2025 CVMSHCP Annual Report

Coachella Valley Multiple Species Habitat Conservation Plan
Natural Community Conservation Plan
Published March 2026

Table of Contents

List of Figures

List Tables

Introduction

This Annual Report describes the progress made on implementation of the Coachella Valley Multiple Species Habitat Conservation Plan for the 2025 calendar year. Acquisition of key properties continued, with 351 acres added to the reserve system to protect habitat for native plants and animals. The Coachella Valley Conservation Commission (CVCC) acquired all those acres. Participating agencies have made significant progress since the Plan's inception, with over 100,000 acres conserved over 17 years. Authorized disturbance in conservation areas remains infrequent: nine acres of disturbance took place in 2025, and only 461 acres have been developed since baseline planning began in 1996. Development outside the conservation areas, including important road projects, water infrastructure, and housing development, continued through the streamlined process facilitated by the Plan.

CVCC continued to make significant progress in closing the gaps in the wildlife corridor along Morongo Wash, acquiring almost 160 acres of property in the Upper Mission Creek/Big Morongo Canyon Conservation Area alone. One of these acquisitions has been a long-standing target for development, and its conservation by CVCC ensures that this critical linkage will continue providing habitat for Palm Springs pocket mouse, burrowing owl, and Little San Bernardino Mountains linanthus in perpetuity. CVCC also completed a like exchange between the East Indio Hills and Dos Palmas Conservation Areas, enabling for the future development of over 9,000 dwelling units in the City of Coachella while simultaneously expanding mesquite habitat around the Salton Sea.

Biological monitoring activities continue to gather important data on covered species, including analyzing undercrossing use across Interstate 10 and proposing infrastructure enhancements to improve connectivity, conducting burrowing owl surveys to assess the distribution of owls across the landscape and collect samples for future genomic testing, and undertaking small mammal trapping to determine metapopulation dynamics and highway undercrossing use. The information gathered through the biological monitoring program helps to better manage 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 leveraged state funds to clear nine encampments and remove 130 tons of debris from conservation lands. The Conservation Ranger program continued to move forward, with CVCC establishing partnerships with the Riverside County Regional Park and Open Space District to potentially provide education and enforcement resources on CVCC managed properties. These efforts were complemented by the establishment of a ranger cadet training curriculum with the Urban Conservation Corps, a long-standing land management partner.

2025 was not without its share of challenges. The potential listing of the burrowing owl inspired questions from local, regional and state agencies about the species' population health in the Coachella Valley, and coordination challenges also prompted CVCC to simplify its Reserve System management committee structures. Funding is always a challenge, and CVCC initiated an update to its development impact fee nexus study to ensure that the costs of land acquisition and improvement were still being adequately mitigated by new development.

We appreciate the support of the members of the CVCC, partners agencies, and non-profit collaborators for the ongoing success of this visionary Plan.

PLAN BACKGROUND

The Coachella Valley Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan (CVMSHCP) is a multi-agency conservation plan that provides for the long-term conservation of ecological diversity in the Coachella Valley region of southern California. The CVMSHCP includes an area of approximately 1.1 million acres and incorporates the watersheds draining into the Salton Sea within Riverside County. 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, 27 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 100,800 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, 2025, to December 31, 2025. As required by Section 6.4 of the CVMSHCP, this Annual Report will be presented at the CVCC meeting on April 9, 2026, 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, 2025, Permittees have conserved 18,576 acres, just over 18% of their conservation goal (Figure 1). State and federal conservation has reached 29,664 acres, or about 74% of their required contribution, and complementary conservation has accounted for 57,213 acres, about 83% of the anticipated acreage. Since 1996, 105,453 acres have been conserved under the CVMSHCP, with the assembly of the Reserve System just over 50% complete (Figure 2).

FIGURE 1: CVMSHCP Conservation Progress Towards Conservation Goals

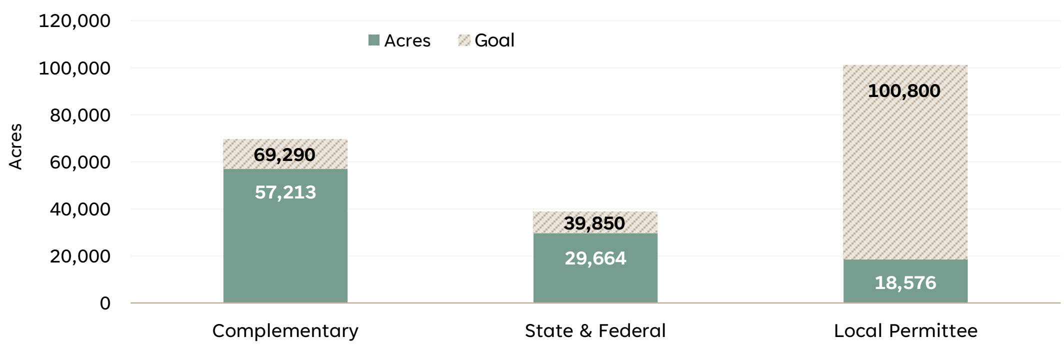
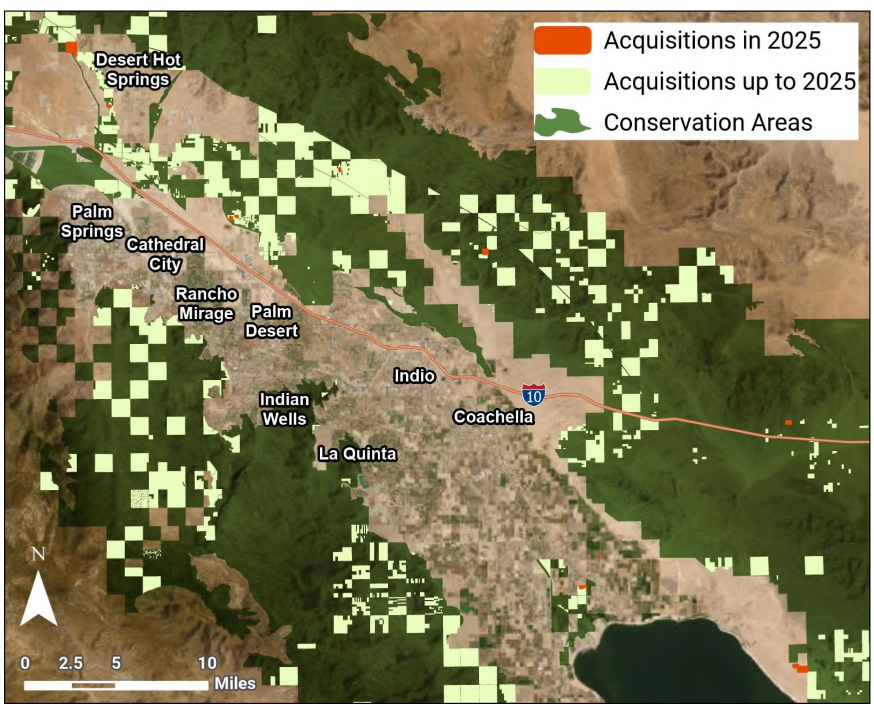


FIGURE 2: CVMSHCP Reserve Assembly Status, Including 2025 Acquisition



Conservation progress is generally allocated based on the source of acquisition funding. Land purchased with funding from the CVMSHCP's Local Development Mitigation Fee or through regional agency mitigation obligations accrues to the Local Permittee obligation, while acquisitions funded by state and federal sources accrue to the state and federal obligation[1]. Land conservation funded by private entities is considered complementary conservation, and, while not an explicit obligation of CVMSHCP Permittees, does aid in Reserve System assembly and long-term management. Acquisitions using a combination of funds from disparate sources are allocated proportionally relative to the amount contributed from each source (Table 1).

TABLE 1: Summary of Annual Progress on Reserve System Assembly

Report Year	Complementary	State & Federal	Local Permittee
1996-2013	49,638	25,661	7,254
2014	1,417	1,291	241
2015	1,127	300	350
2016	669	319	827
2017	1,699	446	793
2018	1,115	711	584
2019	110	747	346
2020	202	0	2,104
2021	1,156	128	849
2022	49	60	3,480
2023	30	0	1,132
2024	0	0	265
2025	0	0	351
Acquisition Credit	**57,213**	**29,664**	**18,576**
Management Credit	**24,442**	**54,042**	**26,969**

Once acquired, lands within the Reserve System are held in public or private ownership and are managed for habitat conservation and open space values. In certain instances, a private conservation entity may acquire land in a CVMSHCP Conservation Area or federally managed landscape, and will transfer the property to CVCC or relevant federal agency. These transfers result in a situation wherein an entity that did not get conservation credit for purchasing the land nonetheless absorbs the long-term management responsibility for it. To acknowledge this management responsibility, Table 1 tracks management credits in addition to acquisition credits.

LAND ACQUISITION

CVCC coordinates its acquisitions with CVMC, who served as CVCC's acquisition manager throughout 2025. Through this partnership, CVCC completed 10 transactions acquiring 14 parcels totaling 351 acres at a cost of $3,003,684 in CVCC funds and including three properties transferred

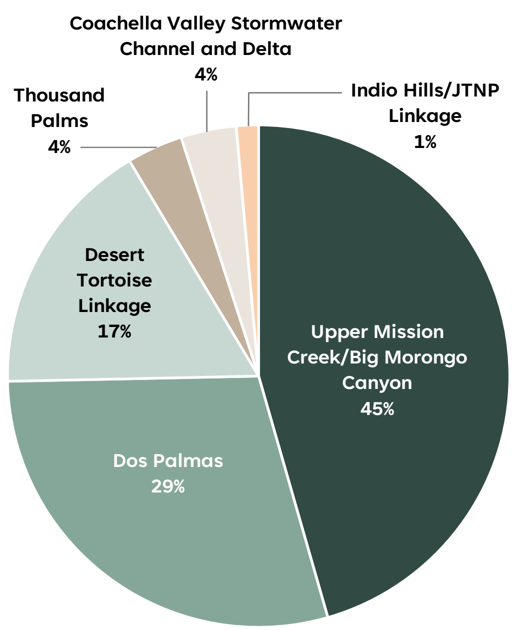
1 State and federal funding for acquisitions made in certain federally designated landscapes, including Joshua Tree National Park, Santa Rosa and San Jacinto National Monument, and Orocopia Mountains Wilderness accrue to complementary conservation.

at no cost as part of a like exchange valued at $1,500,000 (Table 2). CVCC conservation on behalf of local Permittees occurred predominantly in the Upper Mission Creek/Big Morongo Canyon Conservation Area, as well as five other Conservation Areas (Figure 3). Local, state, and federal partners did not acquire any additional acres within CVMSHCP Conservation Areas. All lands conserved pursuant to the CVMSHCP during the period from January 1, 2025, to December 31, 2025, are depicted in Figure 2 and listed in Appendix I.

TABLE 2: Lands Acquired by CVCC in 2025

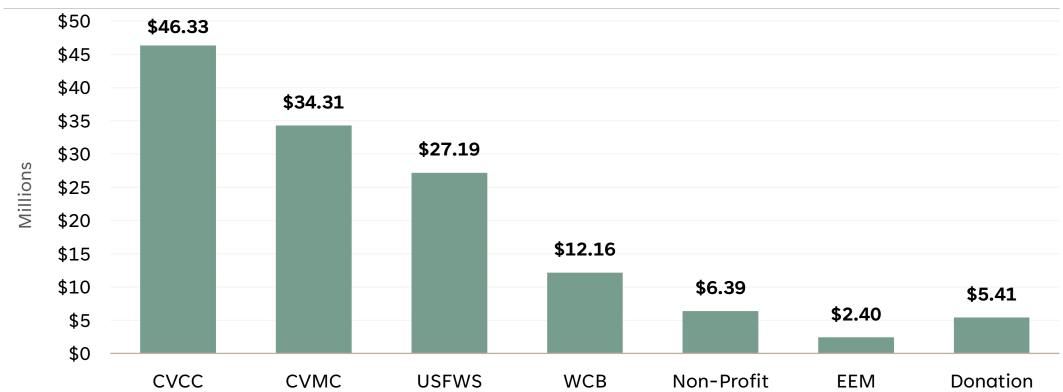
Project	Conservation Area	Parcels	Acreage	Cost
Alvarenga	Thousand Palms	1	9.83	$130,000
Bochner	Upper Mission Creek/Big Morongo Canyon	2	151.60	$1,780,000
Bui	Desert Tortoise Linkage	1	20.53	$28,000
Castro	Thousand Palms	1	2.82	$91,000
KPC Like Exchange	Dos Palmas	3	102.14	$0
Linares	Upper Mission Creek/Big Morongo Canyon	1	5.03	$66,000
North Shore Ranch 3	Coachella Valley Stormwater Channel and Delta	2	12.53	$765,184
Scott	Upper Mission Creek/Big Morongo Canyon	1	3.16	$75,000
Struve	Indio Hills/JTNP Linkage	1	5.00	$12,500
Whitney	Desert Tortoise Linkage	1	38.15	$56,000
Total		**14**	**350.79**	**$3,003,684**

FIGURE 3: Proportional Acquisitions in 2025 by Conservation Area



CVCC acquires lands with funding from CVMSHCP's Local Development Mitigation Fee on private development as well as public agency contributions to mitigate for regional roads and other transportation projects (Figure 4). Significant federal funding has been provided by the U.S. Fish and Wildlife Service (USFWS) through the Cooperative Endangered Species Conservation Fund. State funding includes grants made to the CVCC and conservation partners by the CVMC, Wildlife Conservation Board (WCB) and Caltrans' Environmental Enhancement and Mitigation (EEM) program. The non-profits Friends of the Desert Mountains and Oswit Land Trust have acquired lands using grants from CVMC, private donations, and other sources; many of these lands have been transferred to CVCC or to the Bureau of Land Management (BLM).

FIGURE 4: Cumulative Acquisition Funding Per Source



CVCC continues to improve and revise its land ownership database, which includes all property interests that count towards Permittee conservation obligations under the CVMSHCP. Through this iterative auditing process, CVCC is able to capture errors in acreage allocation, update lot-line adjustments, and update ownership information, which can cause some amount of fluctuation in the total acreages reported from year to year. 2025 data auditing efforts identified a misallocation of credited acres in a property purchased with both grant funds and matching funds in 2013; while overall Reserve acres remain unchanged, the correction did slightly reduce the quantity of Permittee conservation in favor of State and Federal conservation. In addition to maintaining its own records, CVCC is constantly coordinating with conservation partners to ensure that external records are as accurate as possible.

LAND IMPROVEMENT

In 2025, the CVCC acquisitions manager performed pre-acquisition site inspections and job walks on 14 parcels 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, and also 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 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 that additional work will be necessary. After closing, CVCC monitors the sites at least annually for ongoing management and fencing requirements.

This year, the CVCC acquisition manager directed the removal of an estimated 145.93 tons of refuse, including 86 tires, from conservation lands, generating over $27,948 in contractor revenue from sellers' property sales.

Status of Conservation Areas

To ensure the persistence of Covered Species and natural communities, the CVMSHCP includes specific acreage requirements for both the amount of authorized disturbance that can occur and the acres of habitat 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 Processes in the Plan. The planning process for the CVMSHCP began on November 11, 1996, which serves as 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, 2025 (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 or to Permittees for non-Covered Activities lacking take authorization. For the latter two instances, disturbance is allocated directly from the CVMSHCP permits. In 2025, nine acres of authorized disturbance took place within the Conservation Areas. To date, approximately 461 acres of disturbance have taken place within the Reserve System boundaries. As previously discussed, 351 acres of conservation were recorded.

TABLE 3: Conservation and Authorized Disturbance Within Conservation Areas

Conservation Area	Conservation Goal	Conserved in 2025	Conserved to Date	Disturbed 2025	Disturbed to Date
Cabazon	2,340	0.00	0.00	0.00	0.00
Coachella Valley Stormwater Channel and Delta	3,870	12.53	895.00	0.00	5.54
Desert Tortoise Linkage	46,350	58.68	7,049.40	0.00	1.38
Dos Palmas	12,870	102.14	4,807.44	0.00	0.00
East Indio Hills	2,790	0.00	35.44	0.00	0.00
Edom Hill	3,060	0.00	2,119.92	0.00	1.59
Highway 111/I-10	350	0.00	156.26	0.00	0.00
Indio Hills Palms	2,290	0.00	1,039.97	0.00	0.00
Indio Hills/JTNP Linkage	10,530	5.00	9,017.82	0.00	5.73
Joshua Tree National Park	35,600	0.00	13,170.55	0.00	0.00
Long Canyon	0	0.00	15.45	0.00	0.00
Mecca Hills/Orocopia Mountains	23,670	0.00	8,409.72	0.00	0.00
Santa Rosa & San Jacinto Mountains	55,890	0.00	36,011.40	0.00	10.49
Snow Creek/Windy Point	2,340	0.00	907.37	0.00	0.00
Stubbe and Cottonwood Canyons	2,340	0.00	1,061.56	0.00	19.84
Thousand Palms	8,040	12.65	6,181.61	0.00	50.76
Upper Mission Creek/Big Morongo Canyon	10,810	159.80	7,762.52	0.00	75.96
West Deception Canyon	1,063	0.00	1,967.31	0.00	0.00
Whitewater Canyon	1,440	0.00	957.22	0.00	4.65
Whitewater Floodplain	4,140	0.00	1,166.13	0.00	109.98
Willow Hole	4,920	0.00	2,721.27	0.00	0.39
Fluvial Sand Transport	NA	NA	NA	0.00	18.31
Direct Permit Take	NA	NA	NA	9.29	156.67
Total	**234,703**	**350.79**	**105,453.36**	**9.29**	**461.30**

STATUS OF COVERED SPECIES

An overview of the status of each of the Covered Species for each Conservation Area can be found in Appendix II. The Rough Step value for Other Conserved Habitat for Coachella Valley Jerusalem cricket within the Riverside County portion of the Upper Mission Creek/Big Morongo Canyon Conservation Area is negative, indicating that development is outpacing conservation for that Conservation Objective. CVCC will prioritize acquisitions to rectify this imbalance over calendar year 2026, but until adequate conservation acres have been acquired, further development by Riverside County in Jerusalem cricket habitat within the Upper Mission Creek/Big Morongo

Canyon Conservation Area would be deemed inconsistent with CVMSHCP objectives; appropriate mitigation measures – up to and including land conservation – for any such proposed development would need to be identified through the Joint Project Review process.

COVERED ACTIVITIES OUTSIDE CONSERVATION AREAS

The CVMSHCP permits development and other Covered Activities outside the Conservation Areas without requiring the strict standards that apply to projects within the Conservation Areas. An accounting of the acres of habitat for the Covered Species and natural communities that have been developed or otherwise impacted by Covered Activities outside the Conservation Areas can be found in Appendix III. 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 is 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*. 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 for the period between 2017 and 2024, the most recent date for which data is available. The acre figures in Appendix IV are the sum of the two datasets, which gives an estimate of all development impacts between 1996 to 2024. CVCC continues to assess remote sensing technologies and applications to better track development outside of the CVMSHCP-designated Conservation Areas.

Biological Monitoring Program

In 2025, CVCC continued several critical projects aimed at enhancing wildlife conservation and habitat management within the Coachella Valley. CVCC completed focused surveys for burrowing owls and continued work on projects aimed at analyzing landscape connectivity. Additionally, CVCC and parters continued long-term monitoring of aeolian communities. These projects collectively aimed to protect endangered species, improve habitat connectivity, and inform wildlife managers in the region.

WILDLIFE CONNECTIVITY ASSESSMENT

In 2025, CVCC continued making significant progress on its Wildlife Connectivity Assessment for Interstate 10 and Closely Associated Transportation Infrastructure in the Banning Pass project. This initiative aims to study wildlife movement and behavior, focusing on the effectiveness of habitat corridors. Wildlife camera theft proved to be a major issue and necessitated extending the tracking work beyond the spring season into fall and winter. Field visits to map noise and light penetration into the wild spaces on either side of the interstate also took place, as well as surveys to characterize vegetation communities (Appendix IV). Analysis of the collected data identified Stubbe Wash and the Whitewater River as the best locations to focus under-and overcrossing design work, which will begin in earnest in 2026.

CVCC received finalized results from the climate resiliency project funded through a California Department of Fish and Wildlife (CDFW) Local Assistance Grant. This project modeled current and future habitat suitability for several vulnerable species within the region encompassing the Plan area and was completed in March of 2025, results and discussions of which can be found in Appendix V.

BURROWING OWL SURVEYS

In July 2025, CVCC entered into a research agreement with the University of Idaho (UI) to study the movement and productivity of burrowing owls in the Coachella Valley. Researchers used burrow data collected during a separate field effort conducted by the Imperial Irrigation District (IID) in which focused surveys were completed from April 7 to June 13, 2025, and resulted in identification of 321 primary burrows (AECOM 2025). From August 21 to December 28, 2025, researchers from UI completed a total of 44 walking surveys, two driving survey routes, and visited 318 previously active burrow locations. These efforts resulted in recorded detections of 350 owls and 393 burrows. Researchers banded a total of 128 burrowing owls to allow for individual identification and future documentation of owl movements. Biological samples were collected during banding efforts to allow for sex identification and contributions to conservation genomics projects. The final report for these surveys was finalized in January 2026 (Appendix VI). These surveys will continue throughout 2026.

GENETIC ANALYSIS OF SMALL MAMMALS

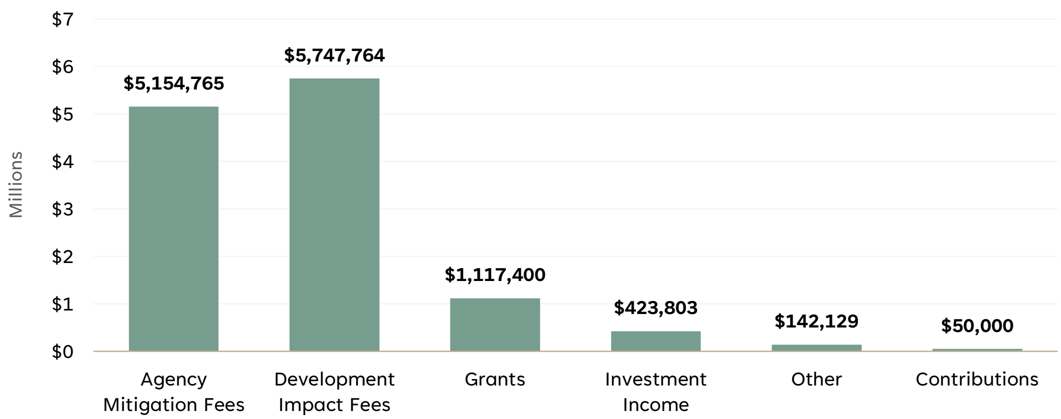
CVCC continued work on a $75,000 grant from CDFW awarded in 2024 for the Genetic Analysis to Test Effectiveness of Linkages for Corridor Dwelling Small Mammals project. This project aims to study habitat corridors and threats to species like the Palm Springs pocket mouse and Coachella Valley round-tailed ground squirrel. Trail cameras were placed at project sites to identify potential predator species starting in July 2025. Two trapping survey bouts were conducted in November 2025 at four of the 12 study sites. During these bouts small mammals were trapped to collect genetic samples. Remaining field surveys and genetic testing are planned to occur in 2026, with a final report expected in March 2027.

AEOLIAN SAND COMMUNITY & TRIPLE-RIBBED MILKVETCH SURVEYS

In 2025, CVCC continued its work with the University of California, Riverside (UCR) to monitor aeolian sand communities at long-term plot-based sites throughout the Plan area. Species including Coachella Valley fringe-toed lizard, Coachella Valley giant sand-treader cricket, and Coachella Valley milkvetch are endemic to the Coachella Valley, and are entirely dependent on these wind-driven habitats. Surveys for flat-trailed horned lizard, Palm Springs pocket mouse, Coachella Valley round-tailed ground squirrel and vegetation mapping were also conducted as part of the long-term monitoring for the suite of aeolian sand community species. The final report and results can be found in Appendix VII.

Surveys were also conducted for the triple-ribbed milkvetch, an elusive plant species endemic to Southern California, with a focus on collection of broad-scale population data to better understand population dynamics. Population surveys were conducted from April 4 through May 21, 2025, at 22 sites in the western Coachella Valley, the Little San Bernardino Mountains, and the Santa Rosa Mountains. Results and discussion of the surveys can be found in Appendix VIII.

FIGURE 5: Cumulative Monitoring and Management Funding Per Source



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 inter-agency Reserve Management Oversight Committee (RMOC) provides a forum for coordination of management and monitoring lands within the Reserve System and makes recommendations to the CVCC. The RMOC is supported by individual Reserve Management Unit Committees (RMUC) and Biological Working Groups (BWG). As discussed in the Significant Issues section of this report, these meetings were reclassified as technical working groups in September 2025.

SUMMARY OF COMMITTEE ACTIVITIES IN 2025

In 2025, the RMOC held several hybrid meetings (Table 4), focusing on updates regarding Reserve assembly and acquisitions, the biomonitoring program, and the land management program. Key topics included burrowing owl monitoring, ranger and enforcement initiatives, and various fencing, cleanup, and signage efforts. The committee also discussed the annual workplan, climate resiliency studies, and the I-10 wildlife connectivity assessment. Required actions generated by these discussions are incorporated into the CVCC budget for the fiscal year.

The RMUC and BWGs held joint meetings throughout the year to facilitate coordinated management and monitoring efforts. Discussions included the status of the aeolian sand community, climate resiliency, vegetation surveys, and the I-10 wildlife connectivity assessment. The committee also addressed invasive species management, fencing, signage, and cleanup projects, as well as the peninsular bighorn sheep fence and guzzler. These meetings seek to align monitoring protocols with research goals and management needs.

The Trails Management Subcommittee (TMS) held multiple hybrid meetings in 2025, focusing on trails management, enforcement of dog ordinances, outreach to the cycling community, and e-bike issues. The subcommittee worked on creating a Trails Plan Working Group, in which members were called to review and enhance the CVMSHCP Trails Plan to ensure it effectively balances the dual objectives of minimizing adverse impacts on Peninsular bighorn sheep and providing sustainable recreational opportunities. They also discussed maintenance, safety signage, and the Conservation Ranger Initiative. The TMS collaborated with various organizations to address trail hazards and install clear directional and safety signage, ensuring the trails' safety and accessibility.

TABLE 4: Meeting Dates for CVMSHCP Oversight Committees, 2025

Reserve Management Oversight Committee	Feb 20, April 24, July 24
Reserve Management Unit Committee / Biological Working Group	March 11
Trails Management Subcommittee	March 19, May 21, September 17

PROPERTY MANAGEMENT AND MONITORING

CVCC lands face significant challenges from illegal dumping, vandalism, off-highway vehicle (OHV) trespass, and encampments, which are costly and complex to remediate due to the presence of hazardous materials requiring specialized abatement.

CVCC secured funding from the California Department of Resources Recycling and Recovery (CalRecycle) through the Illegal Disposal Site Abatement Grant Program to address illegal dumping and related impacts on conservation lands. Following a competitive procurement process, two vendors were chosen for their respective specialties in dumpsite abatement and towing. CVCC identified seventeen dumpsites, including nine encampments within the Upper Mission Creek/Big Morongo Canyon Conservation Area. Eviction notices were issued in advance, allowing 34-days to relocate, followed by outreach and services offered by the Social Welfare Action Group (SWAG), Desert Hot Springs Police Department, and Desert Hot Springs Office of Code Compliance. Final evictions occurred on October 27, 2025, and no arrests or forceful removals were required. The bulk of cleanup work was completed in October and November. Cleanup operations removed approximately 260,000 pounds of debris, including 45 vehicles, 23,300 pounds of tires, hazardous waste, and other illegally discarded materials.

Throughout 2025, the Desert Recreation District (DRD) completed various work orders for CVCC. Key tasks involved repairing damaged fences, removing dumped items and encampments, and repositioning boulders to prevent vehicle access. Twenty work orders were completed and outcomes reviewed by CVCC staff. Detailed records of each work order, including dates, locations, and actions taken, were documented to ensure accountability and effective project management.

From January to September 2025, the Living Desert Zoo and Gardens' Conservation Department (TLD) advanced several projects for CVCC. These projects included invasive plant monitoring with Early Detection Rapid Response (EDRR) techniques, plant propagation and nursing, and seed collection. Additionally, TLD was able to house 400 native plants that were donated to CVCC by the Mojave Desert Land Trust. The plants will remain in their care until they are ready for planting to restore conservation land.

The Urban Conservation Corps (UCC) completed a series of invasive-species, trail-restoration, and fence-repair projects in collaboration with CVCC. Early in the year, crews removed a large tamarisk tree in the Thousand Palms Conservation Area using chainsaws and hand tools. From April through June 2025, UCC restored trail boundaries in the Palm Hills area—redefining official routes, eliminating shortcuts, and reinforcing edges near the Desert Water Agency water tank to prevent erosion and off-trail use. In the final quarter of 2025, UCC conducted three conservation efforts: removing and treating invasive tamarisk near Nancy Drive in the City of Desert Hot Springs, repairing damaged fencing on the Bump and Grind Trail by reinstalling poles with reinforced concrete, and securing multiple fence gaps at Lake Cahuilla to prevent bighorn sheep breaches by filling openings with large rocks.

Unauthorized Activities and Enforcement

Unauthorized activities continue to impact conservation lands within the CVMSHCP reserve system. In 2025 the most common issues observed included unauthorized OHV use, illegal dumping, encampments, vandalism, and trail conflicts such as dogs on restricted trails and the creation of social trails. CVCC continues to work with partner agencies to document these impacts and coordinate responses that combine enforcement, restoration, and public education.

As part of the CalRecycle grant discussed above, up to 25 percent of the funds can be applied to preventative measures designed to deter future dumping and protect sensitive habitat. CVCC applied these funds towards the installation of approximately one mile of post-and-cable fencing along Two Bunch Palms Trail and West Drive in the City of Desert Hot Springs, and is planning for the future deployment of six Flock security cameras to monitor dumping activity, as well as funding for 616 hours of ranger patrols to maintain a consistent on-site presence through June 2027.

CVCC also strengthened partnerships with local jurisdictions to address enforcement challenges. A Memorandum of Understanding with the City of Desert Hot Springs Police Department was extended, enabling continued coordination on illegal dumping, encampments, and unauthorized vehicle access within Conservation Areas. Collaboration with City departments, law enforcement, social services, and code compliance staff has improved response times and coordination when incidents occur on conservation lands.

CONSERVATION RANGER PROGRAM DEVELOPMENT

Significant progress was made in developing a regional Conservation Ranger Program, supported by a Climate Resilience Community Action Grant from CVMC. During 2025, CVCC worked with legal counsel from CVMC and DRD to evaluate potential host agencies and identify the authorities required to support a regional citation program. Initial exploration focused on establishing the program through the Coachella Valley Desert and Mountains Recreation and Conservation Authority; however, legal review determined the agency did not possess the enforcement authority necessary to implement a regional citation program.

CVCC subsequently began coordinating with the Riverside County Parks and Open Space District to explore expanding the County's existing Open Space and MSHCP ranger program into the Coachella Valley. This approach builds on an established enforcement framework and leverages the County's authority to issue citations under applicable ordinances. CVCC also engaged with peer ranger programs and conducted site visits to inform program design and operational planning.

CVCC anticipates deploying two enforcement-focused rangers on conservation lands by July 2026 through a partnership with Riverside County Parks, with potential expansion to additional partner agency lands over time. Once operational, the program will provide consistent on-the-ground presence to address illegal dumping, unauthorized OHV use, encampments, and trail misuse while supporting education and stewardship across the CVMSHCP reserve system.

Additional program development included establishing a ranger cadet training pathway with the Urban Conservation Corps (UCC) to support local workforce development. CVCC also began developing interpretive and digital education materials for rangers to promote responsible recreation and stewardship. This includes a web-based geospatial application highlighting the CVMSHCP reserve system.

Significant Issues in Implementation

In September 2025, CVCC reclassified the Reserve Management Oversight Committee (RMOC), the Reserve Management Unit Committees (RMUCs), and the Trails Management Subcommittee (TMS) as informal working groups under the Executive Director to improve efficiency and strengthen collaboration among scientists and land managers across the Plan area. This shift allows these groups to more effectively identify management issues, discuss scientific data-collection methods, recommend adaptive management actions, and update technical documents such as the Reserve Management Unit Plans and the Trails Management Plan for future CVCC approval, while policy decisions continue to go before the CVCC in public, Brown Act-governed meetings. The RMOC was established as the primary interagency body for coordinating Plan implementation and composed of representatives from federal, state, and local agencies and is supported by the RMUCs, which are staffed by scientific experts and land managers responsible for developing and implementing the six Reserve Management Unit Plans originally adopted in 2012. Although these committees historically operated as Brown Act bodies, a review of comparable conservation plans statewide showed that similar groups function as staff-managed working groups, enabling more flexible participation and more effective technical collaboration.

In March 2024, a coalition of conservation advocates submitted a petition to list the western burrowing owl as threatened or endangered under the California Endangered Species Act, which petition was accepted by the California Fish and Game Commission in October 2024. In February 2025, staff submitted comprehensive documentation to the Commission in response to requests for data and reports that may inform the State's decision regarding the potential listing of the western burrowing owl. The documentation included Annual Reports detailing biological monitoring and management outcomes; and peer-reviewed scientific publications. The California Fish and Game Commission's decision is expected in 2026.

On September 19, 2025, USFWS and CDFW issued a formal letter to the CVCC, with copies going to City Managers and key staff of Permittees participating in the CVMSHCP. The letter addressed compliance concerns related to the interim and long-term conservation strategies, as well as Take allocations of western burrowing owl both inside and outside the Conservation Areas. Since the Plan's adoption in 2008, CVCC has made significant progress in burrowing owl monitoring and management and implemented the Plan's required interim and long-term conservation strategies, including region-wide surveys, development of monitoring protocols, habitat suitability models, and establishment of a georeferenced database of burrowing owl locations. After completion of region wide surveys in 2009 and 2011, and the development of a habitat suitability model, the Interim Conservation Strategy prioritized land acquisition and habitat protection, particularly in Desert Hot Springs and the Upper Mission Creek/Big Morongo Canyon area, which was incorporated into the Plan through a Major Amendment in 2016. Because natural burrows supported stable populations, artificial burrows and perches were not recommended in the Conservation Areas unless a significant population decline was identified and adaptive management techniques implemented through the RMOC. For the long-term conservation strategy, CVCC and partner agencies conducted research on home range, dispersal, reproductive success, and population connectivity. This included feather isotopic analyses, nest monitoring with wildlife cameras, and studies on the effectiveness of burrowing owl relocation. Threats and challenges to the conservation of the species include habitat degradation from homeless encampments, raven predation, and illegal dumping. CVCC has acquired roughly 3,500 acres and installed extensive fencing and signage to reduce threats such as OHV use, dumping, and encampments. Since 2014, CVCC has invested approximately $24 million in land acquisition and $456,000 in fencing, signage, and cleanup, excluding ongoing management and monitoring costs. At the request of the RMOC, additional region-wide surveys resumed in 2025, along with new banding and DNA sampling to assess population viability and movement patterns. CVCC takes the concerns of the wildlife agencies with the utmost seriousness, and a formal response was sent to the wildlife agencies in February 2026. Staff are continuing to actively coordinate with both wildlife agencies and Permittees to ensure compliance with permit obligations.

Permittee Compliance Status

As discussed above, CVCC received a notice from the wildlife agencies in September 2025 indicating concerns regarding Permittee compliance with the conservation requirements identified in the CVMSHCP for burrowing owl. CVCC takes concerns regarding compliance with the utmost seriousness and is actively coordinating with the wildlife agencies, Permittees, burrowing owl specialists, and legal counsel to further investigate the concerns raised by the wildlife agencies; it is CVCC's current position, however, that all Permittees are currently complying with the burrowing owl requirements as described in the CVMSHCP.

CVCC finalized a like exchange initiated in 2024 between the City of Coachella and the County of Riverside. The City of Coachella had requested the like exchange to address inherent CVMSHCP inconsistencies with a proposed master-planned community partially within the East Indio Hills Conservation Area. The City of Coachella identified equivalent habitat around the Dos Palmas Conservation Area within the County of Riverside, and received concurrence on the proposed like exchange from USFWS and CDFW. CVCC took title to the exchanged properties in December of 2025.

CVCC began four Joint Project Reviews for proposed projects in the Santa Rosa and San Jacinto Mountains, Whitewater Floodplain, and Willow Hole Conservation Areas. Due to project complexities or initial inconsistencies, each of these projects is continuing into 2026. These projects will be counted towards the CVMSHCP's authorized disturbance totals upon issuance of a grading permit.

Permittees are also complying with the funding requirements of the CVMSHCP 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 $2,967,541 in Fiscal Year 2025, representing a 15.2%-percent decrease over the $3,498,499 generated in the previous fiscal year. CVCC initiated an update to its LDMF nexus study to reiterate the connection between infrastructure development and conservation, as well as assess whether any changes to the fee schedule are warranted in light of updated land values and implementation costs.

Expenditures

CVCC approved their Fiscal Year 2026 budget (Table 5) at their June 12, 2025 meeting. Note that it differs from the budget for the CVCC as a whole, which includes non-CVMSHCP program funding from an Army Corps of Engineers in-lieu fee program, endowments for conservation easements required by state lake and streambed alteration agreements, and funding for monitoring of Casey's June beetle.

ANNUAL AUDIT

The audit of the expenditures for the period July 1, 2024 to June 30, 2025 was approved by CVCC on January 8, 2026. 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 Dr., Suite 100, Palm Desert, CA 92260. Annual CVCC audits are available at https://cvag.org/cvcc-financial-reports/.

TABLE 5: CVMSHCP Budget for Fiscal Year 2024-2025

	Endowment	General Administration	Land Acquisition	Lizard Endowment	Management & Monitoring	Management Contingency	Travertine Point Monitoring	Total
Beginning Fund Balance	$16,597,478	$-	$18,654,433	$365,007	$493,817	$2,283,588	$596,106.00	$38,990,429
REVENUES / FUNDING SOURCE								
Investment Income	$440,592.72	$-	$560,899.60	$9,985.44	$7,424.02	$62,054.61	$16,307.56	$1,097,263.95
Grants	$-	$-	$-	$-	$838,509.00	$-	$-	$838,509.00
Project Reviews	$-	$6,000.00	$-	$-	$-	$-	$-	$6,000.00
Coachella/Indio Waste Transfer Tipping Fees	$-	$132,000.00	$-	$-	$-	$-	$-	$132,000.00
County Tipping Fees	$-	$325,000.00	$-	$-	$-	$-	$-	$325,000.00
Development Mitigation Fees	$-	$-	$2,139,297.61	$-	$438,169.39	$-	$-	$2,577,467.00
Agencies Mitigation Fees	$777,748.00	$-	$1,222,252.00	$-	$-	$-	$-	$2,000,000.00
Friends of the Desert Mountains	$-	$-	$-	$-	$18,000.00	$-	$-	$18,000.00
Other Revenue	$-	$-	$103,000.00	$-	$-	$-	$-	$103,000.00
Advertising Revenue	$-	$-	$-	$-	$10,441.79	$-	$-	$10,441.79
Total Revenues / Funding Source	**$1,218,340.72**	**$463,000.00**	**$4,025,449.21**	**$9,985.44**	**$1,312,544.20**	**$62,054.61**	**$16,307.56**	**$7,107,681.74**
EXPENDITURES / EXPENDITURE								
Capital Outlay	$-	$-	$40,000.00	$-	$430,300.00	$-	$-	$470,300.00
Professional Services	$-	$127,923.64	$125,000.00	$-	$337,500.00	$-	$-	$590,423.64
Employee Travel or Training	$-	$-	$-	$-	$20,500.00	$-	$-	$20,500.00
Meeting Attendance Stipends	$-	$13,160.35	$-	$-	$-	$-	$-	$13,160.35
Office Operations	$-	$33,520.00	$-	$-	$4,500.00	$-	$-	$38,020.00
LDMF Admin Fee	$-	$-	$21,393.25	$-	$4,381.75	$-	$-	$25,775.00
Land Management Costs	$-	$-	$53,000.00	$-	$1,133,630.00	$-	$-	$1,186,630.00
Miscellaneous	$-	$-	$1,200.00	$-	$-	$-	$-	$1,200.00
Land Acquisitions	$-	$-	$7,088,674.00	$-	$-	$-	$-	$7,088,674.00
CVAG Admin Reimbursement	$-	$872,866.44	$131,683.17	$-	$676,865.02	$-	$-	$1,681,414.62
Memberships	$-	$15,000.00	$-	$-	$-	$-	$-	$15,000.00
Operating Transfers In	$-	$(599,470.43)	$-	$-	$(1,235,103.00)	$-	$-	$(1,834,573.43)
Operating Transfers Out	$1,834,573.43	$-	$-	$-	$-	$-	$-	$1,834,573.43
Total Expenditures / Expenditure	**$1,834,573.43**	**$463,000.00**	**$,460,950.42**	**$-**	**$1,372,573.77**	**$-**	**$-**	**$11,131,097.61**
Net Excess (Deficit)	$(616,232.71)	$-	$(3,435,501.21)	$9,985.44	$(60,029.57)	$62,054.61	$16,307.56	$(4,023,415.87)
Ending Balance	**$15,981,245.29**	**$-**	**$15,218,931.79**	**$374,992.44**	**$433,787.43**	**$2,345,642.61**	**$612,413.56**	**$34,967,013.13**

Appendix I: Conservation Acquisitions during 2025

Conservation Area and APN	Acres
COACHELLA VALLEY STORMWATER CHANNEL AND DELTA	**12.53**
729040020	12.50
729040022	0.03
DESERT TORTOISE LINKAGE	**58.68**
715050018	20.53
745330018	38.15
DOS PALMAS	**102.14**
733190010	82.48
733190012	10.10
733190013	9.56
INDIO HILLS/JTNP LINKAGE	**5.00**
741100006	5.00
THOUSAND PALMS	**12.65**
648110009	9.83
648130008	2.82
UPPER MISSION CREEK/BIG MORONGO CANYON	**159.80**
661020011	147.64
661020012	3.96
664050013	3.16
665100028	5.03
Total	**350.80**

Appendix II: Conservation Objectives by Conservation Area

Conservation Area, Permittee, Conservation Element	Authorized Disturbance	Disturbed 2025	Disturbed to Date	Required Conservation	Conserved 2025	Conservation to Date	Percent Conserved	Rough Step
CABAZON CONSERVATION AREA								
RIVERSIDE COUNTY								
Biological Corridor/Linkage	10	0	0	631	0	0	0.00%	1.00
Mesquite Hummocks	1	0	0	12	0	0	0.00%	0.10
Peninsular Bighorn Sheep	0	0	0	83	0	0	0.00%	0.00
Sand Source Area	181	0	0	1,629	0	0	0.00%	18.10
Sand Transport Area	NA	0	0	NA	0	0	NA	NA
Southern Sycamore-Alder Riparian Forest	1	0	0	9	0	0	0.00%	0.10
COACHELLA VALLEY STORMWATER CHANNEL AND DELTA CONSERVATION AREA								
RIVERSIDE COUNTY								
California Black Rail	6	0	0	52	0	0	0.00%	0.60
Coastal and Valley Freshwater Marsh	6	0	0	51	0	0	0.00%	0.60
Crissal Thrasher	87	0	5	781	11	371	47.53%	40.79
Desert Saltbush Scrub	79	0	5	713	11	351	49.25%	37.90
Desert Sink Scrub	114	0	0	1,026	0	84	8.20%	19.81
Le Conte's Thrasher	78	0	5	706	11	371	52.58%	39.59
Mesquite Hummocks	7	0	0	67	0	20	29.92%	2.48
Yuma Clapper Rail	6	0	0	52	0	0	0.00%	0.60
DESERT TORTOISE LINKAGE CONSERVATION AREA								
COACHELLA								
Desert Dry Wash Woodland	12	0	0	109	0	0	0.00%	1.20
Desert Tortoise	30	0	0	270	0	0	0.00%	3.00
Le Conte's Thrasher	30	0	0	270	0	0	0.00%	3.00
RIVERSIDE COUNTY								
Biological Corridor/Linkage	1,572	0	0	14,143	21	0	0.00%	156.98
Desert Dry Wash Woodland	752	0	1	6,771	5	914	13.50%	165.67
Desert Tortoise	4,998	0	1	44,977	78	7,066	15.71%	1205.13
Le Conte's Thrasher	2,813	0	1	25,319	14	2,582	10.20%	538.12
Mecca Aster	206	0	0	1,855	0	454	24.50%	66.02
Orocopia Sage	44	0	0	398	0	0	0.00%	4.40
DOS PALMAS CONSERVATION AREA								
RIVERSIDE COUNTY								
Arrowweed Scrub	13	0	0	121	0	0	0.30%	1.33
California Black Rail	37	0	0	334	0	305	91.46%	34.16
Cismontane Alkali Marsh	23	0	0	205	0	215	105.07%	24.05
Crissal Thrasher	38	0	0	343	0	267	77.81%	30.41
Desert Dry Wash Woodland	83	0	0	746	0	292	39.12%	37.52
Desert Fan Palm Oasis Woodland	6	0	0	50	0	29	58.80%	3.78
Desert Sink Scrub	487	0	0	4,381	0	1,342	30.63%	182.97

Conservation Area, Permittee, Conservation Element	Authorized Disturbance	Disturbed 2025	Disturbed to Date	Required Conservation	Conserved 2025	Conservation to Date	Percent Conserved	Rough Step
Flat-Tailed Horned Lizard (Predicted)	403	0	0	3,631	0	733	20.19%	113.54
Le Conte's Thrasher	743	0	0	6,689	0	2,636	39.41%	337.82
Mesquite Bosque	36	0	0	320	0	256	80.05%	29.54
Mesquite Hummocks	3	0	0	23	0	11	46.74%	1.56
Yuma Clapper Rail	42	0	0	374	0	326	87.05%	37.10
EAST INDIO HILLS CONSERVATION AREA								
COACHELLA								
Coachella Valley Round-Tailed Ground Squirrel	1	0	0	5	0	0	0.00%	0.10
Flat-Tailed Horned Lizard (Predicted)	1	0	0	5	0	0	0.00%	0.10
Le Conte's Thrasher	6	0	0	56	0	0	0.00%	0.60
Palm Springs Pocket Mouse	1	0	0	7	0	0	0.00%	0.10
INDIO								
Coachella Valley Round-Tailed Ground Squirrel	11	0	0	103	0	0	0.00%	1.10
Flat-Tailed Horned Lizard (Predicted)	11	0	0	100	0	0	0.00%	1.10
Le Conte's Thrasher	12	0	0	105	0	0	0.00%	1.20
Mesquite Hummocks	0	0	0	2	0	0	0.00%	0.00
Palm Springs Pocket Mouse	11	0	0	103	0	0	0.00%	1.10
Stabilized Shielded Desert Sand Fields	11	0	0	100	0	0	0.00%	1.10
RIVERSIDE COUNTY								
Active Desert Dunes	1	0	0	4	0	0	0.00%	0.10
Coachella Valley Round-Tailed Ground Squirrel	100	0	0	896	0	1	0.09%	10.08
Desert Saltbush Scrub	1	0	0	7	0	0	0.00%	0.10
Flat-Tailed Horned Lizard (Predicted)	46	0	0	896	0	0	0.00%	4.60
Le Conte's Thrasher	139	0	0	1,253	0	35	2.83%	17.44
Mecca Aster	116	0	0	1,045	0	0	0.00%	11.60
Mesquite Hummocks	4	0	0	39	0	0	0.00%	0.40
Palm Springs Pocket Mouse	105	0	0	944	0	33	3.48%	13.79
Stabilized and Partially Stabilized Desert Sand Fields	33	0	0	295	0	0	0.00%	3.30
Stabilized Shielded Desert Sand Fields	28	0	0	256	0	0	0.00%	2.80
EDOM HILL CONSERVATION AREA								
CATHEDRAL CITY								
Coachella Valley Fringe-Toed Lizard	1	0	0	16	0	0	0.00%	0.10
Coachella Valley Giant Sand-Treader Cricket	1	0	0	16	0	0	0.00%	0.10
Coachella Valley Milkvetch	15	0	0	136	0	42	30.63%	5.64
Coachella Valley Round-Tailed Ground Squirrel	13	0	0	121	0	42	34.43%	5.33
Le Conte's Thrasher	34	0	0	310	0	75	24.25%	10.82
Palm Springs Pocket Mouse	11	0	0	103	0	41	40.05%	5.07
Sand Source Area	35	0	0	310	0	75	24.25%	11.14
Stabilized and Partially Stabilized Desert Sand Fields	1	0	0	17	0	0	0.00%	0.10
RIVERSIDE COUNTY								
Active Desert Sand Fields	4	0	0	37	0	41	110.08%	4.36
Coachella Valley Fringe-Toed Lizard	5	0	0	40	0	43	107.90%	5.36

Conservation Area, Permittee, Conservation Element	Authorized Disturbance	Disturbed 2025	Disturbed to Date	Required Conservation	Conserved 2025	Conservation to Date	Percent Conserved	Rough Step
Coachella Valley Giant Sand-Treader Cricket	5	0	0	40	0	43	107.90%	5.36
Coachella Valley Milkvetch	134	0	0	1,205	0	1,127	93.50%	126.17
Coachella Valley Round-Tailed Ground Squirrel	145	0	0	1,302	0	1,215	93.35%	136.33
Le Conte's Thrasher	194	0	2	1,745	0	1,527	87.52%	170.61
Palm Springs Pocket Mouse	104	0	0	935	0	880	94.10%	98.48
Sand Source Area	197	0	0	1,770	0	1,622	91.64%	181.86
Sand Transport Area	63	0	1	565	0	421	74.50%	47.25
Stabilized and Partially Stabilized Desert Sand Fields	1	0	0	3	0	2	80.98%	0.83
HIGHWAY 111/I-10 CONSERVATION AREA								
PALM SPRINGS								
Coachella Valley Jerusalem Cricket	37	0	0	335	0	126	37.48%	16.18
Coachella Valley Milkvetch	37	0	0	335	0	126	37.48%	16.18
Coachella Valley Round-Tailed Ground Squirrel	39	0	0	350	0	137	39.08%	17.62
Le Conte's Thrasher	39	0	0	350	0	137	39.08%	17.62
Palm Springs Pocket Mouse	39	0	0	350	0	137	39.08%	17.62
INDIO HILLS PALMS CONSERVATION AREA								
RIVERSIDE COUNTY								
Desert Dry Wash Woodland	4	0	0	33	0	36	109.83%	4.35
Desert Fan Palm Oasis Woodland	5	0	0	42	0	7	16.61%	1.25
Le Conte's Thrasher	1	0	0	7	0	0	0.00%	0.10
Mecca Aster	255	0	0	2,290	0	1,039	45.38%	129.65
Mesquite Hummocks	1	0	0	1	0	0	0.00%	0.10
INDIO HILLS/JOSHUA TREE NATIONAL PARK LINKAGE CONSERVATION AREA								
RIVERSIDE COUNTY								
Biological Corridor/Linkage	1,141	0	6	10,267	5	9,007	87.72%	1009.21
Desert Tortoise	859	0	0	7,735	5	6,560	84.81%	741.54
Le Conte's Thrasher	606	0	0	5,457	1	5,463	100.11%	606.59
Sand Source Area	460	0	0	4,135	0	3,215	77.75%	367.89
Sand Transport Area	681	0	6	6,132	5	5,792	94.45%	641.25
JOSHUA TREE NATIONAL PARK CONSERVATION AREA								
RIVERSIDE COUNTY								
Desert Dry Wash Woodland	13	0	0	119	0	192	161.33%	20.18
Desert Fan Palm Oasis Woodland	0	0	0	5	0	0	0.00%	0.00
Desert Tortoise	1,708	0	0	15,367	0	12,529	81.53%	1424.14
Gray Vireo	134	0	0	1,208	0	1,822	150.85%	195.33
Le Conte's Thrasher	25	0	0	222	0	103	46.58%	12.98
Mojave Mixed Woody Scrub	800	0	0	7,195	0	6,353	88.29%	715.71
Mojavean Pinyon-Juniper Woodland	134	0	0	1,208	0	1,822	150.85%	195.33
MECCA HILLS/OROCOPIA MOUNTAINS CONSERVATION AREA								
RIVERSIDE COUNTY								
Desert Dry Wash Woodland	318	0	0	2,861	0	1,381	48.28%	169.96

Conservation Area, Permittee, Conservation Element	Authorized Disturbance	Disturbed 2025	Disturbed to Date	Required Conservation	Conserved 2025	Conservation to Date	Percent Conserved	Rough Step
Desert Fan Palm Oasis Woodland	0	0	0	0	0	0	0.00%	0.00
Desert Tortoise	2,624	0	0	23,617	0	8,139	34.46%	1076.29
Le Conte's Thrasher	652	0	0	5,866	0	1,578	26.91%	223.09
Mecca Aster	465	0	0	4,181	0	2,122	50.76%	258.95
Orocopia Sage	1,803	0	0	16,227	0	5,468	33.69%	727.05
SANTA ROSA & SAN JACINTO MOUNTAINS CONSERVATION AREA								
CATHEDRAL CITY								
Desert Dry Wash Woodland	2	0	0	18	0	0	0.07%	0.20
Desert Tortoise	11	0	0	95	0	1	1.29%	1.23
Le Conte's Thrasher	1	0	0	11	0	0	0.00%	0.10
Peninsular Bighorn Sheep	11	0	0	97	0	1	1.26%	1.22
INDIAN WELLS								
Desert Dry Wash Woodland	7	0	0	66	0	0	0.00%	0.70
Desert Tortoise	111	0	0	999	0	36	3.63%	14.70
Le Conte's Thrasher	23	0	0	206	0	0	0.06%	2.29
Peninsular Bighorn Sheep	114	0	0	1,158	0	36	3.12%	14.60
LA QUINTA								
Desert Dry Wash Woodland	8	0	0	76	0	15	19.97%	2.24
Desert Tortoise	157	0	1	1,409	0	424	30.07%	57.52
Le Conte's Thrasher	43	0	0	387	0	125	32.24%	16.78
Peninsular Bighorn Sheep	159	0	1	2,545	0	430	16.88%	39.37
PALM DESERT								
Desert Dry Wash Woodland	3	0	0	29	0	0	0.00%	0.30
Desert Tortoise	48	0	0	436	0	206	47.32%	25.24
Le Conte's Thrasher	4	0	0	33	0	0	0.65%	0.42
Peninsular Bighorn Sheep	14	0	0	130	0	392	301.54%	39.39
PALM SPRINGS								
Desert Dry Wash Woodland	4	0	0	36	0	10	28.15%	1.41
Desert Fan Palm Oasis Woodland	9	0	0	76	0	0	0.00%	0.90
Desert Tortoise	1,317	0	0	8,856	0	4,764	53.80%	769.12
Gray Vireo	431	0	0	3,883	0	780	20.08%	120.98
Le Conte's Thrasher	103	0	0	560	0	318	56.85%	63.00
Peninsular Juniper Woodland and Scrub	353	0	0	3,177	0	780	24.54%	113.26
Peninsular Bighorn Sheep	1,092	0	1	7,211	0	10,351	143.54%	1519.41
Semi-Desert Chaparral	51	0	0	571	0	0	0.00%	5.10
Sonoran Cottonwood-Willow Riparian Forest	0	0	0	58	0	1	2.54%	0.00
Southern Arroyo Willow Riparian Forest	0	0	0	0	0	0	0.00%	0.00
Southern Sycamore-Alder Riparian Forest	2	0	0	24	0	0	0.00%	0.20
RANCHO MIRAGE								
Desert Dry Wash Woodland	1	0	0	9	0	1	6.44%	0.16
Desert Tortoise	147	0	0	1,326	0	572	43.11%	71.73
Le Conte's Thrasher	2	0	0	17	0	0	0.00%	0.20

Conservation Area, Permittee, Conservation Element	Authorized Disturbance	Disturbed 2025	Disturbed to Date	Required Conservation	Conserved 2025	Conservation to Date	Percent Conserved	Rough Step
Peninsular Bighorn Sheep	42	0	0	450	0	575	127.73%	52.48
RIVERSIDE COUNTY								
Desert Dry Wash Woodland	298	0	0	1,244	0	1,306	105.00%	311.41
Desert Fan Palm Oasis Woodland	45	0	0	404	0	52	12.95%	9.74
Desert Tortoise	2,950	0	7	23,856	0	20,311	85.14%	2548.95
Gray Vireo	881	0	0	7,930	0	7,811	98.50%	869.05
Le Conte's Thrasher	911	0	0	5,508	0	5,575	101.22%	920.97
Peninsular Juniper Woodland and Scrub	418	0	0	2,899	0	5,050	174.19%	697.05
Peninsular Bighorn Sheep	2,418	0	0	19,205	0	17,856	92.98%	2264.94
Redshank Chaparral	253	0	0	2,274	0	1,835	80.68%	208.99
Semi-Desert Chaparral	233	0	0	2,093	0	927	44.28%	116.15
Southern Arroyo Willow Riparian Forest	2	0	0	15	0	0	0.00%	0.20
Southern Sycamore-Alder Riparian Forest	12	0	0	117	0	5	4.51%	1.69
SNOW CREEK/WINDY POINT CONSERVATION AREA								
PALM SPRINGS								
Active Desert Dunes	7	0	0	62	0	43	69.67%	5.09
Biological Corridor/Linkage	27	0	0	247	0	249	100.91%	27.22
Coachella Valley Fringe-Toed Lizard	75	0	0	672	0	248	36.96%	32.45
Coachella Valley Giant Sand-Treader Cricket	75	0	0	672	0	248	36.96%	32.45
Coachella Valley Jerusalem Cricket	90	0	0	815	0	252	30.88%	34.02
Coachella Valley Milkvetch	91	0	0	816	0	252	30.86%	34.38
Coachella Valley Round-Tailed Ground Squirrel	93	0	0	838	0	253	30.21%	34.58
Ephemeral Desert Sand Fields	68	0	0	610	0	205	33.64%	27.39
Le Conte's Thrasher	86	0	0	775	0	210	27.09%	29.57
Palm Springs Pocket Mouse	93	0	0	838	0	253	30.21%	34.58
Peninsular Bighorn Sheep	15	0	0	144	0	23	16.23%	3.69
Sand Transport Area	93	0	0	838	0	253	30.21%	34.58
RIVERSIDE COUNTY								
Biological Corridor/Linkage	46	0	0	415	0	145	34.86%	19.03
Coachella Valley Fringe-Toed Lizard	55	0	0	502	0	401	79.91%	45.05
Coachella Valley Giant Sand-Treader Cricket	56	0	0	501	0	401	80.07%	45.95
Coachella Valley Jerusalem Cricket	60	0	0	538	0	524	97.47%	58.64
Coachella Valley Milkvetch	134	0	0	1,210	0	855	70.68%	98.64
Coachella Valley Round-Tailed Ground Squirrel	152	0	0	1,371	0	1,039	75.79%	118.88
Ephemeral Desert Sand Fields	45	0	0	409	0	393	96.15%	43.44
Le Conte's Thrasher	162	0	0	1,453	0	1,077	74.11%	124.26
Palm Springs Pocket Mouse	148	0	0	1,331	0	1,085	81.49%	123.35
Peninsular Bighorn Sheep	49	0	0	443	0	264	59.59%	31.18
Sand Transport Area	165	0	0	1,482	0	1,087	73.32%	125.38
STUBBE & COTTONWOOD CANYONS CONSERVATION AREA								
RIVERSIDE COUNTY								
Biological Corridor/Linkage	117	0	0	1,058	0	882	83.33%	99.44

