Dos Palmas Preserve. In 2006, this section of the canal was lined with concrete to provide additional water to the Los Angeles region (CVCC 2016; U.S. Bureau of Reclamation n.d.), effectively cutting off the water seepage from the canal, although there is still limited water being released directly into the Dos Palmas Preserve to mitigate wetland habitat loss. Thus, it is possible that the remaining and historical bajada, wash, and low elevation populations are a relic of a wider distribution, one that may have shrunk due to failed plant succession as a result of flood flows being disrupted by anthropogenic means (specifically, the lining of the canal). However, the case for attribution of climate change-type drought is supported by the increasing mortality with decreased elevation, as well as the trends in the condition of the plants, tending to be higher in upper elevations.

It is worth noting that many *S. greatae* collections and records from the area date to the early 1900s and have vague locality descriptions. There remains the possibility that historical collections were taken in the uplands of the Salt Creek watershed, and locality notation only indicated Dos Palmas as the nearest landmark, as a generalized description of populations occurring two to six kilometers north and east of Dos Palmas. However, one 1922 specimen from botanist Mary F. Spencer would seem to be from Dos Palmas proper; her notes state that the specimen was collected "In arenosis [sandy soils or sand dunes] prope [near] Dos Palmas…160ft [53 m] below sea level" (SNMNH 2020). This habitat description coincides with the sandy soils southwest of Dos Palmas where elevation ranges from –47 m to –69 m below sea level, and where *S. greatae* is not present today. Collections made in the southwestern bajadas of the Chocolate Mountains in 1990 and collections along the Coachella Canal in 1986 support the hypothesis that individuals were present in the southern portions of the Salt Creek watershed. (CNDDB 2019; GBIF 2019).

As stated, we also sought to describe the habitat and co-occurring taxa and vegetation community. Populations at low and mid elevations primarily occurred within broad washes, braided washes within bajadas, and on canyon slopes and benches, characterized by Creosote Bush scrub, Schott's Indigo Bush scrub, and Blue Palo Verde – Ironwood woodland alliances. Using the belt transect survey we found that *S. greatae* was sparse throughout bajadas and not distributed evenly across them. When we did find *S. greatae*, it generally occurred as individual plants, not groupings or separate populations. Although we did not study the dispersal of the species, since these plants occur in isolation, they may be a result of seed inflow from flooding events bringing *S. greatae* seeds from higher elevations that then grow in microhabitats that require immigration to persist.

High and mid-high elevation populations of *S. greatae* occurred in denser, apparently healthier condition populations, residing on steep slopes, bluffs, and canyon walls, within Creosote Bush scrub, Burro Bush, Brittle Bush, and non-vegetated alliances. These individual plants were smaller than those occurring in washes, possibly due to low moisture availability, or small rooting zones within the bedrock. Due to the low number of juveniles and absence of seedlings, very little can be said presently about *S. greatae* recruitment. However, we did see differences in the condition or vigor of individuals across elevation, as shown, this may translate into reproductive potential, even if it may not have been evident during this census. Desert perennials have been shown to reproduce infrequently and mortality patterns may be more significant for population dynamics than seedling recruitment (Miriti et al. 2007).

The most western population that we surveyed piques special interest because it was the only plot that contained juveniles; this single population contrasts our nonetheless statistically significant trend of increased health condition with elevation, as it is at a lower elevation (244 m) with a high proportion of healthy plants. Geologically, this area is interesting because the Mecca Hills are primarily sandstone, yet this population occurs on an isolated patch of Orocopia Schist. As described earlier, within the Mecca Hills, we searched adjacent canyons and in the area near what is known as The Grotto (Fig. 2) to the west of where we found this population of *S. greatae*. These searches were done during concurrent searches for a different species, but we only found *S. greatae* within the Orocopia Schist geology type (as

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mapped and observed). The occurrence of *S. greatae* on this isolated patch of schist implies that the plant may be restricted to a geology or soil type, or excluded from others. Overall, our observations support that this site was different than other plots in the following ways: the plot is the furthest west extent of *S. greatae* range, and it occurs at the base of a canyon slope where we observed a sharp difference in geology/geological boundary (fault or non-conformity) that often result in near-surface water, cool, damp conditions relative to the surrounding landscape. Further investigation would be needed to accurately characterize the geology and soil moisture conditions, however, to determine why this site was a statistical outlier.

This study was part of a periodic monitoring effort of *S. greatae* within the conservation area of the CVMSHP and adjacent Department of Defense lands to identify and evaluate existing and potential threats to the persistence of *S. greatae*. It is important to note that still, little is known about the life history and biology of *S. greatae*. We used apparent plant health as a rough proxy for population viability, but a full life cycle analysis such as conducted by Ebert and Ebert (2006) is recommended. We recommend that studies investigate pollinators and pollination patterns across populations residing in differing topography types. More work also needs to be done to better understand any mechanistic/edaphic role in the coincident occurrence we observed between *S. greatae* and Orocopia Schist, as mapped by C.W. Jennings (1967). Additionally, studies examining how *S. greatae* responds to changes in climate could inform researchers on the relationship between this narrow endemic and anthropogenic related climate change. Genetic studies also may be required to definitively determine the population dynamics of this plant, specifically, whether *S. greatae* is moving up in elevation, or if the lower elevation individuals are descendants of those higher elevation populations.

Through the assemblage of previous documentation and records of *S. greatae*, and through our own mapping and surveys, we have further described the distribution and range extension of *S. greatae*. We have documented and mapped individuals and populations that were not publicly documented, and through closer examination, these populations have revealed that *S. greatae* inhabits a wider variety of topography types and elevation than those previously described. It is encouraging to find more remote populations of *S. greatae* within the Orocopia Mountains, especially as lower elevation populations appear to be disappearing. Climate change may be a significant threat to the persistence of this species, especially considering its possibly limited edaphic associations. Because of this, it is important for land managers to understand the distribution of this plant and identify sustainable populations and bridge the gap in knowledge of the species' biology.

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