Conservation Area, Permittee, Conservation Element	Authorized Disturbance	Disturbed 2025	Disturbed to Date	Required Conservation	Conserved 2025	Conservation to Date	Percent Conserved	Rough Step
Desert Dry Wash Woodland	26	0	0	229	0	137	59.97%	16.63
Desert Tortoise	253	0	20	2,276	0	1,005	44.14%	105.97
Le Conte's Thrasher	123	0	0	1,111	0	825	74.26%	94.27
Sand Source Area	138	0	20	1,241	0	229	18.44%	17.10
Sand Transport Area	125	0	0	1,129	0	832	73.68%	95.16
THOUSAND PALMS CONSERVATION AREA								
RIVERSIDE COUNTY								
Active Desert Dunes	2	0	0	14	0	6	42.65%	0.97
Active Desert Sand Fields	91	0	0	820	0	679	82.81%	76.92
Biological Corridor/Linkage	9,831	0	51	7,816	13	6,044	77.32%	7773.80
Coachella Valley Fringe-Toed Lizard	93	0	0	834	0	684	81.97%	77.91
Coachella Valley Giant Sand-Treader Cricket	93	0	0	834	0	684	81.97%	77.91
Coachella Valley Milkvetch	111	0	4	1,001	0	834	83.27%	90.71
Coachella Valley Round-Tailed Ground Squirrel	468	0	30	2,974	13	2,057	69.17%	308.21
Desert Dry Wash Woodland	4	0	0	34	0	16	47.38%	2.11
Desert Fan Palm Oasis Woodland	0	0	0	0	0	0	NA	0.00
Flat-Tailed Horned Lizard (Predicted)	97	0	0	877	0	721	82.19%	81.45
Le Conte's Thrasher	552	0	24	3,879	13	2,631	67.82%	367.94
Mecca Aster	297	0	5	2,676	0	2,652	99.09%	289.31
Mesquite Hummocks	0	0	0	0	0	0	NA	0.00
Palm Springs Pocket Mouse	518	0	30	3,588	13	2,456	68.44%	340.98
Sand Source Area	412	0	6	3,712	0	3,368	90.73%	371.70
Sand Transport Area	5,731	0	45	4,100	13	2,696	65.75%	3919.55
Sonoran Cottonwood-Willow Riparian Forest	0	0	0	0	0	0	NA	0.00
UPPER MISSION CREEK/BIG MORONGO CANYON CONSERVATION AREA								
DESERT HOT SPRINGS								
Biological Corridor/Linkage	10	0	0	88	0	2	2.38%	1.21
Coachella Valley Jerusalem Cricket	10	0	1	90	0	30	33.80%	2.90
Desert Dry Wash Woodland	8	0	0	76	0	0	0.00%	0.80
Desert Tortoise	252	0	10	2,271	164	1,391	61.24%	154.06
Le Conte's Thrasher	215	0	2	1,931	159	1,081	55.99%	127.53
Little San Bernardino Mountains Linanthus	107	0	0	966	119	613	63.50%	71.85
Palm Springs Pocket Mouse	207	0	2	1,865	164	1,168	62.62%	135.06
Sand Source Area	16	0	7	141	0	66	46.81%	1.11
Sand Transport Area	217	0	2	1,949	164	1,190	61.04%	138.61
PALM SPRINGS								
Le Conte's Thrasher	2	0	0	22	0	0	0.00%	0.20
Palm Springs Pocket Mouse	2	0	0	22	0	0	0.00%	0.20
Sand Transport Area	2	0	0	22	0	0	0.00%	0.20
RIVERSIDE COUNTY								
Biological Corridor/Linkage	76	0	0	688	0	356	51.75%	43.00
Coachella Valley Jerusalem Cricket	47	0	16	419	0	61	14.52%	-4.95

Conservation Area, Permittee, Conservation Element	Authorized Disturbance	Disturbed 2025	Disturbed to Date	Required Conservation	Conserved 2025	Conservation to Date	Percent Conserved	Rough Step
Desert Dry Wash Woodland	8	0	0	76	0	76	100.00%	8.00
Desert Tortoise	882	0	66	7,936	0	5,718	72.05%	594.42
Le Conte's Thrasher	119	0	0	1,072	0	959	89.43%	107.68
Little San Bernardino Mountains Linanthus	117	0	0	1,052	0	945	89.87%	106.34
Palm Springs Pocket Mouse	124	0	0	1,112	0	998	89.78%	112.59
Sand Source Area	721	0	66	6,488	0	4,753	73.25%	481.88
Sand Transport Area	140	0	0	1,259	0	1,209	96.03%	134.81
Sonoran Cottonwood-Willow Riparian Forest	8	0	0	84	0	78	92.49%	7.46
Southern Sycamore-Alder Riparian Forest	0	0	0	13	0	60	459.04%	0.00
Triple-Ribbed Milkvetch	47	0	0	426	0	420	98.69%	46.44
WEST DECEPTION CANYON CONSERVATION AREA								
RIVERSIDE COUNTY								
Sand Source Area	118	0	0	118	0	944	799.77%	861.16
WHITEWATER CANYON CONSERVATION AREA								
DESERT HOT SPRINGS								
Desert Tortoise	0	0	0	0	0	0	NA	0.00
Sand Source Area	0	0	0	0	0	0	NA	0.00
RIVERSIDE COUNTY								
Arroyo Toad	78	0	0	706	0	717	101.55%	79.09
Biological Corridor/Linkage	22	0	1	201	0	0	0.00%	0.79
Desert Fan Palm Oasis Woodland	0	0	0	0	0	0	NA	0.00
Desert Tortoise	120	0	5	1,084	0	742	68.46%	81.29
Little San Bernardino Mountains Linanthus	39	0	0	348	0	277	79.72%	31.88
Sand Source Area	94	0	3	850	0	618	72.73%	67.69
Sand Transport Area	48	0	1	435	0	338	77.77%	36.99
Sonoran Cottonwood-Willow Riparian Forest	11	0	0	107	0	105	98.52%	10.85
Triple-Ribbed Milkvetch	41	0	0	368	0	277	75.38%	31.83
WHITEWATER FLOODPLAIN CONSERVATION AREA								
CATHEDRAL CITY								
Active Desert Sand Fields	5	0	0	43	0	0	0.00%	0.50
Biological Corridor/Linkage	2	0	0	18	0	0	0.00%	0.20
Coachella Valley Fringe-Toed Lizard	7	0	0	61	0	0	0.00%	0.70
Coachella Valley Giant Sand-Treader Cricket	7	0	0	61	0	0	0.00%	0.70
Coachella Valley Milkvetch	7	0	0	61	0	0	0.00%	0.70
Coachella Valley Round-Tailed Ground Squirrel	7	0	0	59	0	0	0.00%	0.70
Le Conte's Thrasher	7	0	0	61	0	0	0.00%	0.70
Palm Springs Pocket Mouse	7	0	0	61	0	0	0.00%	0.70
Sand Transport Area	7	0	0	61	0	0	0.00%	0.70
PALM SPRINGS								
Active Desert Sand Fields	44	0	0	392	0	349	89.06%	39.67
Biological Corridor/Linkage	90	0	8	809	0	33	4.07%	3.93
Coachella Valley Fringe-Toed Lizard	295	0	66	2,659	0	873	32.84%	50.33

Conservation Area, Permittee, Conservation Element	Authorized Disturbance	Disturbed 2025	Disturbed to Date	Required Conservation	Conserved 2025	Conservation to Date	Percent Conserved	Rough Step
Coachella Valley Giant Sand-Treader Cricket	295	0	66	2,659	0	873	32.84%	50.33
Coachella Valley Milkvetch	297	0	66	2,671	0	873	32.69%	50.73
Coachella Valley Round-Tailed Ground Squirrel	328	0	74	2,955	0	875	29.59%	46.05
Ephemeral Desert Sand Fields	132	0	34	1,185	0	523	44.15%	31.23
Le Conte's Thrasher	381	0	74	3,433	0	906	26.40%	54.91
Palm Springs Pocket Mouse	347	0	77	3,122	0	892	28.57%	46.96
Sand Transport Area	387	0	77	3,484	0	906	26.01%	52.04
Stabilized and Partially Stabilized Desert Sand Fields	44	0	0	394	0	0	0.00%	4.40
RIVERSIDE COUNTY								
Biological Corridor/Linkage	53	0	30	475	0	278	58.61%	3.39
Coachella Valley Fringe-Toed Lizard	6	0	0	57	0	6	10.98%	1.19
Coachella Valley Giant Sand-Treader Cricket	6	0	0	57	0	6	10.98%	1.19
Coachella Valley Milkvetch	6	0	0	58	0	6	10.79%	1.18
Coachella Valley Round-Tailed Ground Squirrel	11	0	0	100	0	43	42.80%	5.34
Ephemeral Desert Sand Fields	6	0	0	52	0	0	0.00%	0.60
Le Conte's Thrasher	53	0	30	480	0	290	60.47%	4.27
Palm Springs Pocket Mouse	53	0	30	477	0	288	60.38%	4.28
Sand Transport Area	53	0	30	481	0	290	60.35%	4.21
Stabilized and Partially Stabilized Desert Sand Fields	1	0	0	4	0	6	156.41%	1.51
WILLOW HOLE CONSERVATION AREA								
CATHEDRAL CITY								
Active Desert Sand Fields	4	0	0	33	0	37	110.82%	4.39
Coachella Valley Fringe-Toed Lizard	24	0	0	211	0	194	92.01%	22.27
Coachella Valley Milkvetch	87	0	0	782	0	296	37.86%	38.34
Coachella Valley Round-Tailed Ground Squirrel	140	0	0	1,256	0	741	58.96%	88.29
Ephemeral Desert Sand Fields	20	0	0	178	0	158	88.52%	17.93
Le Conte's Thrasher	168	0	0	1,508	0	807	53.52%	97.72
Palm Springs Pocket Mouse	107	0	0	959	0	753	78.57%	86.36
Sand Source Area	79	0	0	710	0	76	10.68%	15.49
Sand Transport Area	89	0	0	798	0	731	91.64%	82.30
Stabilized and Partially Stabilized Desert Dunes	0	0	0	1	0	0	0.00%	0.00
Stabilized and Partially Stabilized Desert Sand Fields	6	0	0	51	0	0	0.00%	0.60
DESERT HOT SPRINGS								
Biological Corridor/Linkage	31	0	0	277	0	140	50.49%	17.19
Coachella Valley Fringe-Toed Lizard	0	0	0	3	0	0	1.28%	0.00
Coachella Valley Milkvetch	96	0	0	863	0	422	48.91%	51.86
Coachella Valley Round-Tailed Ground Squirrel	0	0	0	3	0	0	1.28%	0.00
Ephemeral Desert Sand Fields	61	0	0	549	0	269	48.98%	32.99
Le Conte's Thrasher	167	0	0	1,499	5	794	52.94%	96.27
Mesquite Hummocks	3	0	0	27	0	16	57.89%	1.86
Palm Springs Pocket Mouse	171	0	0	1,542	0	720	46.69%	88.96
Sand Transport Area	171	0	0	1,542	0	720	46.69%	88.96

Conservation Area, Permittee, Conservation Element	Authorized Disturbance	Disturbed 2025	Disturbed to Date	Required Conservation	Conserved 2025	Conservation to Date	Percent Conserved	Rough Step
Stabilized and Partially Stabilized Desert Dunes	14	0	0	125	0	51	41.10%	6.58
Stabilized and Partially Stabilized Desert Sand Fields	5	0	0	49	0	16	32.03%	1.94
RIVERSIDE COUNTY								
Biological Corridor/Linkage	13	0	0	120	0	0	0.00%	1.30
Coachella Valley Fringe-Toed Lizard	50	0	0	452	0	317	70.20%	36.20
Coachella Valley Milkvetch	99	0	0	888	0	852	95.98%	95.02
Coachella Valley Round-Tailed Ground Squirrel	120	0	0	1,078	0	927	86.01%	104.50
Desert Fan Palm Oasis Woodland	0	0	0	0	0	0	NA	0.00
Desert Saltbush Scrub	17	0	0	152	0	141	92.90%	15.91
Ephemeral Desert Sand Fields	20	0	0	179	0	102	57.04%	12.27
Le Conte's Thrasher	131	0	0	1,178	0	957	81.26%	108.51
Mesquite Hummocks	82	0	0	71	0	75	106.12%	86.51
Palm Springs Pocket Mouse	127	0	0	1,142	0	945	82.75%	106.89
Sand Source Area	2	0	0	17	0	8	48.31%	1.07
Sand Transport Area	133	0	0	1,193	0	949	79.55%	108.12
Stabilized and Partially Stabilized Desert Dunes	21	0	0	194	0	150	77.48%	16.51
Stabilized and Partially Stabilized Desert Sand Fields	9	0	0	79	0	65	82.16%	7.40

Appendix III: Development outside Conservation Areas

Conservation Element and Jurisdiction	Acres Disturbed
ACTIVE DESERT DUNES	**7**
Palm Springs	0
Riverside County	7
ACTIVE DESERT SAND FIELDS	**274**
Cathedral City	1
Indio	0
Palm Springs	0
Riverside County	273
ARROWWEED SCRUB	**0**
Riverside County	0
ARROYO TOAD	**0**
Riverside County	0
CALIFORNIA BLACK RAIL	**4**
Coachella	1
Indio	2
Riverside County	1
CHAMISE CHAPARRAL	**0**
Riverside County	0
CISMONTANE ALKALI MARSH	**0**
Riverside County	0
COACHELLA VALLEY FRINGE-TOED LIZARD	**9,202**
Cathedral City	1,053
Coachella	9
Indian Wells	744
Indio	1,203
La Quinta	575
Palm Desert	1,409
Palm Springs	1,750
Rancho Mirage	1,304
Riverside County	1,155
COACHELLA VALLEY GIANT SAND-TREADER CRICKET	**9,202**
Cathedral City	1,053
Coachella	9
Indian Wells	744
Indio	1,203
La Quinta	575
Palm Desert	1,409
Palm Springs	1,750
Rancho Mirage	1,304
Riverside County	1,155
COACHELLA VALLEY JERUSALEM CRICKET	**4,852**
Cathedral City	1,080
Desert Hot Springs	84
Palm Desert	21
Palm Springs	1,765
Rancho Mirage	1,195
Riverside County	707
COACHELLA VALLEY MILKVETCH	**6,964**
Cathedral City	937
Desert Hot Springs	95
Indian Wells	639
La Quinta	1
Palm Desert	1,397
Palm Springs	1,231
Rancho Mirage	1,093
Riverside County	1,571
COACHELLA VALLEY ROUND-TAILED GROUND SQUIRREL	**16,713**
Cathedral City	1,366
Coachella	139
Desert Hot Springs	897
Indian Wells	1,074
Indio	2,119
La Quinta	1,522
Palm Desert	1,761
Palm Springs	2,193
Rancho Mirage	1,490
Riverside County	4,152
Coastal and Valley Freshwater Marsh	**13**
Coachella	1
Indio	2
Riverside County	10
CRISSAL THRASHER	**1,710**
Cathedral City	0
Coachella	145
Desert Hot Springs	12
Indian Wells	21
Indio	299
La Quinta	717
Riverside County	516
DESERT DRY WASH WOODLAND	**727**
Cathedral City	8
Coachella	0
Desert Hot Springs	0
Indian Wells	185
Indio	0
La Quinta	29
Palm Desert	183
Palm Springs	9
Rancho Mirage	33
Riverside County	280
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	**601**
Coachella	77
Indio	196
La Quinta	71
Riverside County	257
DESERT SINK SCRUB	**207**

Conservation Element and Jurisdiction	Acres Disturbed
Riverside County	207
DESERT TORTOISE	**4,028**
Cathedral City	33
Coachella	4
Desert Hot Springs	855
Indian Wells	208
Indio	0
La Quinta	431
Palm Desert	536
Palm Springs	150
Rancho Mirage	198
Riverside County	1,613
EPHEMERAL SAND FIELDS	**83**
Cathedral City	0
Palm Springs	76
Riverside County	7
FLAT-TAILED HORNED LIZARD	**9,421**
Cathedral City	981
Coachella	7
Desert Hot Springs	70
Indian Wells	744
Indio	1,118
La Quinta	589
Palm Desert	1,409
Palm Springs	1,746
Rancho Mirage	1,295
Riverside County	1,462
GRAY VIREO	**529**
Palm Springs	0
Riverside County	529
INTERIOR LIVE OAK CHAPARRAL	**2**
Palm Springs	0
Riverside County	2
LE CONTE'S THRASHER	**19,643**
Cathedral City	1,360
Coachella	167
Desert Hot Springs	1,463
Indian Wells	1,243
Indio	1,899
La Quinta	1,788
Palm Desert	2,260
Palm Springs	2,168
Rancho Mirage	1,514
Riverside County	5,781
LEAST BELL'S VIREO	**2,342**
Cathedral City	8
Coachella	148
Desert Hot Springs	13
Indian Wells	206
Indio	302
La Quinta	746
Palm Desert	183
Palm Springs	9
Rancho Mirage	33
Riverside County	694

Conservation Element and Jurisdiction	Acres Disturbed
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	**266**
Cathedral City	0
Coachella	19
Desert Hot Springs	12
Indian Wells	21
Indio	89
La Quinta	72
Riverside County	53
MOJAVE MIXED WOODY SCRUB	**32**
Desert Hot Springs	5
Riverside County	27
MOJAVEAN PINYON & JUNIPER WOODLAND	**0**
Riverside County	0
OROCOPIA SAGE	**18**
Riverside County	18
PALM SPRINGS POCKET MOUSE	**17,182**
Cathedral City	1,380
Coachella	75
Desert Hot Springs	931
Indian Wells	1,083
Indio	1,998
La Quinta	1,347
Palm Desert	1,841
Palm Springs	2,348
Rancho Mirage	1,530
Riverside County	4,649
PENINSULAR BIGHORN SHEEP	**599**
Cathedral City	10
Indian Wells	4
La Quinta	131
Palm Desert	268
Palm Springs	110
Rancho Mirage	22
Riverside County	53
PENINSULAR JUNIPER WOODLAND & SCRUB	**3**
Palm Springs	0
Riverside County	3
RED SHANK CHAPARRAL	**0**
Riverside County	0
SEMI-DESERT CHAPARRAL	**2**
Palm Springs	0
Riverside County	2
SONORAN COTTONWOOD-WILLOW RIPARIAN FOREST	**4**
Coachella	0
Indio	0
Palm Springs	0

Conservation Element and Jurisdiction	Acres Disturbed
Riverside County	4
SONORAN CREOSOTE BUSH SCRUB	**2,040**
Cathedral City	1
Coachella	56
Desert Hot Springs	2
Indian Wells	28
Indio	303
La Quinta	202
Palm Desert	192
Palm Springs	23
Rancho Mirage	40
Riverside County	1,193
SONORAN MIXED WOODY & SUCCULENT SCRUB	**1,360**
Cathedral City	29
Desert Hot Springs	291
Indian Wells	0
Indio	7
La Quinta	12
Palm Desert	246
Palm Springs	82
Rancho Mirage	0
Riverside County	693
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	**1,718**
Cathedral City	5
Coachella	35
Desert Hot Springs	2
Indian Wells	209
Indio	236
La Quinta	731
Palm Desert	194
Palm Springs	7
Rancho Mirage	46
Riverside County	253
STABILIZED & PARTIALLY STABILIED DESERT SAND FIELDS	**1**
Cathedral City	0
Indio	0
Palm Springs	0
Riverside County	1
STABILIZED & PARTIALLY STABILIZED DESERT SAND DUNES	**0**
Cathedral City	0
Riverside County	0

Conservation Element and Jurisdiction	Acres Disturbed
STABILIZED SHIELDED SAND FIELDS	**8,370**
Cathedral City	1,030
Coachella	9
Indian Wells	744
Indio	1,202
La Quinta	574
Palm Desert	1,314
Palm Springs	1,483
Rancho Mirage	1,304
Riverside County	709
SUMMER TANAGER	**2,341**
Cathedral City	8
Coachella	148
Desert Hot Springs	12
Indian Wells	206
Indio	302
La Quinta	746
Palm Desert	183
Palm Springs	9
Rancho Mirage	33
Riverside County	694
TRIPLE-RIBBED MILKVETCH	**0**
Palm Springs	0
Riverside County	0
YELLOW WARBLER	**2,371**
Cathedral City	8
Coachella	150
Desert Hot Springs	13
Indian Wells	206
Indio	329
La Quinta	746
Palm Desert	183
Palm Springs	9
Rancho Mirage	33
Riverside County	694
YELLOW-BREASTED CHAT	**2,342**
Cathedral City	8
Coachella	148
Desert Hot Springs	13
Indian Wells	206
Indio	302
La Quinta	746
Palm Desert	183
Palm Springs	9
Rancho Mirage	33
Riverside County	694
YUMA CLAPPER RAIL	**3**
Coachella	1
Indio	2
Riverside County	0
ACTIVE DESERT SAND FIELDS	**274**
Cathedral City	1
Indio	0
Palm Springs	0
Riverside County	273

Conservation Element and Jurisdiction	Acres Disturbed
ARROWWEED SCRUB	**0**
Riverside County	0
ARROYO TOAD	**0**
Riverside County	0
CALIFORNIA BLACK RAIL	**4**
Coachella	1
Indio	2
Riverside County	1
CHAMISE CHAPARRAL	**0**
Riverside County	0
CISMONTANE ALKALI MARSH	**0**
Riverside County	0
COACHELLA VALLEY FRINGE-TOED LIZARD	**9,202**
Cathedral City	1,053
Coachella	9
Indian Wells	744
Indio	1,203
La Quinta	575
Palm Desert	1,409
Palm Springs	1,750
Rancho Mirage	1,304
Riverside County	1,155
COACHELLA VALLEY GIANT SAND-TREADER CRICKET	**9,202**
Cathedral City	1,053
Coachella	9
Indian Wells	744
Indio	1,203
La Quinta	575
Palm Desert	1,409
Palm Springs	1,750
Rancho Mirage	1,304
Riverside County	1,155
COACHELLA VALLEY JERUSALEM CRICKET	**4,852**
Cathedral City	1,080
Desert Hot Springs	84
Palm Desert	21

Appendix IV: Biological Monitoring Results for I-10 Corridor Project: Vegetation Surveys

Report begins on following page.

Coachella Valley Multiple Species Habitat Conservation Plan

2024–2025 BIOLOGICAL MONITORING RESULTS FOR I-10 CORRIDOR PROJECT: VEGETATION SURVEYS

2024-2025 FINAL REPORT

DRAFT REPORT

2024–2025 BIOLOGICAL MONITORING RESULTS FOR I-10 CORRIDOR PROJECT: VEGETATION SURVEYS

Prepared by:

Remy M. Vincent, Scott A. Heacox and Lynn C. Sweet

Center for Conservation Biology
University of California, Riverside
75-080 Frank Sinatra Dr.
Palm Desert, CA 92211

Prepared for:

Coachella Valley Conservation Commission
73-710 Fred Waring Dr.
Palm Desert, CA 92260

Suggest citation: *Vincent, R.M., Heacox, S.A. & Sweet, L.C. (2025) Coachella Valley Multiple Species Habitat Conservation Plan 2024–2025 biological monitoring results for the I-10 Corridor Project: Vegetation Surveys. Final Report. Prepared for: Coachella Valley Conservation Commission.*

1 TABLE OF CONTENTS

LIST OF FIGURES

2 INTRODUCTION

In the winter and spring of 2025 we conducted a series of vegetation surveys at pre-identified wildlife crossing sites along the Interstate 10 and adjacent railroads as part of a collaborative project investigating the wildlife use of underpasses along with University of California, Davis and the Coachella Valley Conservation Commission. Using this data, we created a digital vegetation map for the areas approaching underpass entrances/exits. We assessed species, percent cover for each species, and percent cover by height class for the vegetation, as well as documented certain anthropogenic disturbances such as off-highway vehicle use, illegal dumping, and invasive species. These surveys were conducted contemporaneously with several other associated studies to document what animal species are utilizing these local underpasses: tracking surveys (independent professional tracker, Barry Martin), track plates (Coachella Valley Conservation Commission) and camera traps (Road Ecology Center, University of California, Davis). Details of those methodologies and locations differ from these and those are documented in separate reports by the respective organizations. This product is meant to provide environmental engineers with critical information to help guide future restoration efforts regarding plant community composition, plant spatial structure, and intensity of certain anthropogenic stressors present at these wildlife crossing sites.

3 METHODS

Vegetation surveys took place from January to late May of 2025; of which our first set of surveys in late winter/early spring spanned January-early March (here simply termed “winter”), and late spring surveys were run during late May (termed “spring”). During winter surveys we followed the California Native Plant Society/California Department of Fish and Wildlife Rapid Assessment protocol (CNPS 2024) which is a standardized protocol for recording and describing plant communities. In the spring we inventoried living or recently dead herb species and noted dead herb cover and significant changes in the habitat since the previous survey (e.g. additional dumping, new fence etc.)

Using ArcGIS Pro (Esri 2025a), we designed and mapped survey plots based on the locations of camera traps set by UC Davis. With the guidance of our collaborators at UC Davis as to the most relevant areas to characterize, we set the plot dimensions at a 100m-radius semi-circle centered on the middle of the underpass entrance/exit. This serves to approximate the critical “approach” area used by wildlife attempting to pass through these structures. The “base” of the semi-circle follows the margin of the freeway or railroad containing the underpass and follows the curvature of this feature to maximize potential habitat sampled (Figure 1). We used Esri Field Maps (Esri 2025b) on our phones to reference these plot dimensions while in the field, assisted by laser rangefinders (Nikon ProStaff 550) where necessary to assess relative position with regard to the boundary.

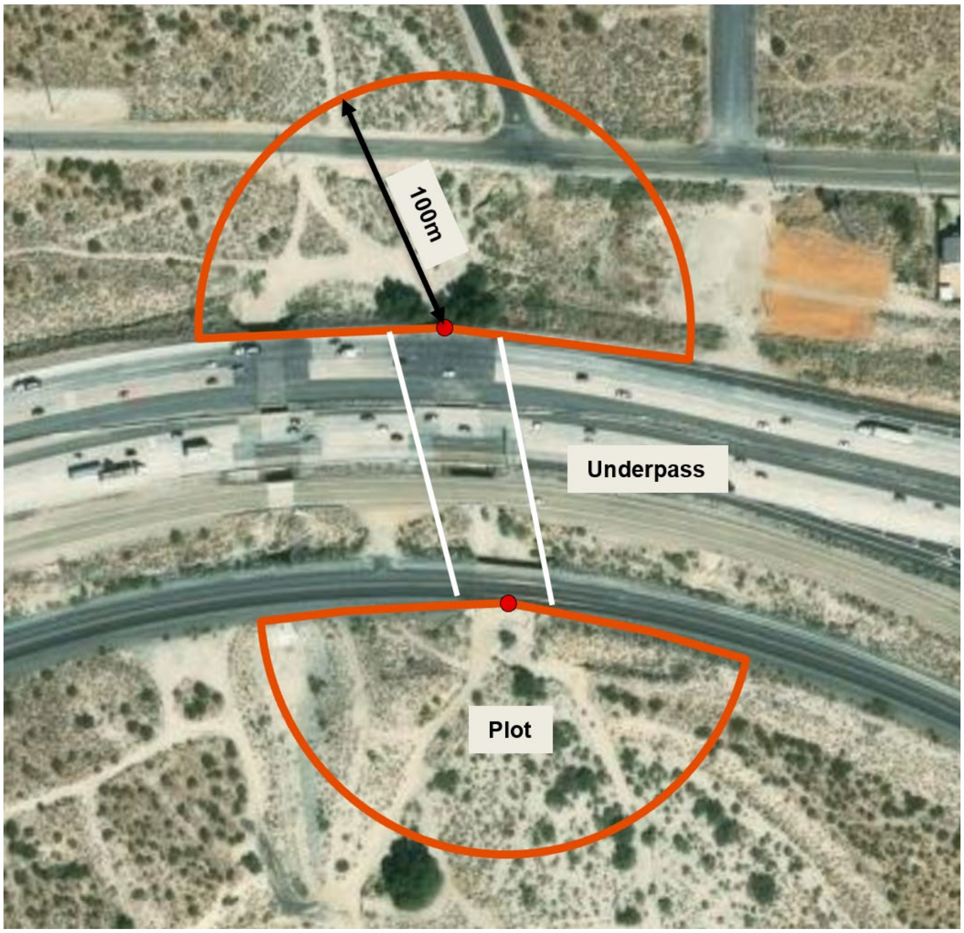


Figure 1. Example of the vegetation study plot layouts, showing the Freeway I-10, the use of the 100 m radius from the underpass, and the resulting delineated plot boundary in red. The white lines represent the underpass area.

During surveys, we began at the plot point (center of underpass entryway/exit) and searched as much of the plot as was safely/legally accessible to document plant species, percent cover, substrate descriptions (as defined in the Rapid Assessment protocol, see CNPS/CDFW, 2024) and percent cover, and both anthropogenic and natural disturbances. To quantify the physical structure of the plant community, and therefore available cover for animals utilizing these approaches, we recorded percent cover of vegetation by internally defined height categories (0-6 in, 6-12 in, 12-24 in, 24-36 in, 36-60 in, 60-120 in, and greater than 120 in). We took four outward-directed cardinal orientation photos at the plot point. Our ability to walk the full extent of plots was limited for several western plots because much of the land surrounding underpasses, washes and culverts is tribal land (Morongo Band of Mission Indians) or private ownership which we did not have permissions to access. While this was limiting, we aimed to replicate a consistent area across sites, and therefore we identified the species and estimated percent cover for these areas that we could not access using both binoculars and the aerial drone imagery that was provided to us by CVCC in the form of digital orthophotos. We were unable to survey the Whitewater River plots (indicated by the black dots) due to land ownership and personal safety problems and so there is no field survey associated with these points. We instead used orthophoto imagery to identify species and percent coverage. We did not perform Spring surveys at the 111 Railroad plots because of concerns about the land ownership for the area necessary to our plot access.

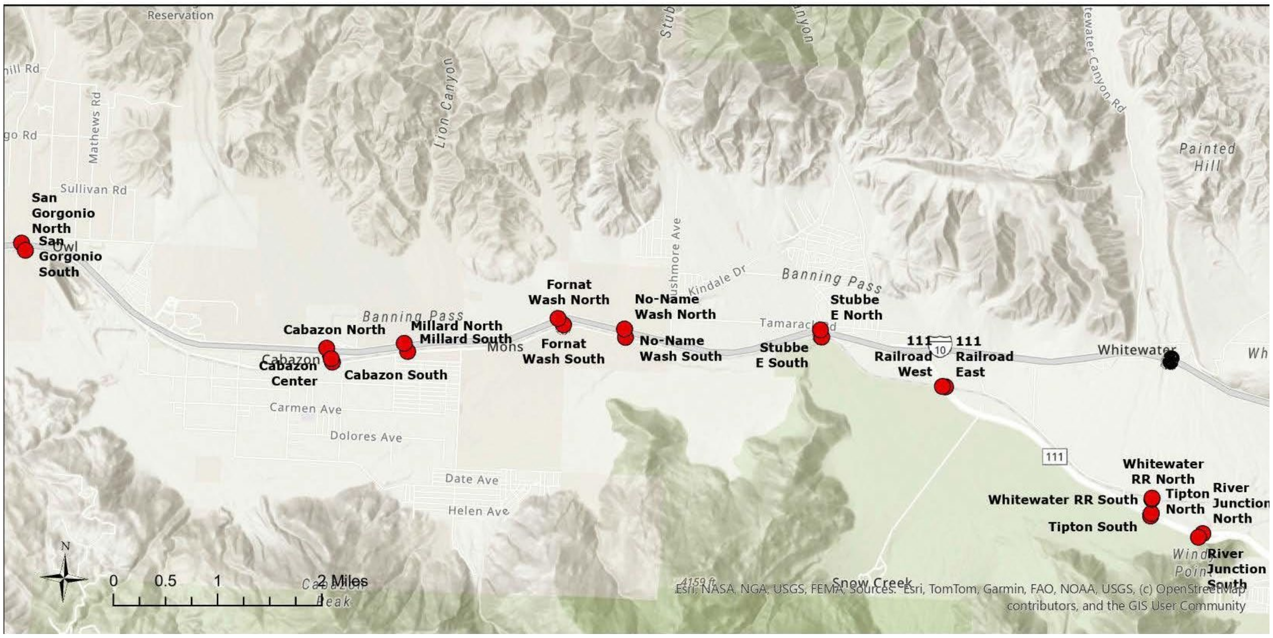


Figure 2. Map of plots corresponding to underpass and camera study locations along I-10 in the Banning Pass, CA. Additional concurrent study localities for concurrent studies that were not assessed during the vegetation study are not shown.

Using the information obtained from field surveys, along with the drone orthophotography, we constructed vegetation maps of the 100 m-radius vegetation plots using Esri ArcGIS Pro (ESRI 2025a). We delineated polygons around anthropogenic features (roads, culverts, embankments,) natural washes, and shrublands/grasslands with different vegetation covers. Each polygon has as set of attributes that defines the "type" (broad category of feature, e.g., shrubland, ruderal grassland, dirt road, sparsely vegetated wash, etc.), the percent cover of plant canopies divided into lifeform (herb, shrub, tree), dominant species (species identifiable from imagery that constitute the major components of the plant assemblage), and acreage of the polygon. In general, we delineated polygons based on guidelines from the Manual of California Vegetation (Sawyer *et al.*, 2009) and California's Vegetation Mapping and Classification Program at the California Department of Fish and Wildlife (CDFW, VegCAMP), where stands of vegetation are characterized by dominant species, lifeform (trees, shrubs or herbs), and/or significant changes in percent cover. However, for the purposes of this study we did not include species alliance or association classifications for several reasons: here we could not adhere to the standard minimum mapping units for these types, in other words, we mapped our polygons at a much finer scale than what would normally be mapped under VegCAMP guidelines; as well, the goals of this study were conducive to mapping vegetation patterns and structure and general type, but the time allotted was not adequate to precisely classify the vegetation at all sites at a fine scale. Our map also deviates from a typical vegetation map by emphasizing certain un-vegetated landforms that may provide cover or barriers to travel for relevant animals, such as boulder fields, small dump sites, and anthropogenic embankments. All of the original survey data for both winter and spring surveys, including survey photos, is contained in the PlotData layer.

4 ACKNOWLEDGEMENTS

We want to express our gratitude to the Coachella Valley Conservation Commission for funding these projects under the Coachella Valley Multiple Species Habitat Conservation Plan and the Coachella Valley Association of Governments staff members, Tony Quiroz and Billy Morrow, for cooperation on these projects. We also want to thank the UC Davis Road Ecology Center, independent professional tracker Barry Martin for their collaboration as well as Trish Smith from The Nature Conservancy who organized the coordinating meetings between partners for this project.

5 LITERATURE

California Native Plant Society. (CNPS) (2024). CDFW-CNPS Protocol for the Combined Vegetation Rapid Assessment and Relevé Field Form. https://www.cnps.org/wp-content/uploads/2024/11/CNPS-CDFW-RA-Releve_Protocol_Code-Key_Descriptions_Cover-Soil-Key_ADA-20240416.pdf

Esri. (2025a). ArcGIS Pro. https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview

Esri. (2025b). ArcGIS Field Maps. https://www.esri.com/en-us/arcgis/products/arcgis-field-maps/overview

Sawyer, J. O., Keeler-Wolf, T., & Evens, J. M. (2009). *CNPS; A manual of California vegetation online.* CNPS. https://www.cnps.org/vegetation/manual-of-california-vegetation

Appendix V: Creating Climate Resiliency in the Coachella Valley Multiple Species Habitat Conservation Plan: Assessing Climate Change Vulnerability for Covered Species

Report begins on following page.

Creating climate resiliency in the Coachella Valley Multiple Species Habitat Conservation Plan: Assessing climate change vulnerability for covered species

Final Report

March 31, 2025

FINAL REPORT

Creating climate resiliency in the Coachella Valley Multiple Species Habitat Conservation Plan: Assessing climate change vulnerability for covered species

Prepared by:
Lynn C. Sweet
Hector Zumbado-Ulate
Luis Barrios
Melanie J. Davis
Rachel Gallardo

Final Report to:
California Department of Fish and Wildlife

On behalf of:
The Coachella Valley Conservation Commission
73-710 Fred Waring Dr.
Palm Desert, CA 92260

Coachella Valley Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan (CVMSCHP/CVNCCP)

Suggested citation: Sweet, L.C., H. Zumbado-Ulate, L. Barrios, M.J. Davis and R. Gallardo, 2025. Creating climate resiliency in the Coachella Valley Multiple Species Habitat Conservation Plan: Assessing climate change vulnerability for Covered Species. Final Report submitted to the California Department of Fish and Wildlife. On behalf of the *Coachella Valley Conservation Commission.*

Introduction:

The Coachella Valley Multiple Species Habitat Conservation Plan/Natural Communities Conservation Plan (CVMSHCP/NCCP; hereafter the Plan) was approved in 2008 with an aim to protect habitats and create a balanced vision for conservation and development within the Coachella Valley. The plan encompasses a diversity of habitats and topography within the Colorado Desert, a rich and biodiverse land containing many endemic and unique plant and animal communities and microhabitats. Desert species are adapted to aridity, but like all organisms, they still grow and thrive in a specific balance of conditions such as temperature, moisture and other environmental and ecological conditions (e.g. specific soils, food plants, or pollinators) that are subject to disruption as climate changes. In the CVMSHCP/NCCP area, longer and more intense droughts and increased aridity associated with climate change (Hopkins 2018) are already affecting the distribution of desert species (Kelly & Goulden 2008; Barrows *et al.* 2020). Although the original plan for conservation area boundaries was designed to best protect the Plan-covered species and their habitats, the areas most suitable for these species are likely to shift due to climate change, requiring a new vision for strategic conservation and acquisition. We proposed this study to evaluate vulnerable species for climate resiliency, with a goal of informing adaptive management.

The Plan designates specific Conservation Areas that are focused on natural communities, Core Habitat for Covered Species, Essential Ecological Processes, Biological Corridors and Linkages. Within the CVMSHCP/NCCP, population changes have been studied for covered species and community types (e.g. Davis *et al*. 2023), which may be indications of the type of changes in store due to a warmer and drier future for the region. Differences in vegetation cover seen in vegetation remapping on the Coachella Valley Floor may also be due to climate change, including a multitude of stressors such as increased heat and aridity, increased inter-annual variability, and intensity of storms, all not originally accounted for in the CVMSHCP/NCCP. The impact of climate change on most or all of these species has yet to be determined, and more importantly, accounted for in the Reserve Management Unit Plans.

Newer empirical (observational-data-driven) studies have detected vulnerability of some species in the region due to climate change (e.g. Barrows *et al.* 2020; Davis *et al.* 2023). In order to protect the species for which these plans were designed, understanding how species may shift on the landscape has become imperative to the success of this and other Plans; species movements are likely to transcend boundaries and place ever increasing importance on biological corridors and upper elevation areas. Species distribution (habitat) modeling can provide critical data to inform supplemental management actions and approaches such as strategic lands acquisition, and the targeted management of the known threats to species (fire and off-highway recreation) within retained future habitat. The vulnerability of species to climate change is commonly assessed according to three dimension sensitivity (the degree to which species are affected), adaptive capacity, and exposure to the changes in climate regimes (Dawson 2011). One way to measure the vulnerability of a species to climate change is to look at the potential shift in the environmental conditions where the species occurs, together with information about how the species may respond to change. These are known as sensitivity and adaptive capacity, which includes species life history (Dawson *et al.* 2011). Species for which the future environmental conditions will not exclude large areas of their current habitat (i.e. retaining habitat), and for whom movement/dispersal is easy, with short generation times for adaptation to changing conditions may be relatively less vulnerable. However, species with very restricted habitat may be challenged by reductions in the geographic space available with appropriate conditions as well further impacted if they have characteristics like limited reproductive capacity or longer generation times.

Future climate information for various climate scenarios, gridded for use in species distribution modeling (habitat modeling), is now available at relatively fine spatial scales, and an additional trove of information is available concerning remote sensing of land cover types, phenological characteristics, topography, soils and other factors. Newer datasets are also fine-scale temporally, with predictions for 20 to 30-year periods from now until the end of this century. This type of information is critical to understand the speed and likely trajectory of changes geographically, in the near-term (2041-2060) and long-term (2081-2100); changes which are likely within the lifetime of humans living within the CVMSHCP/NCCP area today.

This project addresses critical planning initiatives highlighted in the California State Integrated Climate Adaptation and Resiliency Program by modeling vulnerable species to better plan for resiliency in the Coachella Valley. The objective is to model current and future habitat suitability for several Plan-listed 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. This information will help inform what type of resources and funding would be necessary to create a climate-resilient habitat management plan for these species.

We evaluated climate resiliency and addressed the following questions:

1. To what degree do the existing Plan conserved lands boundaries encompass the future habitat of covered species?
2. Is there an existing buffer to allow for species movement/migration already built into the existing design; how should the boundaries be changed or broadened?
3. What resources and funding would be needed to address and support climate resiliency for these biological resources?

In order to test this approach for use with a broader suite of species, we evaluated several CVMSHCP species and created climate-resilience summaries containing concrete, actionable information and recommendations. The species selected for study include: one federal Endangered Species, the Coachella Valley milkvetch (*Astragalus lentiginosus* var. *coachellae)*; one federal Threatened/California State Endangered species, the Mojave Desert tortoise (*Gopherus agassizii*); and three species ranked as rare by the California Rare Plant Ranking system, Little San Bernardino Mountains linanthus (*Linanthus maculatus* ssp. *maculatus*), Mecca aster (*Xylorhiza cognata*), and Orocopia sage (*Salvia greatae*), which carries environmental compliance obligations under California State Law. The results of this study will help address a gap in the current critical management vision for the Plan Area: how can we incorporate the best information on how the climate will change in order to plan for climate resiliency, together with the mitigation of threats within the future-suitable habitat areas?

Methods

To create predictive models that are informative regarding current and future habitat suitability, data about species localities were input together with climate and other environmental data layers for the species distribution model. Resultant habitat maps are representative of current suitable habitat, which were then used to project future habitat areas for the periods we refer to as “very near-term” (2021-2040), “near-term” (2041-2060). “mid-term” (2061-2080) and “long-term” (2081-2100) within the Coachella Valley and environs.

Study area: The CVMSHCP/NCCP is within the Colorado Desert area of southern California, in the central portion of Riverside County. The CVMSHCP/NCCP spans 1.1 million acres across the Coachella Valley, including portions of Joshua Tree National Park to the north and the Imperial Valley to the south, the Coachella Valley is bisected by Interstate 10 which creates a significant barrier to species movement. The highest elevations within the Plan area are those of the Sand to Snow National Monument and Santa Rosa and San Jacinto Mountains National Monument, and the lowest are near Imperial County in the Dos Palmas Conservation area. The plan covers land under various ownership, and specifically, federal and non-federal conservation lands in the CVMSHCP/NCCP area. The study area we considered for analysis was within a 25-km buffered area of the CVMSHCP boundary (Figure 1).

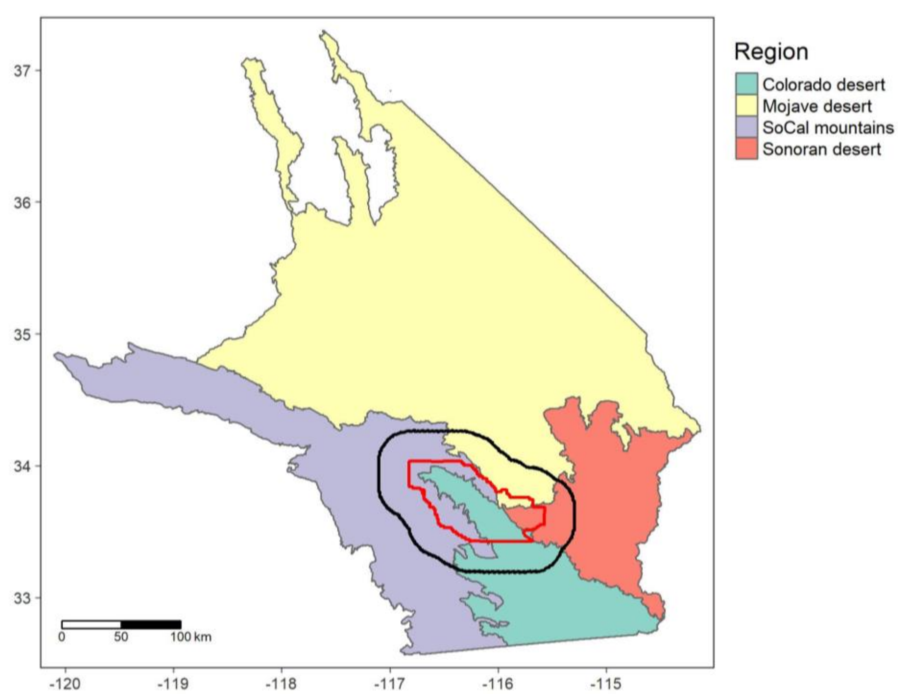


Figure 1: The study area near Palm Springs, California is shown along with the major ecoregions. The CVMSHCP area is shown in red, as well as the full study area buffered beyond that boundary in black.

Species occurrences: We obtained occurrence points for target species from multiple sources from 1990 to data from: 1) experimental plots recurrently sampled by staff of Center for Conservation Biology at University of California Riverside (CCB-UCR) and stored in Network-attached storage, 2) the Global Biodiversity Information Facility (GBIF; www.gbif.org), 3) iNaturalist (www.inaturalist.org) and Calflora database (www.calflora.org). We only considered occurrences previously verified by experts (i.e, research grade quality observation). For the case of the Mojave Desert tortoise only, we also included a research dataset developed by researchers in the U.S. Geological Survey (Lovich, unpublished data), which is the subject of a paper currently in review for publication (Zumbado-Ulate, In Review).

Data preparation: All our analyses were conducted with the R package version 4.4.2 (R core Team 2024). Data was carefully cleaned to obtain a robust and independent set of occurrences. We used the 'Tidyverse', 'CoordinateCleaner', and 'ScrubR' R packages to remove) duplicates, missing and wrong coordinates and name inconsistencies. Additionally, occurrence points with missing or high spatial uncertainty were removed from the dataset. We only considered data that occurred within a 25-km buffered area of the CVMSHCP boundary. We added this buffer to allow natural transition among species distributions and environmental conditions in our dataset.

Climatic data: To assess present and future habitat suitability we downloaded the 19 bioclimatic variables (Booth et al. 2014, Fick and Hijmans 2017) from the WorldClim 2.1 dataset (www.worldclim.org) at a spatial resolution of 30 arc seconds (~1 km at the equator). We extracted environmental information of each occurrence point within the buffered CV polygon to conduct a virtual inflation test (VIF) with the R package 'usdm' (Uncertainty Analysis for Species Distribution Modelling; Naimi et al. 2014) to remove highly correlated variables. This step is needed to increase model robustness by reducing spatial autocorrelation among environmental variables. For future habitat suitability modelling, we used HadGEM3-GC31-LL (third Hadley Centre Global Environment Model in the Global Coupled configuration 3.1) as the global circulation model (GCM). HadGEM3-GC31-LL has been recommended as one of the most accurate GCMs for southern California and can be easily downloaded at the WorldClim website. Specifically we downloaded climatic information for the time periods 2021-2040, 2041-2060, 2061-2080, 2081-2100 and for the following Shared Socio-economic Pathways (SSPs): SSP1-2.6 (mild), SSP2-4.5 (medium), and SSP5-8.5 (high) based on the Coupled Model Intercomparison Project Phase 6 (CMIP-6) that examines different possible future greenhouse gas emissions (Eyring et al. 2016).

Habitat Suitability Model: We used the Maximum Entropy approach (MaxEnt) algorithm (Phillips et al. 2006) with tuned settings (see below) (Anderson and Gonzalez 2011, Radosavljevic and Anderson 2014) implemented in R through the R package 'ENMeval' (Kass et al. 2017). We specifically selected Maxent due to a lack of absence datasets for target species. Although a set of pseudo-occurrences (Kent and Carmel 2011) could be generated to be used with alternative algorithms (e.g., random forests, boosted regression trees), the small number of occurrences for some target species due to restricted distribution or low representation within the study area was a constraint to construct a robust set of pseudo-occurrences. Because MaxEnt is an occurrence background method, MaxEnt is able to discriminate accurately among background points (random occurrences) to generate suitability estimates for each grid (Phillips et al. 2009). We used the following model settings algorithm = maxent.jar; partition method = block; regularization of multiplier values = 1–4 with increments of 1; feature classes = L, H, Q, LQ, LH, QH, LQH; where L = Linear, H = Hinge, Q = Quadratic; and Clamping = True.

Model selection and applications: We selected the model with the best average performance in terms of the area under the curve of the receiver-operating characteristic (AUC). Continuous suitability estimates were transformed into categorical maps to estimate the extent of suitable habitat (Brooks et al. 2019) in km^2 using the maximum training sensitivity plus specificity logistic threshold (MTSS; Liu et al. 2005, 2016). The MTSS maximizes the true positive prediction, resulting in a more restricted definition of suitable areas (Liu et al. 2005). Suitability estimates were categorized in 1) unsuitable habitat, which included all localities with values below the specific threshold value and 2) suitable habitat from the threshold value to 1). The extent of suitable habitat in current and future scenarios was estimated with both the ‘terra’ and ‘sf’ R packages. Although all models were evaluated as above and are internally consistent and robust, all models should be considered for application from a heuristic perspective until peer-reviewed and published.

Results and Discussion

Mojave Desert Tortoise (Gopherus agassizii)

Figure 2: A Mojave Desert tortoise in the Desert Tortoise and Linkage Conservation Area in the eastern end of the study area, near Desert Center, CA. Photo: Lynn Sweet.

CVMSHCP Conservation: The Mojave Desert tortoise (*Gopherus agassizii*) is listed as a Threatened Species federally and in the state of California. The Mojave Desert tortoise occurs west of the Colorado River within the southeastern California deserts, northwestern Arizona southern Nevada, and southwestern Utah. Within California, the Mojave Desert tortoise occurs in the Colorado (Sonoran), and Mojave deserts (Figure 2). Plan covers Core Habitat objectives for the species within seven Conservation Areas, at least one specific objective (Other Conserved Habitat) within one Conservation Area, and is protected by virtue of other conservation objectives where it is present within nine other Conservation Areas as of the latest Plan Amendment in 2016 (Figure 3). Conservation Plan objectives include those consistent with the Desert Tortoise Recovery Plan, maintaining conserved habitat area and minimizing fragmentation, protecting the species across a range of habitats to promote genetic diversity, and protecting corridors (further described in CVMSHCP Section 9.6.1.1).

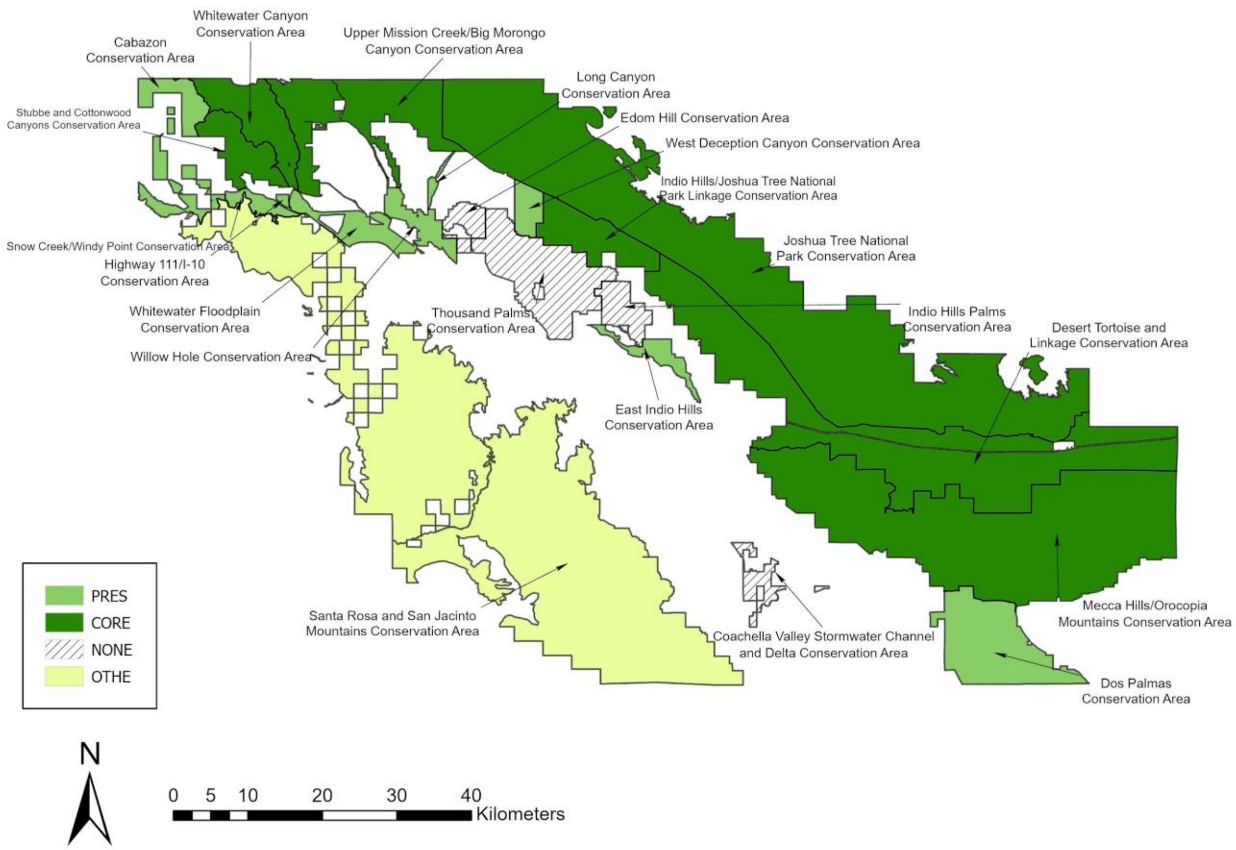


Figure 3: Map of Conservation Areas in the CVMSHCP with or without specific Plan conservation objectives for the Mojave Desert Tortoise. Specific species objectives are included in conservation planning for areas assigned as: Core Habitat (CORE) and Other Conserved Habitat (OTHE). Also indicated on the map are Conservation Areas with Presences (PRES) for the Mojave Desert Tortoise within the CVMSHCP. Note that the Conservation Areas boundaries are represented rather than the species' occupied area.

Modeled Current Distribution: The continuous output of the species distribution model shows the range of habitat suitability for the Mojave Desert tortoise at the current time across the area, from low suitability in the basins and peaks, to highest suitability at low-to-mid elevations (Figure 4; Zumbado-Ulate et al. *In Review*). Geographically, the suitability is high in the eastern areas, Orocopia Mountains and Joshua Tree NP, with some isolated areas of higher suitability locally in the western foothills of the San Bernardino Mountains. The model shows that many of the localities in the Coachella Valley, including those recently documented as part of concurrent studies (Zumbado-Ulate et al. *In Review*), and used to train the model are located in less suitable areas, even at the current time.

Climate Resilience: The results of the future climate models for the low-to-high range scenarios indicate that while there is extensive potential habitat within the CVMSHCP, this is potentially decreasing in the future and contracting to the north and east. The habitat suitability model maps below for this species (Figure 5, 6 and 7) and for other species in subsequent sections describe the outputs for the current period and time periods 2041-2060, 2061-2080, 2081-2100 and for the following Shared Socio-economic Pathways (SSPs): SSP1-2.6 (mild), SSP2-4.5 (medium), and SSP5-8.5 (high). As described in the methods section, the output is shown as a binary, predicted suitable vs. unsuitable habitat. The bar chart showing the suitable area over time (Figure 8) includes the very-near-term time period of 2021-2040 in comparison to the other three future time periods.

Modeled habitat is generally reduced over time in each scenario, and with the greatest reduction in the highest SSP (Figure 8). This species may require a shift in distribution from lower elevation areas upward in elevation within the CVMSHCP area. The modeled suitable habitat within the northern and eastern conservation areas are somewhat continuous, which will aid in species migration, as long as barriers and challenges to species movement and survival are mitigated. These include interstate freeways and major roads (Zumbado-Ulate, *In Revision*), development, and raven abundance due to human activities that supplement the population of these tortoise predators. Further research should therefore focus on the mitigation of barriers that impact the connectivity of tortoises.

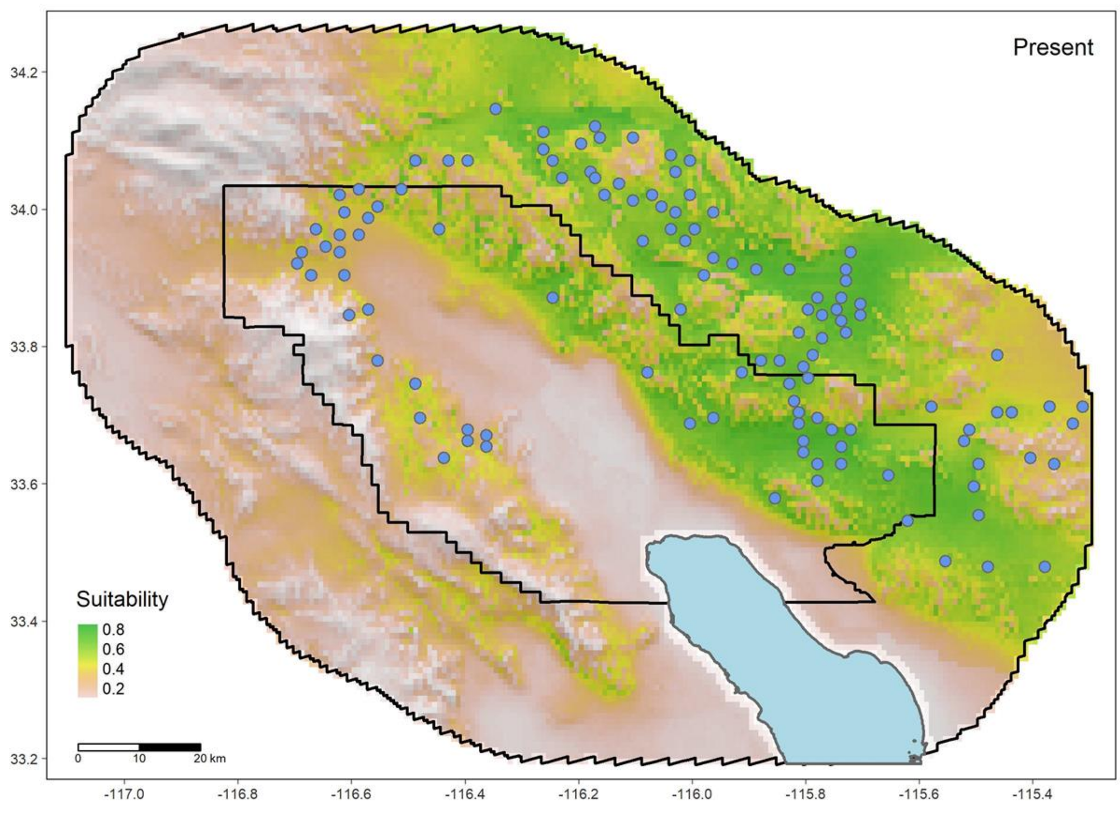


Figure 4: The modeled currently-suitable habitat area projections for the Mojave Desert tortoise within the Coachella Valley, CA and environs. Model training points (presence points) are shown as blue circles. The CVMSHCP boundary is shown in black. Predicted suitability increases from 0 to 1.

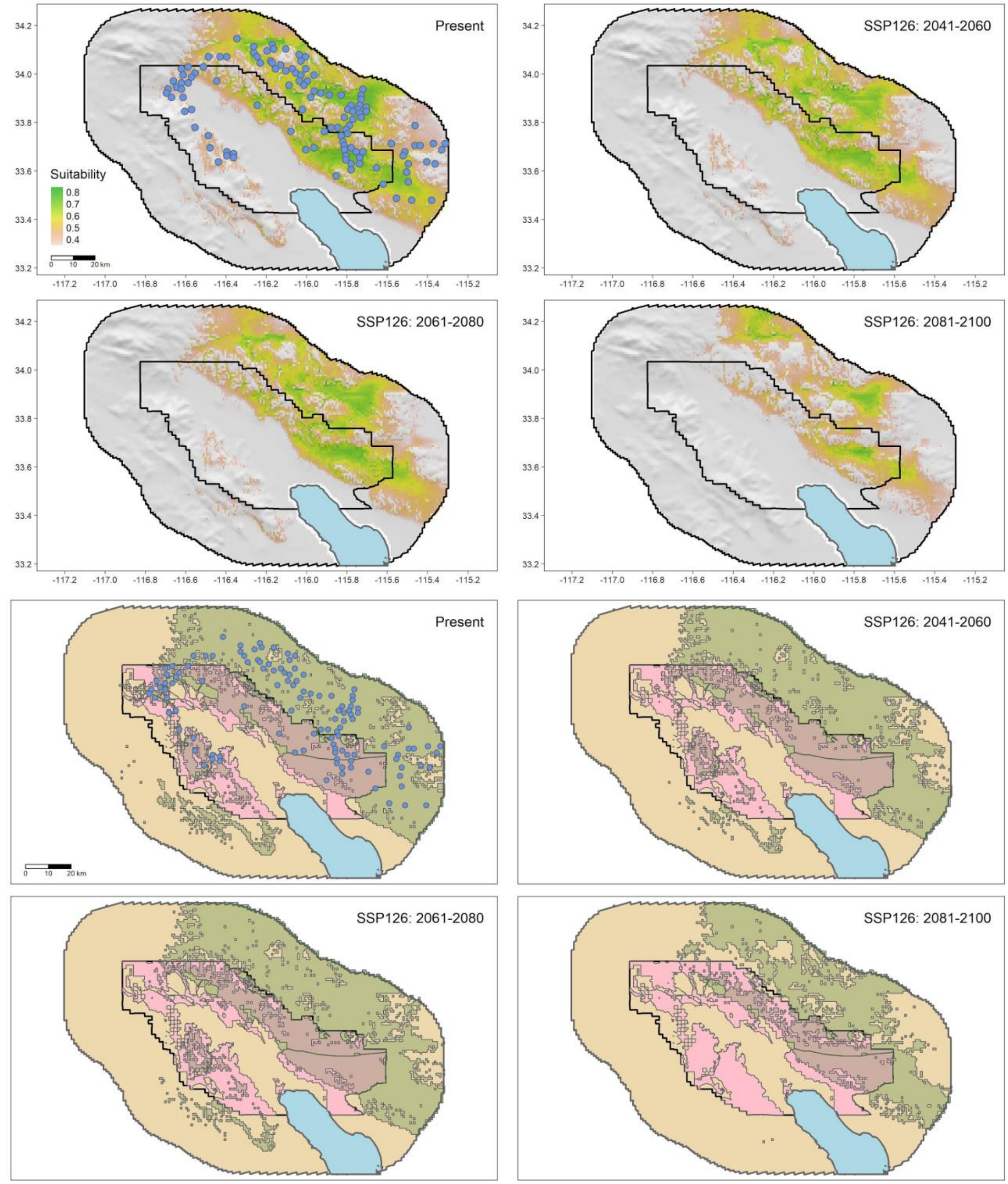


Figure 5: The current and future suitable habitat area projections for the Mojave Desert tortoise within the Coachella Valley, CA and environs under a 1.26 (mild) socioeconomic pathway scenario for the present, and three future periods to 2100, as indicated in the panel. The upper four panels show only suitable habitat above the threshold (0.4). The lower four panels show the same output as a binary where areas meeting or exceeding the threshold of habitat suitability, from marginal to high, are shown in green. CVMSHCP conservation areas are shown in pink, and the CVMSHCP Area boundary is shown in black.

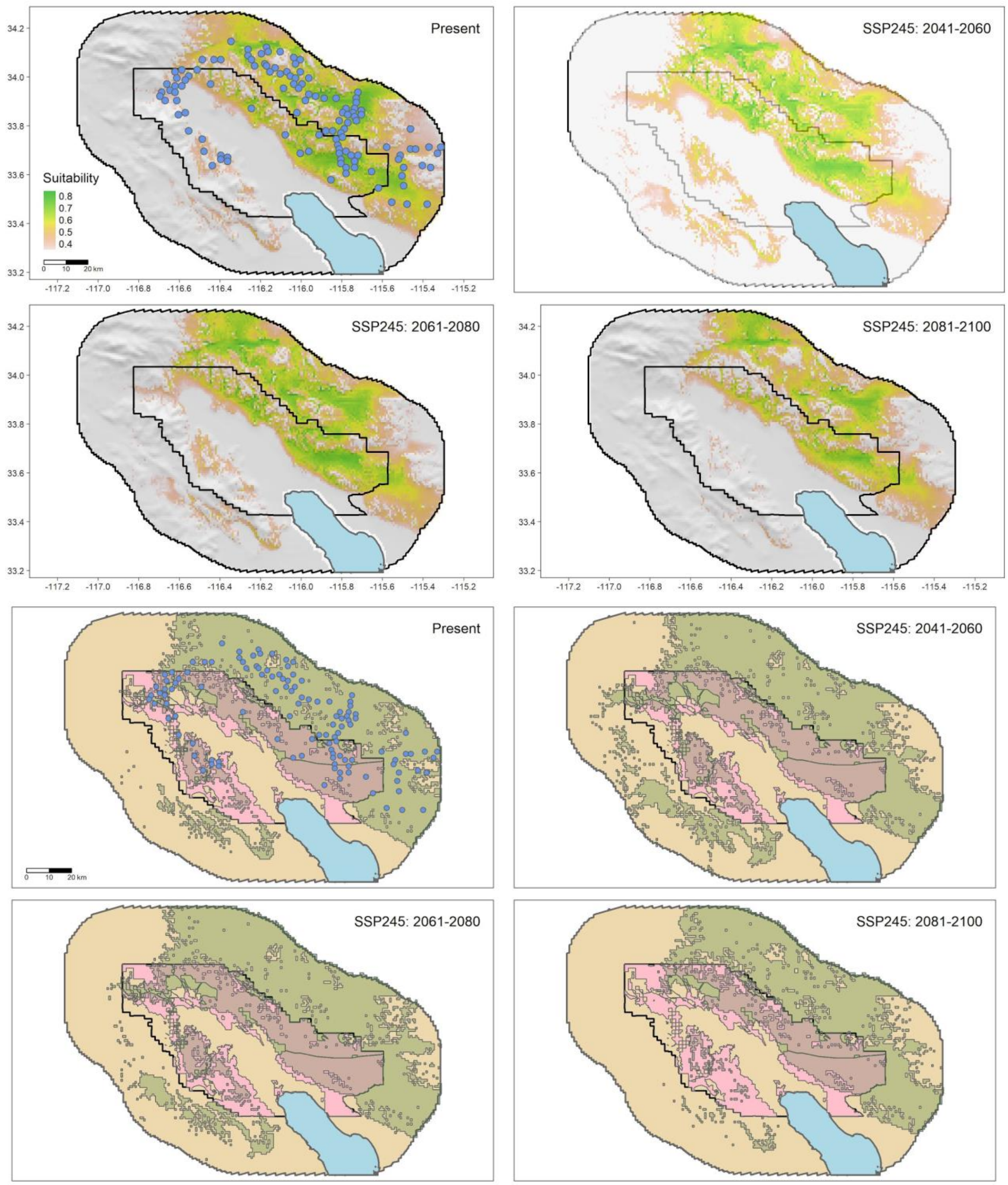


Figure 6: The current and future suitable habitat area projections for the Mojave Desert tortoise within the Coachella Valley, CA and environs under the 2.46 (medium) socioeconomic pathway scenario for the present, and three future periods to 2100, as indicated in the panel. The upper four panels show only suitable habitat above the threshold (0.4). The lower four panels show the same output as a binary where areas meeting or exceeding the threshold of habitat suitability, from marginal to high, are shown in green. CVMSHCP conservation areas are shown in pink, and the CVMSHCP Area boundary is shown in black.

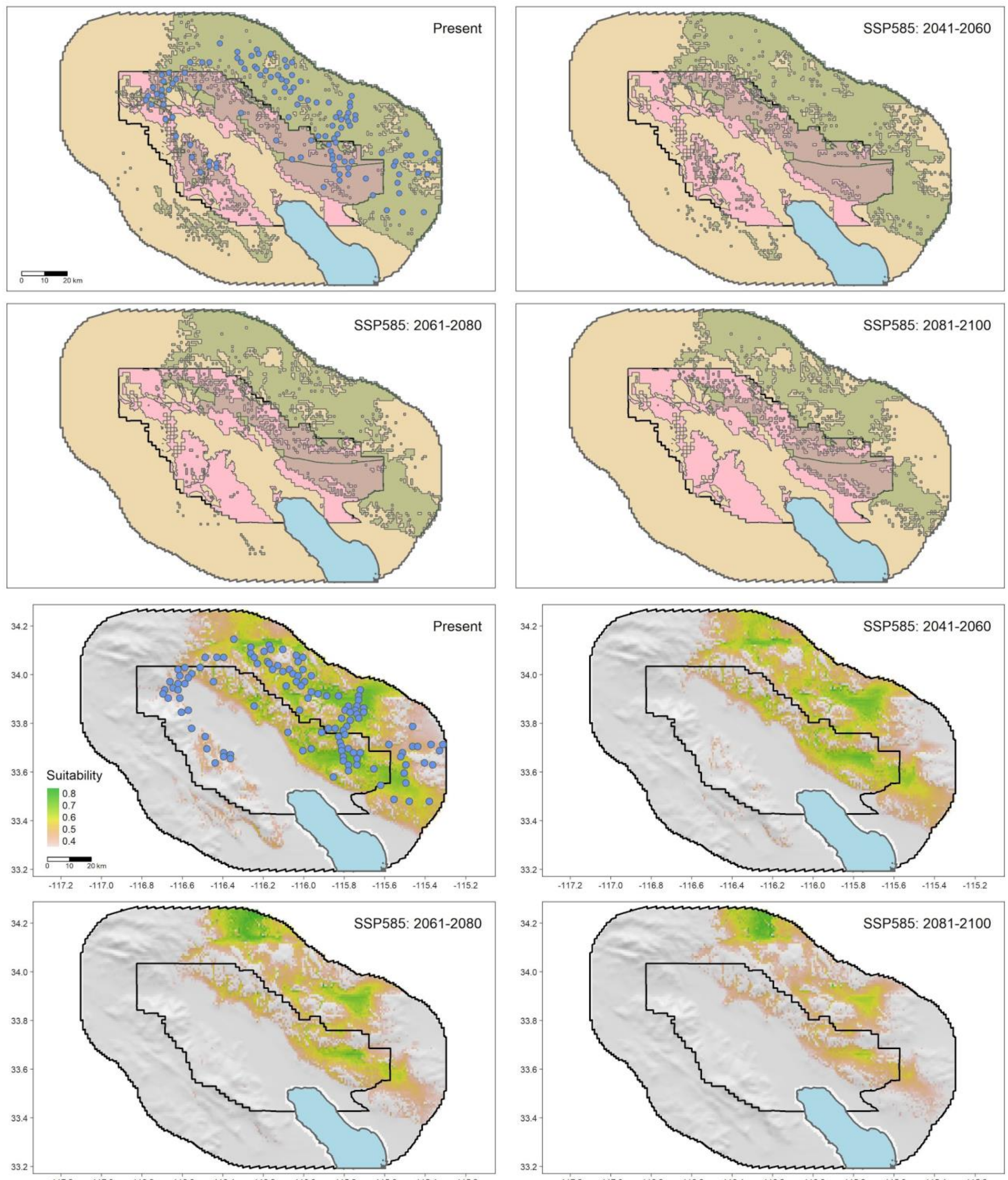


Figure 7: The current and future suitable habitat area projections for the Mojave Desert tortoise within the Coachella Valley, CA and environs under the 5.85 (high) socioeconomic pathway scenario for the present, and three future periods to 2100, as indicated in the panel. The upper four panels show only suitable habitat above the threshold (0.4). The lower four panels show the same output as a binary where areas meeting or exceeding the threshold of habitat suitability, from marginal to high, are shown in green. CVMSHCP conservation areas are shown in pink, and the CVMSHCP Area boundary is shown in black.

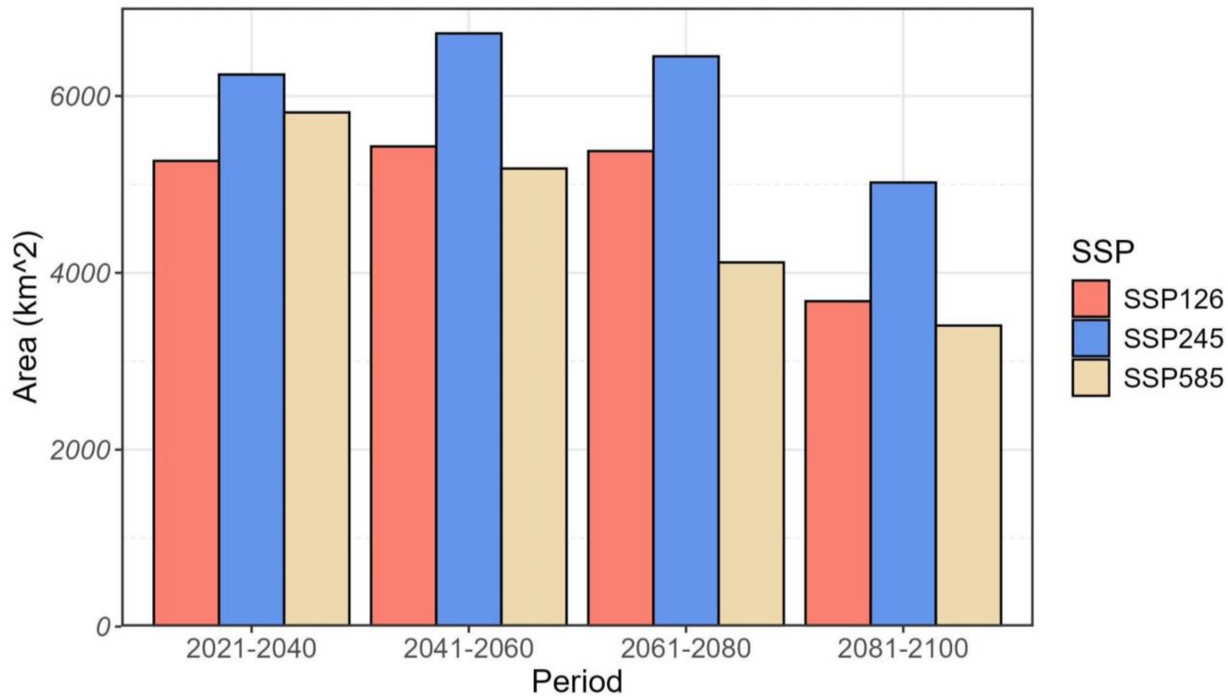


Figure 8: The area (km^2) predicted to support the Mojave Desert Tortoise within the CVMSHCP Plan area in several future time periods, under three SSP's: SSP1-2.6 (mild), SSP2-4.5 (medium), and SSP5-8.5 (high) based on the Coupled Model Intercomparison Project Phase 6 (CMIP-6).

Coachella Valley Milkvetch (Astragalus lentiginosus var. coachellae)

Figure 9: Coachella Valley milkvetch blooming in the central portion of the CVMSHCP area, on the valley floor. Photo: Melanie Davis.

CVMSHCP Conservation: The Coachella Valley Milkvetch (*Astragalus lentiginosus* Hook. var. *coachellae* F. Shreve & Wiggins [Fabaceae]) was listed as Endangered in 1998 under the Federal Endangered Species Act (16 USC §§1531-1544; 50 CFR §§17.1-17.108) and has no concurrent official status in the State of California (Figure 9). The subspecies is endemic to the Coachella Valley in California and it is ranked by a joint State and expert review process as a California Rare Plant Rank 1B.2 (Plants Rare, Threatened or Endangered in California and Elsewhere; Moderately threatened in California; CNDDB & CNPS 2020). The Plan covers Core Habitat objectives for the species within four Conservation Areas, at least one specific objective (Other Conserved Habitat) within two Conservation Areas (Figure 10), and is protected by virtue of other conservation objectives where it is present within nine other Conservation Areas as of the latest Plan Amendment in 2016. Conservation Plan objectives include maintaining conserved habitat area and minimizing fragmentation, protecting the species across a range of habitats to promote genetic diversity, and protecting corridors, and specifically, protecting the sand flow that is essential to its habitat (further described in CVMSHCP Section 9.2.2.1). Approximately 87% of the significant habitat for the species was protected by the Plan at inception (CVMSHCP Section 9.2.2.4).

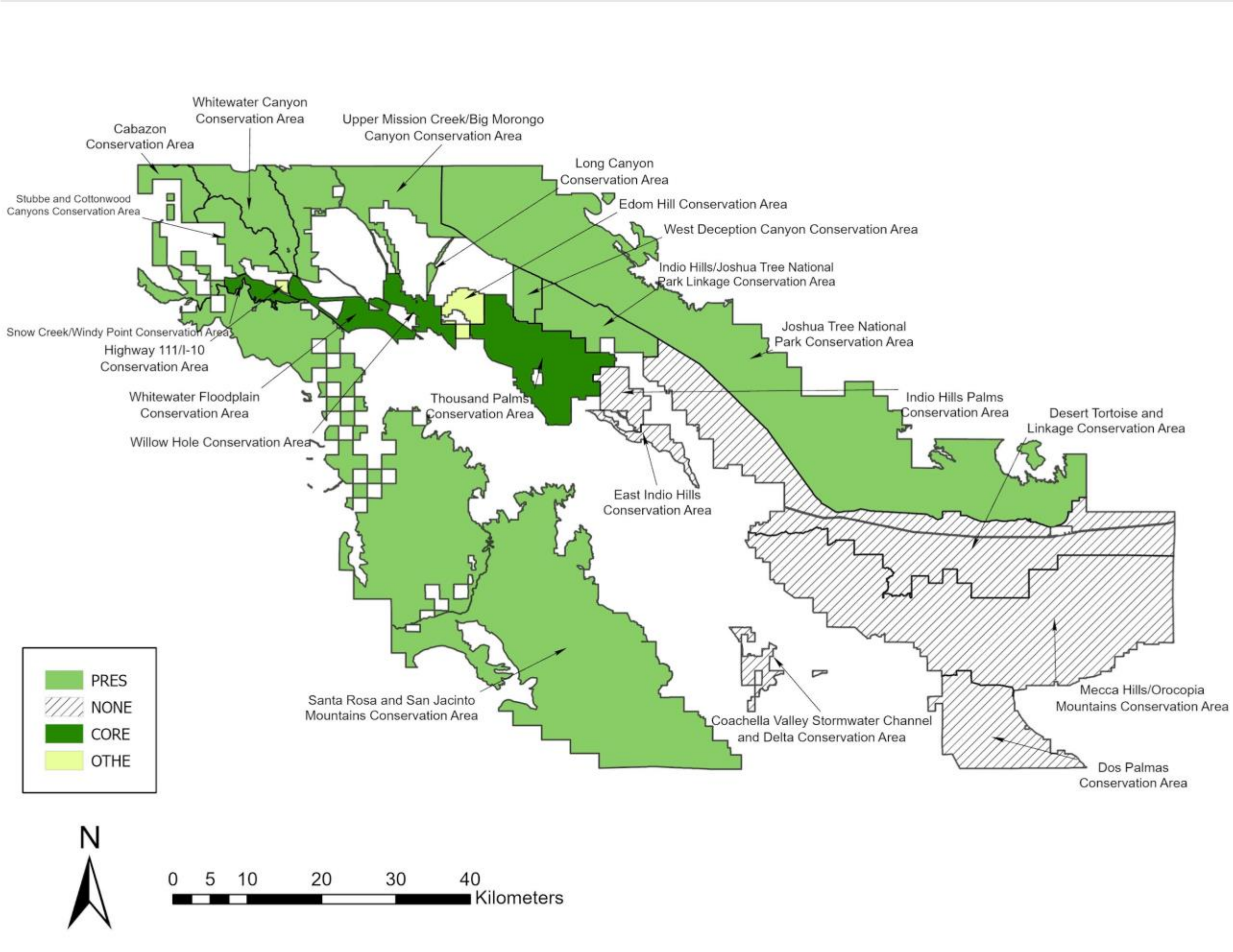


Figure 10: Map of Conservation Areas in the CVMSHCP with or without specific Plan conservation objectives for the Coachella Valley milkvetch. Specific species objectives are included in conservation planning for areas assigned as: Core Habitat (CORE) and Other Conserved Habitat (OTHE). Also indicated on the map are Conservation Areas with Presences (PRES) for the Coachella Valley milkvetch within the CVMSHCP. Note that the Conservation Areas boundaries are represented rather than the species' occupied area.

Modeled Current Distribution: The continuous output of the species distribution model shows the range of habitat suitability for the Coachella Valley milkvetch at the current time across the area, primarily along the valley bottom (Figure 11). Much of this habitat falls within now-urbanized areas, constraining the species to undeveloped and open and/or conserved open land. The species is excluded from the surrounding mountain ranges.

Climate Resilience: The results for the Coachella Valley milkvetch indicate that there may be retained habitat within the CVMSHCP, but this is severely decreased under all scenarios in the future, contracting to the north and west (Figures 12, 13, and 14). There does not appear to be a great expansion potential for the species uphill in elevation, or into the mountains, and this is consistent with expectations for a species that occurs in somewhat flat aeolian sand habitats.

The modeled future suitable habitat within the western Conservation Areas near Desert Hot Springs is essentially a portion of the currently occupied habitat, which will aid in species occupancy/migration, assuming other barriers and challenges are mitigated. However, other factors such as alluvial, rocky deposits, sand stabilization and urbanization are inconsistent with the requirements for this species. Despite overall predicted reductions, we see an increase in predicted habitat at the end of century only under the 1.26 scenario (Figure 15). The Maxent model algorithm predicts suitability using various feature classes or response shapes (described in methods), some non-linear. There also may be challenges of transferability of models when projected into areas lacking sampling (presence), or for which novel climate-topographic areas are the subject of the projections (Peterson et al., 2007). Since the model lacks information concerning salinity, both of these factors may explain why the output predicts an increase in the southeast end of the distribution, near the Salton Sea. The potential to retain this species should be the subject of further research.

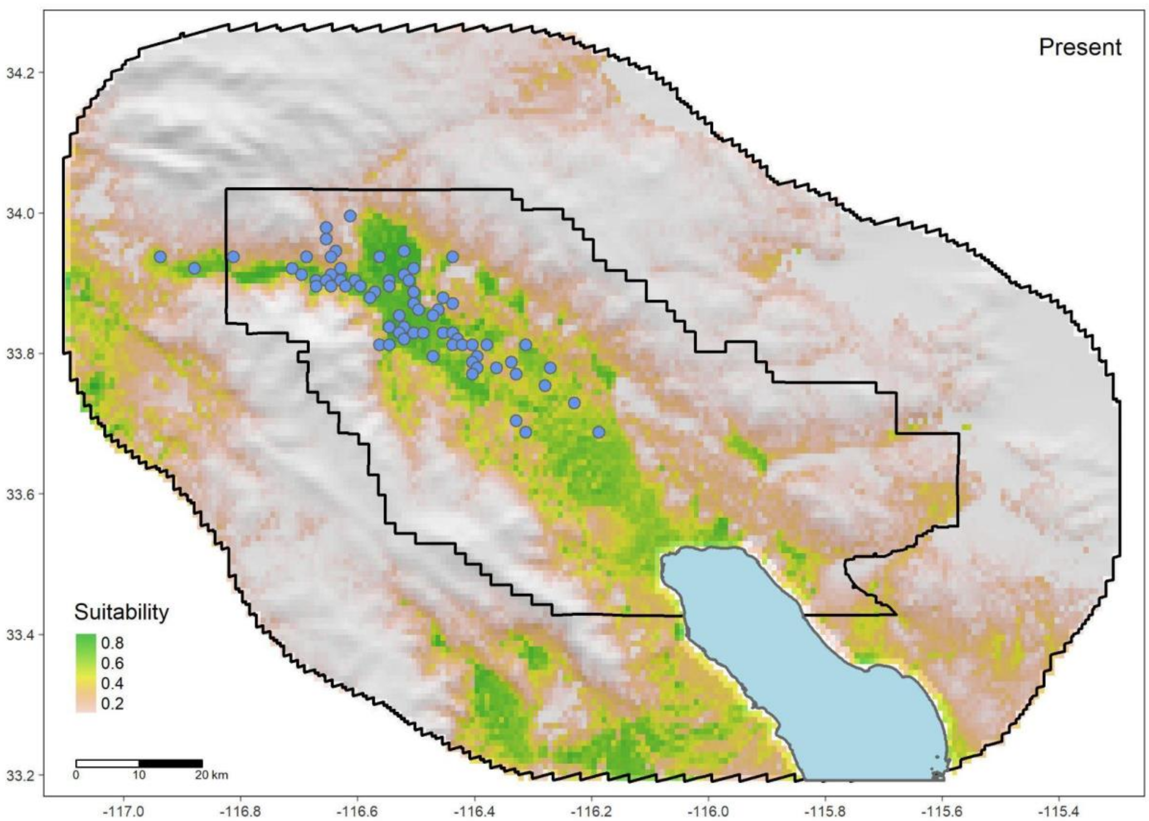


Figure 11: The modeled currently-suitable habitat area projections for the Coachella Valley milkvetch (*Astragalus lentiginosus* var. *coachellae*) within the Coachella Valley, CA and environs. Model training points (presence points) are shown as blue circles. The CVMSHCP boundary is shown in black. Predicted suitability increases from 0 to 1.

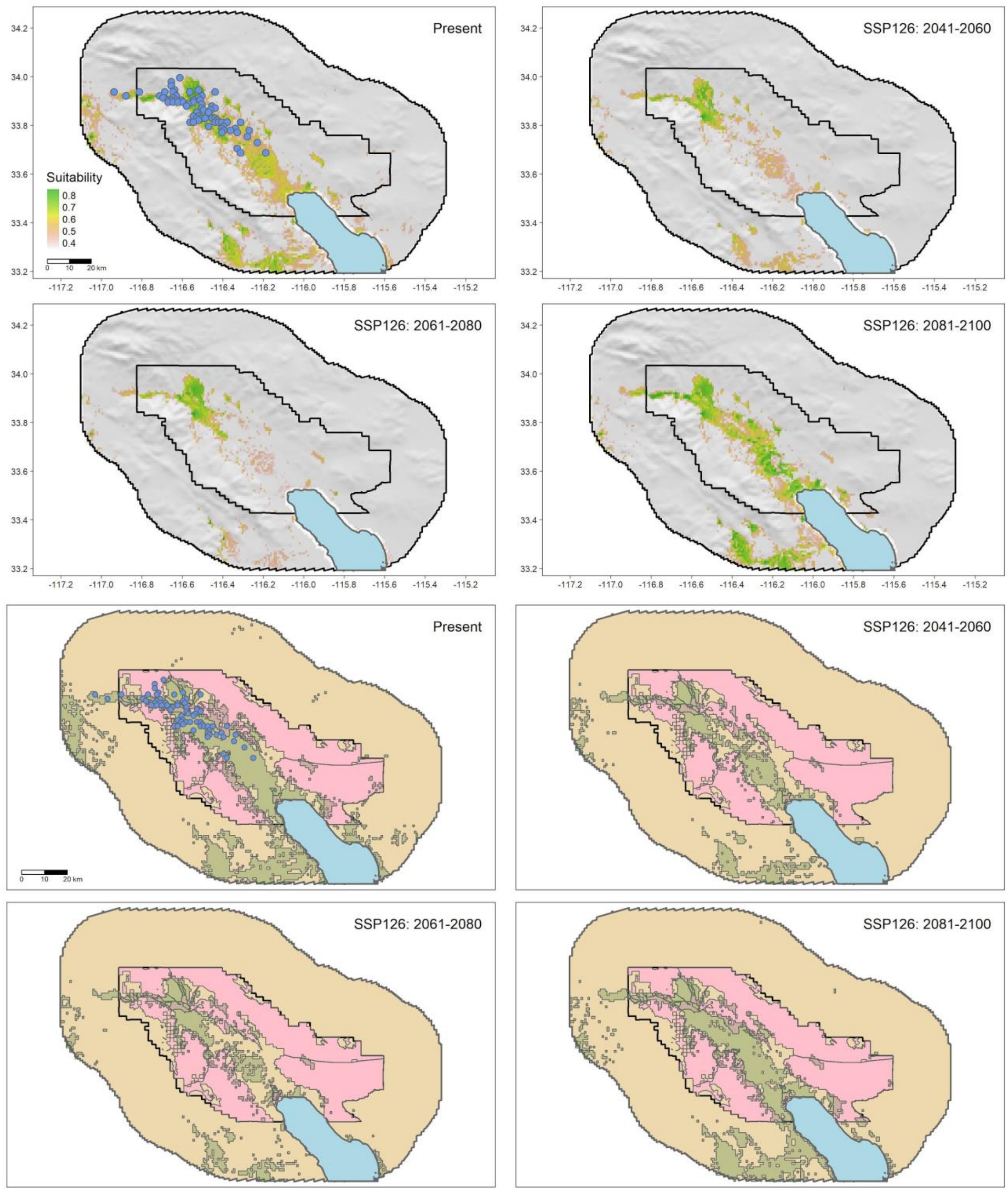


Figure 12: The current and future suitable habitat area projections for the Coachella Valley milkvetch within the Coachella Valley, CA and environs under the 1.26 socioeconomic pathway scenario for the present, and three future periods to 2100, as indicated in the panel. The upper four panels show only suitable habitat above the threshold (0.4). The lower four panels show the same output as a binary where areas meeting or exceeding the threshold of habitat suitability, from marginal to high, are shown in green. CVMSHCP conservation areas are shown in pink, and the CVMSHCP Area boundary is shown in black.

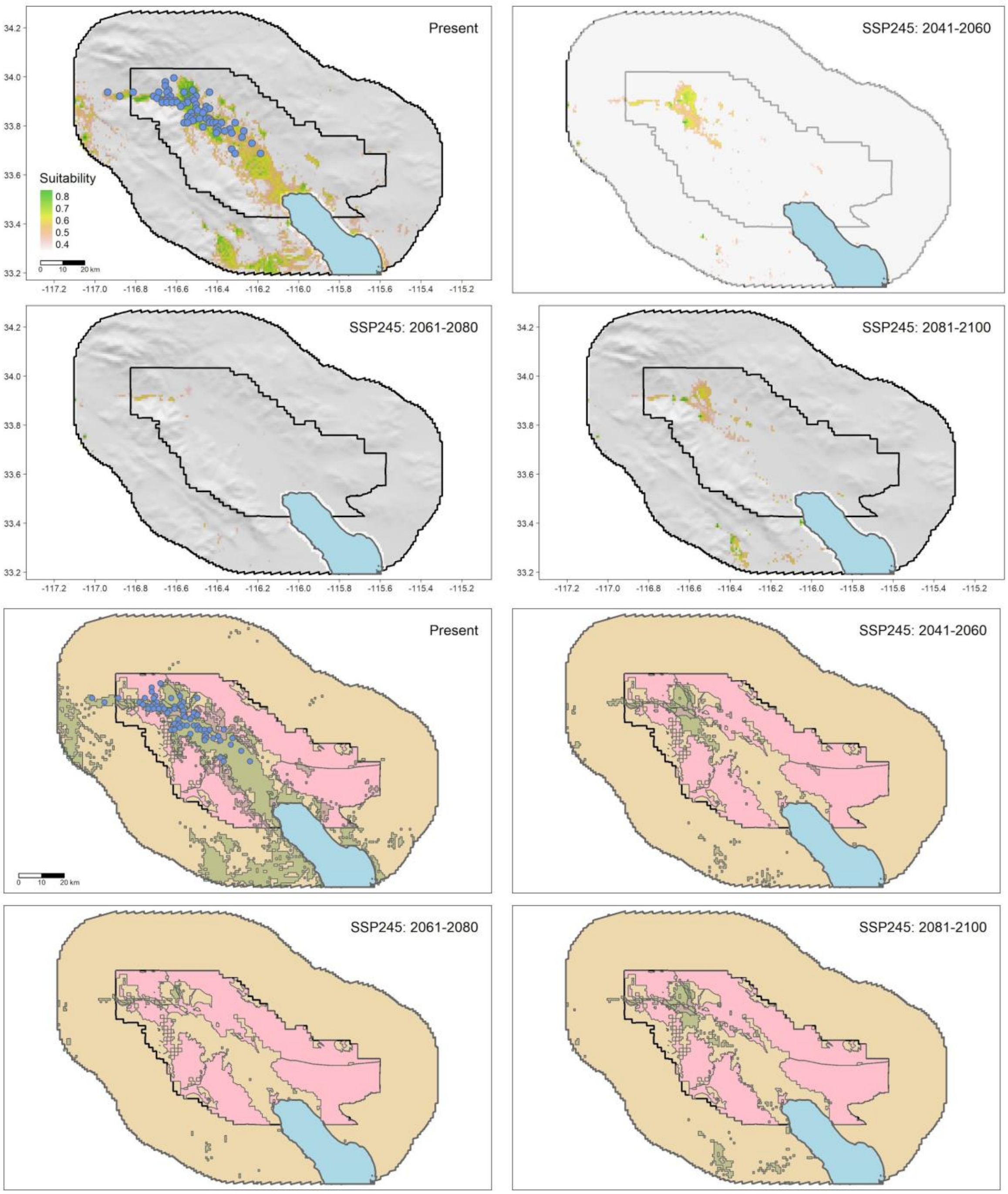


Figure 13: The current and future suitable habitat area projections for the Coachella Valley milkvetch within the Coachella Valley, CA and environs under the 2.45 socioeconomic pathway scenario for the present, and three future periods to 2100, as indicated in the panel. The upper four panels show only suitable habitat above the threshold (0.4). The lower four panels show the same output as a binary where areas meeting or exceeding the threshold of habitat suitability, from marginal to high, are shown in green. CVMSHCP conservation areas are shown in pink, and the CVMSHCP Area boundary is shown in black.

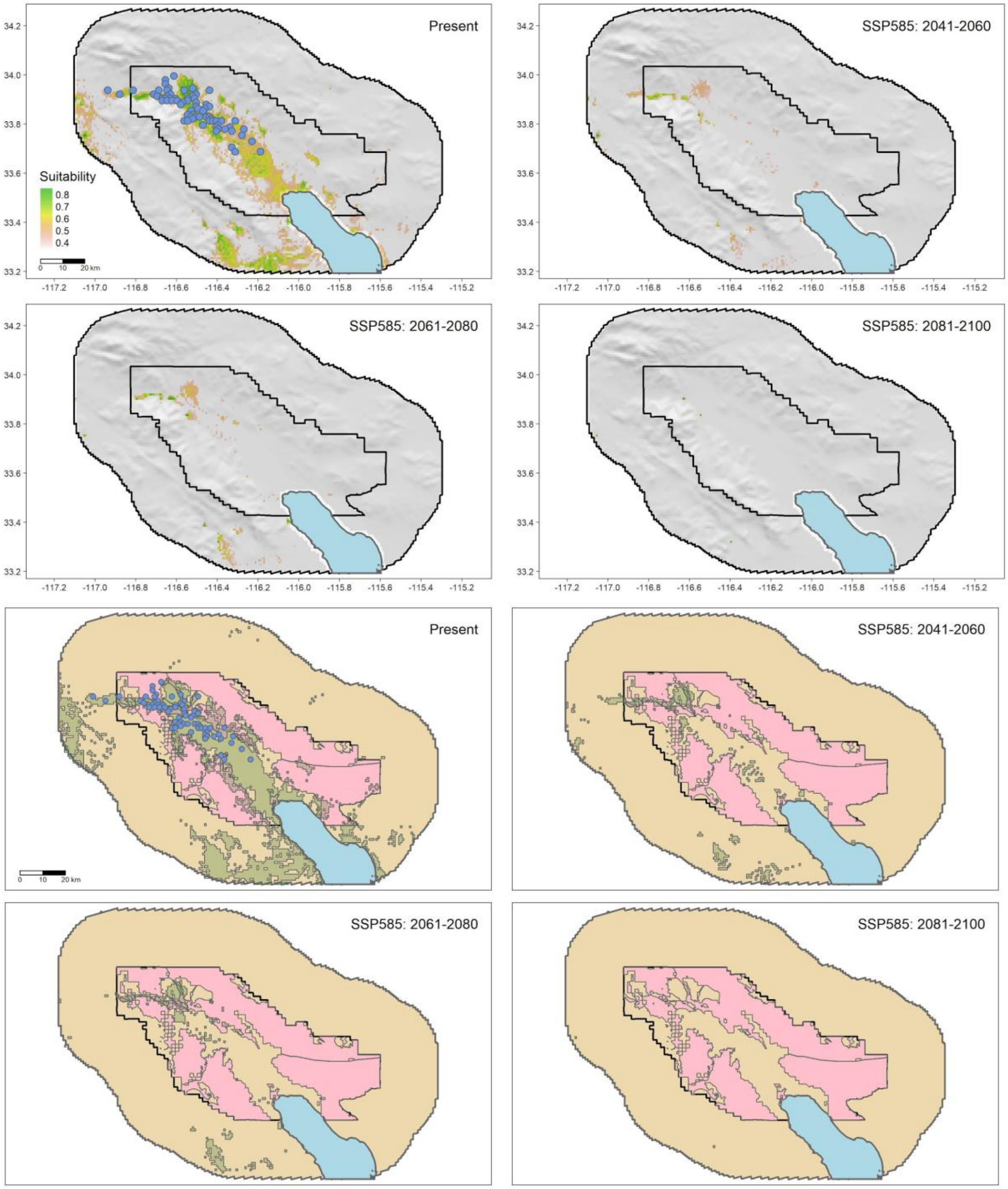


Figure 14: The current and future suitable habitat area projections for the Coachella Valley milkvetch within the Coachella Valley, CA and environs under the 5.85 socioeconomic pathway scenario for the present, and three future periods to 2100, as indicated in the panel. The upper four panels show only suitable habitat above the threshold (0.4). The lower four panels show the same output as a binary where areas meeting or exceeding the threshold of habitat suitability, from marginal to high, are shown in green. CVMSHCP conservation areas are shown in pink, and the CVMSHCP Area boundary is shown in black.

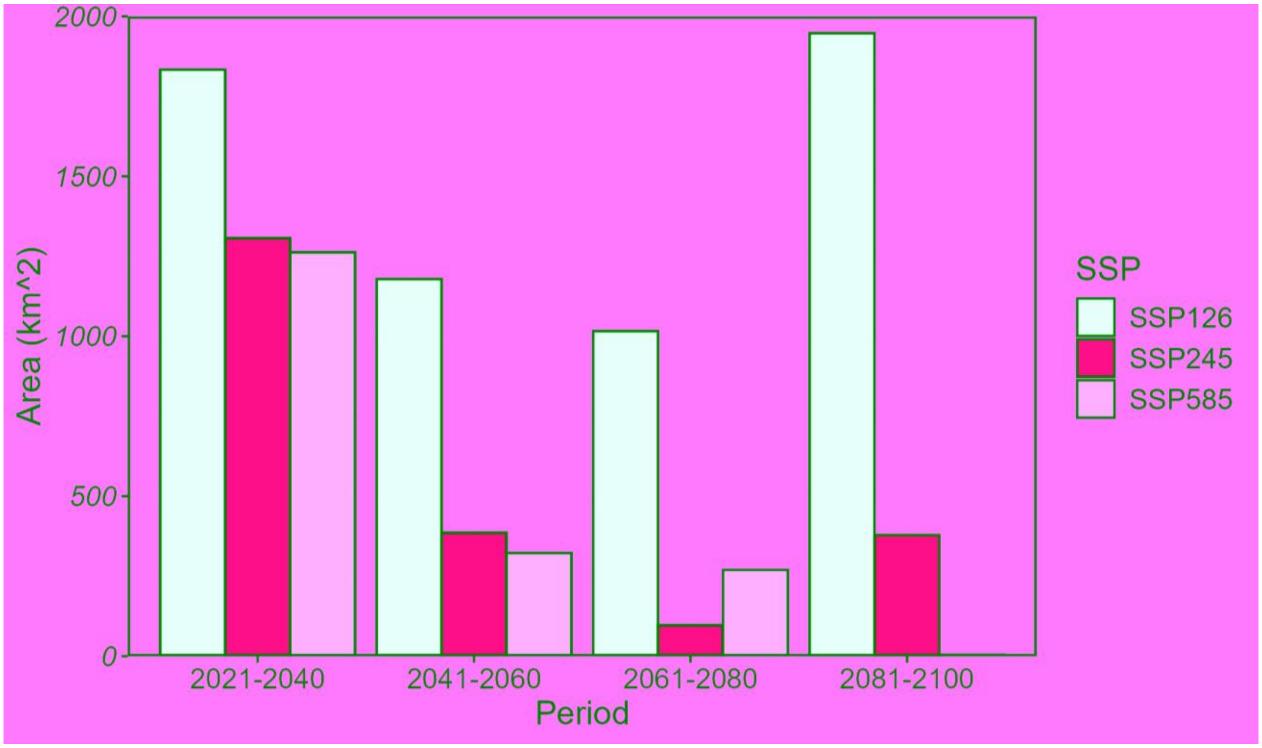


Figure 15: The area (km^2) predicted to support the Coachella Valley milkvetch within the CVMSHCP Plan area in several future time periods, under three SSP's: SSP1-2.6 (mild), SSP2-4.5 (medium), and SSP5-8.5 (high) based on the Coupled Model Intercomparison Project Phase 6 (CMIP-6).

Little San Bernardino Mountains Linanthus (now Linanthus maculatus ssp. maculatus)

Figure 16: San Bernardino Mountains linanthus, which is a subspecies (*Linanthus maculatus* ssp. *maculatus*) occurring in the Snow Creek Conservation Area. Photo: Lynn Sweet.

CVMSHCP Conservation: The Little San Bernardino Mountains linanthus (*Linanthus maculatus* (Parish) Milliken *subsp. maculatus* [Polemoniaceae]) is listed within the Plan as a covered species (now known under its subspecies name) and it has no concurrent official status in the State of California (Figure 16). The subspecies is endemic to the Coachella Valley in California and it is ranked by a joint State and expert review process as a California Rare Plant Rank 1B.2 (Plants Rare, Threatened or Endangered in California and Elsewhere; Moderately threatened in California; CNDDB & CNPS 2020). The species range outside the Plan area in San Bernardino County, is now better described, and these areas are disjunct from Coachella Valley populations, on the eastern flanks of the San Bernardino Mountains in the vicinity of Homestead Valley and on the northern slopes of Joshua Tree National Park near the village of Joshua Tree. The Plan covers Core Habitat objectives for the species within two Conservation Areas, at least one specific objective (Other Conserved Habitat) within one Conservation Area (Figure 17), and is protected by virtue of other conservation objectives where it is present within one other Conservation Area as of the last Plan Amendment in 2016 (CVCC 2016). Conservation Plan objectives include maintaining conserved habitat area and minimizing fragmentation, protecting the species across a range of habitats to promote genetic diversity, and protecting corridors (further described in CVMSHCP Section 9.2.5.1). It was noted at the time of inception that most of the occurrences within the Plan area were on unconserved lands and in all, the Conservation Areas were estimated to cover 86% of the occupied and suitable habitat as mapped and modeled for the species when the Plan was enacted (CVCC 2016; Section 9.2.5.4).

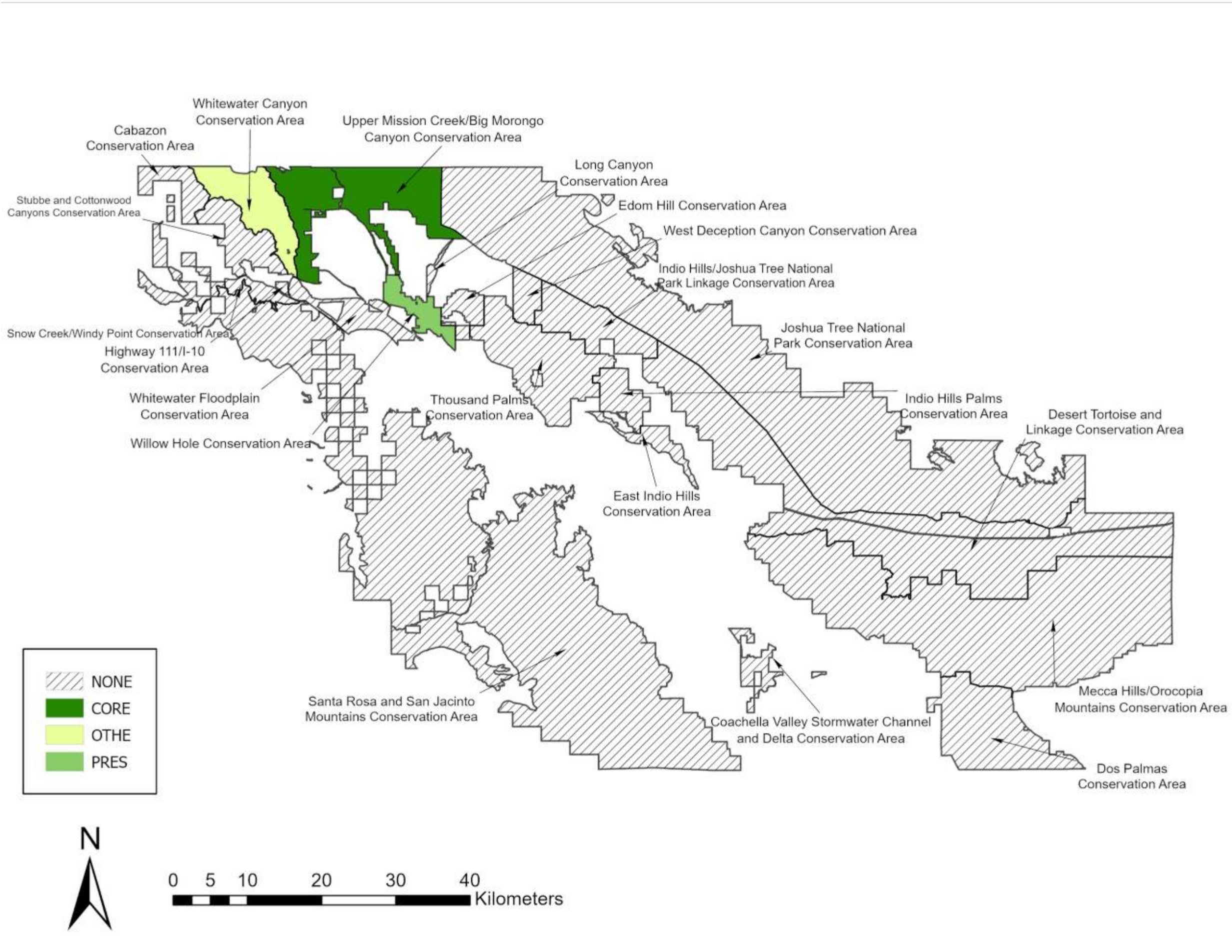


Figure 17: Map of Conservation Areas in the CVMSHCP with or without specific Plan conservation objectives for the Little San Bernardino Mountains linanthus. Specific species objectives are included in conservation planning for areas assigned as: Core Habitat (CORE) and Other Conserved Habitat (OTHE). Also indicated on the map are Conservation Areas with Presences (PRES) for the Little San Bernardino Mountains linanthus within the CVMSHCP. Note that the Conservation Areas boundaries are represented rather than the species' occupied area.

Modeled Current Distribution: The continuous output of the species distribution model shows the range of habitat suitability for the Little San Bernardino Mountains linanthus at the current time across the area, primarily in alluvial fans spreading from the foothills of the Little San Bernardino and San Bernardino Mountains (Figure 8). The species is excluded from the areas with steep slopes or high exposure, excluding surrounding mountain ranges.

Climate Resilience: The results for the Little San Bernardino Mountains linanthus indicate that there may be very little retained habitat within the CVMSHCP in mid-to-late century under all scenarios in the future, losing suitable habitat gradually from the southeast end of the currently-suitable area (Figures 19, 20, and 21). While there is no expansion predicted within the CVMSHCP area, there may be more retention of habitat suitability in areas outside of the area. Areas that will retain the species are primarily contiguous to others as modeled, with contraction within the Coachella Valley as well as the suitable areas to the north (Figure 22).

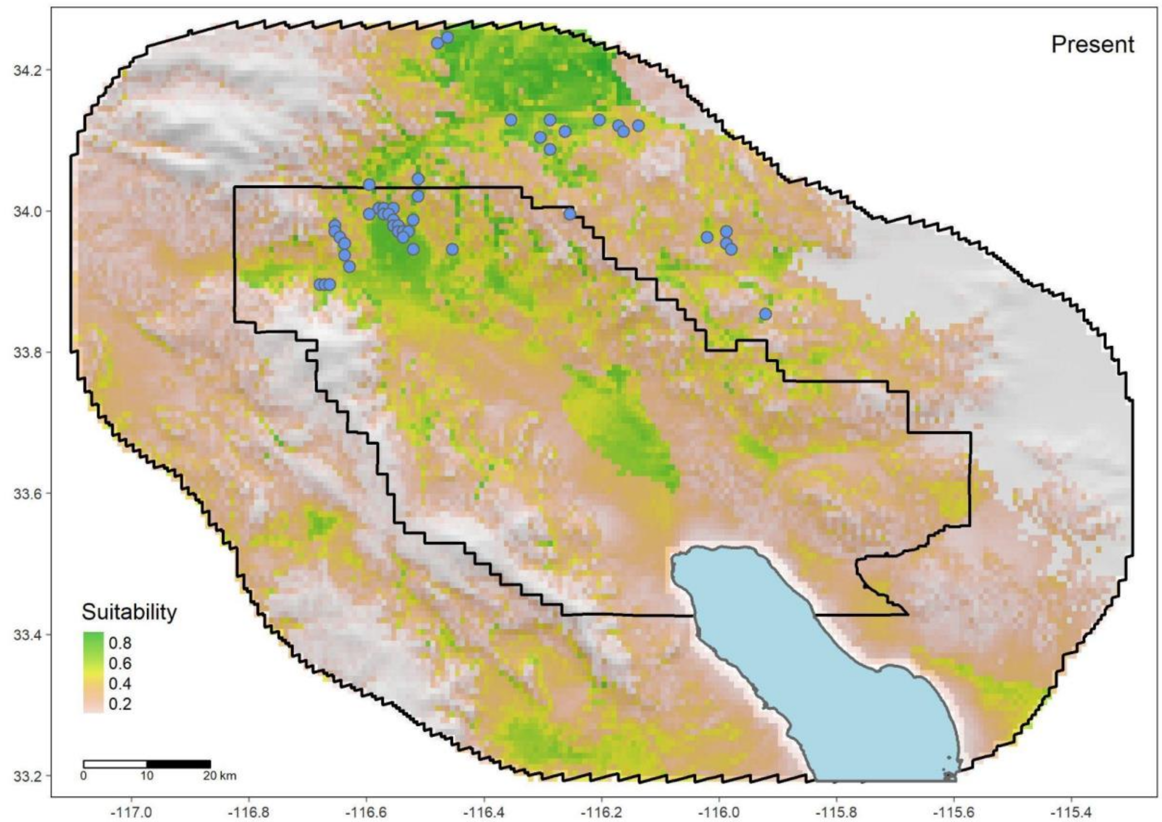


Figure 18: The modeled currently-suitable habitat area projections for theLittle San Bernardino Mountains linanthus within the Coachella Valley, CA and environs. Model training points (presence points) are shown as blue circles. The CVMSHCP boundary is shown in black. Predicted suitability increases from 0 to 1.

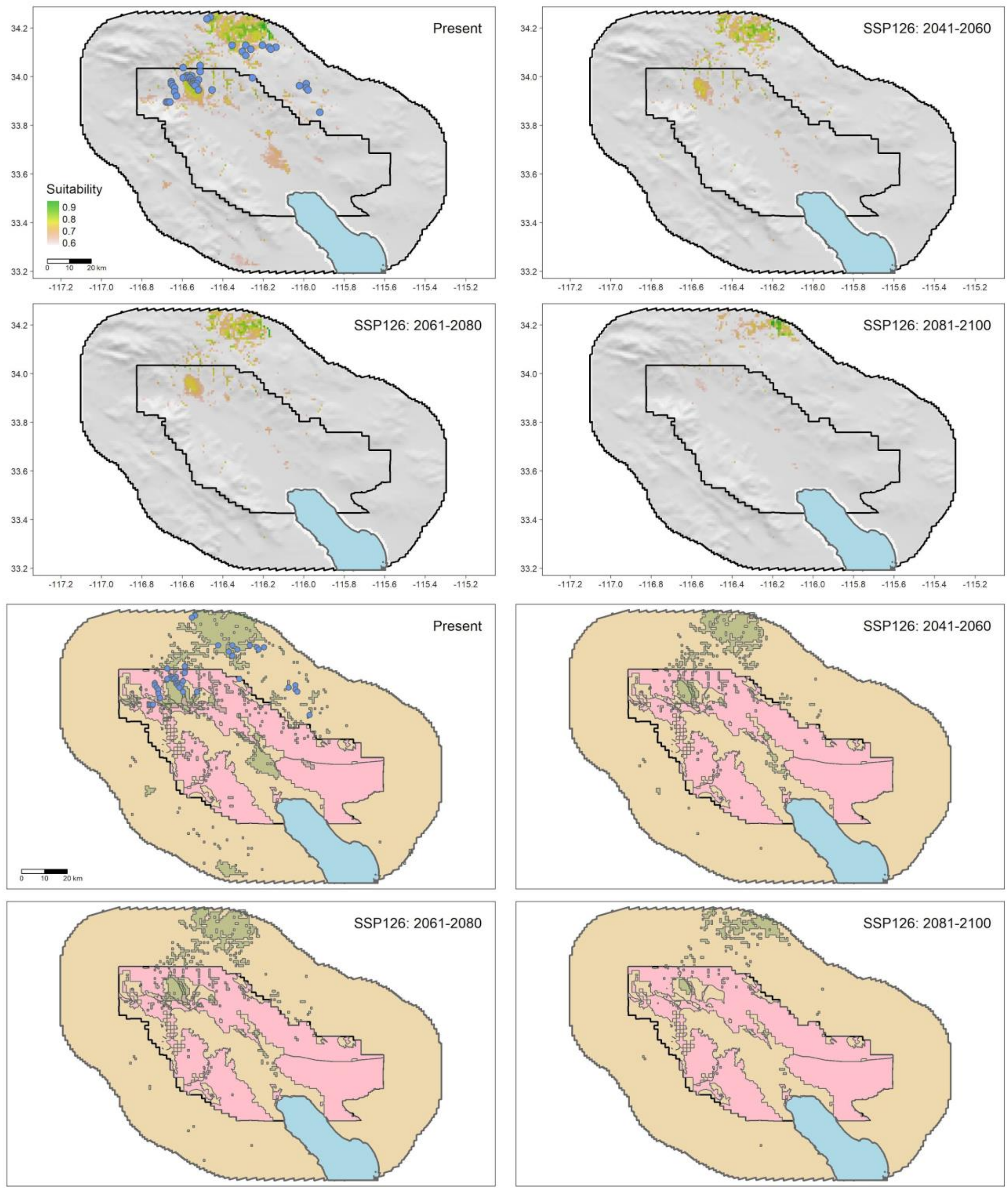


Figure 19: The current and future suitable habitat area projections for the Little San Bernardino Mountains linanthus within the Coachella Valley, CA and environs under the 1.26 socioeconomic pathway scenario for the present, and three future periods to 2100, as indicated in the panel. The upper four panels show only suitable habitat above the threshold (0.4). The lower four panels show the same output as a binary where areas meeting or exceeding the threshold of habitat suitability, from marginal to high, are shown in green. CVMSHCP conservation areas are shown in pink, and the CVMSHCP Area boundary is shown in black.

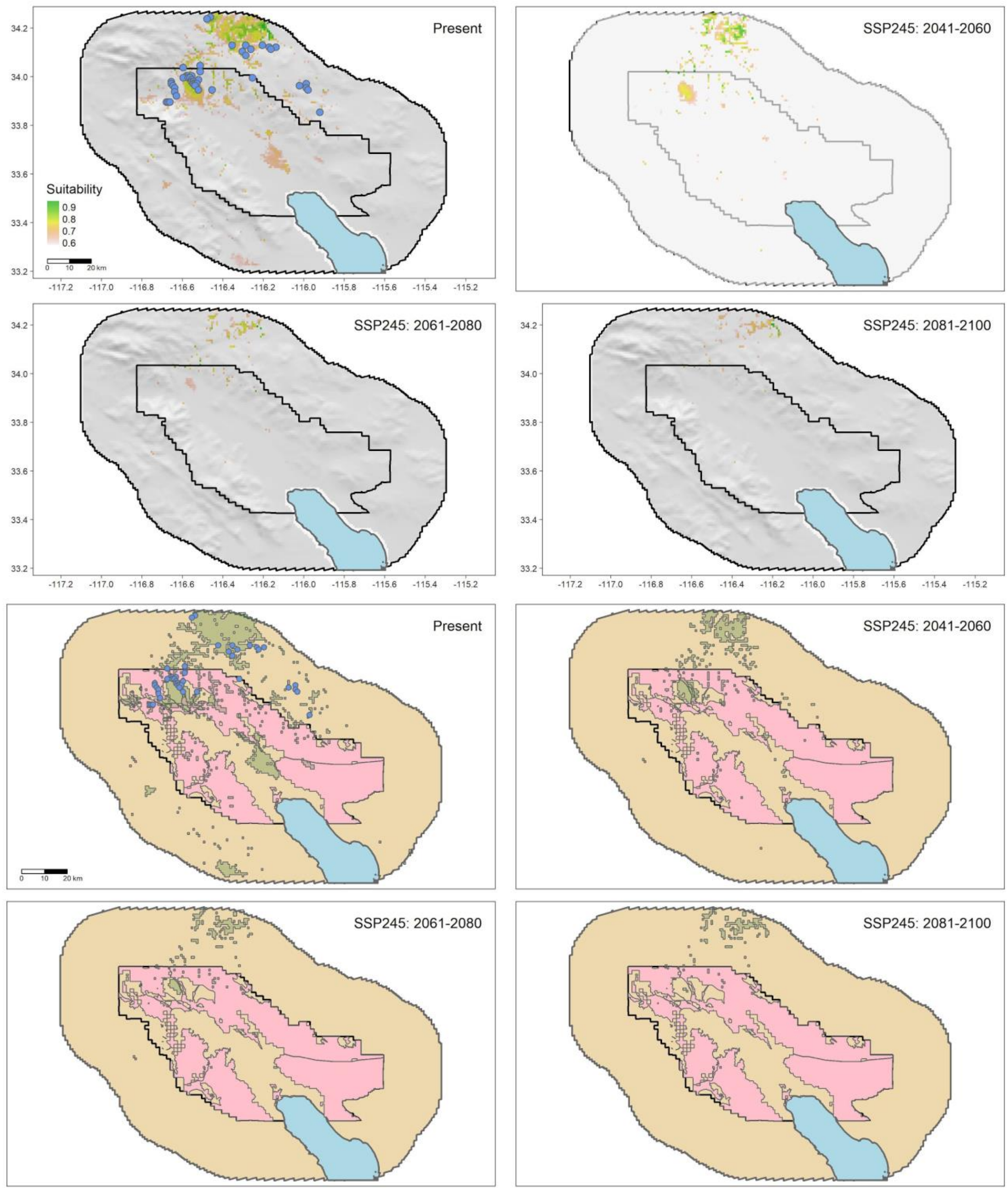


Figure 20: The current and future suitable habitat area projections for theLittle San Bernardino Mountains linanthus within the Coachella Valley, CA and environs under the 2.45 socioeconomic pathway scenario for the present, and three future periods to 2100, as indicated in the panel. The upper four panels show only suitable habitat above the threshold (0.4). The lower four panels show the same output as a binary where areas meeting or exceeding the threshold of habitat suitability, from marginal to high, are shown in green. CVMSHCP conservation areas are shown in pink, and the CVMSHCP Area boundary is shown in black.

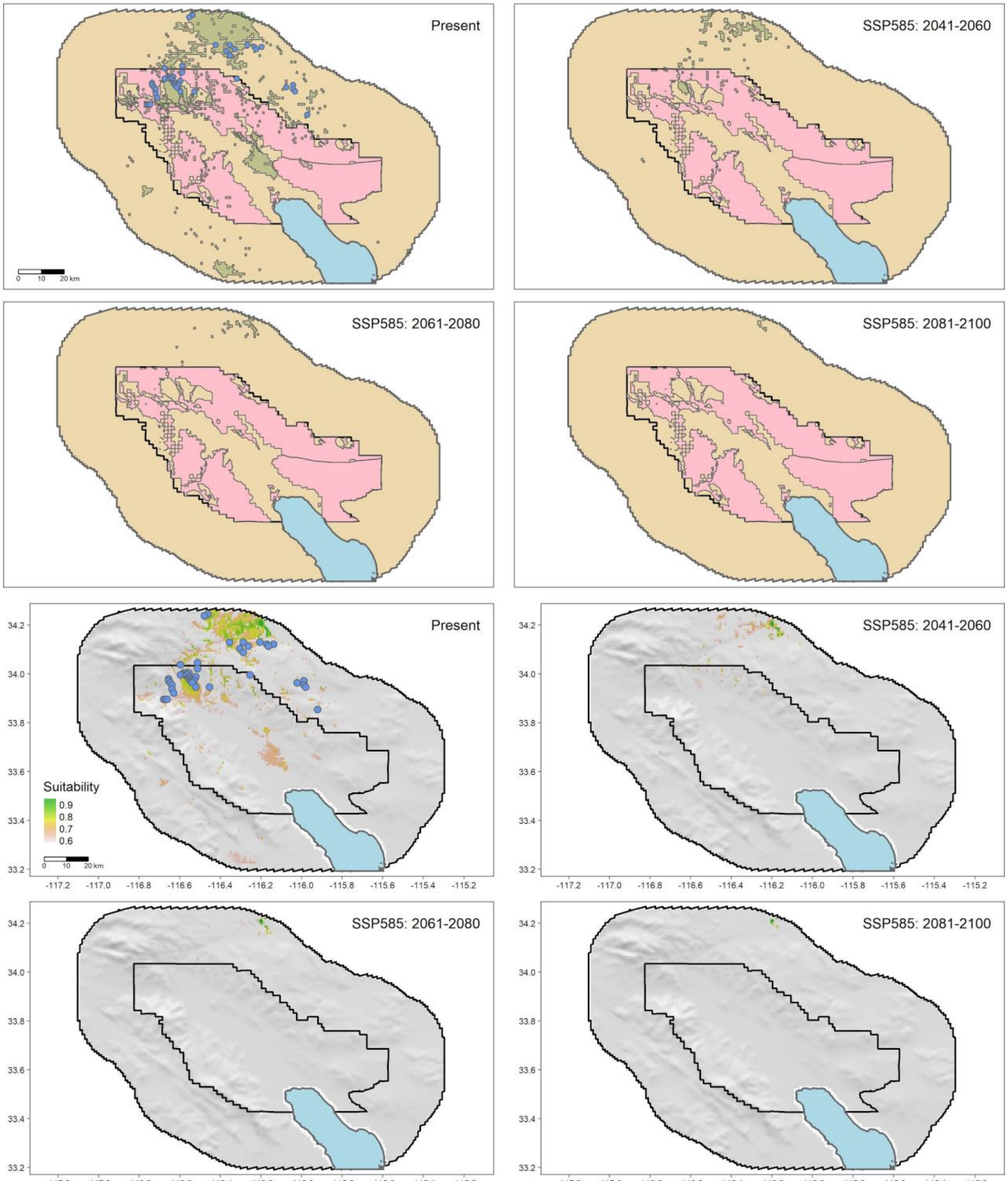


Figure 21: The current and future suitable habitat area projections for the Little San Bernardino Mountains linanthus within the Coachella Valley, CA and environs under the 5.85 socioeconomic pathway scenario for the present, and three future periods to 2100, as indicated in the panel. The upper four panels show only suitable habitat above the threshold (0.4). The lower four panels show the same output as a binary where areas meeting or exceeding the threshold of habitat suitability, from marginal to high, are shown in green. CVMSHCP conservation areas are shown in pink, and the CVMSHCP Area boundary is shown in black.

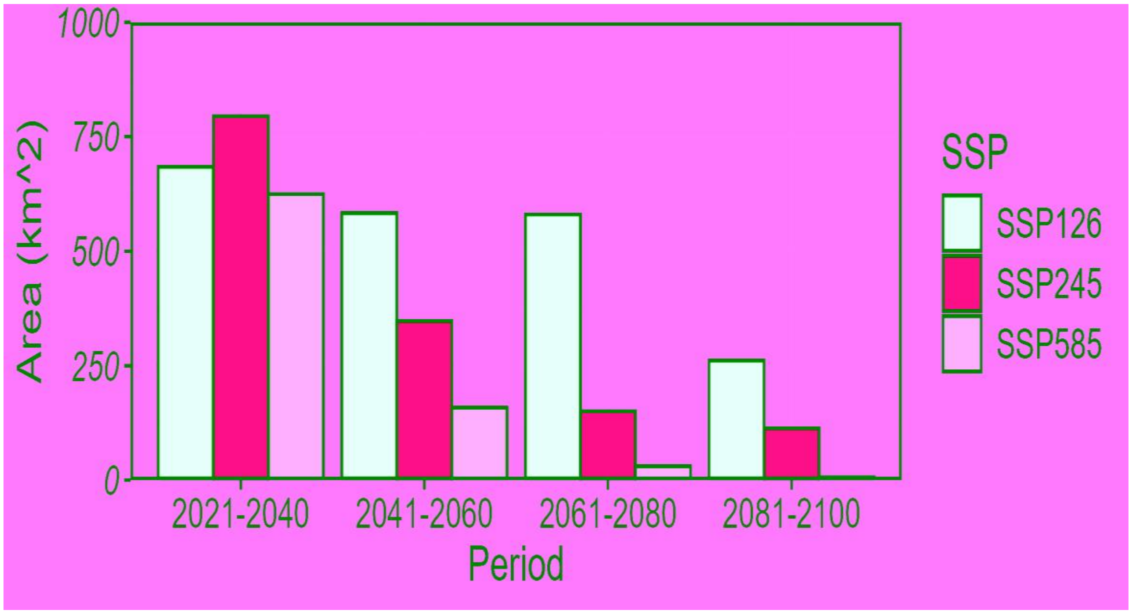


Figure 22: The area (km^2) predicted to support the Little San Bernardino Mountains linanthus within the CVMSHCP Plan area in several future time periods, under three SSP's: SSP1-2.6 (mild), SSP2-4.5 (medium), and SSP5-8.5 (high) based on the Coupled Model Intercomparison Project Phase 6 (CMIP-6).

Orocopia Sage (Salvia greatae)

Figure 23: Orocopia sage occurring in the Orocopia Mountains, California. Orocopia sage is a small endemic shrub. Photo: Melanie Davis.

CVMSHCP Conservation: The Orocopia sage (*Salvia greatae* Brandegee [Lamiaceae]) is listed within the Plan as a covered species and it has no concurrent official status in the State of California. The subspecies is endemic to the mountain ranges to the east of the Coachella Valley in California and it is ranked by a joint State and expert review process as a California Rare Plant Rank 1B.3 (plants rare, threatened, or endangered in CA and elsewhere); Moderately threatened in California; CNDDB & CNPS 2020). The species is known to occur in areas slightly beyond the plan boundaries, including the Chocolate Mountains into Imperial County. The species occurs in multiple microhabitats (alluvial fans, flats and mountain slopes; Figure 23). The Plan covers Core Habitat objectives for the species within two Conservation Areas, at least one specific objective (Other Conserved Habitat) within one Conservation Area (Figure 24), and these comprise the coverage for this species as of the last Plan Amendment in 2016. Conservation Plan objectives include maintaining conserved habitat area and minimizing fragmentation, protecting the species across a range of habitats to promote genetic diversity, and protecting corridors, and specifically, and protecting essential ecosystem functions of its habitat (further described in CVMSHCP Section 9.2.4.1). The ecological and ecosystem requirements being little known, Plan objectives also include studies to provide better understanding of what factors sustain presences across multiple microhabitats (as above). Approximately 87% of modeled and occupied habitat was estimated to be conserved under the

Plan at the time of inception (CVMSHCP Section 9.2.4.4). It should be noted that the Orocopia sage has not been detected in systematic surveys in recent years within the Dos Palmas Conservation Area, possibly due to the effects of climate change and changes in local hydrology (Davis *et al.* 2023).

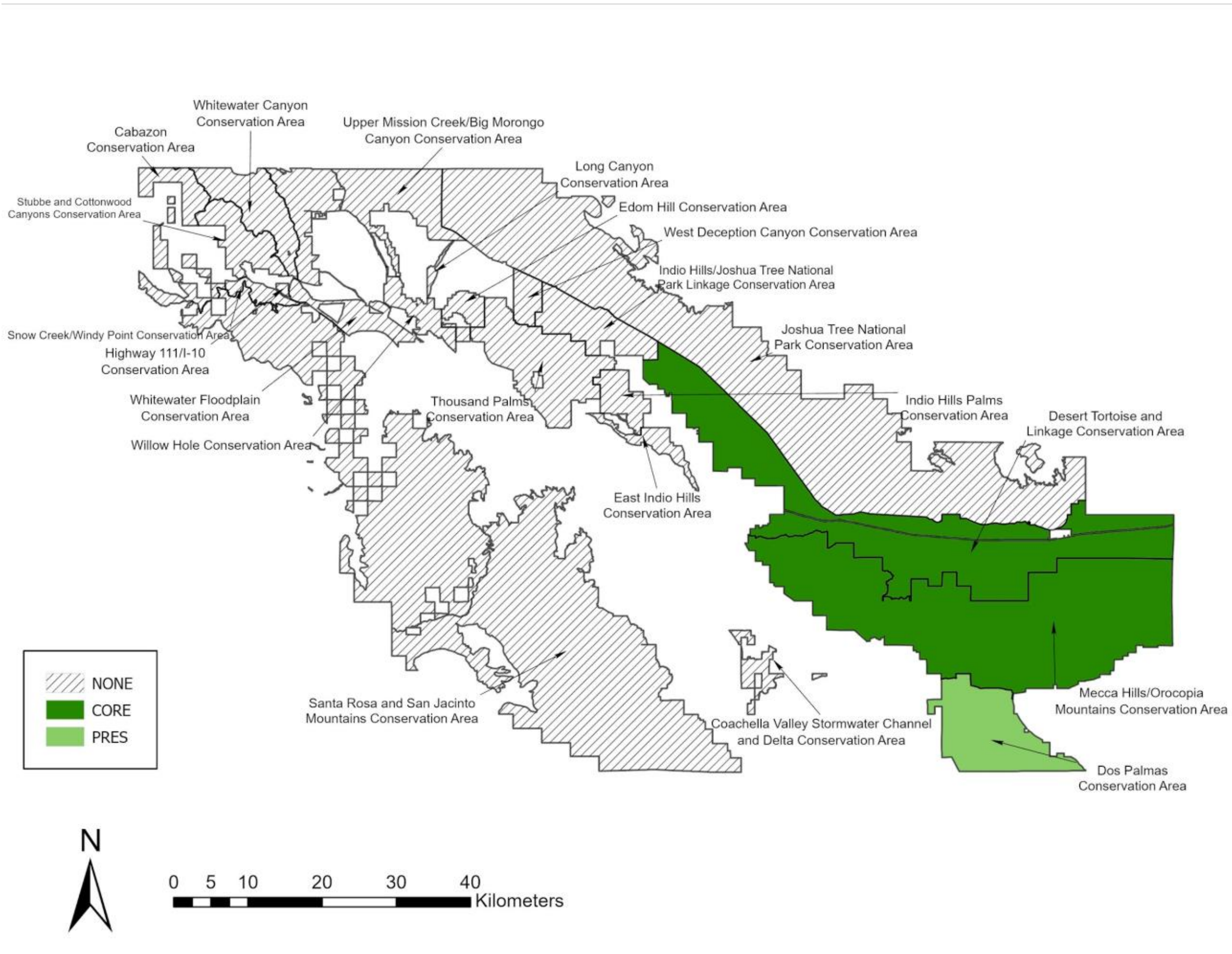


Figure 24: Map of Conservation Areas in the CVMSHCP with or without specific Plan conservation objectives for the Orocopia sage. Specific species objectives are included in conservation planning for areas assigned as: Core Habitat (CORE) and there are no areas assigned as Other Conserved Habitat (OTHE). Also indicated on the map are Conservation Areas with Presences (PRES) for the Orocopia sage within the CVMSHCP. Note that the Conservation Areas boundaries are represented rather than the species' occupied area.

Modeled Current Distribution: The continuous output of the species distribution model shows the range of habitat suitability for the Orocopia sage at the current time across the area, primarily in alluvial fans and slopes in the foothills of the Orocopia and Chuckwalla Mountains (Figure 25) and areas to the north and east, many of which are not known to be occupied by the species, perhaps due to edaphic restrictions (Davis *et al.* 2023).

Climate Resilience: The results for the Orocopia sage indicate that there may be very little retained habitat within the CVMSHCP under all scenarios in the future, losing suitable habitat rapidly by mid-century (Figures 26, 27, and 28). There is no expansion predicted within the CVMSHCP area, and in contrast to other species, there may be little or no retention of habitat suitability in continuous areas to the north that are modeled as currently-suitable beyond the CVMSHCP (Figure 29). THere may be better retention of habitat in the Chocolate Mountains to the southeast, outside of the Plan area. Overall, this species is not expected to thrive overall, and Plan protections may be essential in any retention of habitat for the species.

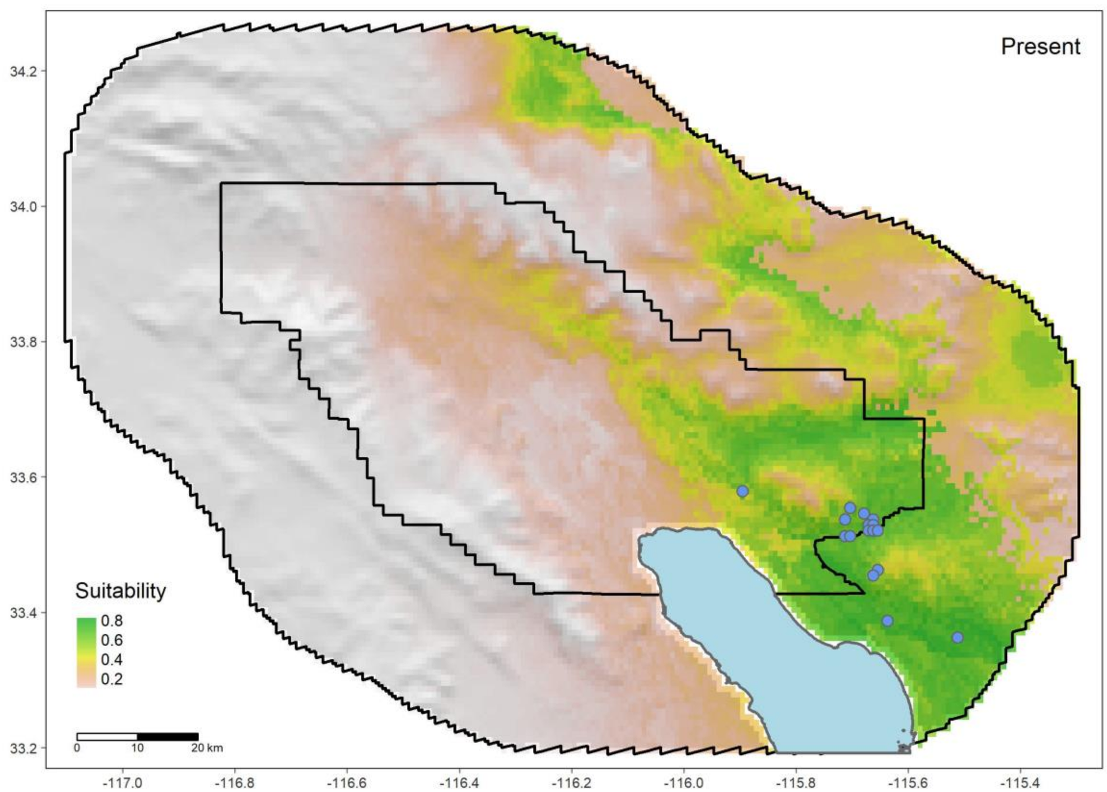


Figure 25: The modeled currently-suitable habitat area projections for the Orocopia sage within the Coachella Valley, CA and environs. Model training points (presence points) are shown as blue circles. The CVMSHCP boundary is shown in black. Predicted suitability increases from 0 to 1.

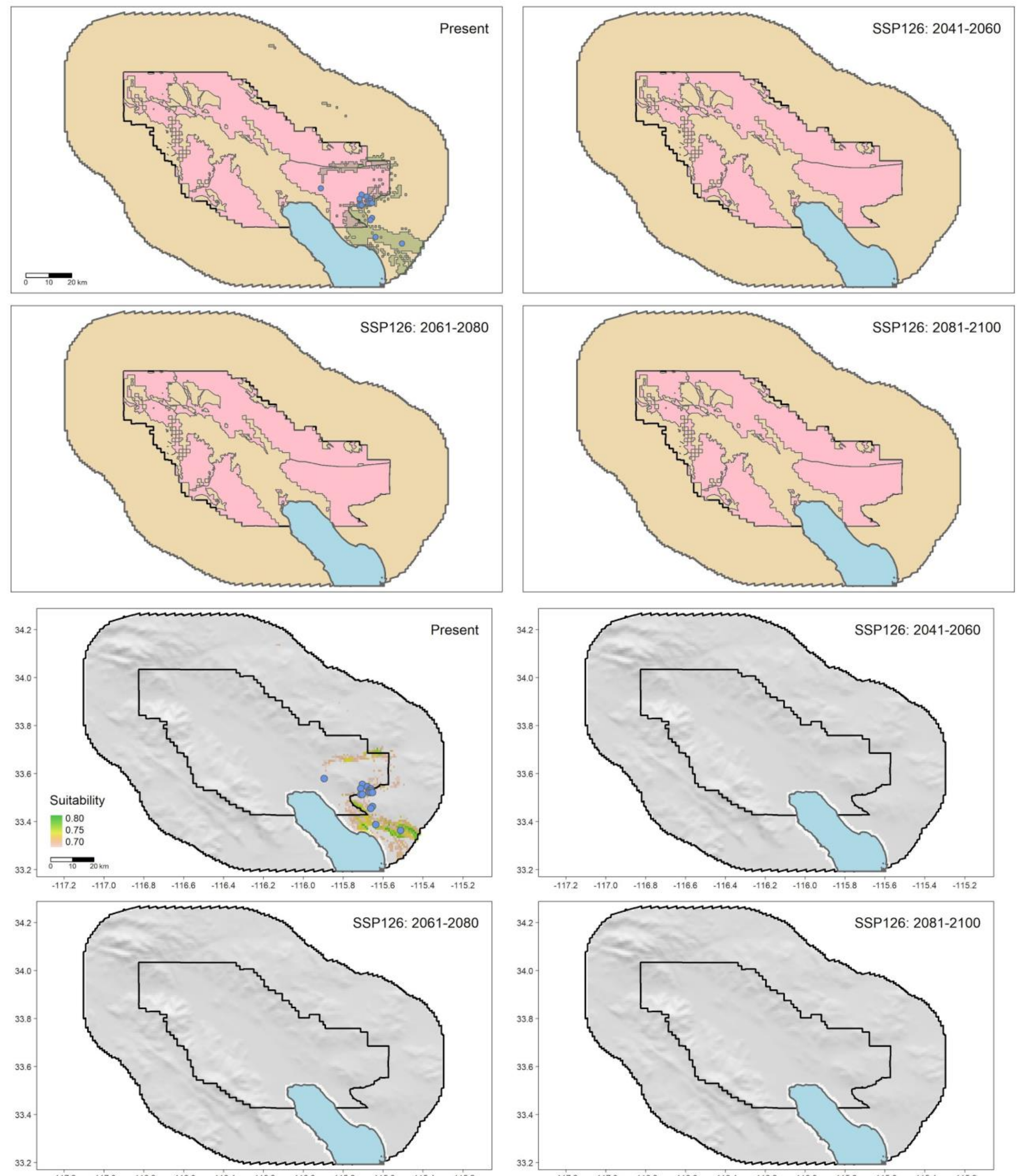


Figure 26: The current and future suitable habitat area projections for the Orocopia sage within the Coachella Valley, CA and environs under the 1.26 socioeconomic pathway scenario for the present, and three future periods to 2100, as indicated in the panel. The upper four panels show only suitable habitat above the threshold (0.4). The lower four panels show the same output as a binary where areas meeting or exceeding the threshold of habitat suitability, from marginal to high, are shown in green. CVMSHCP conservation areas are shown in pink, and the CVMSHCP Area boundary is shown in black.

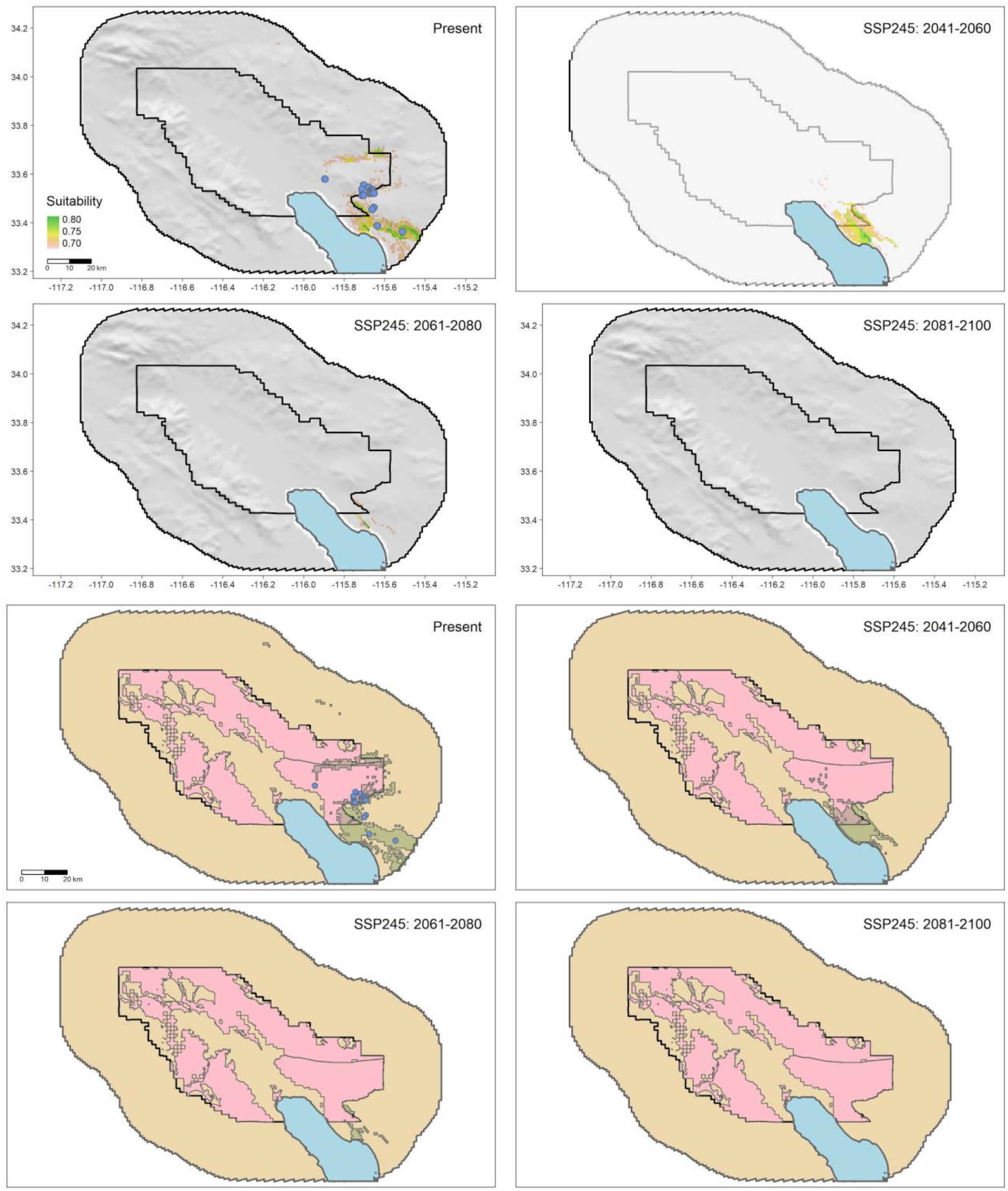


Figure 27: The current and future suitable habitat area projections for the Orocopia sage within the Coachella Valley, CA and environs under the 2.45 socioeconomic pathway scenario for the present, and three future periods to 2100, as indicated in the panel. The upper four panels show only suitable habitat above the threshold (0.4). The lower four panels show the same output as a binary where areas meeting or exceeding the threshold of habitat suitability, from marginal to high, are shown in green. CVMSHCP conservation areas are shown in pink, and the CVMSHCP Area boundary is shown in black.

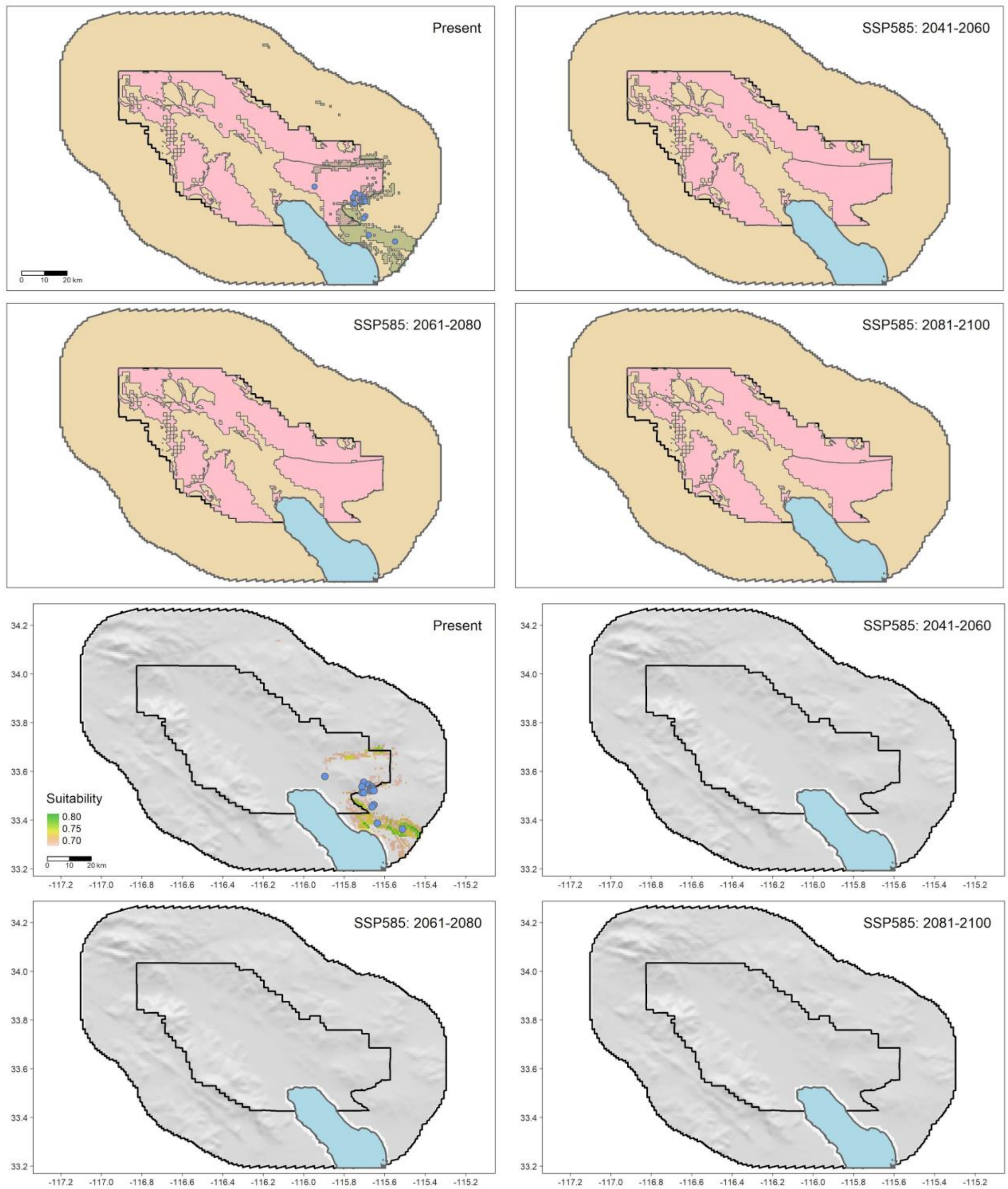


Figure 28: The current and future suitable habitat area projections for the Orocopia sage within the Coachella Valley, CA and environs under the 5.85 socioeconomic pathway scenario for the present, and three future periods to 2100, as indicated in the panel. The upper four panels show only suitable habitat above the threshold (0.4). The lower four panels show the same output as a binary where areas meeting or exceeding the threshold of habitat suitability, from marginal to high, are shown in green. CVMSHCP conservation areas are shown in pink, and the CVMSHCP Area boundary is shown in black.

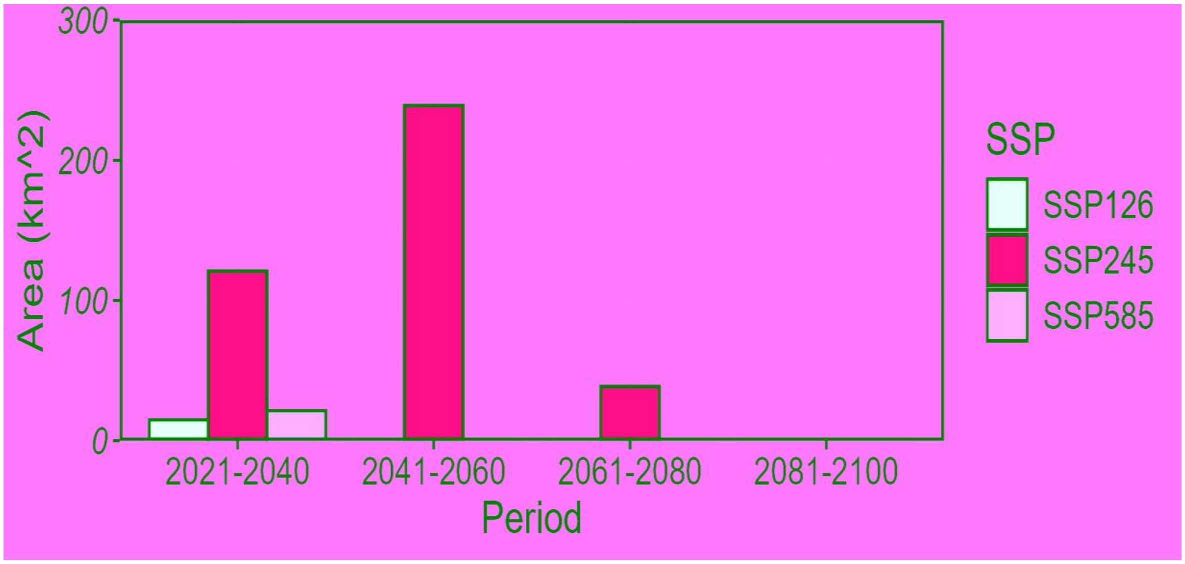


Figure 29: The area (km^2) predicted to support the Orocopia sage within the CVMSHCP Plan area in several future time periods, under three SSP's: SSP1-2.6 (mild), SSP2-4.5 (medium), and SSP5-8.5 (high) based on the Coupled Model Intercomparison Project Phase 6 (CMIP-6).

Mecca Aster (Xylorhiza cognata)

Figure 30: Mecca aster is an endemic species to the Mecca and Indio Hills within the CVMSHCP area. Mecca is seen flowering in a canyon bottom within the Mecca Hills. Photo: Lynn Sweet.

CVMSHCP Conservation: The Mecca aster (*Xylorhiza cognata* (H. M. Hall) T. J. Watson [Asteraceae]) is listed within the Plan as a covered species and it has no concurrent official status in the State of California. This species is endemic to the eastern hills of the Coachella Valley in California and it is ranked by a joint State and expert review process as a California Rare Plant Rank 1B.2 (Plants Rare, Threatened or Endangered in California and Elsewhere; Moderately threatened in California; CNDDB & CNPS 2020). The species occurs in canyons, along slopes and mud hills in the Mecca and East Indio Hills within the Plan area (Figure 30). The Plan covers Core Habitat objectives for the species within five Conservation Areas, at least one specific objective (Other Conserved Habitat) within two Conservation Areas (Figure 31), and is protected by virtue of other conservation objectives where it is present within one other Conservation Area as of the last Plan Amendment in 2016. Conservation Plan objectives include maintaining conserved habitat area and minimizing fragmentation, protecting the species across a range of habitats to promote genetic diversity, and protecting corridors (further described in CVMSHCP Section 9.2.1.1). In all, the Conservation Areas were estimated to cover 90% of the occupied and suitable habitat as mapped and modeled for the species when the Plan was enacted (CVMSHCP Section 9.2.1.4).

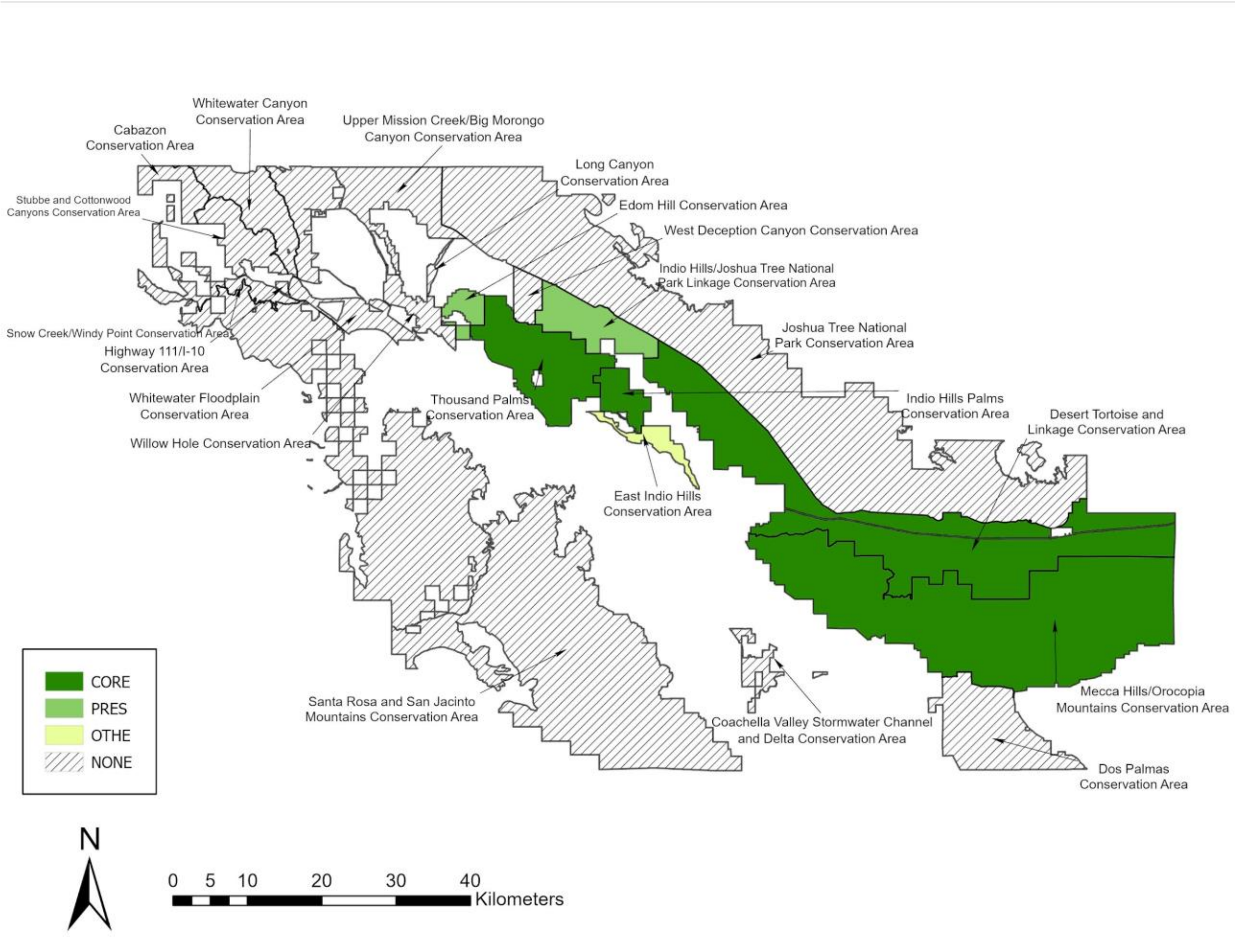


Figure 31: Map of Conservation Areas in the CVMSHCP with or without specific Plan conservation objectives for the Mecca aster. Specific species objectives are included in conservation planning for areas assigned as: Core Habitat (CORE) and Other Conserved Habitat (OTHE). Also indicated on the map are Conservation Areas with Presences (PRES) for the Mecca aster within the CVMSHCP. Note that the Conservation Areas boundaries are represented rather than the species' occupied area.

Current Distribution:

The continuous output of the species distribution model shows the range of habitat suitability for the Mecca aster at the current time across the area, primarily in bottomlands across the eastern side of the valley (Figure 32), and some of these contain the specific microhabitats of the species, although much of the bottomland modeled as suitable to the west is not known to be occupied by the species. The restriction of this species within otherwise modeled suitable area may be due to additional habitat restrictions not captured well by the model at this scale, perhaps microtopography or edaphic requirements, biotic factors (competition from other species or commensalism requirements such as pollinator presence) or unknown factors.

Climate Resilience: The results for the Mecca aster indicate that there may be significant amounts of retained habitat within the CVMSHCP under all scenarios in the future, even with reduced habitat mid-to-late century (Figures Figure 33, 34, 35, and 36). Unlike other species, suitable habitat may generally contract from the northwest into the foothills in the southeastern area of the Coachella Valley/Salton Sink. There is no specific directional expansion predicted within the CVMSHCP area northward or uphill in direction, the species retaining habitat in some of the lowest areas to the southeast. These areas may be impacted by salinity, especially near the Salton Sea, and the tolerance of this species to saline soils is unknown. The species is predicted to retain marginal habitat connectivity to areas in the northeast, however, those areas are not currently known to be occupied by the species. Overall, the species is expected to retain habitat into the future, however, factors that restrict the species within the suitable habitat should be investigated, and these may restrict the species more than predicted in the future.

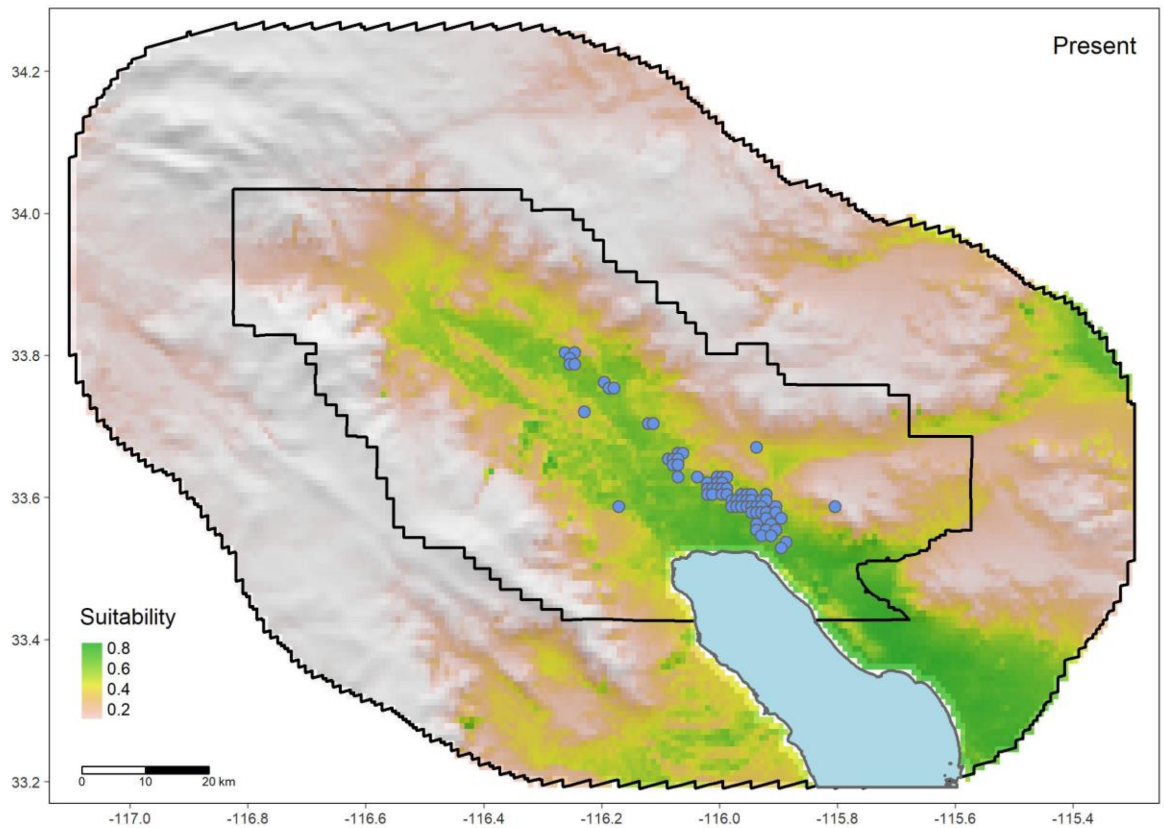


Figure 32: The modeled currently-suitable habitat area projections for the Mecca aster within the Coachella Valley, CA and environs. Model training points (presence points) are shown as blue circles. The CVMSHCP boundary is shown in black. Predicted suitability increases from 0 to 1.

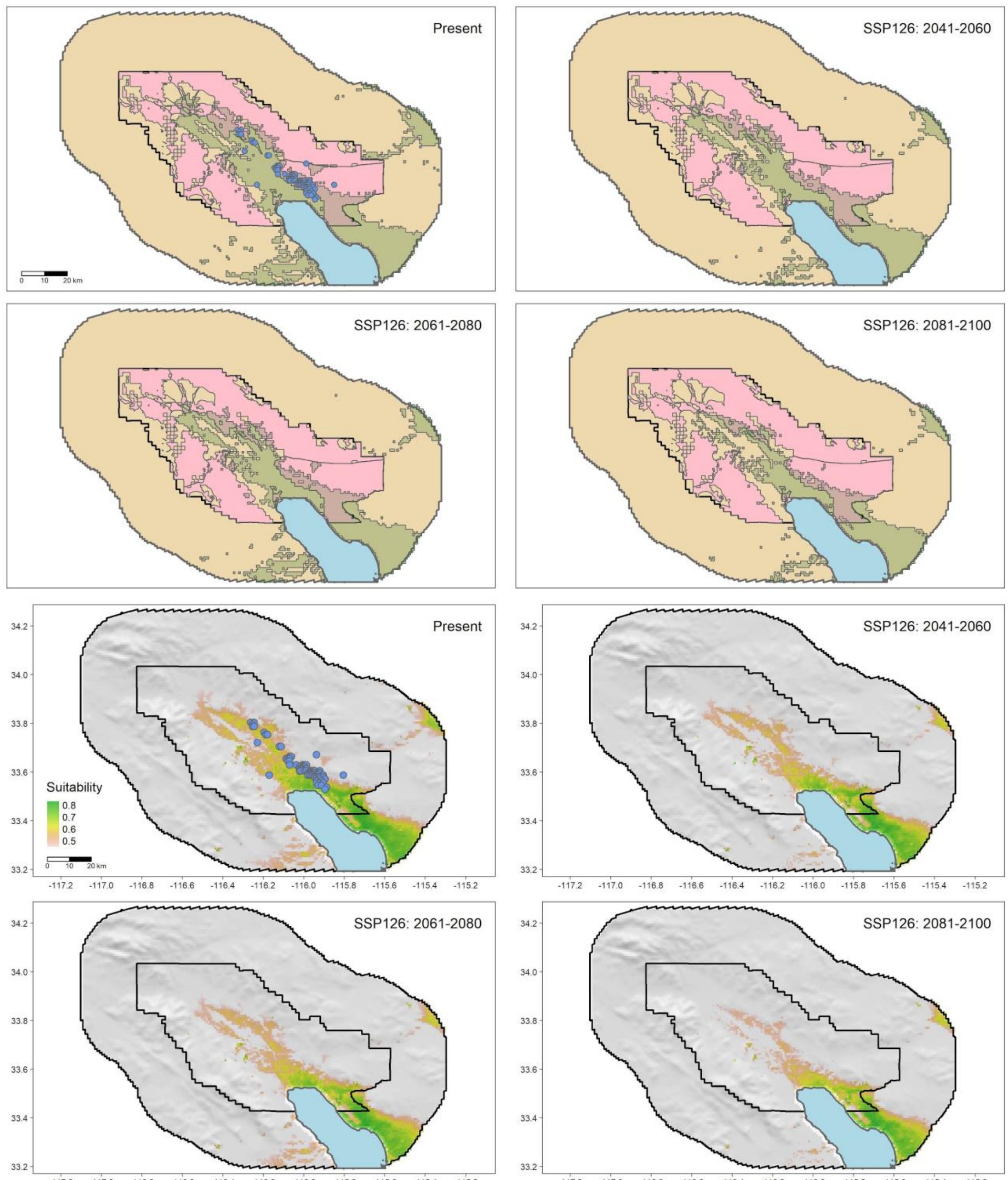


Figure 33: The current and future suitable habitat area projections for the Mecca aster within the Coachella Valley, CA and environs under the 1.26 socioeconomic pathway scenario for the present, and three future periods to 2100, as indicated in the panel. The upper four panels show only suitable habitat above the threshold (0.5). The lower four panels show the same output as a binary where areas meeting or exceeding the threshold of habitat suitability, from marginal to high, are shown in green. CVMSHCP conservation areas are shown in pink, and the CVMSHCP Area boundary is shown in black.

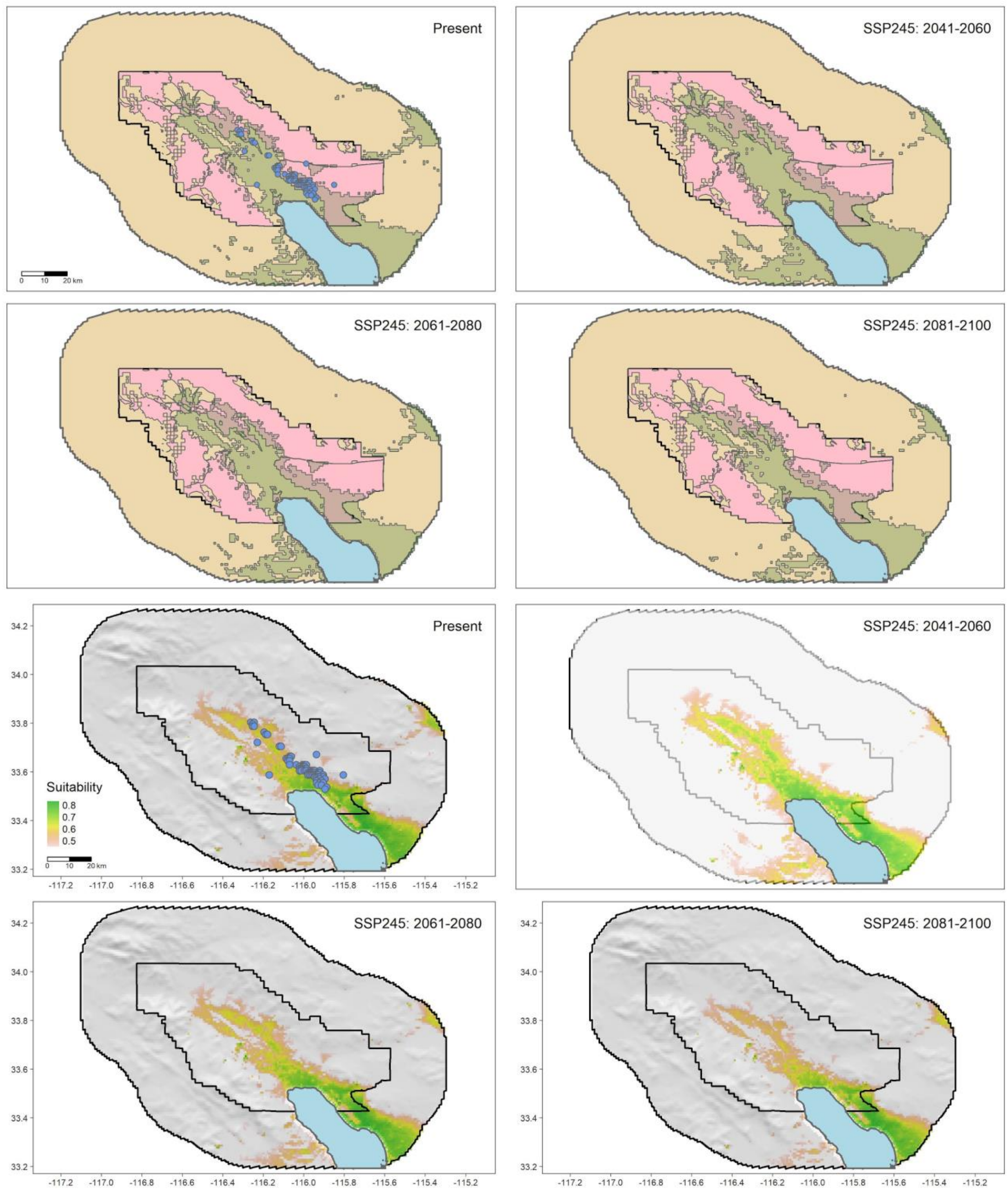


Figure 34: The current and future suitable habitat area projections for the Mecca aster within the Coachella Valley, CA and environs under the 2.45 socioeconomic pathway scenario for the present, and three future periods to 2100, as indicated in the panel. The upper four panels show only suitable habitat above the threshold (0.5). The lower four panels show the same output as a binary where areas meeting or exceeding the threshold of habitat suitability, from marginal to high, are shown in green. CVMSHCP conservation areas are shown in pink, and the CVMSHCP Area boundary is shown in black.

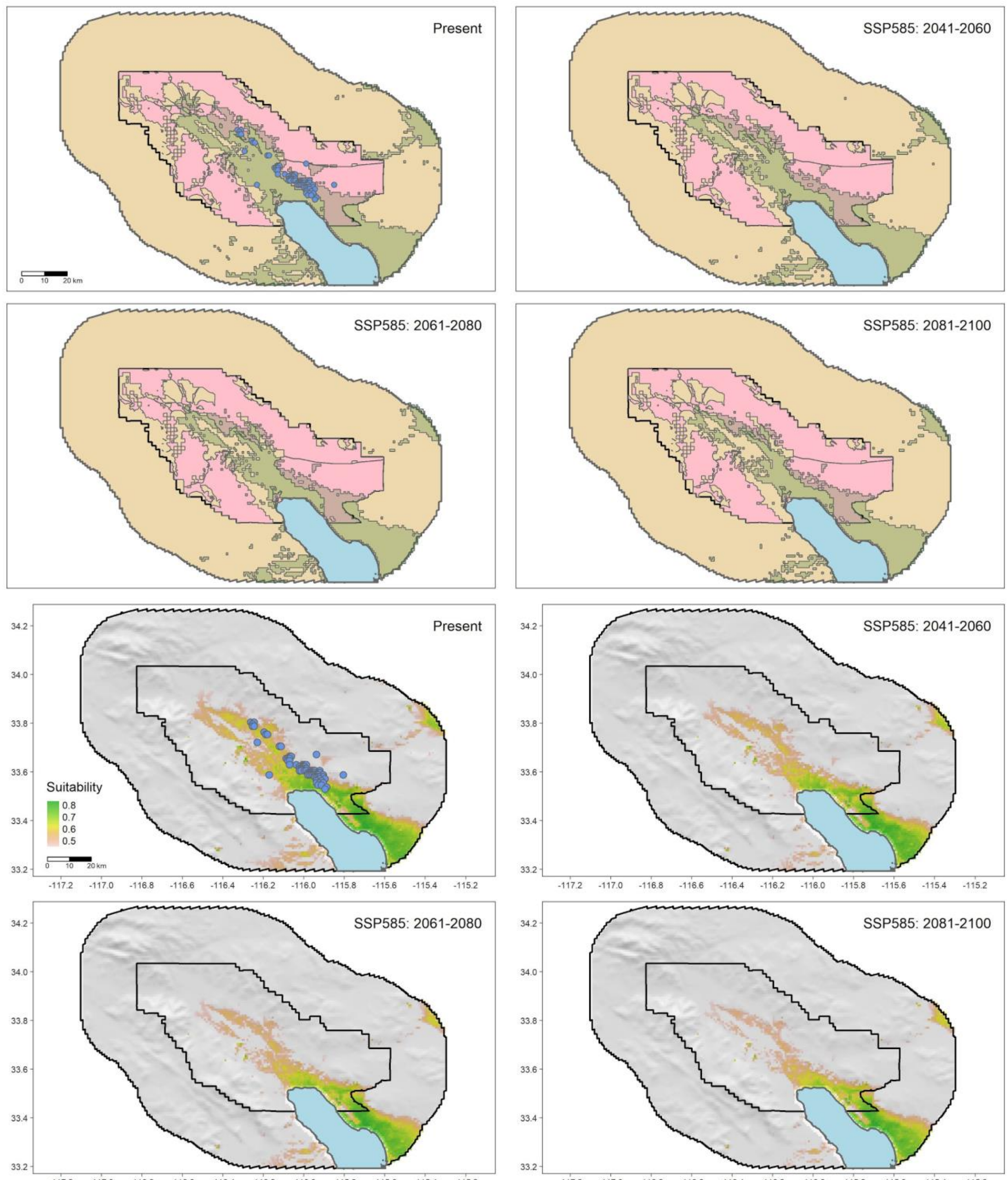


Figure 35: The current and future suitable habitat area projections for the Mecca aster within the Coachella Valley, CA and environs under the 5.85 socioeconomic pathway scenario for the present, and three future periods to 2100, as indicated in the panel. The upper four panels show only suitable habitat above the threshold (0.5). The lower four panels show the same output as a binary where areas meeting or exceeding the threshold of habitat suitability, from marginal to high, are shown in green. CVMSHCP conservation areas are shown in pink, and the CVMSHCP Area boundary is shown in black.

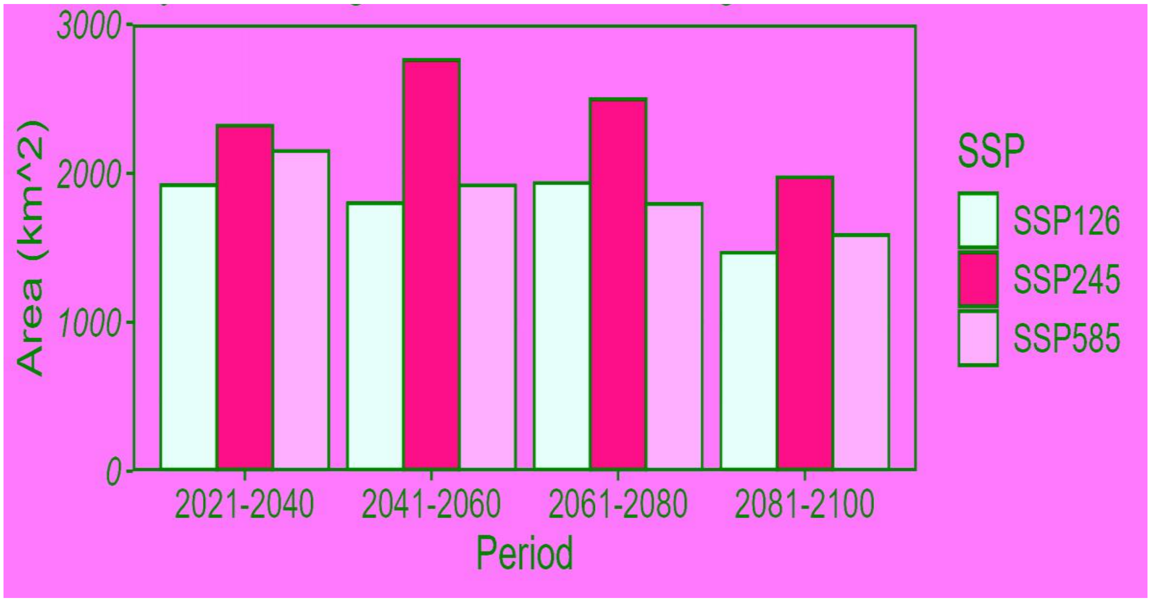


Figure 36: The area (km²) predicted to support the Mecca aster within the CVMSHCP Plan area in several future time periods, under three SSP's: SSP1-2.6 (mild), SSP2-4.5 (medium), and SSP5-8.5 (high) based on the Coupled Model Intercomparison Project Phase 6 (CMIP-6).

Management Applications:

For all species modeled, there are differences in habitat suitability into the future, following the general pattern of decreasing suitable habitat in lower elevational areas within the CVMSHCP, with some exceptions. This is because the Colorado Desert and environs generally represent the hottest-driest conditions that these species can tolerate, and as lower elevations warm, these areas become unsuitable. This shift is more dramatic for some species, but increases with the severity of change by scenario (SSP1.26 to 5.85), and as time progresses from the near-term (2041-2060) to the long-term (2081-2100). We cannot determine which scenario is most likely, but Plan guidance and conservation planning practices recommend evaluating the results of various outcomes. Here the outcomes may differ, however, although the predicted shifts differ across scenarios, the most consistent and actionable result is the directionality of shifts within the set of models for each species. Thus, we are able to direct mitigation efforts into areas likely to support species into the future, regardless of which SSP we are headed into.

It is important to note that species migration that may be necessary due to climate change-induced geographic shifts in habitat suitability may occur on timescales that are unknown in the life histories of these species. In other words, paleo-historical shifts in climate have occurred on longer timescales, which allowed species to migrate on a multi-generational basis. Modern climatic change at the speed that has been documented and predicted to occur will require species to move at unprecedented rates and this is a subject of active research (e.g. Loarie *et al.* 2009). The generational time or velocity of required migration speeds vary by species' life history, such as an individual animal's ability to move distances, establish new home sites, and sessile plants' ability to disperse. Examining this aspect, essentially each species' ability to keep up with these shifts, is beyond the scope of this study, but should be taken into account when considering adaptive management mitigation options. Mitigation may include a range of approaches depending on the individual species' ability to migrate and these include management approaches that vary in intensity: monitoring-only; barrier reduction; habitat restoration to ensure functional corridors that meet species' requirements; or restoration targeted to encourage migration; improvement of future suitable habitat; or establishing populations in refugia or future suitable habitat by physically moving organisms, also known as assisted migration.

These models serve as a basis on which to integrate information about potential threats to species. Each climate summary above contains information about what may challenge a species' movement, which may be the subject of further study. Threat assessments can be done in a second stage; these are species-specific, either due to known, putative or unknown factors. This may be studied using the abundance of species in relation to these factors within current habitats in order to understand how they may impact migration through or occupation of new areas. For example, are there areas of suitable habitat that are not occupied, we may understand with confidence that this is due to, for example, urbanization. If there are other areas that are not occupied but predicted to be suitable, these may be opportunities to understand further habitat and life-history requirements such as edaphic, microtopographic or biotic/trophic requirements of the species. This can be done using specific information in follow-up studies using the predicted suitable habitat. We can add components to analyze these additional factors for different species.

Conclusion

The NCCP highlights in Goals and Objectives of Section 8.1.2, to, "*Develop and refine models describing species distributions relative to Habitat quality and other parameters with data. Model refinement may include analysis of causal factors related to temporal and spatial annual population fluctuations and the amplitude of those fluctuations."* This section of the NCCP also calls for *"Use available data to structure a range of alternative response models to address a given threat or stressor affecting a Covered Species or natural community and evaluate these models."* Here we have summarized models that describe potential responses to climate change.

Here we have created a flexible and robust model that can be applied to other species, using reproducible analysis code. The models showing future suitable habitat for species very near-term (2021-2040), near-term (2041-2060), mid-term (2061-2080) and longer-term (2081-2100) within the Coachella Valley region may be helpful for forming further investigation into particular questions. In some cases we have identified opportunities to better inform species distribution models using additional information. We have also identified that species are not predicted to be uniform in their response to increasing temperatures and evaluating individual cases will be useful for planning purposes.

Literature Cited

Anderson, R. P., and I. Gonzalez. (2011). Species-specific tuning increases robustness to sampling bias in models of species distributions: an implementation with Maxent. Ecological Modelling 222:2796–2811.

Barrows, C. W., L. C. Sweet, J. Rangitsch, K. Lalumiere, T. Green, S. Heacox, M. Davis, M. Vamstad, J. Heintz, J. and E. Rodgers (2020) Responding to increased aridity: Evidence for range shifts in lizards across a 50-year time span in Joshua Tree National Park. Biological Conservation, 248:n https://doi.org/10.1016/j.biocon.2020.108667.

Booth, T. H., H. A. Nix, J. R. Busby, and M. F. Hutchinson. (2014). BIOCLIM: the first species distribution modelling package, its early applications and relevance to most current MaxEnt studies. Diversity and Distributions 20:1–9.

CVCC (2016). Final Major Amendment to the CVMSHCP – August 2016, Final Recirculated Coachella Valley Multiple Species Habitat Conservation Plan and Natural Community Conservation Plan, September 2007. Available at: cvmshcp.org/

The California Natural Diversity Database (CNDDB) and the California Native Plant Society (CNPS). August 2020. The CNDDB and CNPS Cooperative Relationship and Rare Plant Status Review Process. Sacramento, CA. Available online at: https://www.cnps.org/wp-content/uploads/2019/11/rareplants-cnddb-cnps-review-process.pdf

Davis, M. J., Sweet, L. C., Heacox, S. A., & Barrows, C. W. (2023). Range Extensions And Population Decline Of The Endemic Desert Perennial Orocopia Sage (Salvia Greatae [Lamiaceae]) In The Mecca Hills And Orocopia Mountains, California. Madroño, 69(3), 225–234. https://doi.org/10.3120/0024-9637-69.3.225

Dawson, T. P., S. T. Jackson, J. I. House, I. C. Prentice and G. M. Mace (2011) Beyond predictions: biodiversity conservation in a changing climate. science, 332(6025), pp.53-58.

Eyring, V., Bony, S., Meehl, G. A., Senior, C. A., Stevens, B., Stouffer, R. J., and Taylor, K. E. (2016).:Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization, Geosci. Model Dev., 9, 1937-1958, doi:10.5194/gmd-9-1937-2016.

Fick, S. E., and R. J. Hijmans. (2017). WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas. International Journal of Climatology 37:4302–4315.

Flint, L. E., and A. L. Flint. 2014. California Basin Characterization Model: a dataset of historical and future hydrologic response to climate change (ver. 1.1, May 2017): U.S. Geological Survey Data Release, https://doi.org/10.5066/f76t0jpb

Gonzalez, P., F. Wang, M. Notaro, D. J. Vimont, and J. W. Williams. (2018). Disproportionate magnitude of climate change in United States national parks. Environmental Research Letters 13:104001.

Hopkins, F. (University of California, Riverside) (2018). Inland Deserts Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-008.

Inman, R.D., T. C. Esque, K. E. Nussear, P. Leitner, M. D. Matocq, P. J. Weisberg, T. E. Dilts and A. G. Vandergast (2013) Is there room for all of us? Renewable energy and Xerospermophilus mohavensis. Endangered Species Research, 20(1), pp.1-18.

Kass, J. M., R. Muscarella, P. J. Galante, C. L. Bohl, G. E. Pinilla-Buitrago, R. A. Boria, M. Soley-Guardia, and R. P. Anderson. 2021. ENMeval 2.0: redesigned for customizable and reproducible modeling of species' niches and distributions. Methods in Ecology and Evolution 12:1602–1608.

Kelly, A. E. and M. L. Goulden (2008) Rapid shifts in plant distribution with recent climate change. Proceedings of the National Academy of Sciences, 105(33), pp.11823-11826.

Kent, R., and Y. Carmel (2011) Presence-only versus presence–absence data in species composition determinant analyses. Diversity and Distributions 17:474–479.

Loarie SR, Duffy PB, Hamilton H, Asner GP, Field CB, Ackerly DD (2009) The velocity of climate change. Nature, 462, 1052–1055.

Liu, C., P. M. Berry, T. P. Dawson, and R. G. Pearson. (2005). Selecting thresholds of occurrence in the prediction of species distributions. Ecography 28:385–393.

Liu, C., G. Newell, and M. White. (2016). On the selection of thresholds for predicting species occurrence with presence-only data. Ecology and Evolution 6:337–348.

Naimi B, Hamm Na, Groen TA, Skidmore AK, Toxopeus AG (2014). "Where is positional uncertainty a problem for species distribution modelling." Ecography, 37, 191-203.

Peterson, A. T., M. Papes, and M. Eaton (2007) Transferability and model evaluation in ecological niche modeling: A comparison of GARP and Maxent. Ecography 30:550–560.

Phillips, S. J., R. P. Anderson, and R. E. Schapire (2006) Maximum entropy modeling of species geographic distributions. Ecological Modelling 190:231–259.

Phillips, S. J., M. Dudík, J. Elith, C. H. Graham, A. Lehmann, J. Leathwick, and S. Ferrier. (2009). Sample selection bias and presence-only distribution models: implications for background and pseudo-absence data. Ecological Applications 19:181–197.

R Core Team. (2024). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Radosavljevic, A., and R. P. Anderson. (2014). Making better MAXENT models of species distributions: complexity, overfitting and evaluation. Journal of Biogeography 41:629–643

Sweet, L.C., C. Barrows, S. Heacox, M. Davis, R. Johnson (2019) Coachella Valley Multiple Species Habitat Conservation Plan & Natural Community Conservation Plan: Valley Floor Reserve Units 2013 & 2018 Vegetation Map Report. Final Report. Prepared for: Coachella Valley Conservation Commission.

Appendix VI: Monitoring of Burrowing Owls in the Coachella Valley 2025 Annual Report

Report begins on following page.

Monitoring of Burrowing Owls in the Coachella Valley
2025 Annual Report

Submitted to:

Coachella Valley Conservation Commission

Prepared by:

Brandon D. Maiersperger, Courtney J. Conway, and Matthew L. Dunning
Idaho Cooperative Fish and Wildlife Research Unit
University of Idaho
875 Perimeter Drive, MS 1141
Moscow, ID 83844-1141

Suggested Citation:

Maiersperger B. D., C. J. Conway, and M. L. Dunning. 2025. Monitoring of burrowing owls in the Coachella Valley, 2025 annual report. Idaho Cooperative Fish & Wildlife Research Unit, Moscow, ID

EXECUTIVE SUMMARY

Western burrowing owls are declining or have disappeared from many portions of their historic breeding range. The species was recently petitioned as a candidate for listing as threatened or endangered in California. Thought to be extirpated from California's Coachella Valley in the 1990s, surveys conducted in 2006-2007 found that there was a substantial population of breeding owls (53 pairs) in the region. In 2008, the Coachella Valley Multiple Species Habitat Conservation Plan (CVMSHCP) was developed to conserve habitat and protect native species in the region. Implemented by the Coachella Valley Conservation Commission (CVCC), the CVMSHCP includes objectives for burrowing owl monitoring and management. Since 2009, burrowing owl monitoring in the CVMSHCP area has occurred off and on, with a primary focus of determining the number of breeding pairs and assessing reproductive success. In August 2025, the University of Idaho began work in the Coachella Valley to support the CVCC's efforts to provide a long-term conservation strategy for burrowing owls in the CVMSHCP. Our objectives in 2025 were to: 1) revisit survey detections of owls and burrows to determine the proportion that were still occupied; and 2) capture and color band as many adult and juvenile owls as possible to allow for individual identification and future documentation of owl movements. To achieve these objectives, we conducted surveys and banding efforts in the Coachella Valley beginning on 21 August 2025, during the post-breeding season. Between 21 August 2025 and 28 December 2025, we conducted 44 walking surveys, completed 2 driving survey routes, and visited 318 previously active burrow locations within the CVMSHCP area. We recorded detections for 350 owls and 393 burrows. Of the 350 detections, 57 (16%) were inside conserved lands owned by the CVCC or its partners and 161 (46%) were within 1 mile of conserved lands owned by the CVCC or its partners. Of the 350 detections, 87 (25%) were within conservation areas (i.e., including lands already conserved and those planned to be conserved) and 210 (60%) were within 1 mile of conservation areas. Of 318 burrow locations previously recorded during the 2025 breeding season, 194 (61%) were still occupied during the post-breeding season. We banded 128 individual owls with unique numerical aluminum USGS bands, and most owls also received a unique combination of plastic color bands for individual identification without recapture. Of the 128 owls, 6 were juveniles, 25 were adults, and 97 were age unknown. We collected feather samples from all 128 owls and blood samples from 124 owls. Our surveys and banding efforts in 2025 show that burrowing owls are widely distributed across the Coachella Valley, and that areas like the Whitewater Stormwater Channel and Desert Hot Springs are important sites for burrowing owls in the region. Early surveys under the CVMSHCP in 2009 and 2011 reported around 40 breeding pairs in the Coachella Valley. The 2025 breeding season surveys by AECOM and its partners identified 321 breeding pairs in the region. Our subsequent surveys and banding efforts provide additional documentation indicating a large population of burrowing owls in the Coachella Valley. Conservation of burrowing owls in the Coachella Valley will require continued collaboration between organizations in the region, including federal and state government agencies, NGOs, and local resource management agencies like the Coachella Valley Water District. Future research and monitoring needs to include measures of reproductive success, extent of owl movements, and documentation of likely threats to survival. Our banding efforts contribute to these areas of study. The impending decision of whether to list the western burrowing owl as a threatened or endangered species in California emphasizes the importance of monitoring and research efforts in the state. The Coachella Valley may be a critical region for the species' conservation on a statewide level.

INTRODUCTION

The western burrowing owl (*Athene cunicularia hypugaea*; hereafter "burrowing owl") breeds throughout much of western North America including southern Canada, the central and western United States, and northern Mexico (Macías-Duarte and Conway 2015, Poulin et al. 2020). Burrowing owls nest in underground burrows, typically those created by burrowing mammals such as prairie dogs (*Cynomys* sp.), round-tailed, California, and Richardson's ground squirrels (*Xerospermophilus tereticaudus, Otospermaphilus beecheyi, Urocitellus richardsonii*), banner-tailed, Nelson's, and Merriam's kangaroo rats (*Dipodomys spectabilis, Dipodomys nelson, Dipodomys merriami*), and American badgers (*Taxidea taxus*) (Conway 2018). Many burrowing owl populations are migratory and primary wintering areas include California and northern and central Mexico. Burrowing owls are unique among owls in that they are easier to detect during daylight hours and they are frequently visible standing at the entrance to burrows, especially during morning and evening hours (Conway and Simon 2003, Conway et al. 2008). Burrowing owls are opportunistic predators that consume a variety of invertebrates and small vertebrates (rodents, bats, birds, lizards, and amphibians) (York et al. 2002, Hall et al. 2009). Burrowing owls prefer burrows with sparse grass coverage and low vegetation height (Lantz et al. 2007) likely because the lack of cover for their prey makes food more accessible (Green and Anthony 1989).

Burrowing owls are declining or have disappeared from many portions of their historic breeding range (Conway and Pardieck 2006, Macías-Duarte and Conway 2015, Conway 2018, Poulin et al. 2020). They are listed as a bird of conservation concern in most portions of their range in the U.S. (U.S. Fish and Wildlife Service 2021) and are federally listed as endangered in Canada (Committee on the Status of Endangered Wildlife in Canada 2017). Within the United States, burrowing owl status varies by state: endangered in Minnesota, threatened in Colorado, candidates for threatened or endangered in California and Washington, and a species of special concern in Montana, Oklahoma, Oregon, Utah, and Wyoming (Poulin et al. 2020). In 2024, California and Washington granted the burrowing owl candidate species status while the state agencies conduct a species status review to determine whether listing is warranted (Washington Department of Fish and Wildlife 2024, California Department of Fish and Wildlife 2024). The Migratory Bird Treaty Act prohibits the purposeful take (killing, capturing, selling, trading, transport, etc.) of burrowing owls without prior authorization by the U.S. Fish and Wildlife Service.

The decline of burrowing owl populations is often attributed to declines in abundance of burrowing animals that the owls rely on for creation of nest burrows (Conway 2018, Poulin et al. 2020). Other threats to burrowing owl populations may include secondary poisoning by rodenticides (Justice-Allen and Loyd 2017) and insecticides (Gervais et al. 2000) as well as reduction in prey availability caused by large-scale insecticide applications to control grasshoppers. Burrowing owls are common in agricultural areas (Conway et al. 2006, Bartok and Conway 2010, Macías-Duarte et al. 2020) but some agricultural development actions are detrimental to the owls. For example, maintenance practices of irrigation canals are a potential threat in agricultural landscapes where the owls use the sides of irrigation canals for nesting and roosting (Bartok and Conway 2010). Burrowing owls use desert ecosystems during all phases of their annual cycle and are sensitive to drought and climate and weather aberrations. For example, drought affects their reproductive success (Lundblad et al. 2021) and thermal conditions in burrows affect occupancy, fecundity, and burrow suitability (Nadeau et al. 2015, Lundblad and Conway 2021a, 2021b).

The Coachella Valley in California supports a large population of burrowing owls and is therefore an important region for conserving the species in the state. The status of burrowing owls in the Coachella Valley has shifted in recent decades. Based on observations from the early 1980s and statewide surveys conducted from 1991-1993, burrowing owls were thought to be extirpated from the Coachella Valley by the 1990s (DeSante et al. 2007). However, the region was resurveyed from 2006-2007, resulting in an estimate of 53 breeding pairs (Wilkerson and Siegel 2010).

In 2008, the Coachella Valley Multiple Species Habitat Conservation Plan (CVMSHCP) was developed. The CVMSHCP encompasses monitoring and management efforts that conserve >970 km^2 (>240,000 acres) of land and provide protection for 27 species in the Coachella Valley (https://cvmshcp.org). The Coachella Valley Conservation Commission (CVCC) is responsible for implementing the CVMSHCP, which includes objectives for burrowing owl monitoring and research (CVCC 2014). Within the first 3 years of the plan, the CVCC was tasked with conducting systematic surveys and implementing management actions to reduce threats to burrowing owls, with the goal of maintaining a minimum of 16 pairs of burrowing owls in conservation areas (interim conservation strategy of the CVMSHCP). In 2009, surveys were completed in and around conservation areas. Surveys resulted in the identification of 60 occupied locations and 86 owls (40 pairs) during the breeding season, 70% of which were within planned conservation areas (CVCC 2014). The survey protocol was repeated in 2011. In 2011, 98 owls (~40 pairs) were detected during the post-breeding season (CVCC 2014).

In 2011, a study was conducted to examine the spatial ecology of burrowing owls in the region. Feather samples were collected from burrowing owls to determine isotopic signatures and better understand owl movement, space-use, and native/migrant status (CVCC 2014). During the 2011 breeding season in the Coachella Valley, 26 owls were captured and 32 feathers were collected (primarily from nestlings). The feather samples were compared to samples collected from western Riverside County to investigate movement between the regions. After the 2011 surveys, CVCC worked to conserve more burrowing owl habitat within the Coachella Valley. This included acquiring additional parcels, as well as removing debris, posting signage, and installing fencing on existing conservation lands (CVCC 2016). Burrowing owl monitoring efforts in the Coachella Valley were conducted again in 2015, and from 2017-2020. The CVMSHCP was amended in 2016 to add Desert Hot Springs to the plan. Monitoring was not conducted in 2016 due to a severe drought. The CVCC's focus from 2015-2020 was walking transects where owls were previously detected, locating ~10 nests, and monitoring them with trail cameras. The goals of nest monitoring efforts were to assess reproductive success, compare diets between owl populations in the Coachella Valley, and determine potential nest predators and causes of nest failure (CVCC 2021).

No burrowing owl monitoring efforts were conducted from 2021-2023 in the CVMSHCP area. Significant flooding and flood control efforts in 2023 destroyed or damaged a large portion of the burrowing owl habitat in Desert Hot Springs (CVCC 2024). During the 2025 breeding season, the Imperial Irrigation District (a CVCC permittee) contracted AECOM Technical Services, Inc. (a consulting company) to conduct 2 rounds of surveys across the Coachella Valley to assess the number of breeding pairs and their distribution throughout the valley. Blackhawk Environmental and Aardvark Biological Services also contributed to surveys in partnership with AECOM (AECOM 2025). Surveys conducted by AECOM and its partners covered 239 grids (3 km x 3 km) that consisted of suitable burrowing owl habitat (determined from aerial imagery, historical burrowing owl locations, and in-field observations). Pedestrian (walking), driving, and binocular surveys were used. Survey methodology varied depending on the level of access biologists had to grids. The two rounds of surveys were conducted between 07 April 2025 and 13 June 2025, and resulted in the detection of 321 primary burrows (active burrow with the most sign or activity in the area), 514 adult owls, and 58 juvenile owls (AECOM 2025). The 321 primary burrows represent approximately 321 breeding pairs (Malo 2025).

In August 2025, the University of Idaho began work in the Coachella Valley to support the CVCC's efforts to provide a long-term conservation strategy for burrowing owls in the CVMSHCP. Our objectives in 2025 were to: 1) revisit AECOM survey detections of owls and burrows to determine the proportion that were still occupied; and 2) capture and color band as many adult and juvenile owls as possible to allow for individual identification and future documentation of owl movements. To achieve these objectives, we conducted surveys and banding efforts in the Coachella Valley beginning on 21 August 2025.

STUDY AREA

The Coachella Valley extends from around the San Gorgonio Pass to the north end of the Salton Sea. It is located between the San Bernardino and Little San Bernardino Mountains to the northeast, and the San Jacinto and Santa Rosa Mountains to the southwest. The CVMSHCP boundary (Figure 1) encompasses approximately 1.1 million acres (CVCC 2025). The Coachella Valley contains many land uses including residential/urban areas, tribal lands, agriculture, and conserved lands. The most populated urban and residential areas are near U.S. Interstate 10 and CA State Highways 111 and 86, which run through the center of the valley. Agriculture dominates the southern portion of the valley near the Salton Sea. Dates, grapes, and citrus serve as the primary crops.

Burrowing owls are primarily associated with washes and neighboring desert scrub habitat within the Coachella Valley; areas where burrowing mammals like ground squirrels (*Xerospermophilus tereticaudus* and *Otospermophilus beecheyi*) are common (CVCC 2021). They are also frequently found along stormwater/wastewater channels in urban or agricultural areas (CVCC 2021). Burrowing owls in the Coachella Valley are often associated with the distribution of the Palm Springs Pocket Mouse (*Perognathus longimembris bangsii*), which is also found in desert scrub (CVCC 2018). Dominant vegetation in and around desert washes includes Mojave rabbitbrush (*Ericameria paniculata*), creosote bush (*Larrea tridentata*), and burrobush (*Ambrosia dumosa*) (CVCC 2021). Vegetation in urban and agricultural areas includes saltbush (*Atriplex* sp.), honey mesquite (*Prosopis glandulosa*), tamarisk (*Tamarix* sp.), cottonwoods (*Populus* sp.), and cattails (*Typha* sp.) (CVCC 2021).

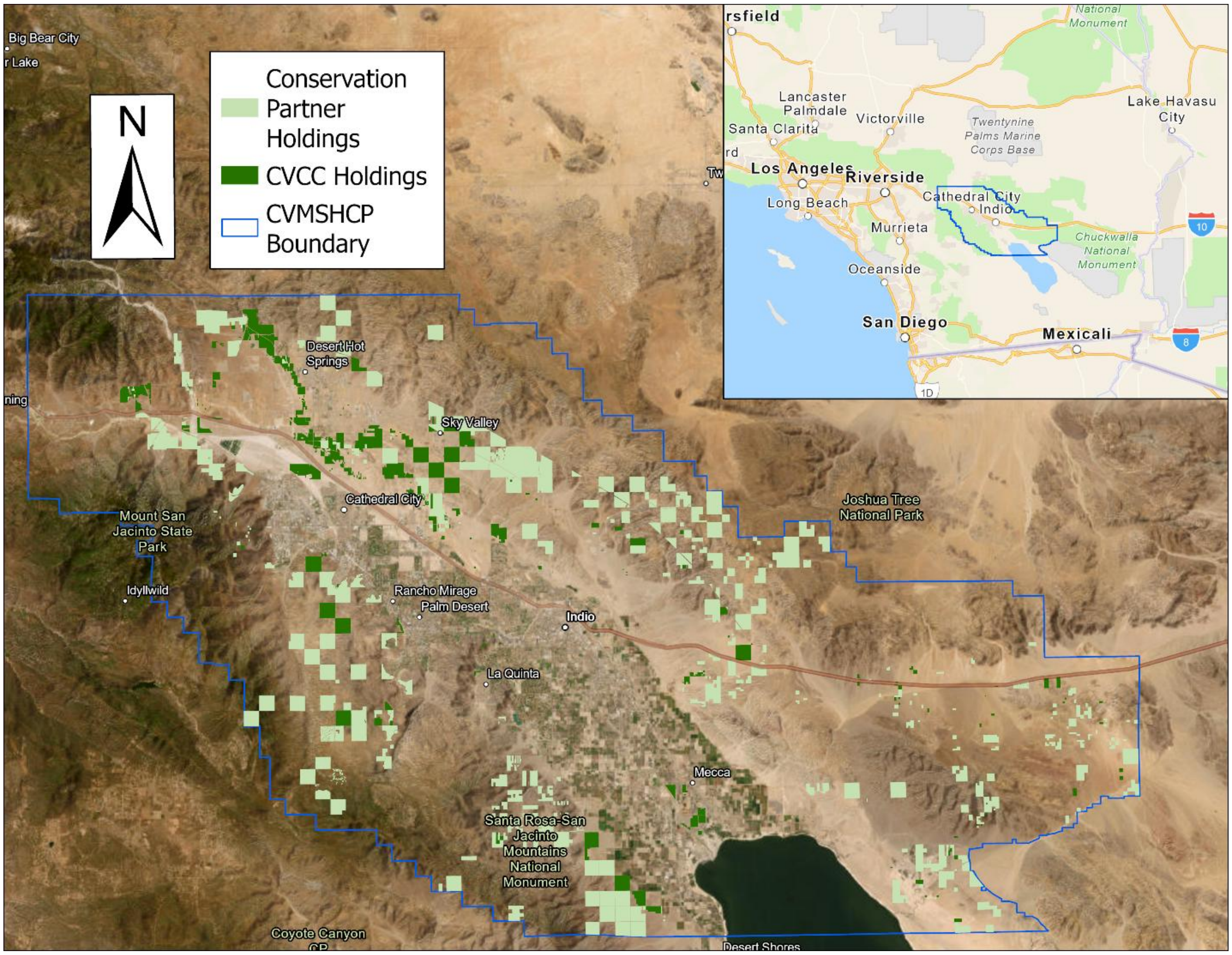


Figure 1. CVMSHCP boundary and conservation holdings of the CVCC its partners as of 2025.

METHODS

Surveys

We began field work in the Coachella Valley during the burrowing owls' post-breeding season, after AECOM finished their 2025 breeding season surveys. Burrowing owls often use different burrows after a nest fledges or fails and typically make more extensive movements after breeding (Rosier et al. 2006, Garcia et al. 2024). Because we expected that owls may not be using the same burrows where they were detected during the breeding season, we revisited burrow and owl detections marked by AECOM to determine if owls were still present and scout locations for trapping owls. AECOM provided us with coordinates of the detections they recorded during 2025 breeding season surveys on 11 August 2025.

Our focus was initially limited to lands held by the CVCC and their conservation partners (Figure 1), while we spent time obtaining permits and permissions from other landowners in the Coachella Valley. Most of the formal surveys we conducted in 2025 were on lands held by the CVCC or its partners. We used three methods to search for burrowing owls throughout the Coachella Valley: walking surveys, driving surveys, and direct visits to AECOM survey detections. Walking surveys (Conway and Simon 2003, Bartok and Conway 2010) and driving surveys (Conway and Simon 2003) were conducted with a formal survey protocol. In each walking survey, the observer thoroughly covered each survey area on foot while visually scanning and listening for burrowing owls, looking for suitable burrows, and checking burrows for sign of owl use (pellets, feces, prey remains, scat, tracks, etc.). Driving surveys consisted of an observer driving < 32 km/hr (< 20 mph) along accessible roads while scanning for burrowing owls. The observer periodically stopped and scanned the area with binoculars or a spotting scope mounted on the vehicle window and documented all detections of owls and active burrows. The survey method we used depended on road accessibility and size of the survey area. Surveys were primarily conducted during one of two survey windows: 1) sunrise until 5 hours after sunrise, or 2) 2 hours before sunset until sunset. We surveyed during periods of no precipitation and when wind speed was ≤ 19 km/hr because these conditions reduce the probability of detecting burrowing owls (Conway and Simon 2003, Conway et al. 2008, Knutson et al. 2016). Our direct visits to AECOM survey detections were more opportunistic, often occurring when we were in the area for formal surveys or trapping. During all formal surveys and direct visits, we recorded all owls and burrows we detected.

Trapping and banding

We used three methods to trap burrowing owls based on methods developed from the past 30 years in our lab group (Conway et al. 2006, Ogonowski and Conway 2009, Lundblad et al. 2021): 1) walk-in box traps (similar to Havahart traps) placed at entrances of active burrows (Figure 2), 2) spring-loaded bow nets (aka spring traps) placed adjacent to active burrows (typically 5-15 m away), and 3) noose carpets (or noose mats) placed near active burrows. We occasionally used playback of burrowing owl vocalizations or a live mouse to attract owls to traps. We conducted trapping primarily from 1400 – 2300 h. From our previous trapping experience, we found that visiting burrows earlier in the day during the non-breeding season can improve the chances of owls being inside their burrows, which in turn increases the likelihood of a successful trapping event. We typically used spring traps later in the day (around sunset) because owls are more likely to be out of their burrows later in the day and therefore more responsive to audio playback. We used a burrow scope to determine if owls were in their burrows and inform trap placement (Figure 2).

We recorded the sex and age of each captured owl based on plumage characteristics (females are often darker than males, juveniles have different plumage than adults), but in many cases we recorded owls as sex and/or age unknown due to the time of year. The post-breeding season for burrowing owls in CA roughly spans August - September. Most nests have fledged or failed by Aug-Sep, and juveniles begin to molt into body plumage similar to that of adult owls. We arrived in the Coachella Valley in late August, which made it challenging to determine sex and age for most owls we captured, because differences in plumage and breeding behavior are not as apparent at that time of year. In some cases, we were able to determine if an owl was an adult based on the presence of flight feather molt (juveniles do not molt flight feathers until the following year), but by late October most owls had finished molting and were therefore considered age unknown.

We collected blood and feathers from most captured owls for sex identification and contribution to two conservation genomics projects: one being conducted by Colorado State University and the other by our lab group (led by Matt Dunning). All adult owls not previously banded received a numerical aluminum USGS band beneath a color band (see exceptions below) to indicate the year the owl was banded (we used black in 2025). All juvenile owls received a numerical aluminum USGS band beneath a color band to indicate the year the juvenile hatched (we used green in 2025). Each owl received a unique combination of color bands on the leg opposite of the aluminum USGS band to allow for visual identification of individuals without recapture. Because juveniles and adults can be difficult to distinguish by plumage during the non-breeding season, all the owls we banded during the non-breeding season were banded with black bands, except for juvenile owls that were young enough to still have distinct plumage characteristics from adults. Due to delays acquiring black color bands, 21 owls were banded with an aluminum USGS band only. We will try to recapture these owls in the future and add color bands.

Figure 2. A field technician uses a burrow scope to examine the contents of a burrow (top left), a technician prepares a walk-in trap at a burrow entrance (top right), an example of a deployed walk-in trap (bottom).

Nest Monitoring

Our agreement with the CVCC to monitor burrowing owls in the Coachella Valley was not finalized until August, hence, we arrived during the post-breeding season. Moreover, we were initially restricted to working on conserved lands (while we sought permits/permissions to access other lands) and, hence, we were unable to locate any active nests and did not conduct any nest monitoring in 2025. We found some evidence of old breeding activity at a few burrows (see Results section). We did not deploy any trail cameras at burrows because we did not find any active nest burrows (due to the issues above) and because of concerns about local residents and homeless people damaging or stealing equipment. We intend to closely monitor as many nests as possible in 2026 to document breeding success, number of breeding pairs, and other reproductive metrics.

Access to Other Lands in the Coachella Valley

As previously mentioned, we initially did not have permission to survey or trap owls on property that was not owned by the CVCC or its conservation partners, but many of the active burrows detected by AECOM were not located on conserved lands. We contacted the Coachella Valley Water District (CVWD) to acquire a permit for work on some of their properties in the Coachella Valley. We requested access to several properties in the area based on previous detections recorded by AECOM. One of the properties is a stretch of the Whitewater Stormwater Channel, which runs through Indio and Coachella. The stormwater channel supports a relatively large number of owls and was one of the primary locations where monitoring efforts by the CVCC took place in 2015 and 2017-2020. We have visited the

Whitewater Stormwater Channel several times since gaining access on 01 October 2025, and we have worked closely with a biologist from the CVWD to coordinate access.

We have reached out to Bureau of Land Management (BLM) and U.S. Fish and Wildlife Service (USFWS) contacts in the region to inquire about owl activity on their lands and gain access to additional sites for surveys and banding. These requests were delayed due to the federal government shutdown from 01 October 2025 – 12 November 2025. As of 28 December 2025, we have an authorization letter from the BLM and have coordinated access to one of their properties.

We searched for owls and placed traps near public roads when possible, but we did not formally survey properties that were privately owned. Of the 321 primary burrows recorded by AECOM during their 2025 breeding season surveys, 60% were located on private lands (AECOM 2025). We plan to reach out to private landowners in the Coachella Valley in the coming months to gain permission for formal surveys, trapping, and future nest monitoring.

RESULTS

Surveys

As of 28 December 2025, we have surveyed 44 walking survey polygons and 2 driving survey routes within the CVMSHCP area (Figure 3). Surveys took place from 21 August 2025 – 19 December 2025. In our first pass of these locations, we detected 51 owls during walking surveys and 14 owls during driving surveys. We began resurveying these polygons and routes in late December.

We visited 318 burrows where owls were previously detected by AECOM during 2025 breeding season surveys and recorded the location of 393 burrows (297 active burrows, 96 inactive) (Figure 4). We considered a burrow to be active when we detected an owl nearby or inside, or if recent owl sign (pellets, feces, prey remains, scat, tracks, etc.) was observed nearby. We detected owls at 194 of 318 burrows recorded by AECOM (61%). We also recorded the location of 6 formerly active 2025 nests. These burrows had substantial sign including decorations and lining that typically indicate a nest burrow (Garcia and Conway 2009). However, none of these burrows were active nests by the time we discovered them. We recorded detections for 350 owls across all our surveys and visits to AECOM survey detections (Figure 4). Of the 350 detections, 57 (16%) were on conserved lands owned by the CVCC or its partners and 161 (46%) were within 1 mile of conserved lands owned by the CVCC or its partners. Of the 350 detections, 87 (25%) were within conservation areas (i.e., including lands already conserved and those planned to be conserved) and 210 (60%) were within 1 mile of conservation areas (Figure 5). Most of the detections and burrows we recorded were clustered around the Desert Hot Springs area or were along or near the Whitewater Stormwater Channel (Figure 6). Some of the 350 detections likely represent the same owls (i.e., 350 detections does not equate to 350 owls), because we revisited some of the locations and burrowing owls can use multiple burrows during the non-breeding season.

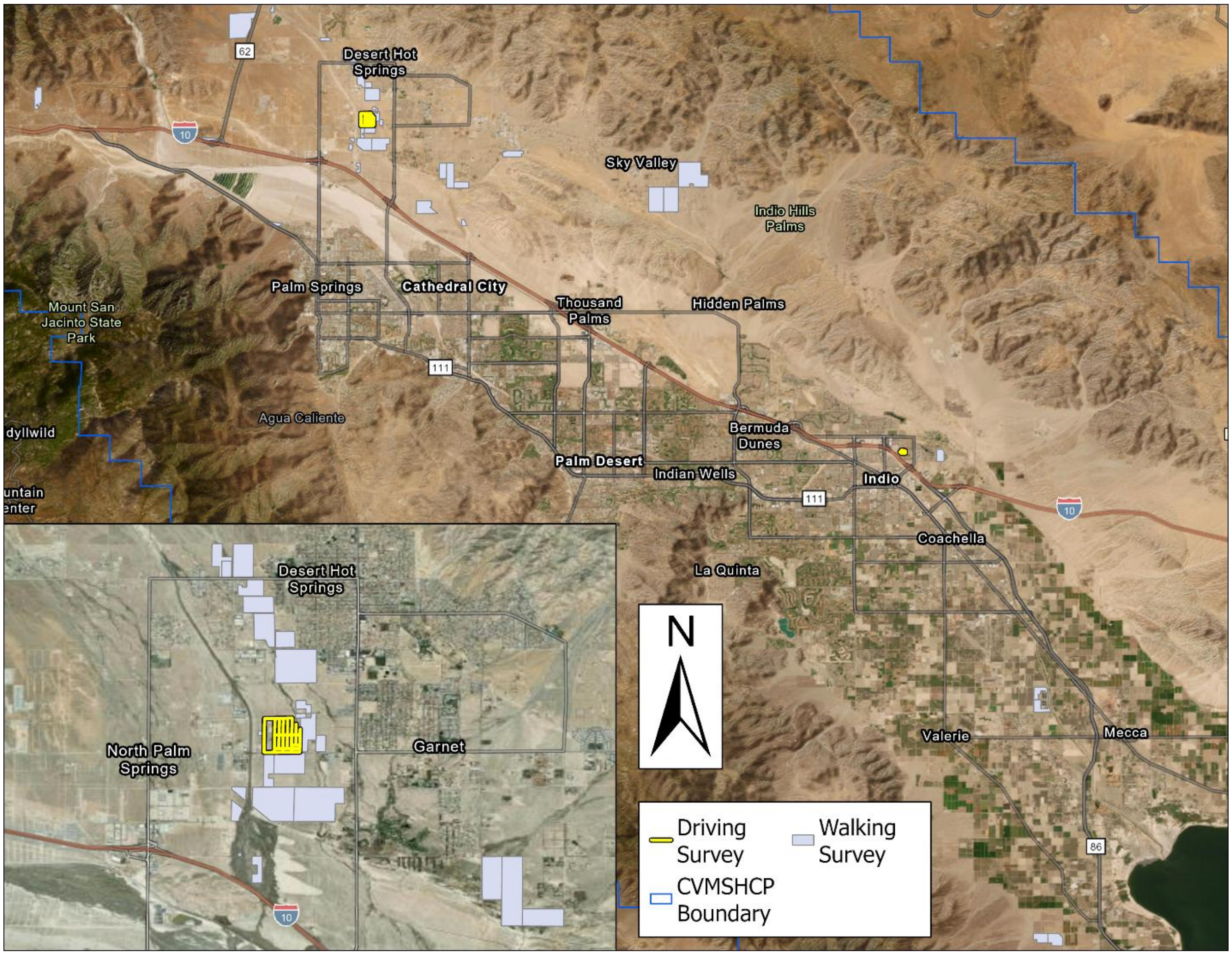


Figure 3. Locations of walking and driving surveys in the Coachella Valley from August – December 2025. Most formal surveys were conducted within the Desert Hot Springs area (lower left).

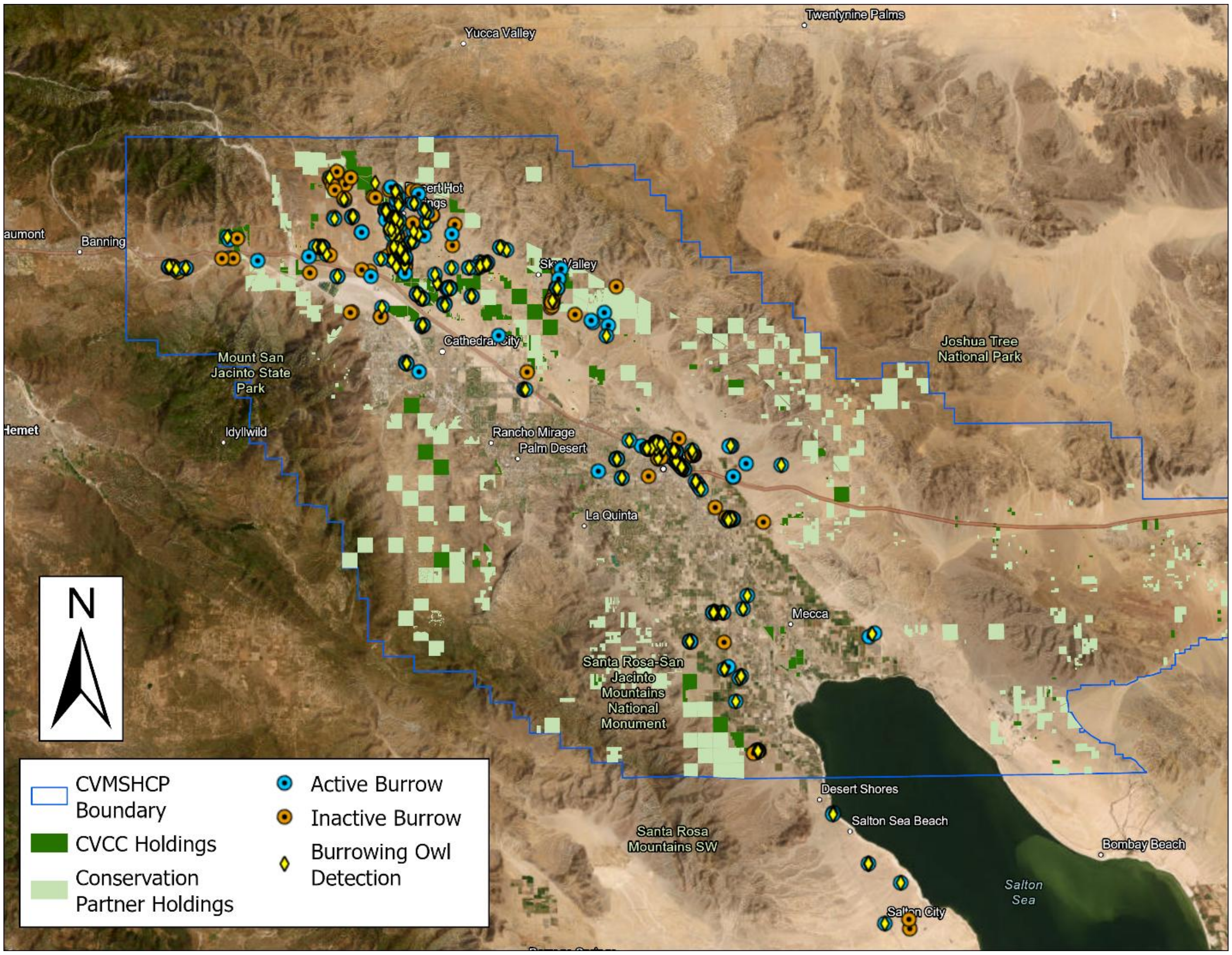


Figure 4. Burrowing owl detections and burrows in the Coachella Valley from August – December 2025. Some of the detections may represent the same owls. Conserved lands owned by the CVCC are shown in dark green. Conserved lands owned by conservation partners are shown in light green. Burrows were recorded as active if we observed an owl or recent owl sign nearby or inside the burrow.

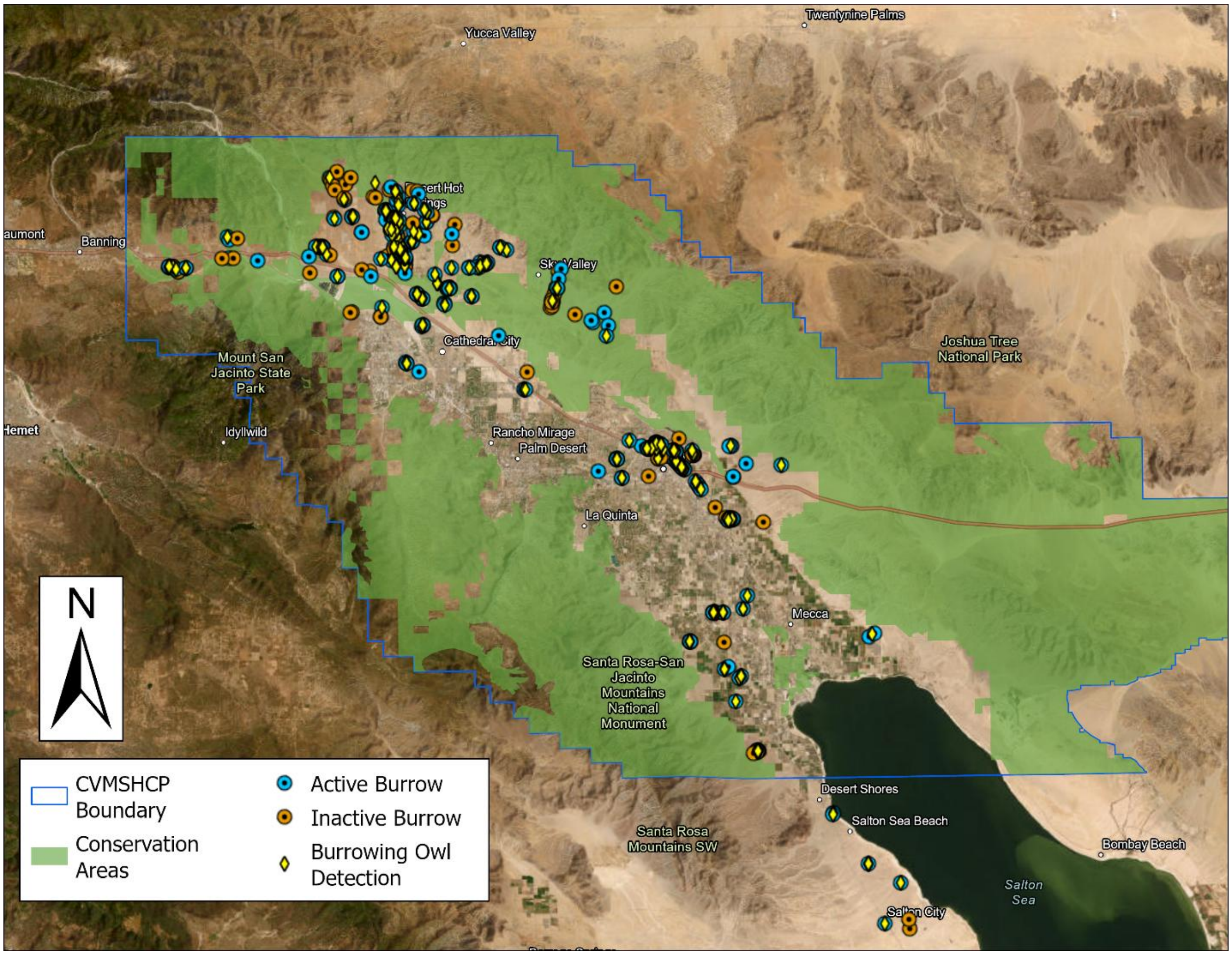


Figure 5. Burrowing owl detections and burrows in the Coachella Valley from August - December 2025. Some of the detections may represent the same owls. Conservation areas (lands currently conserved or planned to be conserved) are shown in green. Burrows were recorded as active if we observed an owl or recent owl sign nearby or inside the burrow.

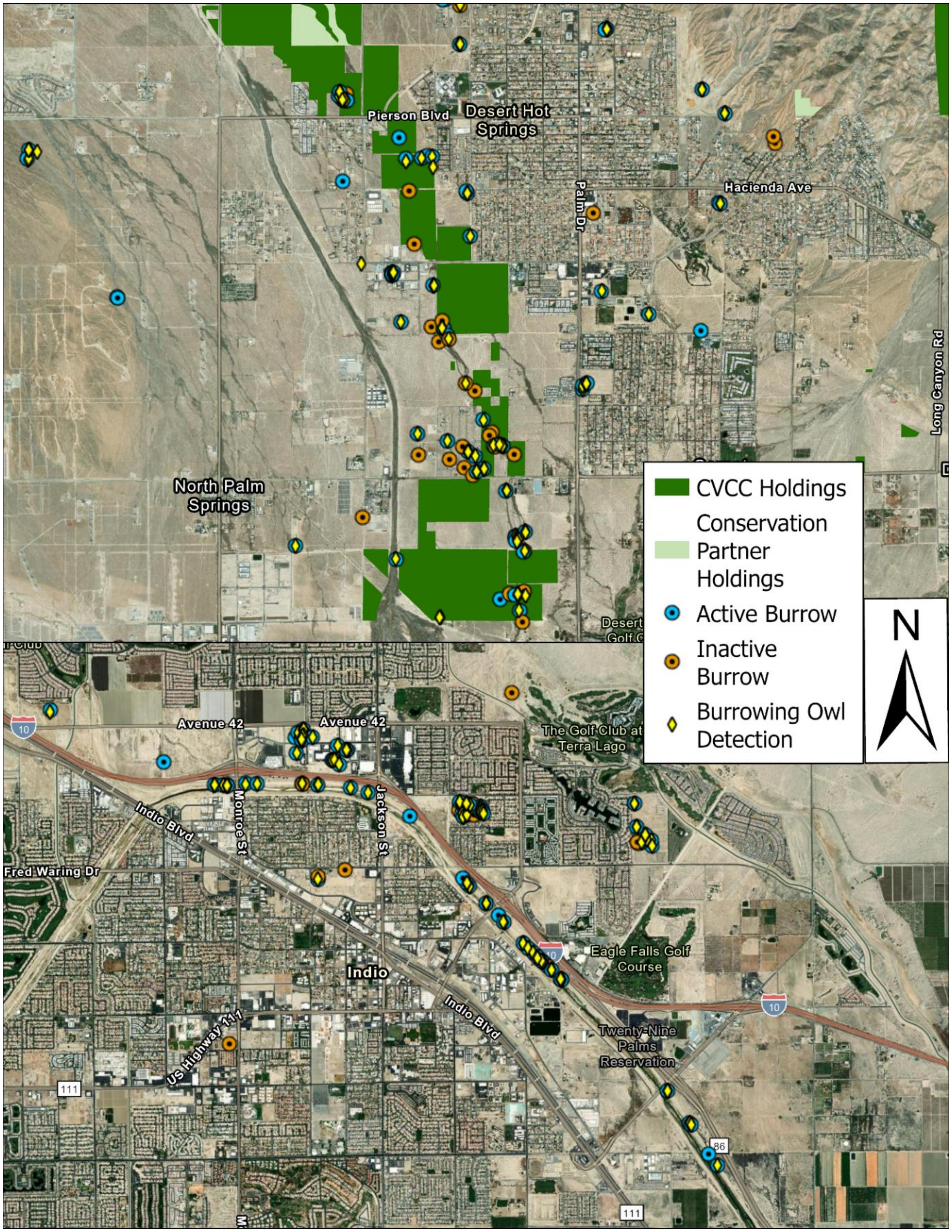


Figure 6. Burrowing owl detections and burrows from August – December 2025 in Desert Hot Springs (top) and along or near the Whitewater Stormwater Channel (bottom). Some of the detections may represent the same owls. Conserved lands owned by the CVCC are shown in dark green. Conserved lands owned by conservation partners are shown in light green. Burrows were recorded as active if we observed an owl or recent owl sign nearby or inside the burrow.

Trapping and Banding
We trapped owls within the CVMSHCP area from 25 August 2025 –28 December 2025. We totaled 775 trap hours (trap hour = 1 trap deployed for 1 hour). We had 116 owl capture events of 141 owls. Our capture rate was 0.18 owls per trap hour. If an owl was captured on multiple occasions during this time span, it was only processed once (unless we needed samples or measurements that were not collected the first time the owl was captured). Thirteen of the owls were recaptures from one of our earlier banding efforts. We banded 128 individual owls: 6 juveniles, 25 adults, and 97 age unknown (Appendix A). Of the 25 adult owls we banded, 4 were females, 3 were males, and 18 were sex unknown. We collected feather samples from all 128 owls, and blood samples from 124 owls. We will determine sex genetically of all owls that were sex unknown at capture. Our banding efforts were spread out across the Coachella Valley, but most of the owls we banded were using burrows along or near the Whitewater Stormwater Channel or in the Desert Hot Springs area, as they had the highest densities of owls (Figure 7; Table 1). These areas have been established as important nesting sites in previous years (Rotenberry et al. 2010, CVCC 2021). For more banding details (including color band combinations), see Appendix A.

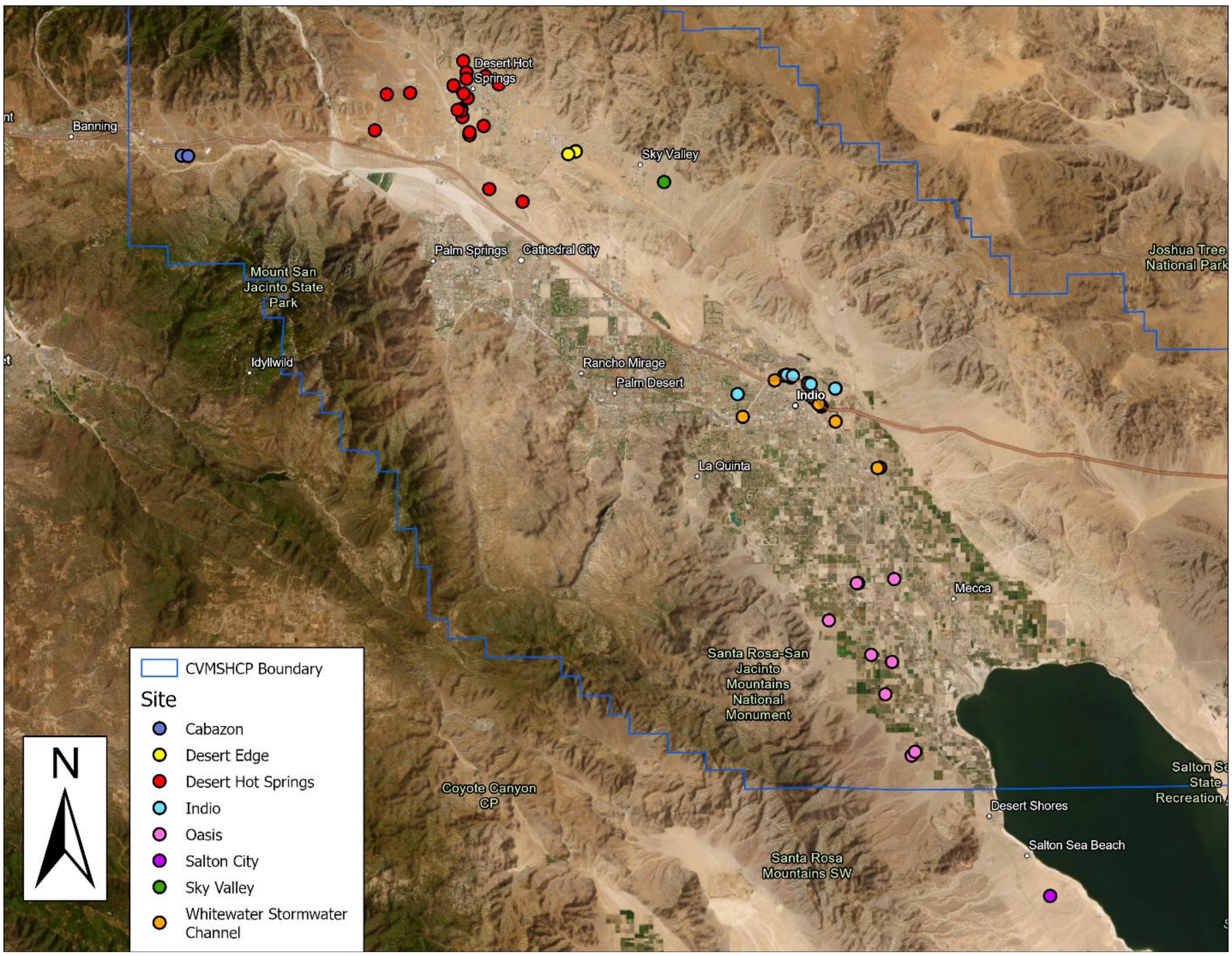


Figure 7. Locations of 128 banded burrowing owls in the Coachella Valley from 25 August – 28 December 2025. Locations are colored by site.

Table 1. Number of burrowing owls banded in the Coachella Valley by the University of Idaho as of 28 December 2025, separated by site.

Site	Individual Owls Banded
Desert Hot Springs	31
Whitewater Stormwater Channel	31
Indio*	33
Sky Valley	2
Oasis**	18
Desert Edge	9
Cabazon	2
Salton City	2
Total	128

* The Indio site includes owls banded near, but not on the stormwater channel. Owls from both sites could reasonably be lumped together geographically

** Encompasses owls banded at several locations in the southern Coachella Valley. Oasis is the nearest census-designated place

DISCUSSION

Between our formal surveys and visits to areas where AECOM detected owls during their 2025 breeding season surveys, we recorded 350 owl detections across the Coachella Valley. Although this number does not equate to 350 individual owls, it does show that burrowing owls are widely distributed in the Coachella Valley. Moreover, we captured and banded 128 owls. Some areas like the Whitewater Stormwater Channel and Desert Hot Springs appear to have relatively high densities of owls and may serve as important nesting habitat during the breeding season. Desert Hot Springs is a particularly important area for achieving burrowing owl conservation goals in the CVMSHCP, as much of the area is already conserved by the CVCC. Over half of the burrows marked by AECOM in the breeding season were still occupied by burrowing owls during the post-breeding season and beginning of the winter season. Early surveys under the CVMSHCP in 2009 and 2011 reported around 40 breeding pairs in the Coachella Valley (CVCC 2014). Approximately 321 breeding pairs were detected during 2025 breeding season surveys by AECOM and its partners (Malo 2025). Our surveys and banding efforts provide additional documentation of a large population of burrowing owls in the Coachella Valley. Some of the owls we detected and/or banded in 2025 are probably migrants or recently fledged juveniles. Therefore, they would not have contributed to the breeding population this past breeding season. Nevertheless, many of the owls we detected and/or banded likely are breeding owls, especially if they were banded prior to peak fall migration which typically occurs in October. We will have a more accurate population estimate of breeding owls in 2026 after April-June surveys and nest monitoring (if follow-on work is approved).

Conservation of burrowing owls in the Coachella Valley will require continued collaboration between organizations in the region, including federal and state government agencies, NGOs, and local resource management agencies like the Coachella Valley Water District. Past monitoring efforts by the CVCC and its permittees have provided important data on the distribution, nesting success, and diet of burrowing owls in the Coachella Valley. Future research and monitoring needs to include measures of reproductive success, extent of owl movements, and documentation of likely threats to survival. Our color banding efforts contribute to all these areas of study. Color banding is valuable because knowing the identity of an individual owl allows for links to be drawn among its behaviors, survival, nesting success, habitat use, and other aspects of its life history.

The impending decision of whether to list the western burrowing owl as a threatened or endangered species in California emphasizes the importance of monitoring and research efforts in the state. The Coachella Valley may be a critical region for the species' conservation on a statewide level.

Future Efforts

If follow-on work is funded in 2026, we plan to continue surveys and banding efforts in the CVMSHCP area through the 2026 breeding season. Additionally, we intend to locate and monitor as many nests in the Coachella Valley as possible this coming year to document breeding success and potential threats to nesting owls (by placing trail cameras at a subset of nests and making regular visits to all nests). We will also continue to collect blood and feather samples to contribute to ongoing conservation genomics work in California. We are eager to continue working with the CVCC in its implementation of the CVMSHCP, and to contribute to the conservation of the western burrowing owl in California.

ACKNOWLEDGEMENTS

Field housing for the project was provided by the CVCC. K. Brundige, B. Morrow, and T. Quiroz provided logistical support. S. Watts provided access to CVWD properties. M. Parr, J. Worwa, and R. Becdach conducted field work and surveys. This work was performed under the auspices of University of Idaho IACUC protocol #2025-06 and USGS Master Banding Permit #22524. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Burrowing owl banded by the University of Idaho in Indio, CA on 13 November 2025.

REFERENCES

AECOM. 2025. Imperial Irrigation District 2025 burrowing owl survey report for Imperial Valley and Coachella Valley. Report prepared for Imperial Irrigation District. AECOM, San Diego, CA.

Bartok, N., and C. J. Conway. 2010. Factors affecting the presence of nesting burrowing owls in an agricultural landscape. Journal of Raptor Research 44:286-293.

California Department of Fish and Wildlife. 2024. California Fish and Game Commission Notice of Findings: Western Burrowing Owl (*Athene cunicularia hypugaea*). https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=227089&inline.

Coachella Valley Conservation Commission. 2014. Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan, 2013 Annual Report.

Coachella Valley Conservation Commission. 2016. Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan, 2015 Annual Report.

Coachella Valley Conservation Commission. 2018. Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan, 2017 Annual Report.

Coachella Valley Conservation Commission. 2021. Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan, 2020 Annual Report.

Coachella Valley Conservation Commission. 2024. Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan, 2023 Annual Report.

Coachella Valley Conservation Commission. 2025. Multiple Species Habitat Conservation Plan/Natural Community Conservation Plan, 2024 Annual Report.

Committee on the Status of Endangered Wildlife in Canada. 2017. COSEWIC assessment and status report on the Burrowing Owl, *Athene cunicularia*, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html

Conway, C. J. 2018. Spatial and temporal patterns in population trends and burrow usage of burrowing owls in North America. Journal of Raptor Research 52:129-142.

Conway, C. J., and J. Simon. 2003. Comparison of detection probability associated with burrowing owl survey methods. Journal of Wildlife Management 67:501-511.

Conway, C. J., and K. L. Pardieck. 2006. Population trajectory of burrowing owls in eastern Washington. Northwest Science 80:292-297.

Conway, C. J., V. Garcia, M. D. Smith, and K. Hughes. 2008. Factors affecting detection of burrowing owl nests during standardized surveys. Journal of Wildlife Management 72:688-696.

Conway, C. J., V. Garcia, M. D. Smith, L. A. Ellis, and J. Whitney. 2006. Comparative demography of burrowing owls within agricultural and urban landscapes in southeastern Washington. Journal of Field Ornithology 77:280-290.

DeSante, D. F., E. D. Ruhlen, and R. Scalf. 2007. The distribution and relative abundance of burrowing owls in California during 1991–1993: Evidence for a declining population and thoughts on its conservation. Pages 1-41 in Proceedings of the California Burrowing Owl Symposium, November 2003. Institute for Bird Populations and Albion Environmental, Inc. Bird Populations Monographs No. 1.

Garcia, V., C. J. Conway, and C. P. Nadeau. 2024. Experimental changes in food and ectoparasites affect dispersal timing in juvenile burrowing owls. PLoS ONE 19(7):e0306660.

Garcia, V., and C. J. Conway. 2009. What constitutes a nesting attempt? Variation in criteria causes bias and hinders comparisons across studies. The Auk 126:31-40.

Gervais, J. A., D. K. Rosenberg, D. M. Fry, L. Trulio, and K. K. Sturm. 2000. Burrowing owls and agricultural pesticides: Evaluation of residues and risks for three populations in California, USA. Environmental Toxicology and Chemistry 19:337-343.

Green, G. A., and R. G. Anthony. 1989. Nesting success and habitat relationships of burrowing owls in the Columbia Basin, Oregon. The Condor 91:347-354.

Hall, D. B., P. D. Greger, and J. R. Rosier. 2009. Regional and seasonal diet of the western burrowing owl in south central Nevada. Western North American Naturalist 69:1-8.

Justice-Allen, A., and K. A. Loyd. 2017. Mortality of western burrowing owls (*Athene cunicularia hypugaea*) associated with brodifacoum exposure. Journal of Wildlife Diseases 53:165-169.

Knutson, M. G., L. O'Brien, T. W. Sutherland, K. L. Carlyle, J. Herner-Thogmartin, and L. Carter. 2016. National protocol framework for the inventory and monitoring of breeding landbirds using point counts. Version 2.0. Natural Resources Program Center, Fort Collins, CO.

Lantz, S. J., C. J. Conway, and S. H. Anderson. 2007. Multi-scale habitat selection by burrowing owls in black-tailed prairie dog colonies. Journal of Wildlife Management 71:2664-2672.

Lundblad, C. G., C. J. Conway, K. Cruz-McDonnell, D. Doublet, M. J. Desmond, C. J. Navis, and K. Ongman. 2021. Long-term population fluctuations of a burrowing owl population on Kirtland Air Force Base, New Mexico. Journal of Raptor Research 55:241-254.

Lundblad, C. G., and C. J. Conway. 2021a. Nest microclimate and limits to egg viability explain avian life-history variation across latitudinal gradients. Ecology 102:e03338.

Lundblad, C. G., and C. J. Conway. 2021b. Intraspecific variation in incubation behaviours along a latitudinal gradient is driven by nest microclimate and selection on neonate quality. Functional Ecology 35:1028-1040.

Macías-Duarte, A., and C. J. Conway. 2015. Distributional changes in the Western Burrowing Owl (*Athene cunicularia hypugaea*) in North America from 1967 to 2008. Journal of Raptor Research 49:75-83.

Macías-Duarte, A., C. J. Conway, and M. Culver. 2020. Agriculture creates subtle genetic structure among migratory and non-migratory populations of burrowing owls throughout North America. Ecology and Evolution 10:10697–10708.

Malo, L. M. 2025. Status review of western burrowing owl populations: Imperial Valley and Coachella Valley. Report prepared for Imperial Irrigation District. Noreas Inc., Irvine, CA.

Nadeau, C. P., C. J. Conway, and N. Rathbun. 2015. Depth of burrowing owl nest boxes affects thermal suitability and occupancy. Journal of Field Ornithology 86:288-297.

Ogonowski, M. S., and C. J. Conway. 2009. Migratory decisions in birds: extent of genetic versus environmental control. Oecologia 161:199-207.

Poulin, R. G., L. D. Todd, E. A. Haug, B. A. Millsap, and M. S. Martell. 2020. Burrowing owl (*Athene cunicularia*), version 1.0. In: The Birds of the World (A. F, Poole, ed.). Cornell Lab of Ornithology, Ithaca, NY.

Rosier, J. R., N. A. Ronan, and D. K. Rosenberg. 2006. Post-breeding dispersal of burrowing owls in an extensive California grassland. The American Midland Naturalist 155:162-167.

Rotenberry, J. R., K. D. Fleming, Q. Latif, R. Johnson, and C. W. Barrows. 2010. Inventory and monitoring of western burrowing owls (*Athene cunicularia hypugaea*) for the Coachella Valley MSHCP. University of California Riverside, Center for Conservation Biology.

U.S. Fish and Wildlife Service. 2021. Birds of Conservation Concern 2021. United States Department of the Interior, U.S. Fish and Wildlife Service, Migratory Birds, Falls Church, Virginia. https://www.fws.gov/sites/default/files/documents/birds-of-conservation-concern-2021.pdf

Washington Department of Fish and Wildlife. 2024. Washington State-Listed and Candidate Species List. March 2024. https://wdfw.wa.gov/sites/default/files/2024-03/wa-state-listed-and-candidate-species-list.pdf.

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

York, M. M., D. K. Rosenberg, and K. K. Sturm. 2002. Diet and food-niche breadth of burrowing owls (*Athene cunicularia*) in the Imperial Valley, California. Western North American Naturalist 62:280-287.

Appendix VII: Biological Monitoring Results for the Coachella Valley Aeolian Sand Species

Report begins on following page.

Coachella Valley Multiple Species Habitat Conservation Plan

2024–2025 BIOLOGICAL MONITORING RESULTS FOR THE COACHELLA VALLEY AEOLIAN SAND SPECIES

2024-2025 FINAL REPORT

COACHELLA VALLEY MULTIPLE SPECIES HABITAT CONSERVATION PLAN: 2024–2025 BIOLOGICAL MONITORING RESULTS FOR THE COACHELLA VALLEY AEOLIAN SAND SPECIES

Prepared by:

Remy M. Vincent, Rachel Gallardo, Scott A. Heacox, Brenda A. Fisher, and Lynn C. Sweet

Center for Conservation Biology
University of California, Riverside
75-080 Frank Sinatra Dr.
Palm Desert, CA 92211

Prepared for:

Coachella Valley Conservation Commission
73-710 Fred Waring Dr.
Palm Desert, CA 92260

Suggest citation: *Vincent R.M., Gallardo R.H., Heacox, S.A., Fisher B.A., Graham J.J., Baronia D., Davis, M.J., and Sweet, L.C., (2025) Coachella Valley Multiple Species Habitat Conservation Plan: 2024–2025 biological monitoring results for the Coachella Valley aeolian sand species. Final Report. Prepared for: Coachella Valley Conservation Commission*

TABLE OF CONTENTS

List of Figures (captions abbreviated)

LIST OF TABLES (CAPTIONS ABBREVIATED)

1 INTRODUCTION

Habitat conservation plans are designed to provide support for the multifaceted aspects of policy, planning, coordination and research for the conservation of species. As long-term plans, they provide opportunities for the evaluation of the status of species' populations and interrelationships between species over time, and this information is a vital component of management planning. This information may then be interpreted in the context of information about dynamic threats such as ongoing urban development, changes in the connectivity of habitats and the vitality of ecosystem processes that sustain habitat as well as direct threats such as dumping, poaching, predation and other factors, to support adaptive management.

The Coachella Valley Multiple Species Habitat Conservation Plan, or CVMSHCP (hereafter "Plan"), signed in 2008, is designed to ensure long-term protection for 27 of the Coachella Valley's most vulnerable plant and animal species within the Palm Springs region in Southern California. The Plan expands upon the original 1986 habitat conservation plan (HCP) created following a 1982 amendment to the Endangered Species Act and focused on protecting the federally-threatened and state-endangered Coachella Valley fringe-toed lizard (*Uma inornata*) and the habitat it relies upon. This lizard is found solely within the now-rare sand dune habitats of the Coachella Valley, which are home to five additional Plan-covered species. These sand dunes are fed by sediments deposited from floodwaters arising from San Gorgonio Mountain (Whitewater River and Mission Creek), Palm Canyon in the Santa Rosa Mountains, and Thousand Palms Canyon in the Indio Hills, and by many smaller ephemeral washes. Many of these drainages have experienced alteration by human activity, thus limiting the efficiency by which sediments are deposited in a way that is useful for recharge of downwind sand habitats (Beheiry 1967, Barrows 1996, Katra et al. 2009). Importantly, these habitat conservation plans not only put forth realistic species-focused conservation goals, but also serve to protect important landscape-scale processes, such as here, these major sand sources and the corridors over which the sand must then travel to reach dune habitats, that are necessary for the long-term survival of these species.

The Coachella Valley fringe-toed lizard (*Uma inornata)*, Coachella Valley giant sand-treader cricket (*Macrobaenetes valgum*), and Coachella Valley milkvetch (*Astragalus lentiginosus* var. *coachellae*) are entirely dependent on aeolian (wind-driven) sand systems and are found only in the Coachella Valley. The full range of the flat-tailed horned lizard (*Phrynosoma mcallii*) extends south along both sides of the Salton Sea and into northern Mexico, and is now restricted within its northern range extent in the Coachella Valley to only a small portion of the extant aeolian habitat (Barrows 2009). The Palm Springs pocket mouse (*Perognathus longimembris bangsi*) and Palm Springs round-tailed ground squirrel (*Spermophilus tereticaudus chlorus*) rely heavily on aeolian systems but can also be found in adjacent landscape types within the Coachella Valley (Swei et al. 2003, Hoefler & Harris n.d.).

The Coachella Valley's aeolian habitat in its pre-colonial form covered an interconnected area exceeding 100 square miles (Barrows and Heacox 2021). Now, after decades of urban development, only 5-10% of that original sand habitat remains (Barrows 2006, Barrows and Heacox 2021). The present dune habitat is facing a series of complex pressures from invasive plants, interruptions in fresh sand input, rising temperatures, drought, flooding, severe fragmentation, and other challenges. In order to monitor the abundance of species, including relevant abiotic (environmental) and trophic (food web) factors that may drive changes, we installed a set of long-term monitoring plots, across conserved portions of the remaining dune habitat which we survey annually since at least 2005 (in some cases since 2003). In particular, we track the populations of several ecologically important arthropod species that are either critical food sources for the Coachella Valley fringe-toed lizard and flat-tailed horned lizard, or that are useful indicator species of habitat quality.

Here we present the results of our 2024-2025 studies on covered species in the aeolian sand communities. We also carry out periodic surveys of other non-dune species covered by the plan (monitored every 2-5 years), and those results are described under separate reports; including this year: monitoring results for triple-ribbed milkvetch, an add-on study of the vegetation at set undercrossings within the I-10 corridor and a multi-year climate resilience study investigating the potential future geographic changes for several species. The present report covers our annual aeolian habitats monitoring efforts and how plan-covered species respond to these pressures. We also present detailed information on annual and perennial plant communities (including invasive/nonnatives) which represent key variables in determining the overall stability, productivity, and structure of these habitats. We put these results in context of management threats and recent significant weather events, such as recovery from the 2023 Tropical Storm Hilary (tropical storms infrequently occur in this region), and near-term climate, such as the current drought. The data collected during this monitoring season adds to a much larger dataset spanning more than two decades, allowing us to understand and anticipate how the populations of these important species change over time. Furthering our fine-scale knowledge of the dynamics of the abundances of these species as well as potential drivers of change will result in more informed and effective management actions.

2 METHODS: AEOLIAN COMMUNITY PLOT NETWORK

Aeolian community monitoring is performed across 79 rectangular plots, each measuring 0.1 hectares (10 m x 100 m) in size, located throughout the Coachella Valley (Figure 1). Monitoring of aeolian habitat species dates to the 1980s, with the Coachella Valley Fringe-toed Lizard Habitat Conservation Plan (HCP) and transitioned to the current long-term plot-based approach by approximately 2003. To assist researchers in relocating and navigating the plots, each plot was marked with five slender fiberglass poles positioned every 25 meters along the central line. We chose these poles specifically because their thin design prevents predatory birds from perching on them to hunt and prey on lizards.

The plots were organized into 18 "plot clusters," with each cluster containing between 3 and 7 plots situated within nearby habitats. Researchers strategically selected locations for each cluster within various aeolian habitats or arranged them in a random or nonrandom manner to explore specific research questions. For instance, we positioned the three clusters labeled J, L, and H at the Coachella Valley National Wildlife Refuge at particular distances from a roadside to examine the influence of power lines on lizard predation by perching birds of prey. Within each cluster, we ensured that plots were spaced at least 25 meters apart, typically over 50 meters, to prevent resampling of individuals across plots. The Coachella Valley fringe-toed lizard has an estimated home range of 25-29 meters (Fisher et al. 2020), which is considerably smaller than the distances maintained between plots within a cluster.

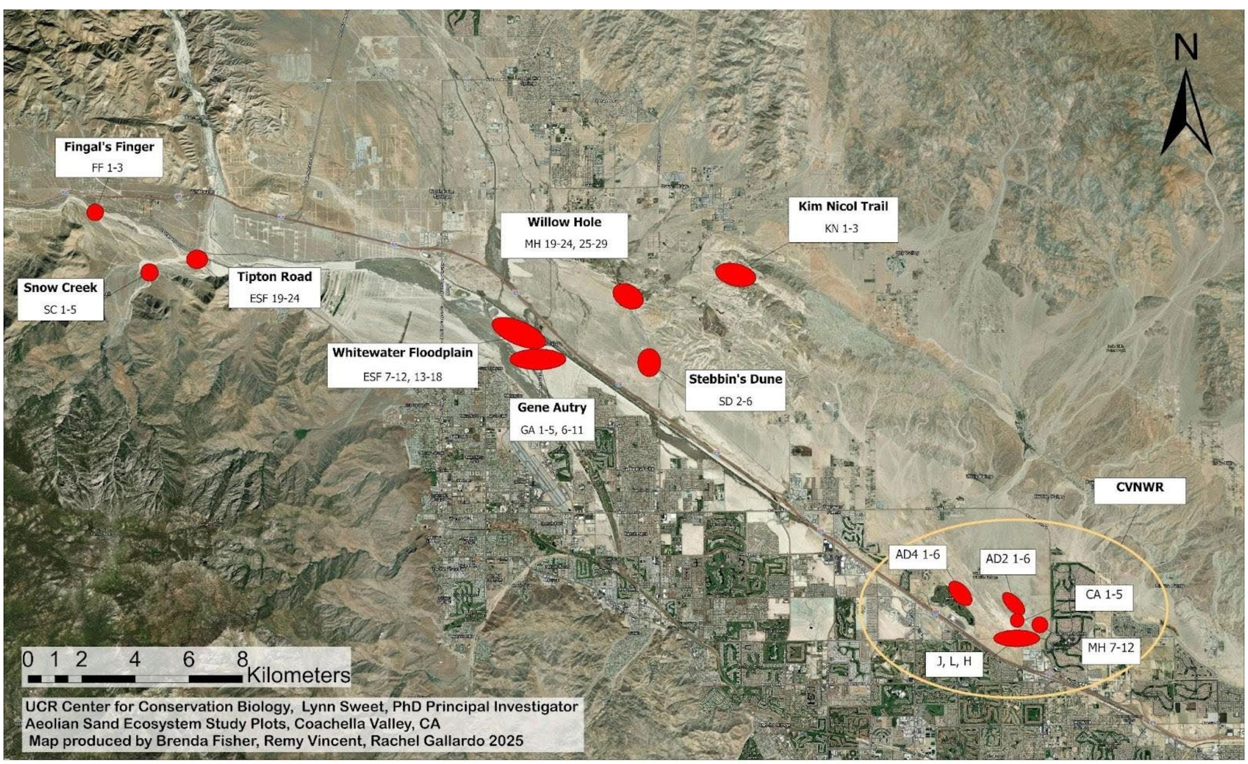


Figure 1. Map of plot network (79 active plots, 17 clusters) used in this study. CVNWR = Coachella Valley National Wildlife Refuge, indicated in the solid circle. This map also includes Stebbins' Dune, which is not currently being used in monitoring efforts.

We placed our plot clusters within the remaining significant dune fragments' habitat. Hereafter the names of the plot clusters are as follows, with locations starting at the western most plot moving east: "Fingal's Finger" cluster FF 1-3, near the Haugen-Lehmann exit on I-10 (north of the geographic feature "Fingal's Finger"), "Snow Creek" cluster (ESF 25-30) near Snow Creek Rd and HWY 111, "Tipton Road" cluster ESF 19-24 (near the intersection of Tipton Road and Highway 111), "Whitewater Floodplain" clusters ESF 13-18 and ESF 7-12, (New Gene Autrey PLOTS 1-5,6-11), "Willow Hole" clusters MH 19-24 and MH 25-29 (located in the mesquite dunes near the Willow Hole oasis), "Stebbins' Dune" cluster SD 2-6 (an informal place name, after accomplished herpetologist Robert Stebbins, located just south of Willow Hole), "Kim Nicol" cluster KN 1-3 (named after the Kim Nicol Trail adjacent to the plots locations), and the Coachella Valley National Wildlife Refuge "CVNWR" clusters AD4 1-6, AD2 1-6, CA 1-5, J 0-250, L 0-250, H 0-250, and MH 7-12 (Figure 1). We installed plots at Fingal's Finger, in the Kim Nicol Trail area, and Stebbins' Dune between 2018 and 2019.

In an agreement with the Coachella Valley Commission for Conservation (CVCC) we decided to remove the field site at Stebbins' Dune from our active plot monitoring, so that we could establish new plots at Snow Creek and along the Whitewater River floodplain near Gene Autry Dr. We made this decision to take down the SD plots after years of surveys showing no sign of CVFTL at Stebbins' Dune and reported degradation of the habitat from loss of sand transportation and increased sand compaction of the plots. As per the request of CVCC, we established three new plot clusters in their newly acquired parcels within the aeolian habitat. Snow Creek (SC 1-5) plot cluster located south-west of our Tipton Rd plots (ESF 19-24) and two plot clusters established along Gene Autry Rd in the Whitewater Floodplain- GA 1-5 located on the east side of Gene Autry and GA 6-11 located south of our ESF 7-12 plots on the west side of Gene Autry.

Due to the size of the Snow Creek parcel, the five plots we established cover most of aeolian habitat within the parcel. We toured the extent of the Gene Autry parcels with CVCC and again with our biologists in February 2025 to identify areas within the parcels that have suitable aeolian habitats. We utilized our on-the-ground information and used ArcPro (ESRI, 2025) to create a preliminary map of the new plots. First, using the field information regarding the extent of suitable habitat, we used recent aerial imagery to delimit GIS polygons around the three study areas. We populated 15 randomized points within each the polygon. We chose 5-6 points that met the requirement of 50 m apart from one another, a measurement used to prevent data inaccuracies by exceeding the known distance of movement of CVFTL individuals between plots. Once we mapped the starting points, we added 25 m, 50 m, 75 m, and 100 m points. In May, we uploaded the preliminary map to Field Maps (ESRI 2025) to help us navigate to the location of the plots. We used a Skadi 100 GNSS receiver (EOS Positioning Systems, 2025) to get a high precision location for our plot stakes. Once we established the 0 m point stake, we laid out a 100 m line using a reel and created a straight line distance using the mapped line in GIS as a guide. We used the reel to refine precise and accurate measurements for our 25 m, 50 m, and 75 m stakes. When we established a stake, we held the GNSS receiver over the stake and created a new point on the Field Map, using the receiver's location to record the most accurate position of the stake on the map.

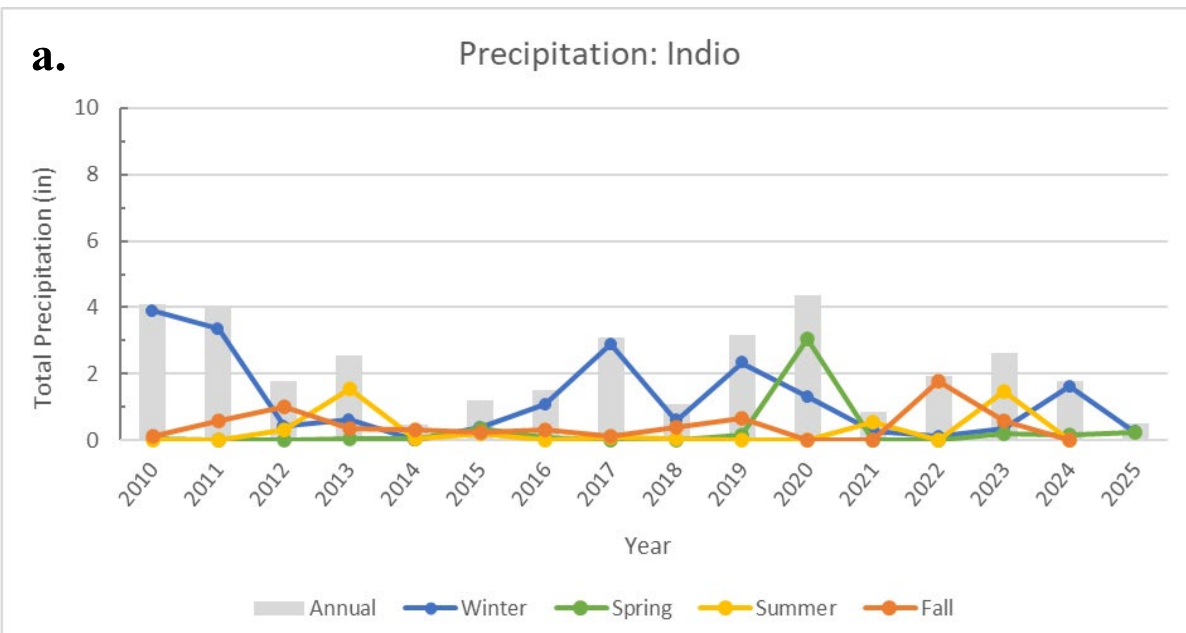
The remaining plots have been in service since before the inception of the Plan, some as early as 2003. Specifically for the year 2014, data was not collected and is therefore missing in the dataset due to a lack of funding allocations for surveys. However, we conducted surveys at the Thousand Palms Preserve at no charge on behalf of the CVMSHCP to maintain some portion of this critical data set. Our previous reports often categorized and analyzed our plots based on aeolian habitat type groupings (see Introduction). Due to recent fluctuations in sand deposition, we have decided to keep the clusters ungrouped to reevaluate the most optimal assignment of plots to their respective habitat types. Therefore, we discuss the changes at each plot in terms of their respective locally measured biophysical factors.

3 INDEPENDENT VARIABLES

3.1 PRECIPITATION

Arid ecosystems are defined by low precipitation with interannual variability, making it a dominant driver of biological processes (Noy-Meir 1973). Precipitation in the Coachella Valley is supplied primarily by winter storms and inconsistent summer monsoonal rains following a general trend of higher precipitation in the west and less in the east. We acquire our local precipitation data from two public weather stations located in the east valley at the Indio Fire Station (Station 044259) and in the west valley at the Palm Springs International Airport (Station 046635), both administered by the National Weather Service Cooperative Observer Program (WRCC 2025). The data from these weather stations contain gaps; thus, the following precipitation data extends from 2010 to spring 2025 for Indio and 2008 to spring 2025 for Palm Springs (Figure 2). In addition to looking at total annual precipitation by location, precipitation is also separated into seasons to provide a basis to understand how shifts in the timing of precipitation affect plant and animal populations.

The period covered by fall 2024 to spring 2025 experienced very little precipitation. Fall 2024 precipitation totals were 0.00 inches in Indio and 0.02 inches in Palm Springs, winter 2024-2025 totals were 0.25 inches in Indio and 0.95 inches in Palm Springs, and spring 2025 totals were 0.26 inches in Indio and 0.60 inches in Palm Springs. These low precipitation totals



resulted in a late wildflower season and poor annual plant emergence and survival.

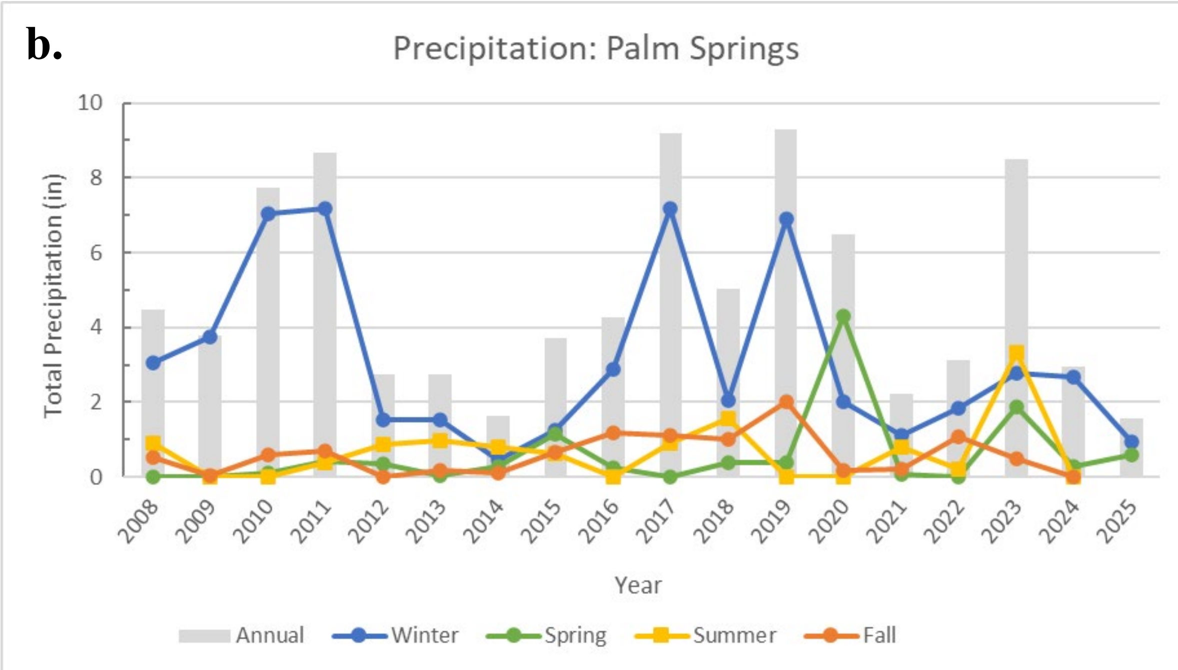


Figure 2. Seasonal and yearly precipitation for Indio (a) and Palm Springs (b), representing the precipitation in the eastern and western parts of the Coachella Valley, respectively. The seasons were divided as follows: Spring (March, April, May); Summer (June, July, August); Fall (September, October, November); and Winter (December, January, February). Data are summarized through the complete spring season ending in May 2025.

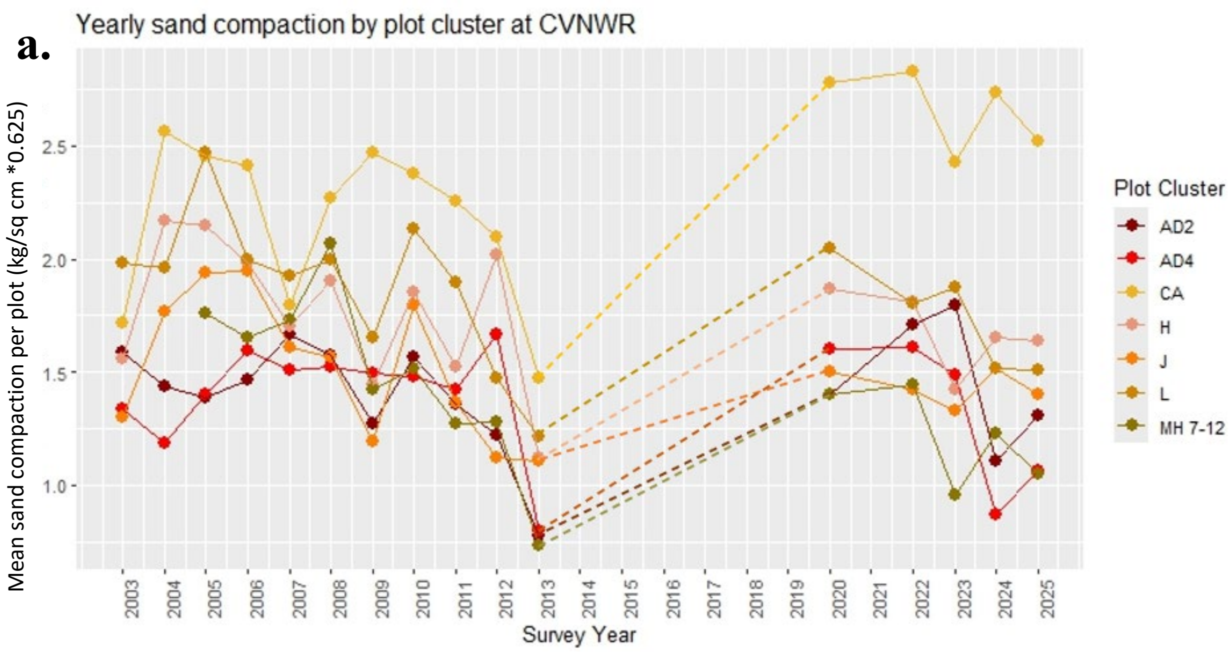
3.2 Wind Patterns

We reference wind data from NOAA in this section (NOAA 2025). This region experienced faster east-west wind speeds (in comparison to the 1991-2020 mean) in September, October, and November 2024 and March 2025. April, May, and June of 2025 experienced less windy conditions than average. North-south winds experienced higher wind speeds in October 2024 and March through June 2025 and there was less wind for September and November 2024.

We note wind trends because deviation from normal wind patterns impact sand transport to aeolian habitats. For example, wind patterns can reestablish sand in areas where it was once removed by past flooding, as demonstrated by the effects of Tropical Storm Hillary in 2023. Wind patterns also influence our ability to monitor certain species. Our vertebrate tracking survey protocol requires overnight periods of wind at least 20 mph for at least a few hours to remove old tracks and ensure recorded tracks are all from a known time period.

3.3 SAND COMPACTION

Sand compaction provides information on a vital habitat feature of aeolian habitats, soft dune sand, which is crucial for species, like the Coachella Valley fringe-toed lizard (*Uma inornata*), that depend on the loose sand for survival (Barrows 2006). We measure sand compaction during the fall perennial plant surveys using a Pocket Penetrometer (AMS Inc.) fitted with a “foot” attachment for use in loose substrates. We take measurements every 4 meters along the 100 m transect (see section Perennial Plant Communities, Methods) measured to the nearest ¼ value, which is later converted to kg/cm^2 (converted value = measured valued * 0.625). We have collected sand compaction data from 2003 to 2013 and 2020 to 2025 (Figure 3).



b.

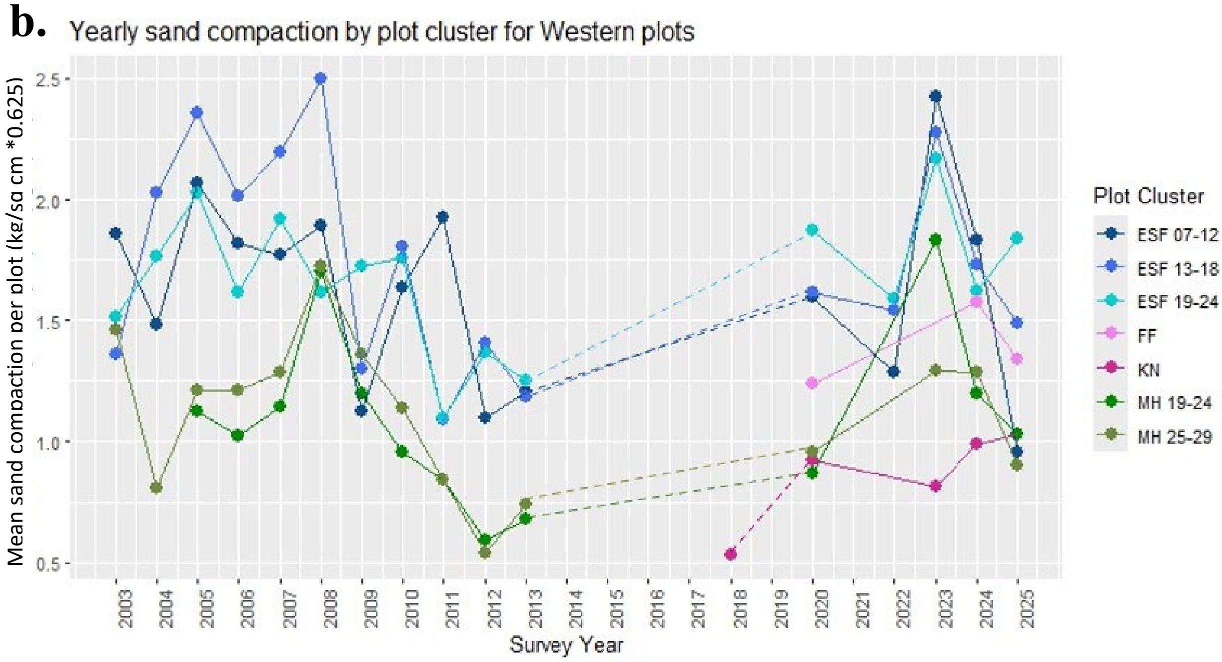


Figure 3. a. Mean sand compaction (kg/sq cm) by plot cluster over time at the CVNWR. Years missing: 2014-2017, 2019, and 2021. Data not collected from MH 19-24 and MH 25-29 in 2022. b. Mean sand compaction (kg/sq cm*0.625) by plot cluster over time at the western plots. Years missing: 2014-2017, 2019, and 2021. Data not collected from MH 19-24 and MH 25-29 in 2022.

In fall 2024, we observed an overall trend of decrease in sand compaction on most of our plots, except for AD2 and AD4 at the CVNWR, ESF 19-24 and KN. We see a decrease in sand compaction at some of the plots at the Refuge (e.g., CA, H, and J), which experienced an increase after flooding from Tropical Storm Hilary in August 2023 which removed sand and deposited a layer of silt. Decreases in sand compaction at these sites can be attributed to more blow sand being transported into these plots after a windier than average September. The increases in sand compaction this year could be a result of sand stabilization from increased plant cover in AD2, AD4, ESF 19-24, and KN. Despite the increased compaction at AD2 and AD4 the mean compaction still reads on the softer end of this measurement in comparison to our historical data for these sites, especially for AD4. The ephemeral nature of sand movement of ESF 19-24 means that sand compaction at this cluster often fluctuates as sand moves out of the site leaving behind gravel and revealing the harder compacted sand underneath. While KN remains one of our softest-sand plot clusters we want to note the gradual increase of sand compaction at this site over the past few years. Our perennial plant monitoring (See section Perennial Plant Communities, Results) revealed a sharp increase in dead invasive annual plant cover at KN and the stabilizing impacts of invasive plants could contribute to this steady rise at this plot. We will continue to investigate potential causes of increasing sand compaction at our sites and determine whether intervention is necessary.

4 VERTEBRATES

Our current long-term vertebrate tracking surveys aim to gather demographic, habitat use/occupancy and environmental information on a suite of animal species inhabiting dune habitat, with a focus on four species protected under the CVMSHCP: the Coachella Valley fringe-toed lizard (*Uma inornata*), the flat-tailed horned lizard (*Phrynosoma mcallii*), the Coachella Valley round-tailed ground squirrel (*Spermophilus tereticaudus chlorus*), and the Palm Springs pocket mouse (*Perognathus longimembris bangsi*). We draw upon information gathered from concurrent aeolian surveys and environmental data, including predator abundance, climatic and weather fluctuations, vegetation cover, sand quality, arthropod activity, and seed availability to construct a detailed image of some important factors influencing population density.

4.1 METHODS

Professional biologists from the University of Riverside, Center for Conservation Biology (CCB), supported by volunteer community biologists record the vertebrate activity in the field. Surveyors carefully walk along the designated 100 m transects, fanning out 5 m on each side of the midline to encompass the entirety of the 100 m by 10m belt, and documenting all visible and identifiable tracks after validation by the biologist. Our team employs a standardized protocol that utilizes traditional tracking methods to identify and record species during vertebrate monitoring. The soft sandy habitat allows for reliable species-level tracking where footprints, appendage drags, or full-body silhouettes are present.

We can use these tracks to determine which vertebrate species visited the survey plots during the night or early morning prior to the survey. This requires specific wind activity that is strong enough to sweep tracks from previous days but becomes calm at least a few hours before dawn so there is enough time for nocturnal species like the Palm Springs Pocket Mouse to leave tracks. Diurnal species, like most lizards in this habitat, leave tracks in the post-dawn hours before the survey takes place, commonly decreasing in activity later in the midday heat. This allows for an accurate count of species presence from a known period spanning one consecutive night and morning. Vertebrate tracks often cover a large area and follow rambling patterns, so we follow tracks as much as possible to ensure can discern among separate individuals. Additionally, we verify species by noting vocalizations, visual observations, and scat. Combining these methods enhances identification accuracy.

Ideally, we survey on sunny and clear days when the morning sun is still low in the sky, when the contrast of the tracks on the sand is at a maximum; cloud cover or having the sun too high overhead reduces the shadows needed to ascertain small tracks. We also ensure that mornings are warm enough for adequate lizard activity (roughly greater than 80°F at time of survey). If due to time constraints, we perform surveys under less ideal conditions, we record notes pertaining to the reliability of the data collected which may prompt a re-survey under better conditions.

We aim to conduct three surveys (or more) on each plot during the monitoring season to account for day-to-day variability in animal activity. We survey from April to July in the spring and from September to November in the fall, to gather data on adult and hatchling populations, respectively. The fluctuating weather during the fall season makes conducting surveys more difficult due to the limited number of days where conditions meet the necessary thresholds needed for successful tracking (wind to clear old tracks, high enough temperature for reptile activity, etc.). As such, we were unable to obtain a complete set of surveys in the fall of 2024. We conducted our essentially complete set of spring surveys from May 20th to July 15th 2025, consisting of three surveys across all plot clusters, except for CA and Fingal's Finger, which we visited twice. We end surveys when the temperatures become too hot for us to survey safely and when the lizard activity is reduced. Additionally, we conducted one set of preliminary surveys at the two newly-established plot clusters in the Whitewater Floodplain off of Gene Autry Trail.

We record tracks of as many vertebrate species as possible to produce a clear picture of the overall vertebrate community. Identifiable tracks of vertebrates, besides the four Plan-covered species, include desert iguanas (*Dipsosaurus dorsalis*), zebra-tail lizards (*Callisaurus draconoides*), western whiptail lizards (Aspidoscelis tigris), side-blotched lizards (*Uta stansburiana*), long-tailed brush lizards (*Urosaurus graciosus*), sidewinder rattlesnakes (*Crotalus cerastes*), shovelnose snakes (*Chionactis occipitalis*), species of kangaroo rats (*Dipodomys spp.*), desert pocket mice (*Chaetodipus penicillatus*), black-tailed jackrabbits (*Lepus californicus*), coyotes (*Canis latrans*), and a variety of birds including important predators such as ravens (*Corvus corax*), kestrels (*Falco tinnunculus*), loggerhead shrikes (*Lanius ludovicianus*) and greater roadrunners (*Geococcyx californianus*). In the sections below, we review background information and numerical results regarding detected occupancy for plan-covered species and any additional findings related to non-target species.

4.2 COACHELLA VALLEY FRINGE-TOED LIZARD (*UMA INORNATA*)

Figure 4. Coachella Valley Fringe-Toed Lizard (*Uma inornata*) displaying its camouflage patterning on the characteristic sand composition of the area. Photo credit: Rachel Gallardo

4.2.1 Introduction

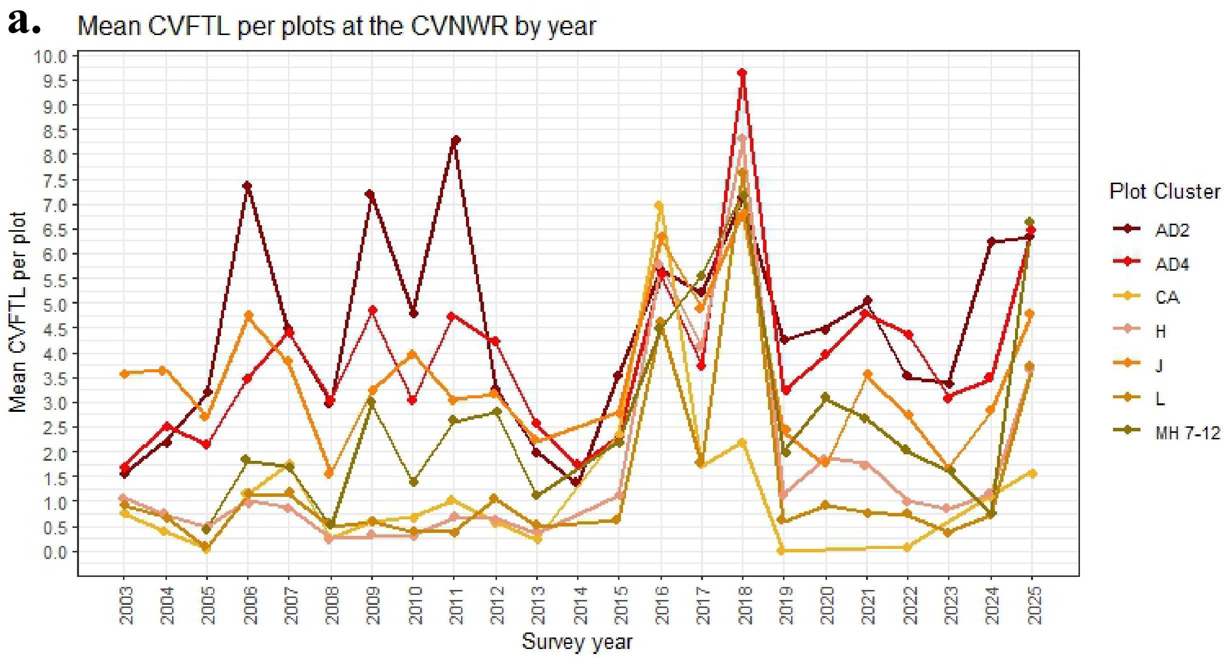
The Coachella Valley Fringe-toed Lizard (*Uma inornata*) possesses several physical adaptations that make living in aeolian habitats more efficient than other species. The namesake "fringes" refer to enlarged scales that line the lizard's toes, improving stability and reducing the likelihood of the lizard sinking while running on the soft, sandy substrate. The CVFTL's bottom jaw is slightly recessed into the top jaw, enabling it to keep its mouth tightly closed as it dives under the sand to escape predators. These adaptations, and others, allow the CVFTL to thrive in harsh aeolian habitats. However, nearly 90% of this species' habitat has been lost to urban development or habitat degradation. These threats leave the CVFTL vulnerable to extinction, resulting in its listing as threatened under the USFWS Endangered Species Act (USFWS, 1980) and as endangered under the California Endangered Species Act. Regular monitoring of the CVFTL enables us to learn about this species' natural population fluctuations and determine whether it requires management intervention.

Here we summarize findings from our 2024-2025 field surveys, conducted to coincide with the relevant activity periods for this species. Adult populations become more active during their breeding season that spans from late April to mid-August, during which we conduct our spring surveys. Our fall surveys begin when hatchlings emerge, roughly late September to October. We incorporate data from our spring pitfall surveys here as well, because ants and other arthropods serve as a primary food source for lizards and as such affect the reproductive success of CVFTLs. Additionally, seasonal precipitation and sand transport in aeolian habitats influence the abundance and richness of plants which the lizards use as cover from predators and the head as well as available dune habitat contributing to the overall reproductive success of CVFTLs.

4.2.2 **Results**

Unfavorable weather conditions prevented us from completing a full suite of hatchling surveys during the fall of 2024 and we did not have sufficient data to run an analysis. We performed spring surveys from May 20, 2025, to July 15, 2025, at all 18 designated plot clusters throughout the Coachella Valley. The rise in the adult population density recorded during our spring surveys suggests a high rate of hatchling survival during the fall 2024 season, more so in the CVNWR plots than other plots. We observed an overall increase in CVFTL populations in every plot, except for ESF 13-18 in the Whitewater floodplain, where a slight decrease from a mean of 4.6 individuals per plot in 2024 to 4.4 individuals occurred this year. The highest recorded increase in abundance was found at MH 7-12 at the CVNWR, which had a mean of 0.7 individuals per plot cluster in 2024 increasing to a mean of 6.6 individuals this year. The L plot cluster also increased considerably, from 0.7 in 2024 to 3.7 in 2025, although its population remains relatively low compared to other plots in the CVNWR. Plot clusters ESF 19-24 (Tipton Rd), KN (Kim Nicol), MH 25-29 (Willow Hole), AD4, and J all nearly doubled their individual counts (Figure 5). Meanwhile, ESF 7-12, FF (Fingal's Finger), MH 19-24 (Willow Hole), AD2, and CA, showed slight increases and remained in a similar range to last year.

a.



b.

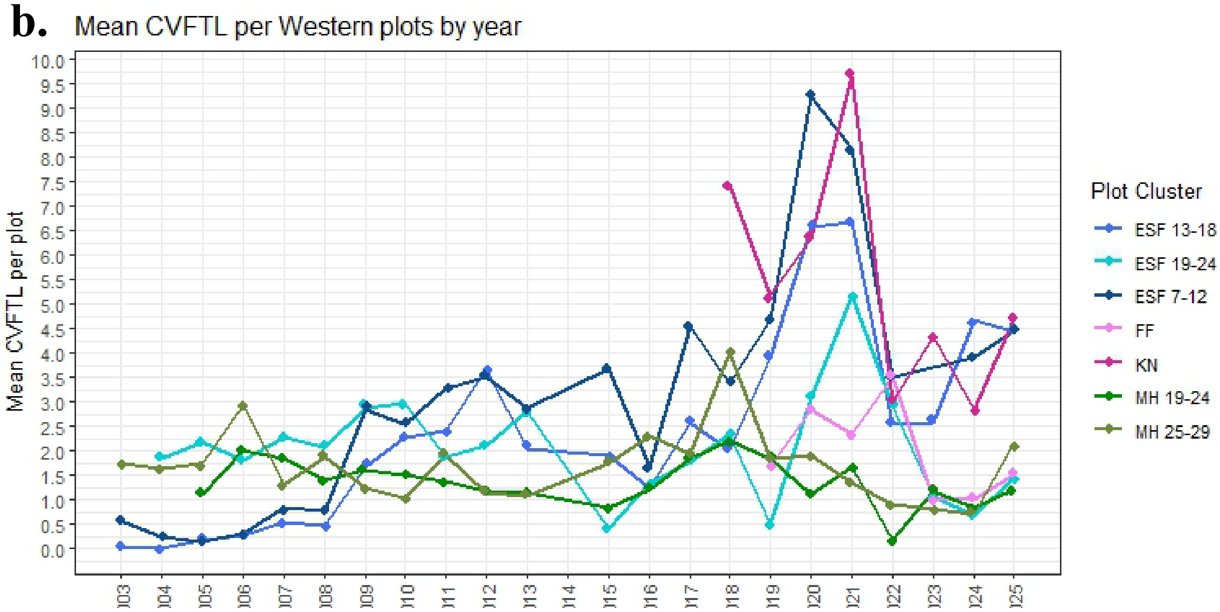


Figure 5. Mean density of CVFTL during spring surveys across plot clusters at the CVNWR to the east (a) and western plots (b) from 2003 to 2025.

4.2.3 **Discussion**

Recent increases in the populations of CVFTL reflect favorable habitat conditions compared to the previous year. An overall rise in CVFTL populations was observed across all monitoring plots, (except for ESF 13-18), despite low annual plant cover and declines in arthropod populations across a majority of plots. We did, however, see a slight decrease in perennial plant cover at ESF 13-18 which serves as cover from predators for lizards. It is possible that the lower cover resulted in higher predation, taken together with visual sightings of raven tracks crossing lizard tracks at that plot cluster and tailless lizards. While our analysis this year did not include an analysis of raven tracks, we did see a drop in raven tracks at ESF 13-18 compared to last year; however further east on the Whitewater floodplain we observed an increase in raven tracks at ESF 7-12. The higher perennial plant cover at our other sites over the fall and winter months may have guarded hatchlings from predators improving recruitment into adult size classes.

4.2.4 **Recommendations**

The monitoring of the CVFTL is mandated under the CVMSHCP. Considering this species narrow ecological requirements, which put them at risk with any environmental changes, we recommend continuing these monitoring activities, including habitat characteristics such as sand, perennial and annual plant composition, and prey species. Additionally, documenting changes in abundance of predatory species, especially ravens, should be a primary focus moving forward.

4.3 FLAT-TAILED HORNED LIZARD (*PHRYNOSOMA MCALLII*)

Figure 6. Flat-tailed horned lizard (*Phrynosoma mcallii*) warming up in the morning at the CVNWR. Photo credit: Rachel Gallardo

4.3.1 Introduction

The flat-tailed horned lizard (*Phrynosoma mcallii*, hereafter FTHL) inhabits areas with sparse vegetation, fine-textured soils such as sandy flats, and stabilized sand dunes throughout the Colorado Desert (Belnap et al., 2016). Desert pavement and gravel flats may also be suitable habitat for this lizard. The FTHL has the most restricted range of any horned lizard species in the United States (SDNHM, 2019). In the Coachella Valley, the FTHL historically could be found near the Whitewater Floodplain, east beyond the Indio Hills, and south toward the US/Mexico border. Extensive urban and agricultural development has eliminated roughly 92% of their habitat within the Coachella Valley (Rorabaugh & Young, 2009; Barrows et al., 2008). According to recent records, FTHL now persists only at the Coachella Valley National Wildlife Refuge (CVNWR) and has been extirpated from most other remaining suitable habitat fragments in the Coachella Valley, where they are often replaced by the desert horned lizard (*Phrynosoma platyrhinos*) (Barrows et al., 2022).

FTHLs effectively stay out of sight by remaining still and camouflaging with the sand until they sense danger nearby and then escape. This makes visual detection difficult because they will not move unless you pass directly next to them, making tracking the most effective way to detect this species. Their diet consists almost exclusively of ants, particularly harvester ants, though they occasionally consume other insects, including spiders that mimic ants and various other arthropods (Turner & Medica, 1982). Two of the most important ant species at the

CVNWR in FTHL diet are the "big-eyed" harvester ant (*Pogonomyrmex magnacanthus*) and the more common California harvester ant (*P. californicus*).

4.3.2 Results

Mean FTHL densities at the CVNWR are shown in Figure 7. In the spring of 2025, vertebrate surveys revealed an increase in the population of FTHL at several CVNWR plots. We recorded slight population increases this year at plot clusters AD2 with 0.16 mean individuals per plot, J with 0.04 mean individuals, and MH 7-12 with 0.05 mean individuals, all of which had a recorded population of zero mean individuals per plot cluster in 2024. Cluster L had the highest overall population growth, increasing from 0 in 2024 to 0.3 mean individuals per plot in 2025. In contrast, the remaining plots either experienced slight decreases in population density or remained the same. Plot CA stayed at 0.1 mean individuals per plot cluster, H decreased slightly from 0.19 in 2024 to 0.14 in 2025, and we recorded no FTHLs at AD4. We did not detect any FTHLs at plot clusters outside of the CVNWR.

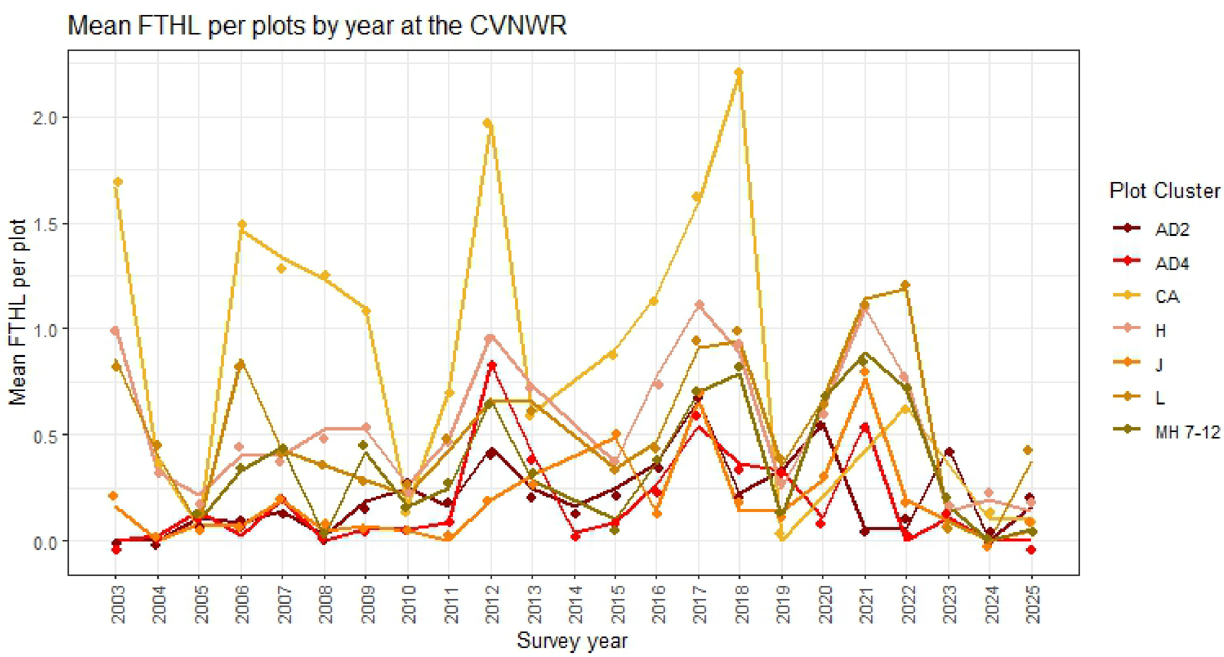


Figure 7. Mean density of FTHL during spring surveys on our plots within the CVNWR from 2003 through 2024.

4.3.3 Discussion

According to the results of our spring survey, we recorded a slight increase in sightings and tracks of the Flat-tailed horned lizard in 4 out of the 7 monitored plots. We faced some challenges in surveying due to the continued presence of large swaths of hard-packed silt resulting from the flooding brought on by Tropical Storm Hilary in August of 2023. By spring of this year, soft sand had not been sufficiently redistributed in these areas, making it difficult to track within some plots, particularly at H, J, L, and CA at the CVNWR. These factors complicated our fieldwork, and they likely affected our ability to detect lizards, therefore we cannot determine definitively the true abundance of this species in these plots this year. Abundance may have remained high, as research has not found a strong negative correlation between the conditions noted, past precipitation (and therefore primary productivity/annual plant growth) and sand compaction with FTHL densities (Barrows et al. 2022). On the other hand, if abundance was low, based on the data collected on this species since monitoring began in 2003, populations seem to naturally fluctuate based on a period of roughly four to five years. The relatively low numbers this year could in that case reflect the end of one of the natural "low points" in abundance. We may expect populations to increase over the next couple of years, and deviation from this prediction may warrant concern.

4.3.4 Recommendations

Similar to the monitoring of the CVFTL, we recommend continuing to assess ecological factors that may be impacting the population of the FTHL. This year's data concerning sand compaction revealed that most plots experienced a decrease in sand compaction, except for AD 2, AD 4, ESF 19-24 and KN. However, remnants of prior flooding were still recorded in four plots in the CVNWR, complicating monitoring efforts. We do not recommend altering the survey methodology at this time, as maintaining compatibility with the long-term dataset is important for any comparisons. If warranted, add-on surveys may be used with alternative methodology if low detectability in these plots continues to hinder conclusive analysis. The landscape changes and post-flood recovery observed in these areas provide vital clues to understanding the observed population fluctuations. Predator populations and extreme weather events also warrant increased attention.

4.4 PALM SPRINGS ROUND-TAILED GROUND SQUIRREL (*XEROSPERMOPHILUS TERETICAUDUS CHLORUS*)

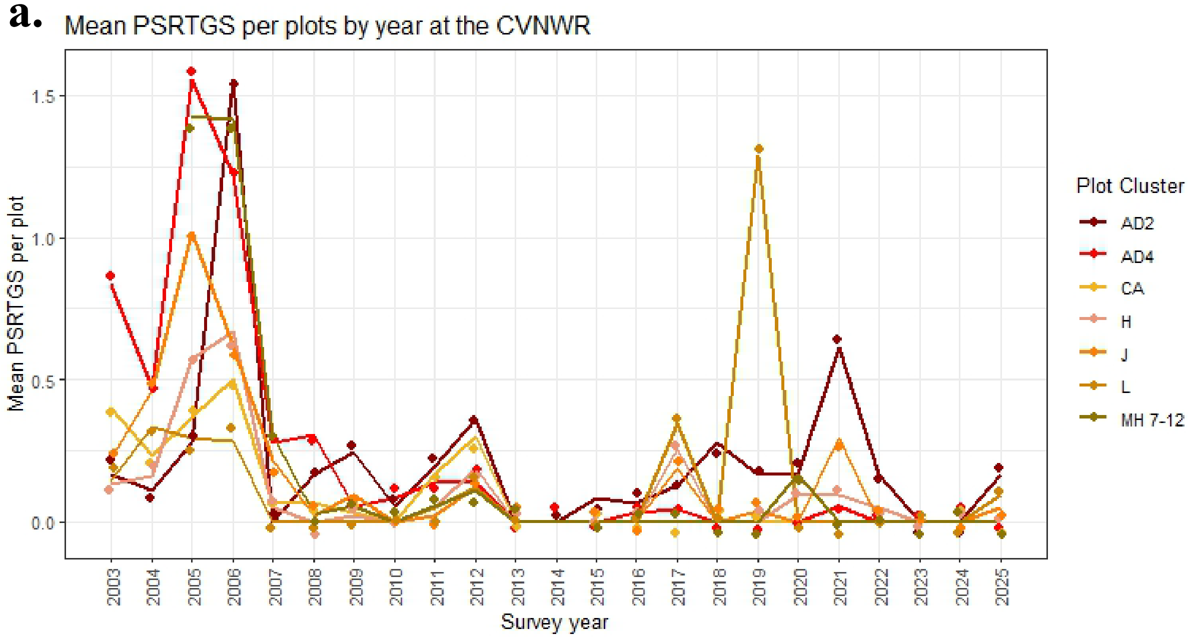
4.4.1 Introduction

The Palm Springs round-tailed ground squirrel (PSRTGS), also referred to as the Coachella Valley round-tailed ground squirrel in the Multiple Species Habitat Conservation Plan, is an opportunistic small rodent that survives in aeolian habitats by feeding on groundwater-dependent, deep-rooted plants that provide cover, such as honey mesquite (*Neltuma odorata*, previously *Prosopis glandulosa* var. *torreyana*). The squirrel consumes mesquite seeds as food and uses the shrub as structure and shelter for their burrows. Omnivorous in their diet, the PSRTGS will also consume insects such as ants, termites, and grasshoppers when vegetation is scarce. Within our network of plots, we regularly observe PSRTGS at Willow Hole, Fingal's Finger (FF), and Tipton Road, where sandy soils and adequate vegetation support stable populations. Biologists differentiate this species by their unique vocal patterns and tones. During surveys, we record the number of alarm calls heard, which helps indicate their presence even when tracks are absent during standardized tracking, such as during extreme heat conditions, as squirrels adapt to extreme heat and arid conditions by excavating deep burrows and limiting activity during excessive heat. Hudson (1964) suggested that this species does not hibernate but exhibits periods of torpor (inactivity).

4.4.2 Results

This year, we detected PSRTGS (tracks and/or alarm calls) at eight plot clusters: AD2, J, L, Fingal's Finger (FF), Tipton Road (ESF 19-24), Willow Hole (MH 19-24, MH 25-29), and Kim Nicol (KN 1-3). Fingal's Finger reported a mean density of 3.4 individuals per plot. Willow Hole (MH 19-24) experienced a mean density rise from 1.6 in 2024 to 3.2 this year, while MH 25-29 increased in density from 2.4 in 2024 to 3.5 this year. The Tipton Road (ESF 19-24) plot cluster experienced a decline in mean individuals per plot cluster from 3.6 in 2024 to 2.5 this year. All plots in CVNWR showed somewhat low densities in comparison to previous years, with slight increases at AD2, J, and L; however, we detected no individuals at CA, AD4, or MH 7-12.

a.



b.

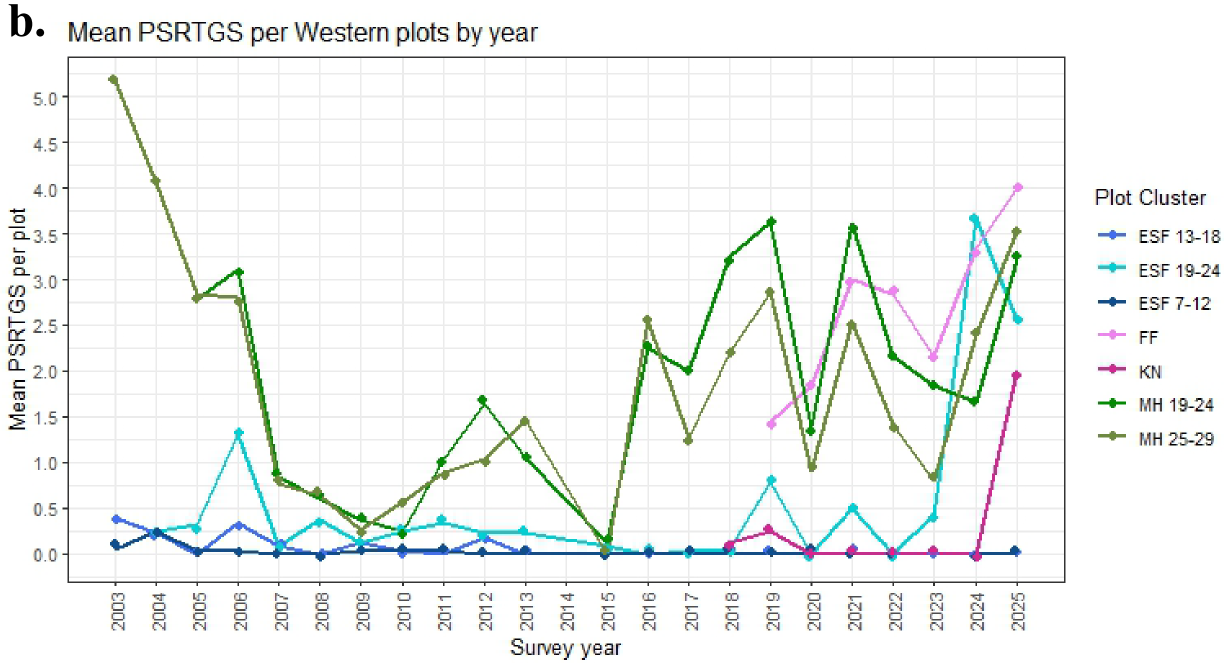


Figure 8. Mean Palm Springs round-tailed ground squirrel densities per plot cluster at the CVNWR (a) and Western plots (b) since 2003. Data shown is from tracking surveys only.

4.4.3 Discussion

After two years of low densities at the CVNWR plots, we find it encouraging to see signs that this species persists at these sites. Lower numbers aren't unprecedented in our record, and we found similarly low abundance of this species during and after the severe drought period of 2012-2015. Impacts to habitat from Tropical Storm Hilary in habitat, combined with a recent dry period may have caused a similar drop in numbers We continue to see no signs of the PSRTGS at our plots in the Whitewater Floodplain. This squirrel species appears to prefer habitats that provide cover, particularly from large, dense shrubs. Fingal's Finger (FF) and Tipton Road (ESF 19-24) feature abundant and thick creosote, while the vegetation at Willow Hole (MH 19-24, MH 25-29) is comprised primarily of dense mesquite thickets interspersed with sandy clearings. These habitats likely contribute to the robust squirrel populations in these areas, as supported by similar studies in the literature (Ball et al. 2010). The decrease in PSRTGS at Tipton Road, despite an increase in perennial plant cover (Figure 8), could be explained by the lower precipitation we received this year or normal population fluctuations. Despite the decrease in population at Tipton Road, the population remains higher than in all years before 2024 and therefore does not concern us at this time. Notably, we recorded the first presence of PSRTGS at KN since 2019.

4.4.4 Recommendations

We advocate for the continued monitoring of this species, as well as the assessment of vegetation coverage, to better understand the factors influencing the population dynamics of the Palm Springs Round Tailed Ground Squirrel.

4.5 PALM SPRINGS POCKET MOUSE (*PEROGNATHUS LONGIMEMBRIS BANGSI*)

4.5.1 Introduction

The Palm Springs pocket mouse (*Perognathus longimembris bangsi*, or PSPM) is a primarily nocturnal, granivorous rodent that inhabits areas of sandy creosote scrub of the Coachella and Imperial Valleys (Swei et al. 2003). Typically, the length of the PSPM's entire track is smaller than a thumbprint from our researchers, making it typically easy to differentiate from the larger desert pocket mouse (*Chaetodipus penicillatus*), which occupies much of the same habitat in the Coachella Valley. The Palm Springs pocket mouse has adapted to feeding on native plants, with seeds from herbaceous plants and grasses providing the primary food source for the species (Dodd 1996). This small rodent requires a substrate that can support its burrows, which can be up to 2 to 3 feet deep. These burrows serve as nests and food storage for the mouse. This subspecies is classified as a "sensitive species" by the Bureau of Land Management and a "species of special concern" by the state of California. The combination of isolated populations, small range, and little remaining habitat within the range makes the species highly susceptible to extinction due to urban development and random events such as fire, drought, disease, or other occurrences (M. L. Shaffer 1981; M. Shaffer 1987; Meffe & Carroll 1994, Primack 1998).

4.5.2 Results

We noted changes in the density of Palm Springs pocket mice across various plot clusters. In clusters AD4 and CA in the CVNWR, we saw an increase of 0.3 pocket mice for both plots from 2024. The ESF 19-24 cluster increased mean individuals per plot cluster from 0.7 in 2024 to 2.1 this year, while the MH 19-24 plot numbers rose from 0.4 individuals in 2024 to 1.4 individuals this year. The MH 25-29 cluster population increased from a mean density of 0.2 individuals in 2024 to 1.2 individuals this year, and cluster KN saw a rise from 0.5 individuals in 2024 to approximately 3 individuals per plot cluster this year. Some clusters showed declines; in cluster AD2, the population decreased from 1 individual per plot cluster in 2024 to 0.8 this year, and cluster H dropped from 2.0 in 2024 to 1.7 this year. Fingal's Finger fell from 0.5 in 2024 to 0.1 this year, and ESF 13-18 decreased from 1 in 2024 to 0.5 this year. Clusters with larger declines included MH 7-12, which went from 4.0 in 2024 to 2.9 this year, and cluster L, which dropped from 2.7 last year to 0.9 this year. The population at cluster J remained stable over the past two years.

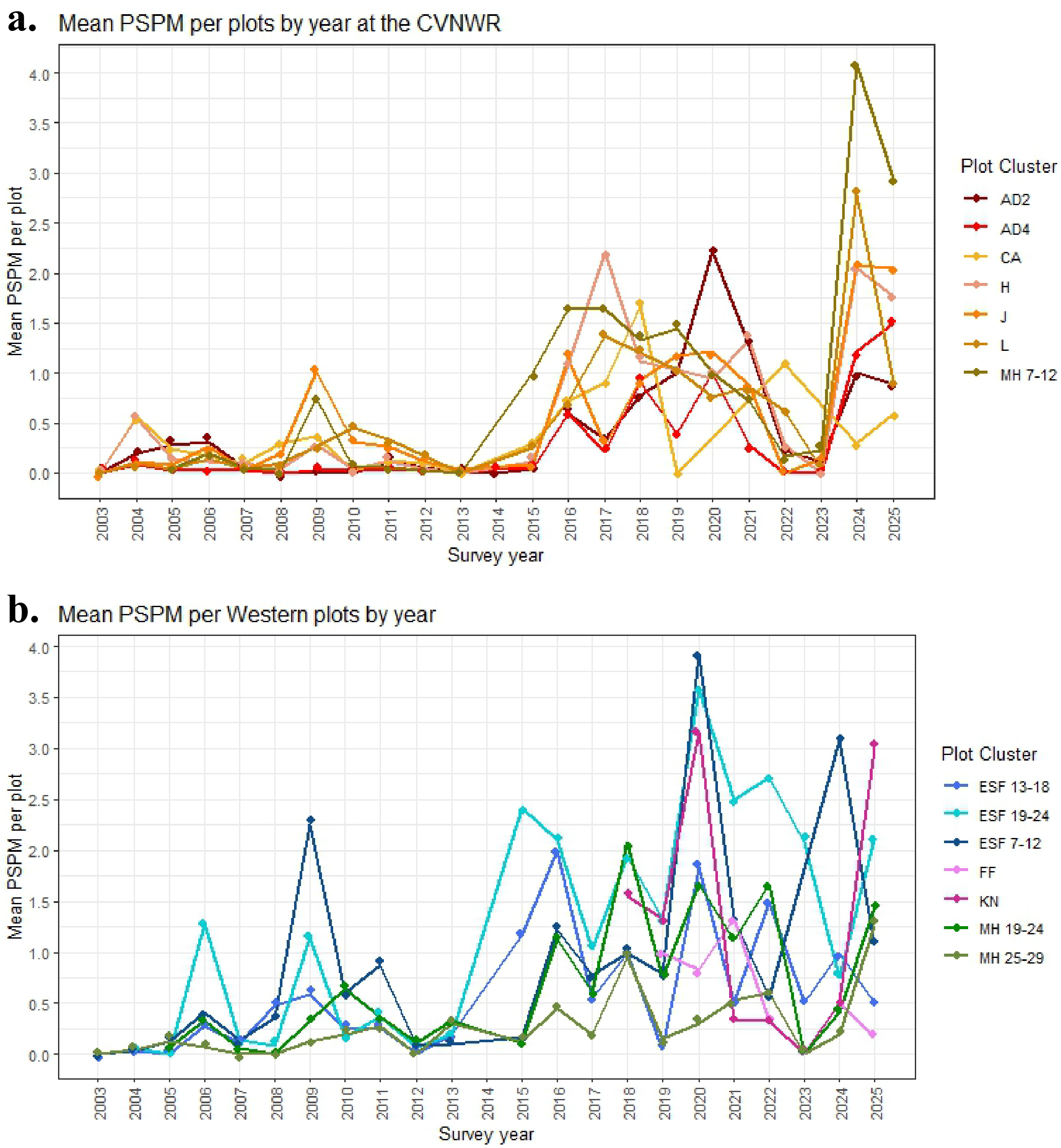


Figure 9. Mean Palm Springs pocket mouse densities per plot cluster at the CVNWR (a) and Western plots (b) since 2003.

4.5.3 **Discussion**

The Palm Springs pocket mouse demonstrates a reliance on vegetation and seeds for both food and shelter. Five plots within the CVNWR recorded a decline in Palm Springs pocket mouse activity (Figure 9), which likely correlates with the lack of annual plant vegetation observed this year in these areas. During the Fall of 2024 and the Winter of 2024-2025, precipitation levels were low, registering approximately 0.02 inches in Indio and 0.95 inches in Palm Springs. Our surveys at the Coachella Valley National Wildlife Refuge (CVNWR) and ESF 7-12 and ESF 13-18 on the Whitewater Floodplain, revealed that native annual plant cover at these monitored plots, measured either 0% or 0.1% when rounded to the nearest tenth (refer to the Annual Plant Monitoring section).

The possible causes of the declining population in plot ESF 7-12 include low annual plant numbers, increased competition, predation, or other impacts, such as substandard monitoring conditions. Datasheets noted each survey was taken in a “breezy” weather condition, and since this species has the lightest footprint of all of the mammals we record, our low numbers may be because the wind may have blown out the tracks of this nocturnal species. The ESF 7-12 plot in the Whitewater floodplain also contains more gravel than other plots, making track detection more difficult.

Simultaneous studies such as the CVCC and partner-coordinated I-10 connectivity and corridor project and studies using small mammal trapping may help discern if there is a change in the population numbers of Palm Springs pocket mice within the western corridor due to unknown causes. Overall, population trajectories are positive, showing recovery after a longer-term drought period.

4.5.4 Recommendations

We advocate for the continued monitoring of this species, as well as the assessment of vegetation coverage, to better understand the factors influencing the population dynamics of the Palm Springs pocket mouse.

5 VEGETATION

5.1 ANNUAL PLANT MONITORING

5.1.1 Introduction

The inter-annual variation of precipitation within arid ecosystems drives the species composition, abundance, and density year-to-year of annual plant communities (Inouye 1991, Guo & Brown 1996). On average, the Coachella Valley receives most of the yearly precipitation in the winter, which results in the bulk of plant growth occurring in the spring (McHargue 1973, Barrows & Heacox 2021). The region also receives summer precipitation which can produce a smaller growing period in the fall due to the less reliable and variable nature of monsoonal storms. Our yearly annual plant-focused surveys take place in the spring, and so these most effectively describe the plant communities that rely on winter precipitation.
This study aims to track the population dynamics of native annual plant species, including the federally-endangered and Plan-protected Coachella Valley milkvetch (*Astragalus lentiginosus* var. *coachellae*), as well as the impact of invasive plants on native species. For example, our long-term study showed how Sahara mustard (*Brassica tournefortii*) population dynamics affect native plant and wildlife populations (Barrows et al. 2009, Hulton VanTassel et al. 2014, Rodriguez et al. 2025). Our annual plant monitoring can clarify remaining questions regarding the effects of invasive plants at these aeolian areas, as well as provide critical information on relatively new arrivals to this area, such as stinknet (*Oncosiphon pilulifer*), which will aid in early detection and control efforts.

5.1.2 Methods

Our annual monitoring protocol uses 1 m² quadrat frames to sample plant cover and density. We place the frame four times at the 0 m, 50 m, and 100 m poles, for a total of 12 quadrat frame samples per plot (Figure 10). We identified, counted, and visually estimated percent cover of all live annual plants, plus identifiable dead annual plants (noted separately from live) and perennial seedlings within the quadrat frame. We then recorded total plant cover which includes both annual and perennial plant growth. We visually estimated the percent cover of different substrate types by the same definitions we used for LPI protocol (see section Perennial Plant Communities, Methods). When estimating percent cover, we record to the nearest whole percentage, meaning that species and ground cover types that are less than 1% are recorded as "<1%". For the purpose of calculating means, we used a value of 0.5% in place of percent cover values below 1%.

In 2025, we performed our annual plant surveys from late March to early May in the spring season of 2024 on 79 of our long-term plots, many of which have been regularly surveyed since 2003 (Figure 1). Data was not collected in 2014 (no funding allocated) and 2021 (we found inadequate justification in the survey effort across sites due to the lack of annual plant cover because of a drought). Overall, these metrics provide us with species richness, abundance, and habitat composition.

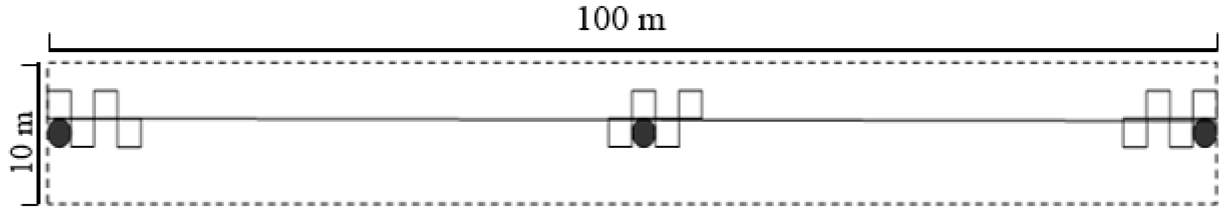


Figure 10. Diagram of quadrat layout along a plot midline. Black filled circles indicate end and middle points along the centerline. Small squares indicate locations of 1x1 meter quadrats.

5.1.3 Results

This year, the Coachella Valley received little precipitation in the winter and spring months leading up to the spring annual plant season and we saw decreases in most measured aspects of plant productivity- species richness and native and invasive annual plant cover- with few exceptions. We observed an overall decrease in richness across most plots aside from ESF 19-24 (Tipton Rd) which experienced the highest richness with 22 plant species documented with a slight increase from 2024 (17 species) (Figure 11). The mean native annual plant percent covers for all plot clusters decreased except at FF (Fingal's Finger), which increased from last year and had the highest native annual plant cover at 5.6% (Figure 12). FF likely received more precipitation and slightly lower temperatures due to its position as our most western survey location. Notably, native annual plant cover at all plots at the CVNWR, and ESF 7-12 and ESF 13-18 on the Whitewater Floodplain measured either 0% or 0.1% (Figure 12).

We noticed the same decreases and low plant productivity for the invasive annual plants as well. Mean invasive plant percent cover was below 0.5% for all plot clusters except FF which saw 4.3% invasive plant cover. We recorded one plot cluster at the CVNWR, J, which had slightly higher invasive plant cover (0.2%) compared to native plant cover (0.1%). But overall, we measured low invasive plant cover this year, likely due to the small amount of precipitation ahead of the spring growing season.

Table 1. Summarizing the annual plant species richness as well as mean total percent cover of native annuals and total cover of non-native annuals by plot cluster for the 2025 spring quadrat surveys.

CVNWR	Plot Cluster	Species Richness 2025	Species Richness 2024	Mean Native % Cover 2025	Mean Native % Cover 2024	Mean Invasive % Cover 2025	Mean Invasive % Cover 2024

	AD2	5	32	0.1	5.1	0	3.4
	AD4	2	18	0	1.7	0	0.7
	CA	1	38	0	19.4	0	2.8
	H	5	21	0.1	7.5	0	0.5
	J	4	21	0.1	5.5	0.2	0.8
	L	4	21	0.1	17.5	0	1.1
	MH 7-12	0	18	0	14.8	0	1.3
Western Plots	ESF 07-12	1	9	0.1	2.4	0	0.0
	ESF 13-18	1	7	0	1.3	0	0.0
	ESF 19-24	22	17	2.6	2.9	0.3	0.3
	FF	17	18	5.6	1.9	4.3	1.6
	KN	10	21	1.1	5.1	0.3	5.7
	MH 19-24	11	25	0.3	2.4	0	1.0
	MH 25-29	11	19	0.35	1.7	0.2	1.6

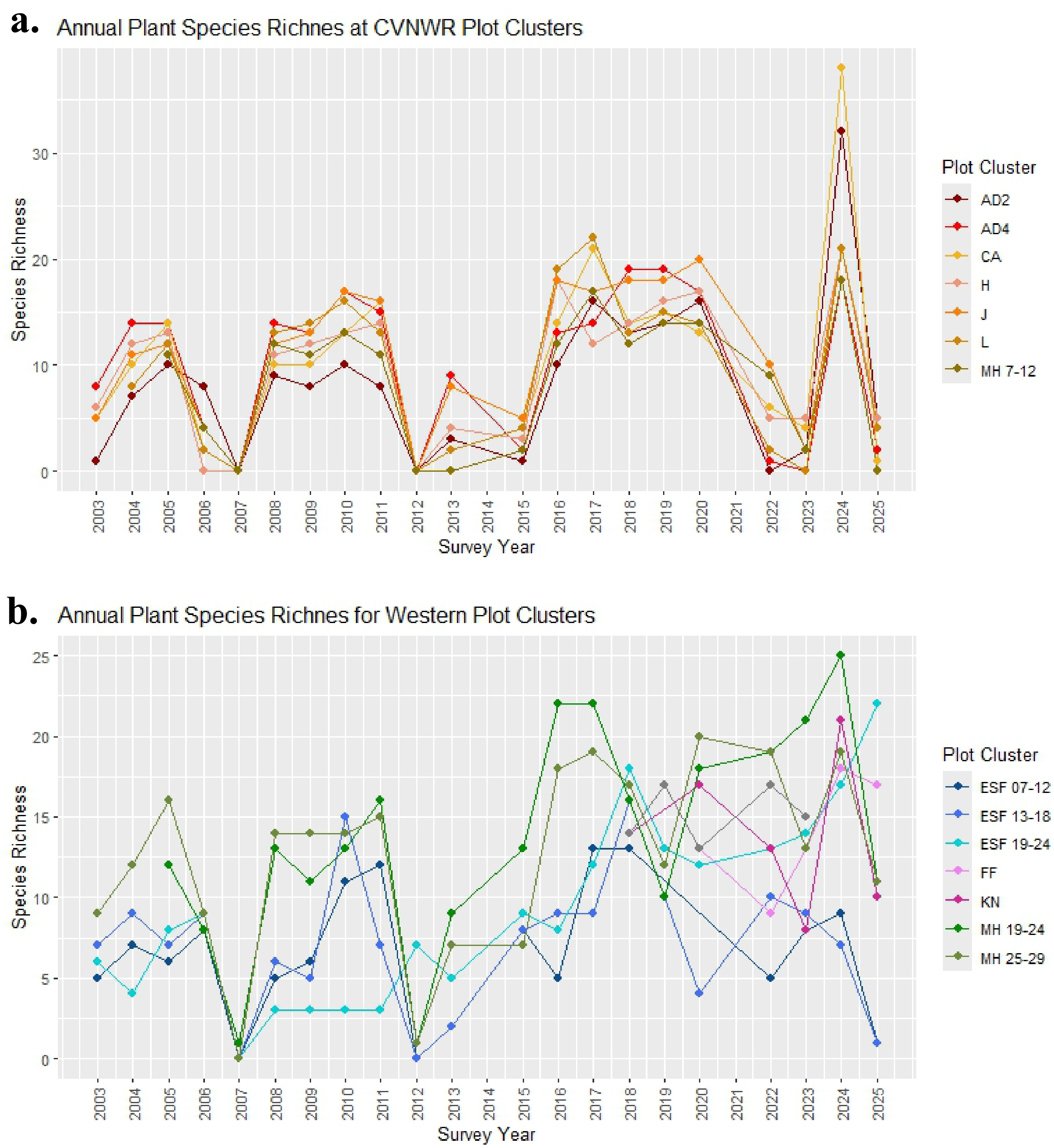
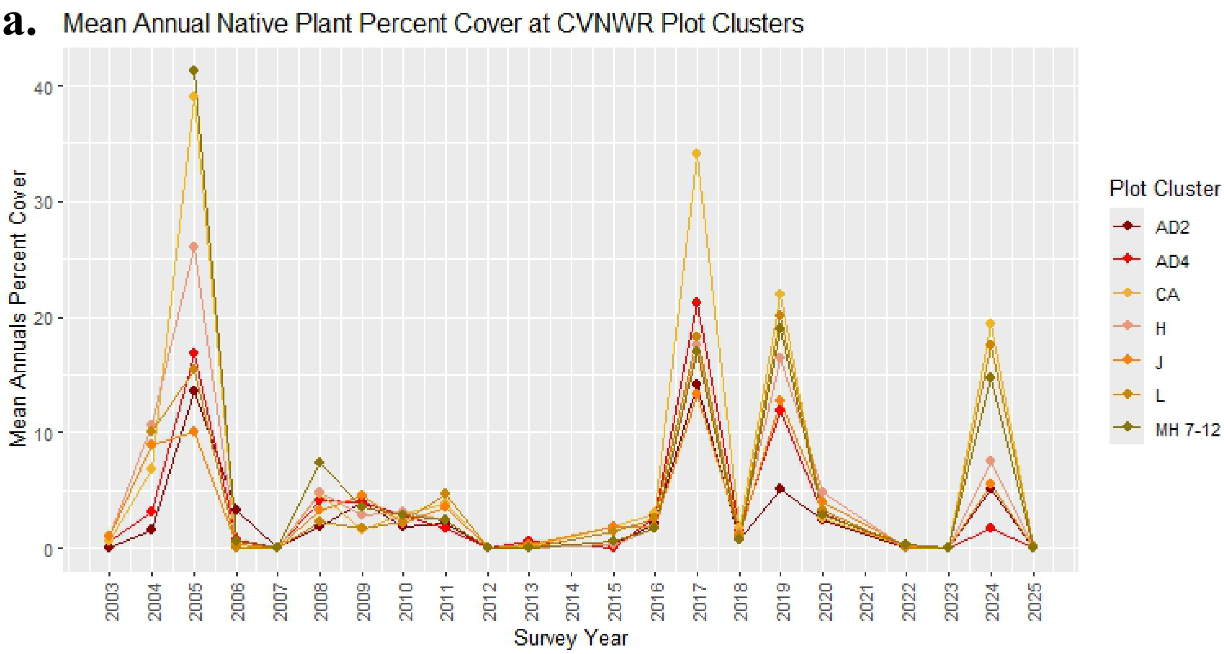


Figure 11. Annual plant species richness per plot cluster at the CVNWR (a) and Western plots (b) from 2003 to 2025. Data was not collected in 2014 (no funding allocated) and 2021 (due to the drought). Points represent the total number of species recorded at each plot cluster per survey year.

a.



b.

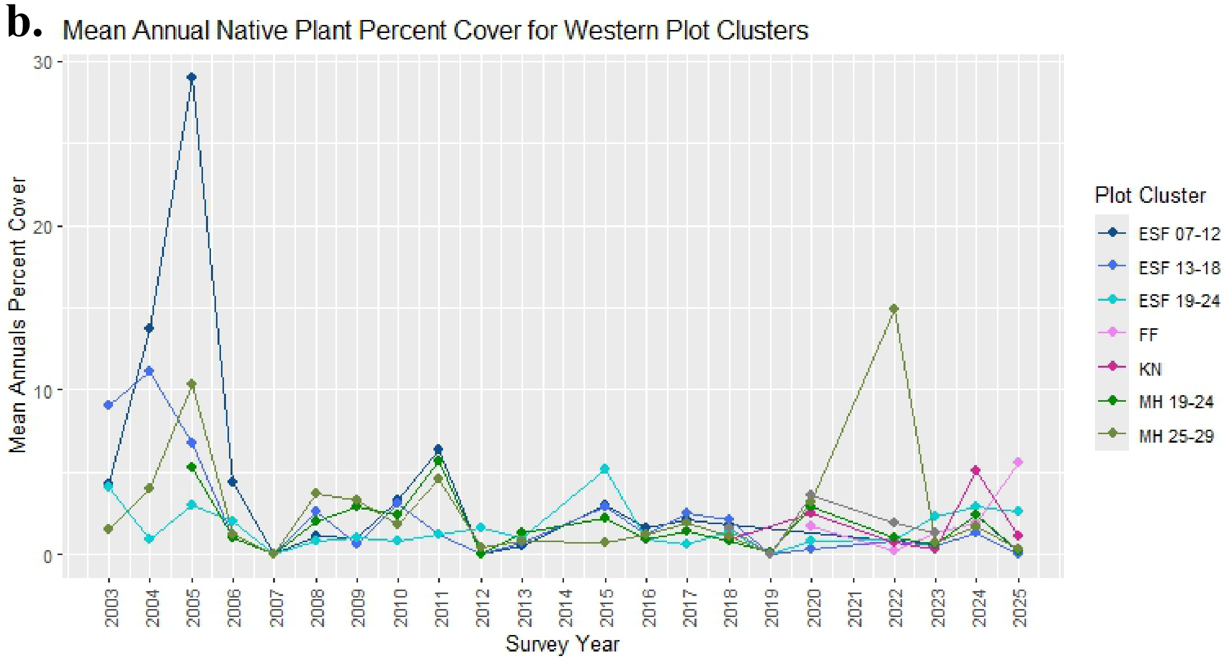
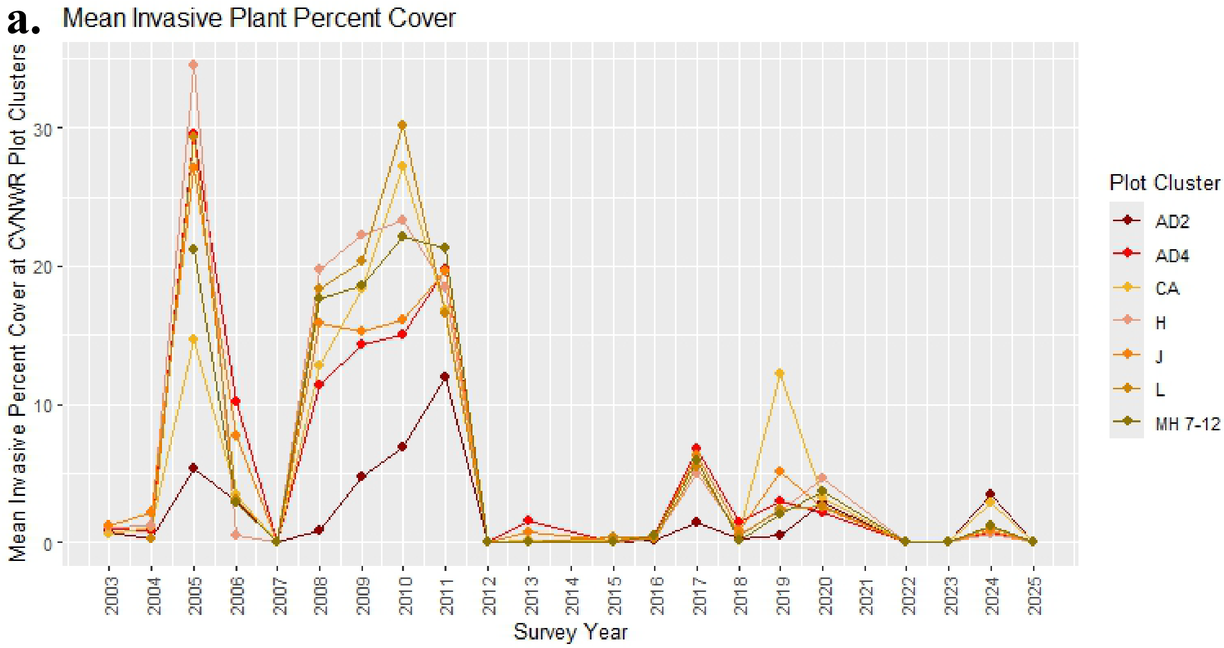


Figure 12. Mean annual native plant percent cover per plot cluster at the CVNWR (a) and Western plots (b) from 2003 to 2025. Data was not collected in 2014 and 2021.

a.


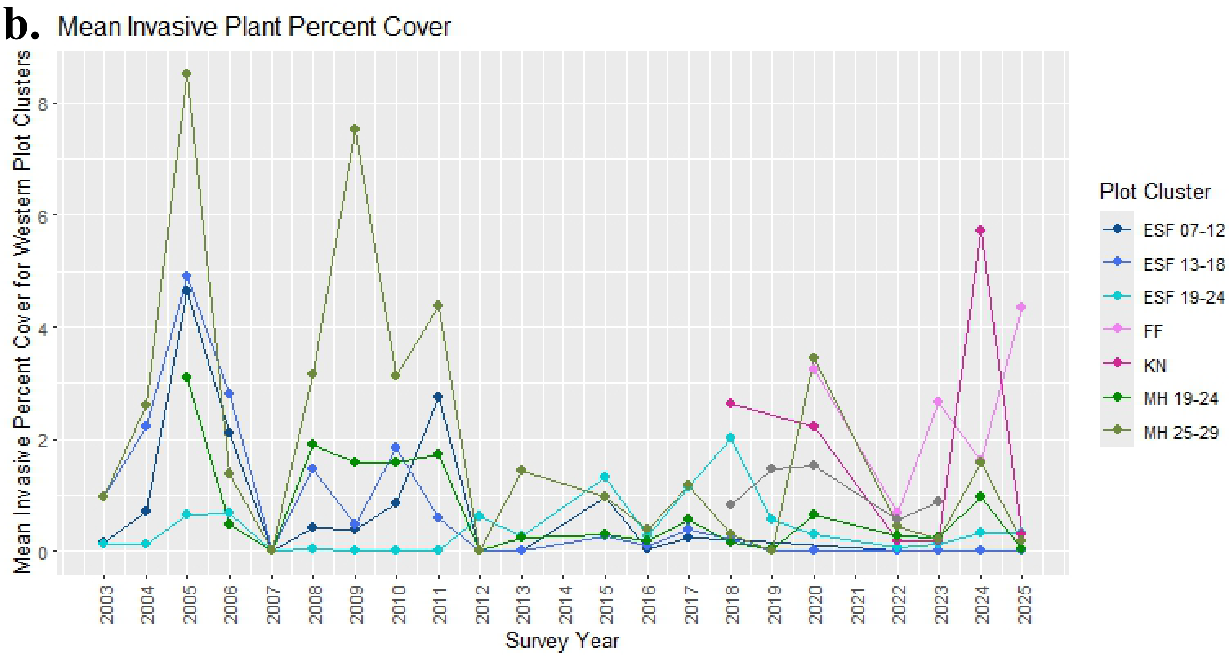
b.


Figure 13. Mean non-native annual plant percent cover per plot cluster at the CVNWR (a) and Western plots (b) from 2003 to 2025. Data was not collected in 2014 and 2021.

5.1.4 Discussion

The low annual plant productivity this year reflects the relatively small amount of precipitation the Coachella Valley received in the months leading up to monitoring. Our western-most plots, Fingal's Finger (FF) and Tipton (ESF 19-24), showed notably higher richness and native annual plant cover than the rest of our study plots, likely due to their geographic position closer to the Inland Empire, which results in higher precipitation and cooler temperatures than the rest of the valley. We continue to see lower numbers of invasive annual plant cover than native annual plant cover aside from Fingal's Finger, a trend that has persisted since beginning annual plant monitoring of this plot in 2020.

We did not note a resurgence of the non-native stinknet (*Oncosiphon pilulifer*) at Willow Hole (MH 19-24, MH 25-29) or between ESF 23 and ESF 24 at Tipton this year. However, we did find an emerging stinknet patch on the side of road along Hwy 111 in front of our access point to our Tipton Rd plot cluster (ESF 19-24). The first detection was on April 24th when staff pulled the flowering plants and seedlings and placed them in a gallon plastic bag and disposed of it. We revisited the site three more times throughout our vertebrate surveys and continued to pull stinknet if present until the end of our surveys at that plot cluster on July 3rd, 2025. We did not detect any stinknet on our last visit to that site. We do not find the location of this new stinknet patch along heavily trafficked Hwy 111 particularly surprising. The small seeds of *Oncosiphon pilulifer* get stuck in tire treads and deposited to new locations when drivers pull to the side of the road, and can be found in abundance on dirt shoulders where it has established populations. While we find the lack of resurgence of stinknet following last year's management by removal encouraging finding new patches of stinknet presents the ongoing concern of stinknet becoming more abundant throughout the Coachella Valley similar to coastal and inland areas to the west (UC ANR 2023). We continue to not document this invasive plant on our plots, however we believe it to be crucial to continue to monitor its progress and anticipate areas of concern and continue coordinating eradication efforts.

5.1.5 Recommendations

Continued monitoring of species composition of annual plants across our long-term monitoring sites will provide us with an understanding of annual plant response to precipitation and those effects on habitat health. We will continue to monitor *O. pilulifer* near our plots and pull on-site following appropriate containment procedures and recommend eradication efforts and education to reduce the spread of this invasive species.

5.2 PERENNIAL PLANT COMMUNITIES

5.2.1 Introduction

Perennial plant communities affect the sustainability of aeolian habitats due to their long-term impacts on sand movement across landscapes and fine-scale patterns of aeolian sand deposition and particle size discrimination. In general, vegetation aids in sand retention and sand stabilization within aeolian habitats. Sand accumulation is necessary for the survival of several species monitored under the CVMSHCP as they rely on mounds of soft sand as cover to evade predation. Other impacts of sand deposition include the retention of soil water, which contributes to annual plant growth, feeds back to higher water availability to perennial plants, and both of which contribute to inputs of organic biomass that provide resources to animals. However, vegetation can also lead to stabilization by increasing the compaction of the substrate thus reducing the quality of the habitat for species that rely on softer sand. In order to capture these habitat shifts over time, we perform Line Point Intercept surveys on our long-term plots in aeolian habitats during the fall to monitor the condition of perennial plant communities and take sand compaction measurements to assess how much soft sand remains in the habitat. The timing of these surveys coincides with hatchling season for lizards and provides information about the amount of cover available to these and likely many other species (Barrows & Allen 2010). In this section, we aim to understand and measure long-term diversity and stability of perennial plants in aeolian habitats as a measure of conservation success and how environmental and anthropogenic pressures may change these vegetation stands over time.

5.2.2 Methods

We continued the use of Line Point intercept (here after LPI), a survey method we began using in 2022, because when tested, it reduced error in data collections for sparsely vegetated communities when compared to the previously used belt- and line-intercept methods (Mueller-Dombois et al. 1974, University of Idaho 2009, Drezner et al. 2021, UCR 2022, USDA n.d.). This protocol captures changes in species richness, canopy density, and substrate type over time resulting in a usable and repeatable survey across a wide range of habitats. We conducted all surveys on our long-term plot network of 79 0.1 ha plots (Figure 1; and as described in Methods: Aeolian Community Plot Network). We did not have time this season to survey the newly established plots near Gene Autry Trail and Snow Creek and this will be accomplished in 2025-2026.

We ran a 100-meter measuring tape down the midline of each 0.1 ha plot to mark where measurements are taken (Figure 14). Each plot midline (transect) has permanent fiberglass poles every 25 m, (0 m, 25 m, 50 m, 75 m, and 100 m) to help ensure the surveyor consistently lines the tape along the same midline year-to-year. We laid the transect line as close to the ground as possible and pulled it taut before taking measurements. Surveyors began at the 0 m pole and walked on one side of the line towards the 100 m pole. During the survey we dropped a 30" 15.5-gauge (1.75mm) wire pin flag (hereafter referred to as "the pin") next to the other side of the line every meter on the half-meter (0.5, 1.5, 2.5…99.5) (Figure 14). We held the pin vertically and lined it up at each half-meter point, releasing it approximately 6" from the ground.

To avoid bias, we did not guide the pin from the tape to the ground, instead allowing the pin to fall freely rather than precisely on the mark. We recorded everything that touched the pin according to four positional categories: Top Canopy, Lower Canopy, Litter, and Soil Surface (Figure 15). We took soil compaction measurements using a Pocket Penetrometer (AMS Inc.) every 4 meters along the midline, totaling 25 measurements every transect.

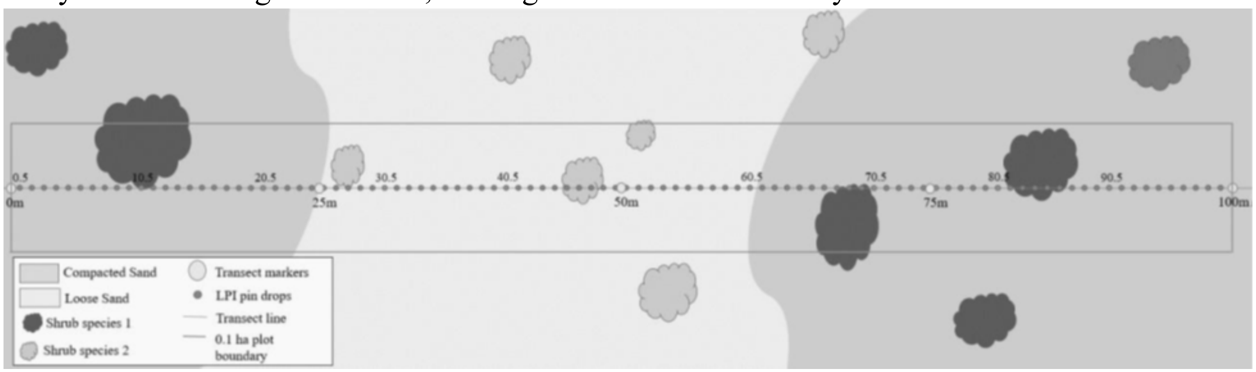


Figure 14. Illustrated example of the line-point intercept protocol, showing pin drops every meter on the half-meter mark down the centerline of the 0.1 ha plot. This example shows 9 intercepts for shrub species 1 (9% cover), 5 intercepts for shrub species 2 (5% cover), 35 intercepts for loose sand (35% cover), and 65 intercepts for compacted sand (65% cover).

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

The bulk of the annual plant biomass is dead or dormant by the fall; however, fall surveys serve to tally the surface cover and habitat, composed of perennial shrubs, long-lived perennial herbs, and live and dead summer annual herbs. We identified live and dead annual species, if rooted, to the degree possible using field identification (we did not collect samples). If not identifiable, we documented plants as “annual forb” and grasses as “unknown grass.” We recorded non-native species, dead or alive, to species level as well. We classified unrooted plant matter as follows: windblown debris as “litter”, understory leaf litter as “duff”, or coarse woody debris as “wood”.

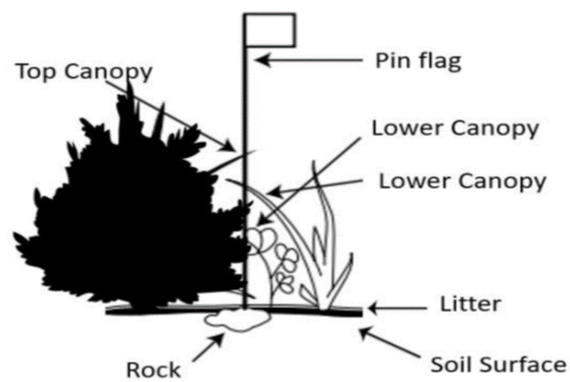


Figure 15. Illustrated example of a pin intersecting cover categories. Adapted image from USDA, n.d.

Lastly, we recorded the soil surface types: blow sand, compacted sand, large rocks, small rocks, and silt, defined by the size of granules and compaction. We classified blow sand as loose sand on the ground surface that could be moved with 20 mph winds and with granules larger

(0.5-2mm) than silt. We defined compacted sand as sand that was stabilized, or not easily moved by wind, and with granules less than 2 mm in diameter (Moorberg and Crouse 2021). While sand compaction may be measured as a continuous variable from very loose to well-compacted; defining a threshold between blow and compacted sand remains challenging. We consider the defining line between blow and compacted sand to be attributed by how Plan protected species use sand within habitats for cover and camouflage. We identified silt as a very fine substrate lacking easily visible granules like sand. We defined small rocks as having a diameter from 2 – 10 mm and large rocks as having greater than 10 mm diameter (USDA n.d.).
All cover types are calculated as a percent for each plot by averaging the number of intercepts per category across the number of pin drops total at the site, using the following equation:

$$Cover\ of\ spp\ A = \left(\frac{\#\ spp\ A\ intercepts}{total\ \#\ drops}\right)\ x\ 100$$

5.2.3 **Results**

We conducted this set of surveys from October 2024 through December 2024. Plot clusters varied between 5-7 plots per cluster except for Fingal's Finger and Kim Nicol which both have 3 plots per cluster (Figure 1). We documented 18 species of perennial plants (10 shrubs/trees, 4 perennial herbs and 4 perennial grasses) (Table 2) and we calculated the mean number of perennial, native annual, and invasive annual plant intercepts per plot by cluster, which is approximately equivalent to mean percent cover.

While the change in cover was not tested statistically, the following general trends were observed, which may also be attributable to slight variations in sampling. We saw increases of perennial plant cover at all the plots at the CVNWR with a notable 5% or above cover increases at CA and H. KN (Kim Nicol), ESF 19-24 (Tipton Road), MH 19-24, and MH 25-29 (Willow Hole) plots saw slight increases with MH19-24 having the highest perennial plant cover this year at 21.8% and ESF19-24 having the third highest percent cover at 19.5% (Figure 13). We saw slight decreases at ESF7-12, ESF13-18 (Whitewater Floodplain), and FF (Fingal's Finger) although FF still had the second highest cover at 21% (Figure 13). MH7-12 at the refuge continues to have the lowest cover 2.8% despite the slight increase it saw from 2024. *Larrea tridentata* was the only perennial species present across all plot clusters and among other dominant species, *Atriplex canescens* and *Atriplex polycarpa* were present at all plot clusters at the CVNWR as well as MH 19-24 (Table 2). We also saw *Atriplex canescens* present at MH 25-29 (Willow Hole). Additionally, we recorded dead *Atriplex canescens* at the same plots we saw alive shrubs (Table 2).

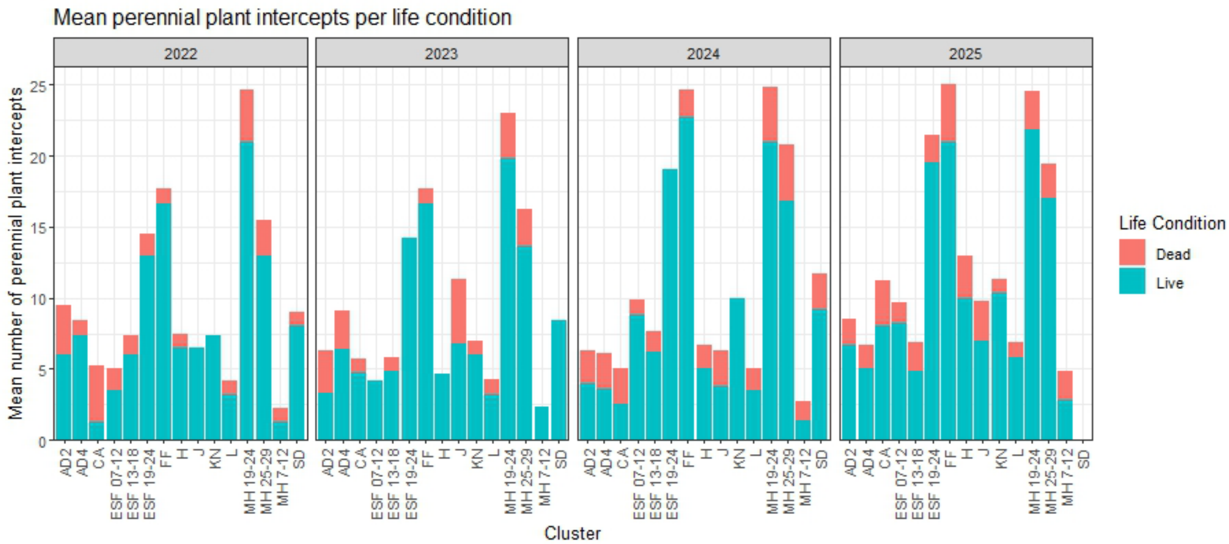


Figure 16. Mean number of live and dead perennial shrub intercepts per plot cluster for 2022, 2023, 2024, and 2025. Mean number of intercepts is approximately equal to mean percent cover.

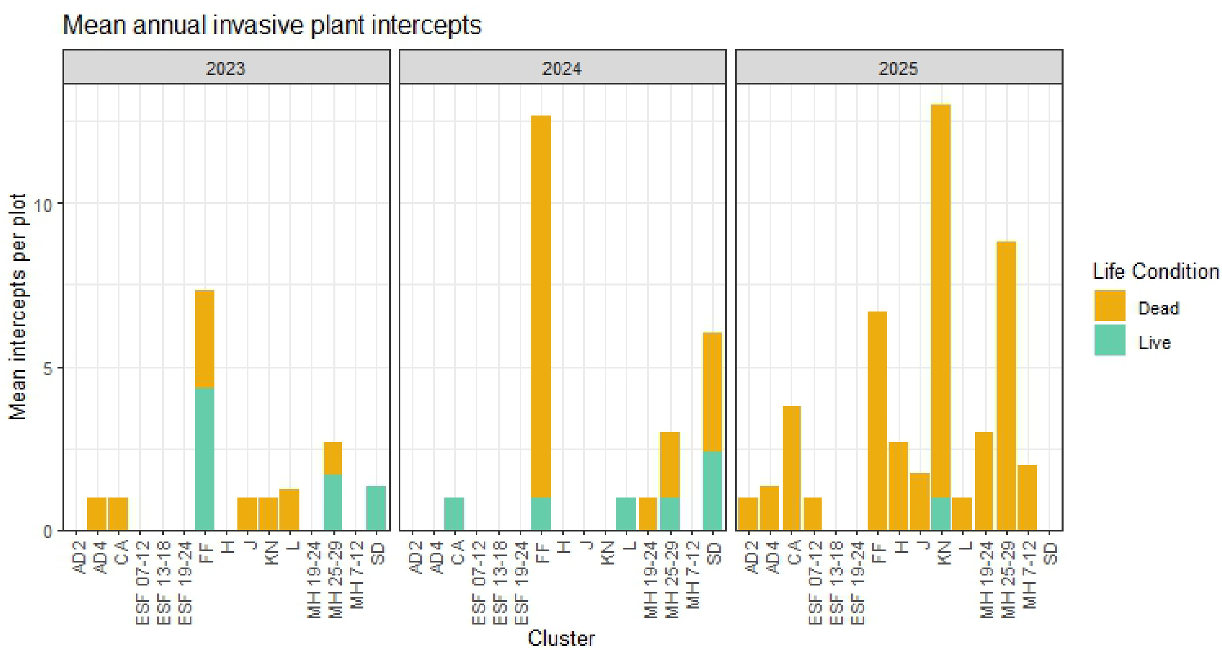


Figure 17. Mean number of live and dead invasive annual plant intercepts per plot cluster for 2023, 2024, and 2025. Mean number of intercepts is approximately equal to mean percent cover. We excluded 2022 from this graph because the majority of the annual data collected was marked as ‘annual forb’ and nativity could not be determined from that classification.

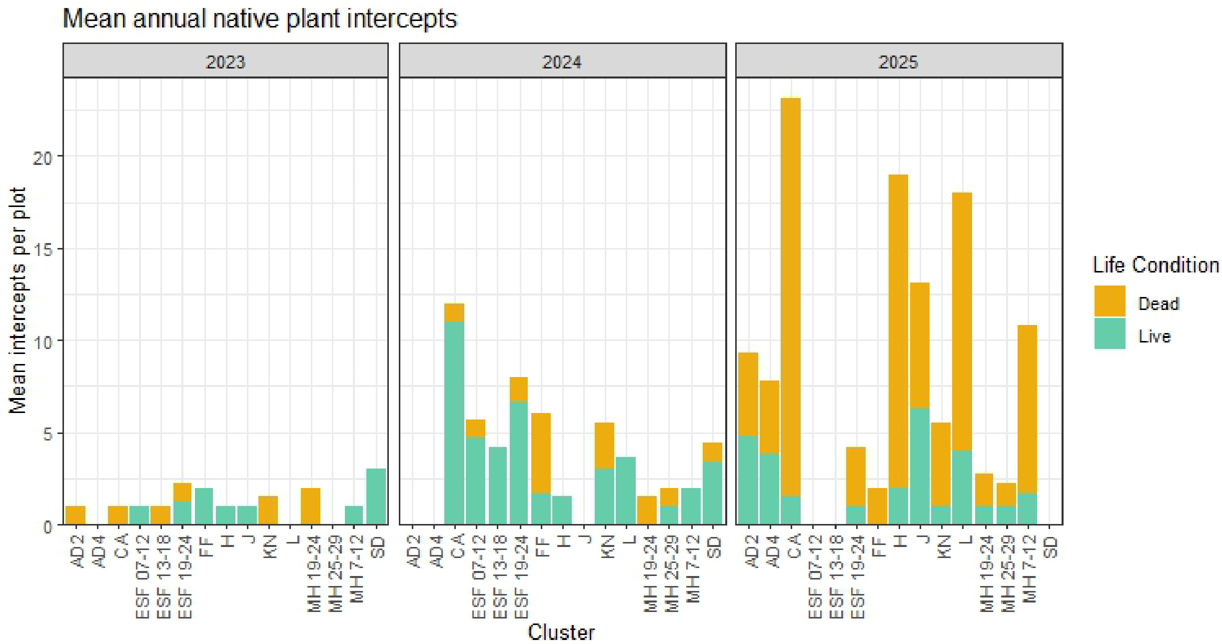


Figure 18. Mean number of live and dead native annual plant intercepts per plot cluster for 2023, 2024, and 2025. Mean number of intercepts is approximately equal to mean percent cover. We excluded 2022 from this graph because the majority of the annuals data collected was marked as 'annual forb' and nativity could not be determined from that classification.

We found an increase in invasive plant cover in one plot KN (Kim Nicol) while dead invasive cover increased across all plots except FF (Fingal's Finger). We recorded dead invasive species to be dominant in the landscape, and while past the point of control, this still gives us information on where invasive species exist within our aeolian habitats. We found the presence of *Brassica tournefortii* at all plots at the CVNWR except MH7-12 and most western plots with the exception of ESF13-18 (Whitewater Floodplain) and ESF19-24 (Tipton Rd) (Figure 14). Notably, we recorded *Salsola tragus* in all plots at the CVNWR except AD4. We saw *Schismus* sp. along the roadside plots (H, L, J) and CA at the CVNWR and FF (Fingal's Finger), KN (Kim Nicol), and MH19-24, MH25-29 (Willow Hole) (Table 2).

We saw increases in dead annual vegetation cover in a majority of plots due to the high spring annual bloom seen in 2024. We recorded increases in live native annual plants at AD2, AD4 and J at the CVNWR and MH19-24 at Willow Hole (Figure 15). We saw decreases in live annual plant cover for CA at the CVNWR, ESF 7-12, ESF 13-18 (WWFP), ESF 19-24 (Tipton Rd), FF (Fingals Finger) and KN (Kim Nicol) (Figure 15). We recorded either dead or alive *Abronia villosa, Chylismia claviformis, Geraea canescens, Johnstonella angustifolia* and *Palafoxia arida* on all plots within the CVNWR and *Dicoria canescens* in all plots except L (Table 2). Notably, we found no evidence of native annual plants remaining, live or dead, at ESF 7-12 and ESF 13-18 (Whitewater floodplain) (Table 2).

Table 2. Species, growth form, and mean percent cover of plants recorded at each plot cluster surveyed this year. White cells indicate the presence of a species at a plot cluster and black cells indicate a species was not recorded at a particular plot cluster.

		CVNWR							WWFP		West Valley		West Indio Hills		
	Species	**AD2**	**AD4**	**CA**	**H**	**J**	**L**	**MH 07-12**	**ESF 07-12**	**ESF 13-18**	**ESF 19-24**	**FF**	**KN**	**MH 19-24**	**MH 25-29**
Perennial Shrubs*	*Ambrosia dumosa*											■	■		
	Atriplex canescens	■	■	■	■	■	■	■						■	■
	Atriplex polycarpa	■	■	■	■	■	■	■						■	
	Isocoma acradenia													■	
	Krameria bicolor											■			
	Larrea tridentata	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Petalonyx thurberi								■		■				
	Prosopis glandulosa var. torreyana													■	■
	Psorothamnus arborescens								■	■	■				
	Psorothamnus emoryi	■											■	■	
Perennial Shrubs - Dead*	*Atriplex canescens*	■	■	■	■	■	■	■						■	■
	Atriplex polycarpa			■	■										
	Atriplex species	■		■		■	■	■						■	■
	Bebbia juncea										■				
	Larrea tridentata			■											
	Native shrub													■	
	Prosopis glandulosa var. torreyana							■							■
	Psorothamnus arborescens									■					
Perennial Herbs**	*Croton californicus*								■	■	■	■	■		
	Datura wrightii														
	Tiquilia plicata	■	■			■			■		■			■	
Perennial Grasses**	*Hilaria rigida*												■		
	Panicum urvilleanum										■				
	Stipa hymenoides										■	■	■		
	Perennial grass species			■											
Exotic Annuals**	*Brassica tournifortii*	■	■	■	■	■	■		■			■	■	■	■
	Salsola tragus	■		■	■	■	■	■				■			
	Schismus barbatus			■	■	■	■					■	■	■	■
Native Annuals**	*Abronia villosa*	■	■	■	■	■	■	■							■
	Astragalus lentiginosus var. coachellae												■		
	Baileya pauciradiata	■	■				■								
	Chaenactis fremontii					■									
	Chylismia claviformis	■	■	■	■	■	■	■							
	Cryptantha micrantha													■	■
	Datura wrightii						■								
	Descurania pinnata													■	
	Dicoria canescens	■	■	■	■	■		■			■	■	■		■
	Eremalche exilis			■	■		■	■							
	Eriastrum eremicum													■	
	Geraea canescens	■	■	■	■	■	■	■							
	Johnstonella angustifolia	■	■	■	■	■	■	■							
	Lupinus arizonicus														
	Malacothrix glabarta				■										
	Native annual forb species			■	■						■				
	Nicotiana obtusifolia														■
	Oeoethra deltiodes	■	■		■	■	■	■							
	Oligomeris linifolia			■											
	Palafoxia arida	■	■	■	■	■	■	■			■	■	■		■
	Stephanomeria exigua						■						■	■	
Mean # of plant intercepts by lifeform	Perennial Shrubs*	0.07	0.05	0.07	0.10	0.06	0.05	0.02	0.07	0.05	0.17	0.21	0.09	0.22	0.17
	Perennial Shrubs - Dead*	0.01	0.01	0.02	0.01	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.03
	Perennial Herbs**	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.03	0.01	0.00	0.00
	Perennial Grasses**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.04	0.00	0.00
	Exotic Annuals**	0.00	0.01	0.04	0.02	0.01	0.01	0.02	0.00	0.00	0.00	0.07	0.04	0.02	0.09
	Native Annuals**	0.09	0.07	0.20	0.19	0.11	0.16	0.10	0.00	0.00	0.04	0.01	0.04	0.01	0.01

* includes trees (PROGLA)

** includes dead

5.2.4 Discussion

This marks the fourth year that we have used the LPI protocol to effectively monitor perennial plant community structure and the condition of the sand substrate throughout our aeolian plot network. This year we saw shifts in perennial shrub cover across plots and we expect some inter-annual changes in shrub cover depending on precipitation. This may be reflective of the growth of individual shrubs, or recruitment of new shrubs on the landscape. CA and H at the CVNWR saw a 5% or more increase in perennial shrub cover, areas that flooded during the previous summer and perhaps still benefiting from water remaining in the soil. Another example of how we continue to see the after-effects of the previous year's precipitation is the higher than normal dead native annual cover. The remnants of the fall 2023 and spring 2024 annual growth continue to provide ecosystem services by supplying extra cover for prey animals and shade for all animals within aeolian habitats. This protocol serves as a valuable look into how plant cover, dead or alive, contributes to the habitat, giving us a better picture about the seasonality of aeolian habitats.

5.2.5 Recommendations

We will continue monitoring during the fall-winter field season, as this allows us to track shifts for both perennial and annual plant communities across our aeolian habitat plot network. We recommend continuing to build on this LPI dataset with further fall/winter surveys to capture the results of summer growth. Adding additional years of data will greatly improve the ability to leverage this data into management actions.

6 COACHELLA VALLEY MILKVETCH (*ASTRAGALUS LENTIGENOSUS* VAR. *COACHELLAE*)

Figure 19. *Astragalus lentiginosus* var. *coachelleae.* CVNWR 2024. L. Sweet, photo.

6.1 INTRODUCTION

Coachella Valley Milkvetch, *Astragalus lentiginosus* (Douglas) Barneyby var. *coachellae* [Fabaceae] (hereafter ASTLEN) is an endemic plant of the Coachella Valley that occurs throughout a wide portion of the CVMSHCP area. ASTLEN is listed as endangered in both California and federally (CNPS 2023, USFWS 1998) and is categorized as California Rare Plant Rank (CRPR) 1B.2. This taxon is listed due to its endemism and limited range, within which development and OHV activity are the highest ranked threats to the species (USFWS 1998, CNPS 2023). It is found only in areas with abundant loose, wind-blown sand, as seed scarification aids germination (Meinke et al. 2007). 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 the San Gorgonio River in Cabazon, CA.

Yearly counts of ASTLEN provide us with a snapshot of the condition of the overall population throughout aeolian habitats in the Coachella Valley through presence and abundance data. These surveys also identify the relationship between this species and other co-occurring native and invasive species, and other ecological factors. While our past work has indicated that greater than one survey per season would be useful in improving population trends per site, this year the emergence was too poor to justify an intensive effort.

Figure 20. *Astragalus lentiginosus var. coachellae* seedling (left) and perennial "second year" plant (right) at CVNWR, spring 2025. Photos, R. Gallardo.

6.2 Methods

We have conducted ASTLEN count surveys since 2005 (excluding 2014 and 2021) across all active 0.1 ha aeolian plots, surveying each plot once per year (see section Methods: Aeolian Community Plot Network, and note that Stebbins' Dune is no longer included in survey efforts). Surveys typically take place in the spring, approximately from late March to late April. This year, surveys took place between the 26 of March and the first of May, 2025. At least two surveyors search the 0.1 ha plots (10 x 100 meter belt). We tally all ASTLEN individuals found within the belt area and make a distinction in the data recorded based on phenology as such: a 'seedling' is defined for our purposes as a live plant that had germinated this year and showed no sign of having reproduced; 'flowering' is assigned to plants that are exhibiting flowering stages up until fruiting (including flower buds); 'fruiting' was any stage in the development of fruit, or if it showed sign of having had fruited this season; '2nd year' was assigned to perennialized individuals that were not seedlings, but did not meet the criteria for flowering and fruiting in the current year (Table 3). While most individuals complete their lifecycle in the span of a single year, some individuals will persist for several years given adequate resources (Wojciechowski & Spellenberg 2023) and we identified these perennial individuals by the presence of a woody caudex (perennialization of the stem). We produced data summaries to visualize the variability in abundance this year as compared to prior years. However, we determined that the sample size was not adequate to perform statistical analysis regarding the differences in abundance across sites, relationship with invasive species, and the influence of interannual precipitation in abundance.

6.3 RESULTS

Over our 79 plots surveyed, our site at Tipton Road (ESF 19-24), a sand field, had the highest density of plants, mostly seedlings (Table 3). Our site at Kim Nicol, a topographically variable site composed of stabilized and active sand dunes, had the second highest density of plants, with many perennial plants. Our active sand dune plots on the CVNWR (AD2 and AD4) had the third highest density of plants. Only one plant was recorded at both our mesquite hummock and stable sand fields sites at the CVNWR, and no plants were recorded on any of the ephemeral sand fields at our six ephemeral sand plots near Gene Autry Trail, or at our westernmost sand field plot, Fingal's Finger. While pre-reproductive individuals (seedlings) made up the highest proportion of plants recorded (87/139), perennial plants made up the second highest proportion of plants (51/139), and only one individual was noted to be fruiting. The total number of plants at all sites was lower this year than last year, with some slight variability such as a gain of one plant at a stable sand site (Figures 2-4).

Table 3. Results of the ASTLEN surveys in spring 2025 showing the total number of plants and mean number of plants per 0.1 ha plots by habitat type and the average per type. We summarize the FF, KN and Tipton plots separately due to variation in geography, terrain, and substrate at those sites.

Habitat Type/Plot Name	Plots (*n*)	Seedling	Flowering	Fruiting	2nd Year	Total	Mean #/ Plot
Active Sand Dune *(AD2, AD4)*	17	2	-	-	17	19	1.12
Ephemeral Sand Field *(ESF 7-12, 13-18)*	12	-	-	-	-	0	0.00
Fingal's Finger *(FF)*	3	-	-	-	-	0	0.00
Kim Nicol *(KN)*	3	5	-	-	22	27	9.00
Mesquite Hummock *(MH19-24, MH25-29)*	11	1	-	-	-	1	0.09
Stable Sand Field (CA, H, J, L)	27		-	-	1	1	0.04
Tipton Rd. *(ESF19-24)*	6	79	-	1	11	91	15.17
TOTAL	*79*	*87*	-	*1*	*51*	*139*	*1.76*

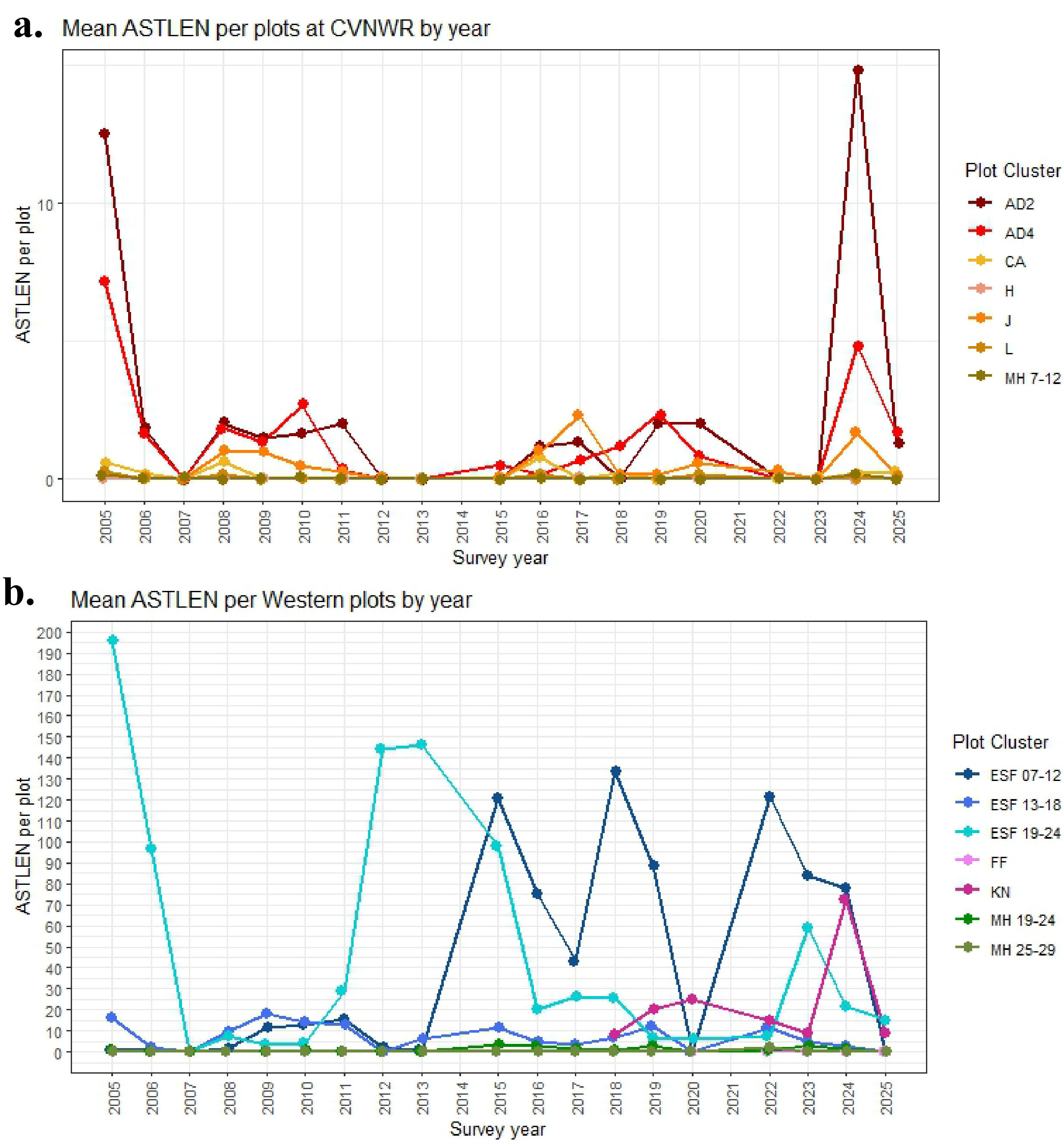


Figure 21. Mean ASLTEN density per plot across 0.1 ha plot clusters for the years surveyed 2005-2025, excluding 2014 and 2021, for the CVNWR (a) and the western set of plots (b).

6.4 Discussion

As stated above, we attribute the low emergence of this species to low precipitation (total winter and spring seasonal precipitation recorded: 0.51” Indio, 1.55” Palm Springs). We observed a similar response in many native annual plants as well as invasive plants such as *Brassica tournefortii* and *Schismus* spp. We determined that the low productivity of this plant this year was inadequate for statistical analysis of phenology or emergence. The poor emergence of annual plants across the suite of spring surveys this year made these results unsurprising. The active dunes, ephemeral sand fields and Kim Nicol continue to consistently support this species across survey years. The number of perennial plants surviving from the prior year was interesting and may be a normal pattern for years following those with higher counts; in other words, the proportion of plants surviving interannually as perennials may dominate the counts in following, low-emergence years. As we continue to grow our phenological data on this species we will be able to see if perennial plants have a competitive effect on plants emerging in subsequent years such as reducing the density of populations in subsequent years.

As described in prior reporting, this species responds to seasonal rainfall patterns, with the highest emergence in wetter years, likely due to an increase in water availability but also sand movement within the aeolian habitat. There may be some variability due to the timing of precipitation with high summer rainfall supporting higher spring counts (see discussion, *CVMSHCP Annual Report, CCB 2024*), this should be investigated in the upcoming 2026 season due to the moderate summer rainfall received as of September 2025 (recorded as of August 2025: 0.2” Indio; 0.65” Palm Springs).

6.5 RECOMMENDATIONS

As discussed, a single timing or survey to adequately capture count and population dynamics remains elusive, as climatic variability in amount and timing requires adapting the timing of surveys each year. As previously recommended, the best approach would be to individually mark and track plants throughout the growing season. Future study designs should also address other specific challenges to this approach, including how to account for reduced detectability in the late surveys, investigating the impacts of precipitation timing on emergence and survivorship of plants, and continuing to consider range-wide presence of the species. An understanding of present and future species climate-induced migration, if any, is especially important for climate resiliency planning.

In addition to continued and more intensive survey efforts, we also recommend active management for populations threatened by the invasion of *Brassica tournefortii* and *Oncosiphon pilulifer* (CCB 2024). This may be most effective in the form of manual weed pulling treatments specifically targeting the depressions and bowls where sand collects, and where CVMV generally grows at higher densities. Additionally, continued care when accessing, managing and monitoring the sites and guiding the public and others to minimize impact using the best available knowledge is necessary in order to conserve this species.

7 AEOLIAN COMMUNITY ARTHROPODS

7.1 INTRODUCTION

Every spring, we measure ground-dwelling arthropod species richness and abundance across our aeolian community plots using non-lethal pitfall traps. This year, similar to previous years, we focused on describing changes in abundance for three species of harvester ants (ants that collect and store seeds as a food source): *Pogonomyrmex californicus* (California bearded harvester ant), *Pogonomyrmex magnacanthus* (big-eyed harvester ant), and *Veromessor pergandei* (black harvester ant), and three species of large darkling beetles: *Asbolus laevis* (smooth death-feigning beetle), *Asbolus verrucosus* (blue death-feigning beetle), and *Eleodes armata* (armored stink beetle).

Ants are ecosystem engineers in many parts of the world, including deserts. Ant species in the Coachella Valley almost exclusively nest in the ground, and the act of creating intricate networks of subterranean tunnels, food chambers, and refuse piles is known to improve soil turnover, fertility, and water infiltration, enhancing plant growth (Brown et al. 2012, Farji-Brener & Werenkraut 2017). Additionally, the selection, transport, and occasional abandoning of seeds by harvester ants play an important role in determining spatial composition of plant species (MacMahon et al. 2000, Brown et al. 2012). Ants, especially harvester ants, are critical food sources for flat-tailed horned lizards and Coachella Valley fringe-toed lizards. Big-eyed harvester ants strongly prefer aeolian habitats (Johnson et al. 2013), while black harvester ants appear to mostly avoid dunes, and California harvester ants are relatively unparticular regarding substrate type.

Darkling beetles (*Tenebrionidae*) are one of the most diverse beetle families and are especially diverse in arid and semi-arid habitats worldwide (Fattorini 2023). Most darkling beetles in our area feed on decaying plant and animal matter, although some are myrmecophilous (associated with ants). Two common darkling beetle species in the Coachella Valley, *Asbolus laevis* (smooth death-feigning beetle) and *Asbolus verrucosus* (blue death-feigning beetle) may have potential value as indicator species due to their distinct habitat preferences (Barrows and Heacox 2021). Specifically, *Asbolus laevis* has a strong affinity for active dune habitat, and its presence may be an indicator of a healthy aeolian system (Barrows 2000). Conversely, *Asbolus verrucosus* occupies a wide range of desert habitat types but tends to be less abundant on the more active dunes. *Eleodes armata* are another large darkling beetle common to a large portion of the Colorado Desert, however they appear to be less common on sand dunes in the Coachella Valley, so we also investigate their potential as a habitat indicator.

7.2 METHODS

Each trap consists of a single plastic 1-liter plastic cup, funnel, and shade cover (Figure 17). We sink the cup into the ground so that the top of the cup is flush with ground level and then 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 we do not cause harm by exposing them to the sun and daytime temperatures.

Each plot hosts 3 pitfall traps – one trap per 0 m, 50 m, and 100 m 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 filling with 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 10 to June 27. Unlike the previous three years, we were able to complete many more surveys due to more favorable wind conditions. The only plot clusters that we were unable to survey this year were KN, and FF.

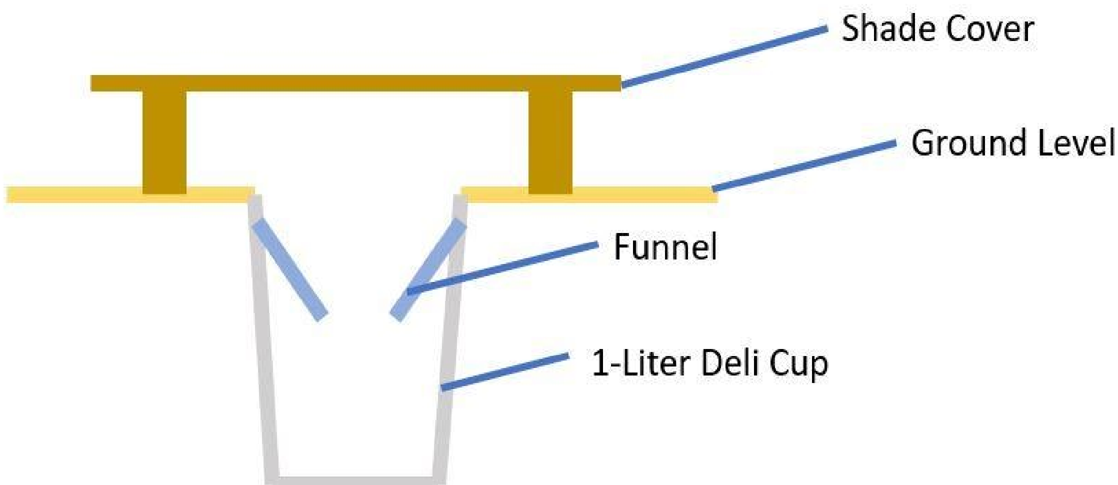


Figure 22. Diagram of the pitfalls used in this study.

7.3 RESULTS

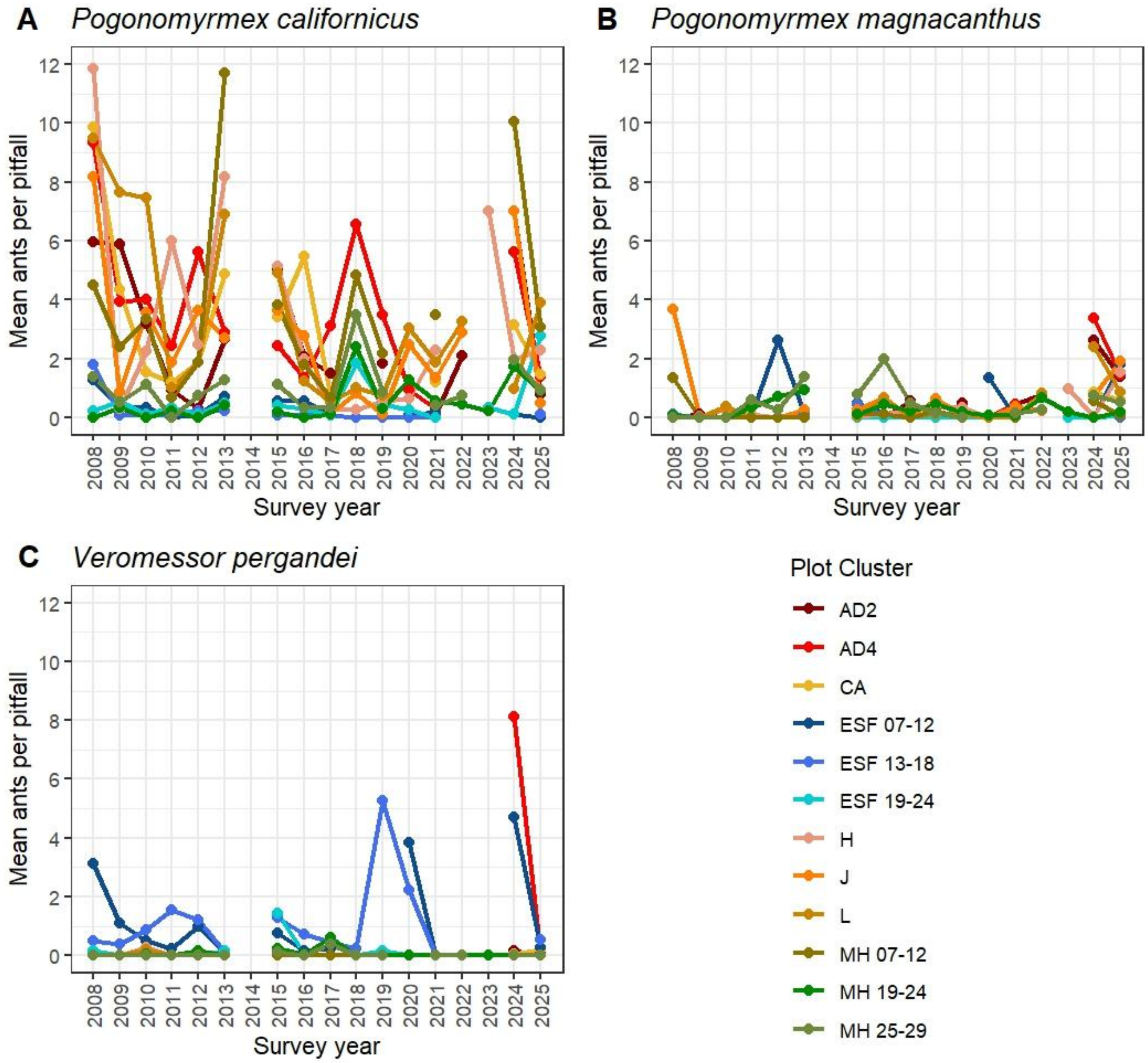


Figure 23. a-c. Results of our pitfall trapping of three harvester ant species, California harvester ants (*Pogonomyrmex californicus*), big-eyed harvester ants (*Pogonomyrmex magnacanthus*), and black harvester ants (*Veromessor pergandei*), since 2008 to 2025.

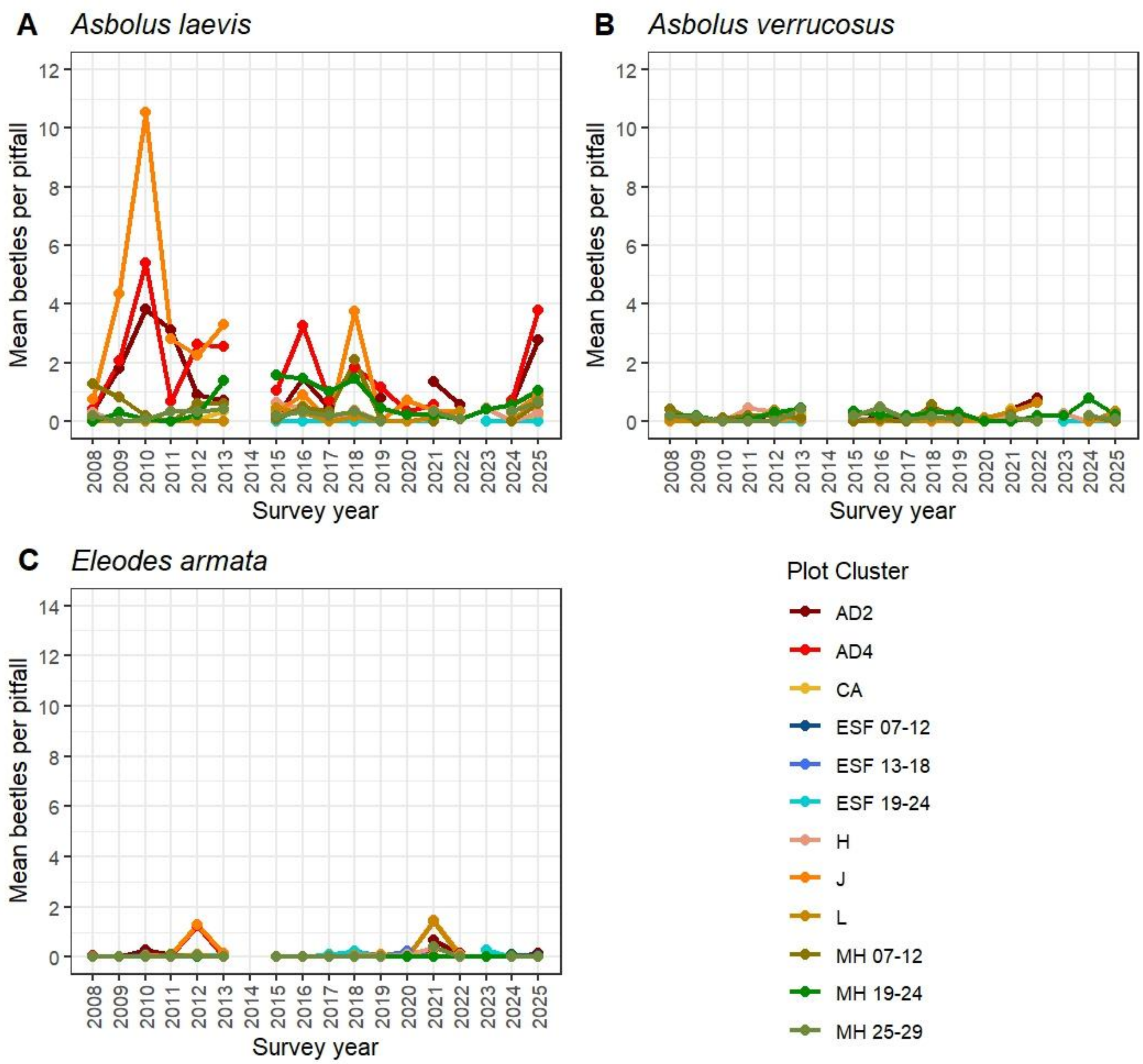


Figure 24 a-c. Results of our pitfall trapping of three darkling beetle (Tenebrionidae) species, the smooth death-feigning beetle (*Asbolus laevis*), the blue death-feigning beetle (*Asbolus verrucosus*), and the armored stink beetle (*Eleodes armata*) at all monitored plot clusters since 2008 to 2025.

7.4 RESULTS

Harvester Ants (Figure 18 a-c): Compared to 2024 abundance, *Pogonomyrmex californicus* increased at L, H, and ESF 19-24 and decreased at all other plot clusters. *Pogonomyrmex magnacanthus* abundance increased at H, J, ESF 19-24, and MH 19-24 and decreased at the remaining plot clusters. *Veromessor pergandei* increased at CA, decreased at AD2 and AD4, and was still undetected at the remaining plot clusters. *Veromessor pergandei* was not detected at AD2 this year.

Darkling Beetles (Figure 19 a-c): *Asbolus laevis* saw an increase in abundance since 2024 at all clusters except ESF 19-24, where it was not detected in 2024 or 2025. *Asbolus verrucosus* abundance increased at AD2, CA, H, and L, decreased at J, MH 19-24, and MH 25-29, had no change in abundance at AD4, and was still undetected at ESF 19-24. *Eleodes armata* increased at AD2 and AD4, decreased at MH 19-24, and was undetected at the remaining clusters.

We recorded two previously undocumented beetle species, the two-dotted ant-like flower beetle (*Stricticomus tobias*) at ESF 13-18 in the Whitewater Floodplain, and a species of bark-gnawing beetle (Trogossitidae), likely of the genus *Temnoscheila* at L and AD4 at the CVNWR. *Stricticomus tobias* is a cosmopolitan adventive species, likely originally from the Middle East (Nardi and Mifsud 2003).

7.5 Discussion

Abundance of both *Pogonomyrmex* species decreased at most plot clusters since 2024. Decreases were most prominent with *P. californicus* at clusters AD2, AD4, J, and MH 07-12 at the CVNWR. Decreases in harvester ant abundance (foraging activity) would not be unexpected following the poor germination of annual species, and therefore minimal seed rain, experienced this spring. When seed availability is scarce, harvester ants may reduce their above-ground activity and shift to relying on stored seeds as a food source (Whitford & Ettershank 1975). The spring of 2024 saw high annual plant cover and extremely high species diversity, which will have helped harvester ants replenish their seed stores. At least some harvester ant species may also reduce foraging activity during periods of low humidity to reduce water loss, at the expense of decreased food replenishment (Gordon et al. 2023). Both *Pogonomyrmex* species increased in abundance at our Tipton Road plot cluster (ESF 19-24), which was one of the few clusters in the study area to receive enough precipitation to generate meaningful annual plant cover, lending additional evidence to this feeding strategy. However, some of the plot clusters showed an average increase in worker abundance since 2024, which may be the result of day-to-day changes in environmental conditions, such as humidity, which are not captured in our current dataset.

Veromessor pergandei abundance decreased substantially since 2024 at ESF 07-12 and AD2. The high abundance recorded here last year is likely due to the pitfalls, by chance, being set in the path of a column of foragers formed the morning after installation and was not a realistic representation of forager activity. We believe that *Veromessor pergandei* may be an important habitat indicator due to its relative reluctance to establish colonies on active sand dunes or sand fields at the CVNWR. However, due to its foraging strategy (forming massive columns of workers oriented in one direction), pitfall sampling alone may be inadequate to fully investigate this species' activity. Low pitfall representation of this species in areas where it is known to be a dominant part of the ant fauna, such as the Whitewater Floodplain, further indicates that pitfalls may only be useful to detect this species, but not to describe their activity patterns.

The increased abundance of *Asbolus laevis*, a species that is hypothesized to prefer abundant aeolian sand, at every plot where it was detected in 2024, may indicate an increase in sand deposition and/or activity at these sites. This corresponds with an influx of fresh sediment deposited into the aeolian system after Tropical Storm Hilary in August of 2023. However, contradicting this idea, abundance increased most dramatically at AD2 and AD4, which also showed a slight increase in sand compaction. This unexpected change can be explained by the heterogeneous nature of the sand deposits at these plots. It is common for otherwise large, well-developed sand dunes to be separated by hard-packed silt interdune areas. This creates outliers in the sand compaction data, demonstrated by the median sand compaction of 0.9375 kg/cm2 for both AD2 and AD4, indicating loose aeolian sand is still present over the majority of these clusters (see section Methods: Aeolian Community Plot Network, Sand Compaction) *Asbolus laevis* remains more abundant at most plot clusters than either *A. verrucosus* or *Eleodes armata*, suggesting that these sites are still retaining the aeolian characteristics preferred by *A. laevis*.

7.6 Recommendations

Pitfall trapping continues to be useful not only for assessing food availability for myrmecophagous reptiles such as the flat-tailed horned lizard and Coachella Valley fringe-toed lizard, but also for assessing overall habitat quality. Ant behavior is complex, and day-to-day activity is determined by a complex set of environmental and social cues, so experimenting with integrating some form of climate data collection during surveys will likely help decipher the variability seen in our long-term dataset. Additional environmental data is also important for understanding darkling beetle behavior and their responses to habitat changes.

8 COACHELLA VALLEY GIANT SAND-TREADER CRICKET (*MACROBAENETES VALGUM*)

Figure 25. Coachella Valley giant sand-treader cricket (*Macrobaenetes valgum*) found during a survey.

8.1 INTRODUCTION

The Coachella Valley giant sand-treader cricket (*Macrobaenetes valgum*, or CVGST) is a large, wingless camel cricket of the family Rhaphidophoridae endemic to the Coachella Valley that is protected under the CVMSHCP due to its specific habitat requirements: areas with large amounts of fine, actively windblown sand. The development and compromised sand sources that threaten aeolian habitats additionally constricts the habitat available for the CVGST which garners the need for protecting this endemic cricket. However, these crickets are often relatively abundant in areas with large dunes, such as the CVNWR. While we know little of their biology, their lifecycles appear to be closely linked to winter rains (Tinkham 1962, Barrows 2012). Nymphs (juveniles) appear in large numbers during the autumn months, but their small size makes them difficult to detect. After their rapid growth period throughout the winter, the surviving CVGST reach a large enough size in late winter and early spring to detect during standardized surveys. CVGST serve as important nocturnal generalist detritivores, feeding opportunistically on decaying plant and animal matter (Polis 1991). Every morning, they excavate a new burrow extending deep enough into the soil to reach cool, moist conditions where they safely wait out the heat of the day (Tinkham 1962). Their method of excavation leaves behind a characteristic triangle-shaped pile of sand tailings at the mouth of each burrow (Figure 20). By the time summer temperatures reach their maximum, around July and August, adult CVGST have mostly completed their life cycle and died off. The CVGST's reliance on favorable winter conditions to provide the cool, wet soil conditions that they rely on during hotter days may become more difficult to obtain as climate shifts toward hotter and drier winters.

8.2 METHODS

Our surveys of CVGST take place in late winter to early spring from approximately February to April, when the crickets reach a size large enough to detect. We conducted surveys across all of our 0.1 ha aeolian community plots except CA at the CVNWR due to a lack of soft sand available for surveys at that plot cluster. This year, we conducted surveys from February 6th to March 25th, 2025, and surveyed each plot once during the monitoring season. We recorded CVGST by counting the diagnostic triangle-shaped sand piles at the mouths of their burrows (Figure 20) and only record burrows that appear "closed" (the entrance is blocked with sand), as this indicates that a CVGST occupies the burrow at the time of the survey. We try to avoid duplicate counts by only considering a maximum of one cricket per square meter, unless the tailings have notably different sizes and have the same freshness which would indicate that multiple crickets likely occupy the same area. We make this count more conservative to account for the possibility that crickets may make burrows in the same area on consecutive days.

We use this survey method for several reasons: first, the shape of the burrow tailings makes them distinct from the burrows of other arthropod species. Second, this method does not require the use of microscopes or technical skill in insect taxonomy in the field for identification, making it easier to apply in the field and train staff and volunteers on detection. Additionally, this method allows for burrow counts during daylight hours; direct counts of above-ground crickets would otherwise need to be performed at night due to their nocturnal habits, or we would have to excavate them from the ground during the day. Both of these alternative sampling methods would risk the health of these animals and cause unnecessary damage to the habitat.

Figure 26. Example of a typical closed CVGST burrow used as an indication of occurrences in our surveys. The circled area on the right-hand image indicates the burrow entrance, and the two trailing lines delineate the triangular pattern left by excavated sand.

8.3 Results

We recorded an increase in mean CVGST abundance at all plot clusters at the CVNWR. We saw the highest cricket densities at the active dune plots AD2 (22 crickets per 0.1ha) and AD4 (21.3 crickets per 0.1ha). We continue to see lower cricket numbers at L (2.1) and H (2.5), a trend that has persisted at these plots since 2020, which could be attributed to the non-homogenous distribution of fine sand at these clusters. In other words, H and L have patches of packed silt throughout, meaning that the sand habitat suitable for crickets to occupy is a bit patchier than other areas on the Refuge, which was exacerbated by flooding in fall 2023. J saw a slight population rebound this year at a mean of 12 crickets per 0.1 ha, an increase from a mean of 7 crickets per 0.1 ha in 2024 after being impacted by Tropical Storm Hilary. The cricket population at MH 7-12 experienced a notable increase going from a mean of 1 cricket per plot in 2024 to 11 crickets per plot this year. Meanwhile, nearly all of the western plots experienced decline in population density, with the exception of ESF 7-12, which continued a steady increase in mean crickets per cluster since 2022, reaching an average of 17 crickets per 0.1ha. We recorded fairly low average cricket densities at ESF 19-24 (1.7/0.1ha), MH 19-24 (2.7/0.1ha) MH 25-29 (2.2/0.1ha), KN (2.7/0.1ha) and FF (1.3/0.1ha).

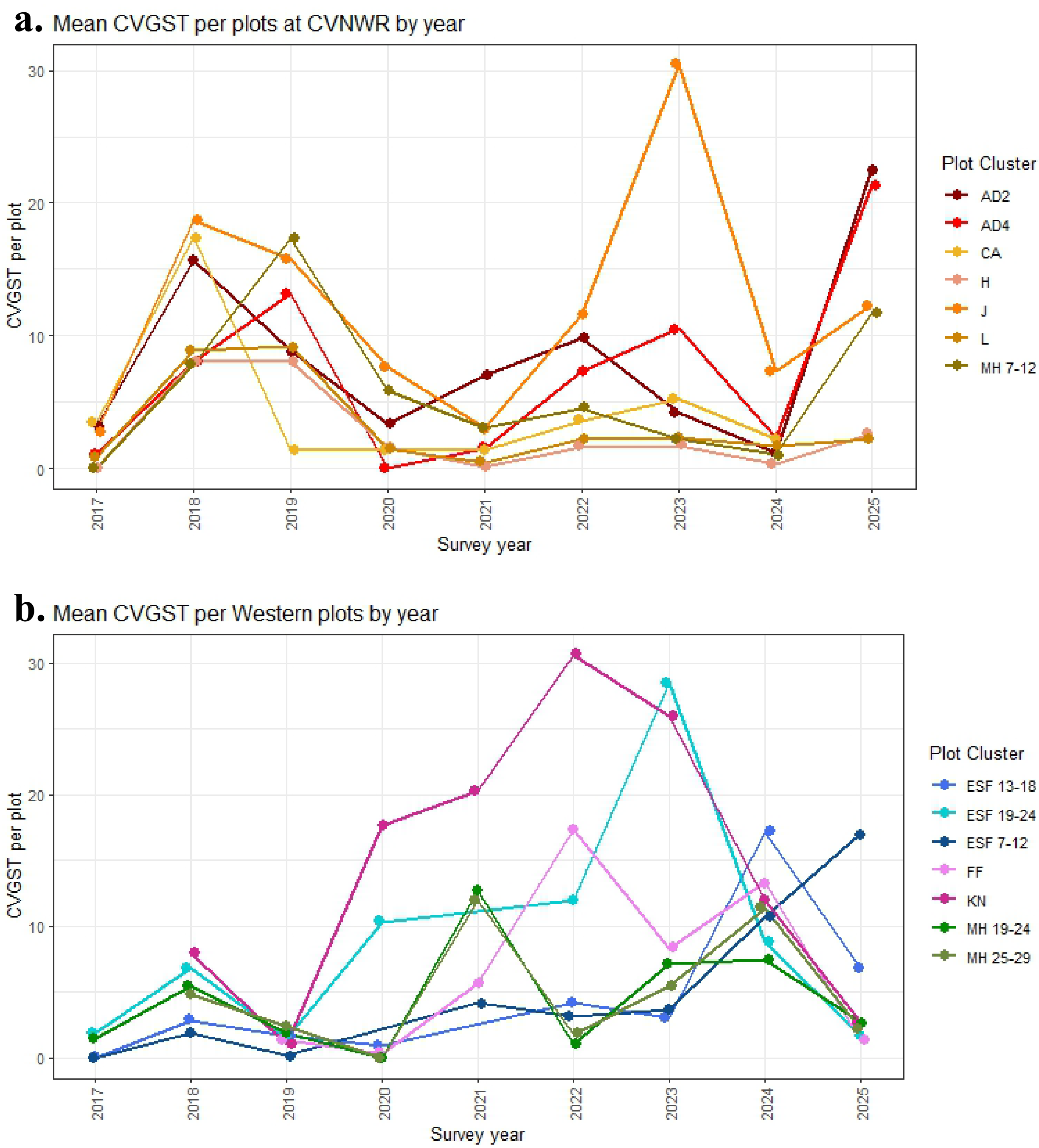


Figure 27. a Mean CVGST density per 0.1 ha by plot cluster at the CVNWR, 2017- 2025, we did not survey CA in 2025. b. Mean CVGST density per 0.1 ha by plot cluster at the western plots, 2017- 2025.

8.4 Discussion

Due to their need for deep, soft sand, we would expect to see cricket density decrease with an increase in sand compaction. We continue to see areas of the CVNWR recovering after the flooding from Tropical Storm Hilary in 2023 removed fine sand leaving silt flats. Sand compaction at H and L at the CVNWR measured almost the same as last year (see Methods: Aeolian Community Plot Network, Sand Compaction), meaning some fine sand has moved back into the habitat but there remain patches of silt between areas of soft sand. The patchiness of the habitat at these two plots might make these areas less suitable for the crickets compared to nearby areas that have more continuous soft dune sand. Another CVNWR plot cluster at the refuge that got impacted by flooding in 2023, J, saw a recovery in the cricket population and a decrease in sand compaction. Plot cluster J had fewer swathes of hard-packed silt compared to H and L, and this likely benefits the crickets returning to this plot cluster.

The sharp decline in CVGST populations across a majority of the western plot clusters is notable. Tipton Rd (ESF 19-24) showed an increase in sand compaction which could explain why cricket populations may have declined at that plot cluster. The substrate at Tipton Rd varies between the soft sand of the creosote hummocks and the packed gravel flats that separate hummocks. The increase in sand compaction could indicate an increase in gravel areas between the sandy hummocks which would create a patchy habitat for the crickets - similar to the issue presented for H and L. Although Kim Nicol also saw an increase in sand compaction this year, it still remains one of the least-compact plot clusters. The local area containing the Kim Nicol plots have management challenges including high unauthorized OHV traffic and an increase in invasive plants which both may negatively affect cricket populations. We would expect the decrease in sand compaction at Fingal's Finger and both Willow Hole clusters to have a positive effect on cricket populations, but populations declined at all three of these clusters. We do not have a clear reason for these declines. Fingal's Finger has some of the highest invasive plant cover out of all the clusters, and years where invasive cover is higher in the spring are often coupled with lower cricket populations (e.g. 2020 and 2023). A definitive link between CVGST density and invasive plant cover requires additional investigation. Willow Hole, on the other hand, does not show the same preponderance of invasive plant growth – possible explanatory factors for lower detected densities there could be increased predation there or perhaps that site received less precipitation than other areas.

8.5 Recommendations

Due to the lack of knowledge about the CVGST we must continue to explore different environmental variables that could affect their populations. Continuing to look at sand movement and landscape changes remains pertinent to this species' survival because they require the presence of deep, soft sand. We should also explore how plant composition contributes to population fluctuations. The crickets eat dead organic material, and the amount of dead plant material or what kind of plant material is available to them could affect their ability to survive.

9 ACKNOWLEDGEMENTS

We want to express our gratitude to the Coachella Valley Conservation Commission for funding these projects under the Coachella Valley Multiple Species Habitat Conservation Plan and the Coachella Valley Association of Governments staff, Tony Quiroz and Billy Morrow, for cooperation on these projects. We also wish to thank Dr. Cameron Barrows for his guidance, insight and support, and Luis Barrios in our lab group for subject matter discussions, our volunteer community scientists, agency partners, and staff who have helped facilitate and conduct our lizard and habitat monitoring efforts.

10 LITERATURE

Ball, L. C., Ostermann-Kelm, S. D., McDonald, M. W., & Doherty Jr, P. F. (2010) Effects of rain on Palm Springs ground squirrel occupancy in the Sonoran Desert. *The Journal of Wildlife Management*, *74*(5), 954-962.

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

Barrows, C. W. (2000) Tenebrionid species richness and distribution in the Coachella Valley sand dunes (Coleoptera: Tenebrionidae). *The Southwestern Naturalist,* 45(3): 306-312.

Barrows, C. W. (2006) Population dynamics of a threatened sand dune lizard. *The Southwestern Naturalist, 51*(4), 514-523.

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

Barrows, C. W., & Allen, M. F. (2009) Conserving species in fragmented habitats: population dynamics of the flat-tailed horned lizard, Phrynosoma mcallii. *The Southwestern Naturalist, 54*(3), 307-316.

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

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

Barrows, C. W., & Heacox, S. A. (2021) Forty years later: monitoring and status of the endangered Coachella Valley fringe-toed lizard. *California Fish and Wildlife Journal*, *107*, 243-257.

Barrows, C. W., Heacox, S. A., & Sweet, L. C. (2022) Flat-Tailed Horned Lizards—20 Years Of Research At The Northwestern Edge Of Their Range. *The Southwestern Naturalist, 66*(4), 309-316.

Beheiry, S. A. (1967) Sand forms in the Coachella Valley, southern California. *Annals of the Association of American Geographers, 57*(1), 25-48.

Belnap, J., Webb, R. H., Esque, T. C. Brooks, M. L., Defalco, L. A. & Macmahon. J. A. (2016) Deserts. Pages 635–667 in *Ecosystems of California* (H. Mooney and E. Zavaleta, editors). University of California Press, Oakland.

Brown, G., Scherber, C., Ramos Jr, P., & Ebrahim, E. K. (2012). The effects of harvester ant (Messor ebeninus Forel) nests on vegetation and soil properties in a desert dwarf shrub community in north-eastern Arabia. *Flora-Morphology, Distribution, Functional Ecology of Plants*, *207*(7), 503-511.

California Native Plant Society, Rare Plant Program. (CNPS) (2023). Rare Plant Inventory (online edition, v9.5). Retrieved 15 June, 2023 from https://www.rareplants.cnps.org.

Drezner, T. D., & Drezner, Z. (2021) Informed cover measurement: Guidelines and error for point-intercept approaches. *Applications in Plant Sciences*, *9*(9-10), e11446.

ESRI. (2025). ArcGIS Pro. https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview

Farji-Brener, A. G., & Werenkraut, V. (2017). The effects of ant nests on soil fertility and plant performance: a meta-analysis. *Journal of Animal Ecology*, *86*(4), 866-877.

Fattorini, S. (2023). Adaptations of tenebrionid beetles to Mediterranean sand dune environments and the impact of climate change (Coleoptera: Tenebrionidae). *Fragmenta entomologica*, *55*(1), 1-20.

Fisher, M., Muth, A. & Johnson, R. F. (2020). A Long-term Study of Home Range of Coachella Fringe-toed Lizards, Uma inornata. *Journal of Herpetology, 54*, 174-182.

Gordon, D. M., Steiner, E., Das, B., & Walker, N. S. (2023). Harvester ant colonies differ in collective behavioural plasticity to regulate water loss. *Royal Society Open Science*, *10*(9), 230726.

Guo, Q., & Brown, J. H. (1996) Temporal fluctuations and experimental effects in desert plant communities. *Oecologia*, *107,* 568-577.

Hoefler, G. & Harris, J. (n.d.). Life history account for round-tailed ground squirrel. California Wildlife Habitat Relationships (CWHR) System. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=2421

Hudson, J. W. (1964). Temperature regulation in the round-tailed ground squirrel, *Citellus tereticaudus*. *Annales Academiæ Scientiarum Fennicæ A (IV), 71,* pp. 219-233.

Hudson, J. W., & Bartholomew, G. A. (1964). Terrestrial animals in dry heat: estivators. In D. B. Dill (Ed.), *Handbook of physiology* (pp. 541-550). American Physiological Society.

Hulton VanTassel, H. L., Hansen, A. M., Barrows, C. W., Latif, Q., Simon, M. W., & Anderson, K. E. (2014). Declines in a ground-dwelling arthropod community during an invasion by Sahara mustard (Brassica tournefortii) in aeolian sand habitats. *Biological Invasions*, *16*(8), 1675-1687.

Inouye, R. S. (1991) Population biology of desert annual plants. *The ecology of desert communities*, 27-54.

Johnson, R. A., Overson, R. P., & Moreau, C. S. (2013) A new species of seed-harvester ant, Pogonomyrmex hoelldobleri (Hymenoptera: Formicidae), from the Mohave and Sonoran Deserts of North America. *Zootaxa*, *3646*(3), 201-227.

Katra, I., Scheidt, S., & Lancaster, N. (2009) Changes in active eolian sand at northern Coachella Valley, California. *Geomorphology, 105*(3), 277–290.

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

McHargue, L. T. (1973) A Vegetational Analysis of The Coachella Valley, California. University of California, Irvine.

Meffe, G. K. & Carroll, C. R. (1994). Principles of conservation biology. Sunderland, Massachusetts Sinauer Associates, Inc.

Meinke, R. J., Amsberry, K., Currin, R. E., Meyers, S. C., & Knaus, B. (2007) Evaluating the Biological Conservation Status of the Coachella Valley Milkvetch (Astragalus lentiginosus var. coachellae). *Native Plant Conservation Program,* pp.11-19.

Moorberg, C. J., & Crouse, D. A. (2021) *Soils laboratory manual: K-state edition, version 2.0*. New Prairie Press.

Mueller-Dombois, D., and Ellenberg H. (1974) Aims and methods of vegetation ecology. John Wiley and Sons, New York, New York, USA.

NOAA. (2025) U.S. Wind Climatology | National Centers for Environmental Information (NCEI). https://www.ncei.noaa.gov/access/monitoring/wind/

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

Polis, G. A. (1991) Complex trophic interactions in deserts: an empirical critique of food-web theory. *The American Naturalist, 138*(1), 123-155.

Primack, R.B. (1998). Essentials of conservation biology. Sinauer Associates, Sunderland, Massachusetts.

Rodriguez, C., Sweet, L. C., Davis, M., Heacox, S., Barrows, C. & Larios, L. (2025) Temporal Invasion Regime Attributes Influence Community Synchrony and Stability in an Arid Land System. *Ecology* 106.4 (2025): e70081.

Rorabaugh, J. C., & Young, K. V. (2009. Flat-tailed horned lizard Pages 182–185 in *Lizards of the American Southwest* (L. C. Jones and R. E. Lovich, eds). Rio Nuevo Press, Tucson, Arizona.

San Diego Natural History Museum (SDNHM). (2019, October 16). *Using data to drive decisions about the flat-tailed horned lizard.* The nat. https://www.sdnhm.org/blog/blog_details/using-data-to-drive-decisions-about-the-flat-tailed-horned-lizard/130/

Shaffer, M. L. (1981). Minimum population sizes for species conservation. *BioScience, 31*(2), 131-134.

Shaffer, M. (1987). Coping with uncertainty. *Viable populations for conservation*, 69.

Swei, A., Brylski, P. V., Spencer, W. D., Dodd, S. C., & Patton, J. L. (2003) Hierarchical genetic structure in fragmented populations of the little pocket mouse (Perognathus longimembris) in southern California. *Conservation Genetics*, *4,* 501-514.

Tinkham, E. R. (1962) Studies of Nearctic desert sand dunes Orthoptera, Part VI. A new genus and three new species of large camel crickets from the Colorado Desert with keys and notes. *Bulletin of the Southern California Academy of Sciences*, *61,* 89-111.

Turner, F. B., & Medica, P. A. (1982) The distribution and abundance of the flat-tailed horned lizard (Phrynosoma mcallii). *Copeia.* 815–823

UC ANR 2023. Pest Notes: Stinknet UC ANR Publication 7601. https://ipm.ucanr.edu/natural-area-pests/stinknet/#gsc.tab=0

[UCR CCB] Barrows, C. W., Sweet, L. C., Heacox, S., & Davis M. (2019) Coachella Valley Multiple Species Habitat Conservation Plan Aeolian Sand Species Trends 2019. Final Report. Prepared for: Coachella Valley Conservation Commission.

[UCR CCB] Barrows, C. W., Sweet, L. C., Heacox, S., Davis, M., Ramstead, P. (2021) Coachella Valley Multiple Species Habitat Conservation Plan Aeolian Sand Species Trends 2021. Final Report. Prepared for: Coachella Valley Conservation Commission.

[UCR CCB] Davis, M. J., Sweet, L. C., Barrows, C., Heacox. S. (2021) 2020-2021 Monitoring Results for the Coachella Valley Milkvetch (Astragalus lentiginosus var. coachellae) within the Coachella Valley. Final Report. Prepared for: Coachella Valley Conservation Commission.

[UCR CCB] Davis, M. J., Sweet, L. C., Barrows, C., Heacox. S (2022) 2022 Monitoring Results for the Coachella Valley Milkvetch (Astragalus lentiginosus var. coachellae) within the Coachella Valley. Final Report. Prepared for: Coachella Valley Conservation Commission.

[UCR CCB] Sweet, L. C., Heacox, S., Davis, M., Barrows, C. W. (2022) Coachella Valley Multiple Species Habitat Conservation Plan Aeolian Sand Species Trends 2022. Final Report. Prepared for: Coachella Valley Conservation Commission.

[UCR CCB] Davis, M. J., Sweet, L. C., Barrows, C., Heacox, S. (2023) 2023 Monitoring Results for the Coachella Valley Milkvetch (Astragalus lentiginosus var. coachellae) within the Coachella Valley. Final Report. Prepared for: Coachella Valley Conservation Commission.

[UCR CCB] Sweet, L. C., Vincent, R. M., Heacox, S. A., Davis, M. J., Baronia, D. (2024). Coachella Valley Multiple Species Habitat Conservation Plan 2023–2024 biological monitoring results for the Coachella Valley aeolian sand species. Final Report. Prepared for: Coachella Valley Conservation Commission

University of Idaho (2009) Point Intercept Techniques. https://www.webpages.uidaho.edu/veg_measure/Modules/Lessons/Module%208(Cover)/8_3_Points.htm.

USDA (n.d.). Point Intercept (PO) – Sampling Method. https://www.fs.fed.us/rm/pubs/rmrs_gtr164/rmrs_gtr164_09_point_inter.pdf

U.S. Fish and Wildlife Service (USFWS) (1980) *Uma inornata*, Reproposal of Critical Habitat. Federal Register. May 28, 1980:36038-41.

U.S. Fish and Wildlife Service (USFWS) (1998) Final Rule: Determination of Endangered or Threatened Status for Five Desert Milk-vetch Taxa from California. Federal Register *63*, 53596-53615.

Whitford, W. G., & Ettershank, G. (1975). Factors affecting foraging activity in Chihuahuan desert harvester ants. *Environmental Entomology*, *4*(5), 689-696.

Wojciechowski M. F., Spellenberg R. (2023) *Astragalus lentiginosus var. coachellae*, in Jepson Flora Project (eds.) Jepson eFlora, Revision 12, https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=54786 [accessed June 14, 2023]

WRCC (2025) Western Regional Climate Center: https://wrcc.dri.edu/summary/Climsmsca.html

Appendix VIII: Biological Monitoring Results for Triple-ribbed Milkvetch *(Astragalus Tricarinatus)*

Report begins on following page.

Coachella Valley Multiple Species Habitat Conservation Plan

2024–2025 BIOLOGICAL MONITORING RESULTS FOR TRIPLE-RIBBED MILKVETCH (*Astragalus tricarinatus*)

2024-2025 FINAL REPORT

<u>FINAL REPORT</u>

COACHELLA VALLEY MULTIPLE SPECIES HABITAT CONSERVATION PLAN 2024–2025 BIOLOGICAL MONITORING RESULTS FOR TRIPLE-RIBBED MILKVETCH (*Astragalus tricarinatus*)

Prepared by:

Remy M. Vincent, Scott A. Heacox, Melanie J. Davis, and Lynn C. Sweet

Center for Conservation Biology

University of California, Riverside

75-080 Frank Sinatra Dr.

Palm Desert, CA 92211

Prepared for:

Coachella Valley Conservation Commission

73-710 Fred Waring Dr.

Palm Desert, CA 92260

Suggest citation: *Vincent R.M., Heacox, S.A., Davis, M.J. & Sweet, L.C. (2025) Coachella Valley Multiple Species Habitat Conservation Plan 2024–2025 biological monitoring results for the triple-ribbed milkvetch (Astragalus tricarinatus). Final Report. Prepared for: Coachella Valley Conservation Commission*

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

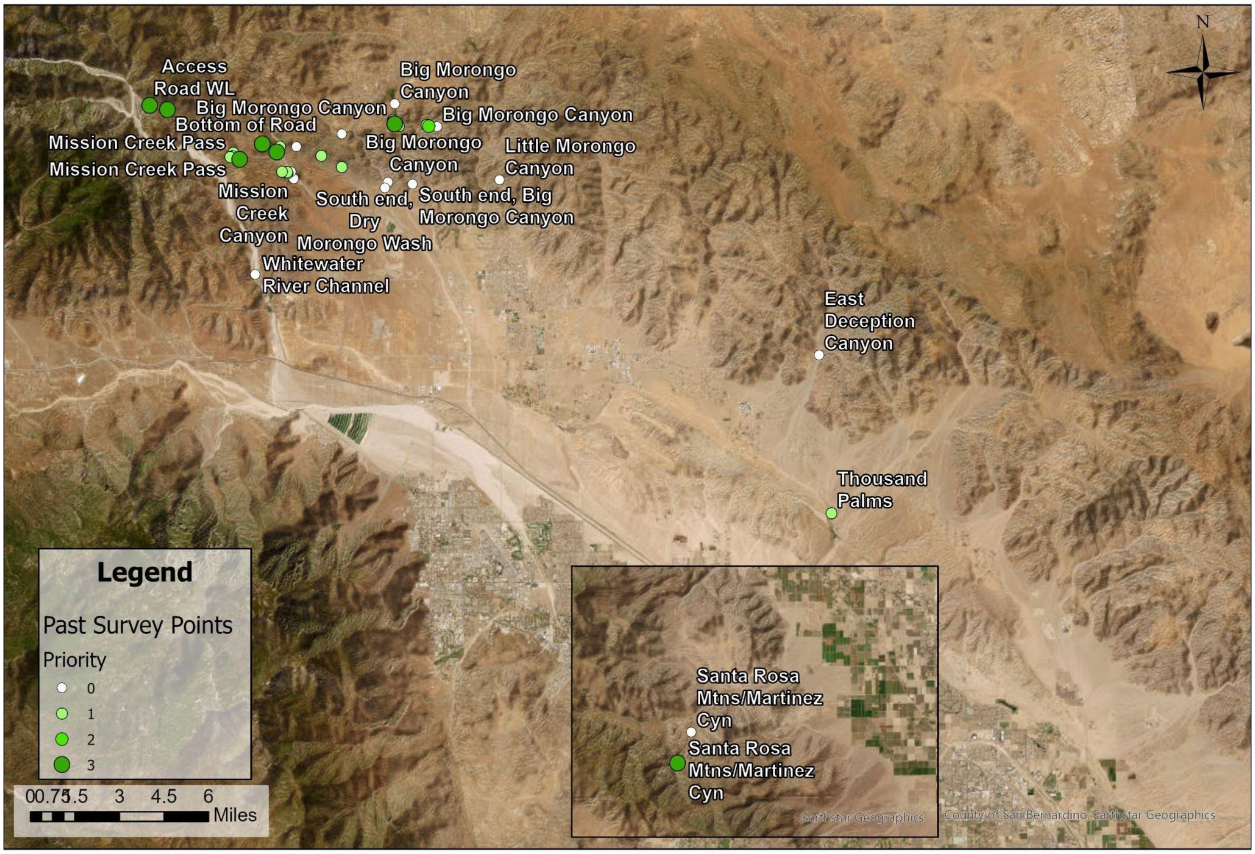
Triple-ribbed milkvetch, *Astragalus tricarinatus* A. Gray (Fabaceae), is a short-lived perennial herb endemic to Southern California, occurring along the ecotone of the Mojave and Colorado Deserts in the San Bernardino and Little San Bernardino Mountains, with disjunct occurrences in the Santa Rosa Mountains (Bell & Fraga 2021; USFWS 2009; Fraga & Pilapil 2012; Jepson Flora Project 2017). It has also been reported from further east in the Orocopia Mountains by Barneby (1959, 1964), but these occurrences have not been verified (USFWS 2009; Bell *et al.* 2017). A specimen collected by M. F. Spencer dated April 6, 1921 indicates the locality as "Chuckwalla Mtns" [sic] and resides at Harvard University Herbarium where staff have indexed it and provide an image online (Harvard University Herbaria and Libraries 2020). In 1998, US Fish and Wildlife Service listed this species as endangered based in part on what we knew about the species at the time-- that it occurred as small, ephemeral groups of plants on benches along desert washes and canyon bottomlands. Since then, research suggests such occurrences to be waif groups (Barneby 1959; Sanders 1999; USFWS 2009; Fraga *et al.* 2015); plants dispersed from local populations upland. Research now identifies *A. tricarinatus* habitat as topographically rugged, friable soils, often in upper watersheds (White 2004; USFWS 2009; Fraga *et al.* 2015; Bell *et al.* 2017).

We (UCR Center for Conservation Biology; UCR CCB) began the study of this protected species under the Coachella Valley Multiple Species Habitat Conservation Plan (CVMSHCP). This year we focused on collecting broad-scale population data in an effort to better understand the population dynamics of this species. Our aim was to collect data that will contribute to management decisions that support the long-term persistence of this species (Coachella Valley Conservation Commission, 2016). In part, we evaluated threats to the persistence of known occurrences of this species in the Little San Bernardino, San Bernardino and Santa Rosa Mountains within the CVMSHCP to support future land management protocols and a possible update for the listing status.. These threats include human disturbance, invasive species, natural stochastic events, and climate change (Fraga *et al.* 2015, Heintz *et al.* 2018).

2 METHODS

Triple-ribbed milkvetch (*Astragalus tricarinatus*) generally flowers from February to May (Barneby 1964), and produces pale yellow pea-like flowers that mature into light green slender puffed pods. This year we performed 22 population surveys which ran from April 4 to May 21, 2025. We would generally begin surveys earlier in the bloom season of this species, however we conducted several field reconnaissance trips throughout February and March of 2025 and found that plants were still dormant, likely due to a dry winter, where the Coachella Valley did not receive winter precipitation until February 2025, with another storm occurring in March 2025 (NOAA 2025). Dormant plants can be hard to detect on the landscape, so once we determined that the plants were responding to the February rains, we started conducting surveys. Within our surveys, we conducted population counts, recorded life stages of individual plants (e.g. seedling, juvenile, adult) and phenology at the time of the survey (e.g. vegetative, flowering, or fruiting), documented cooccurring species in the vicinity of the stand, slope of the terrain, and other stand history notes (evidence of fire, invasive intensity, erosion, etc.) We used past survey data from 2017, 2018 and 2020 to determine this year's survey locations (Figure 1). We created a map using ESRI Field Maps (ESRI 2025) with the UTMs from previously recorded populations and ranked them by the amount of individuals found at those survey sites: High Priority: >5 individuals, Medium Priority: 1-5 individuals, Low Priority: 0 individuals (in the latest census; Figure 1). Populations with higher recorded densities in previous years were prioritized, while populations where *A. tricarinatus* was not recorded in the most recent census was deprioritized, to maximize effort.

During our approach to a survey point we periodically scanned viable habitat, i.e. canyon walls and washes for live or dead individuals using binoculars. The silver blue leaflets of *A. tricarinatus* make it distinct from other species in the area, and when dead, dormant, or senesced, the bright yellow hay-like color of dried stems accompanied by old flower stalks differs from other dead plant material and make it possible to spot this species from a distance. Once we located the first individual within the stand we recorded start UTMs and considered this individual the beginning of the population, we then continued to scan along the canyon walls, recording data on individual plants within the stand. We marked the end of the population by taking the UTMs at the last individual found within the same canyon, or the individual furthest from the start point. We took induvial plant data by first assessing if the plant was dead or alive and then chose one of the following categories: <1yr live: vegetative, flowering, fruiting, dead and >1yr live: vegetative, flowering, fruiting, dead. Vegetative refers to plants that have new leaf growth but no signs of flowering or fruiting at the time of the survey. We searched adjacent slopes if we detected the fine, decomposed granite soil preferred by this species. We recorded the number of seedlings in each stand, and estimated seedling counts for survey areas that had a population of over 20 individuals. We identified >1yr plants by the presence of senesced flower stocks and stems from the previous year. We marked the end of the population by taking the UTMs at the last individual found within the same canyon. We took 'stand' UTMs in the middle of the population if it was small and confined to a solitary slope. We took stand photos to make future re-surveys easier to locate, and compare erosion and plant species composition through the years; if populations stretched an area that could not be captured by one photo, we took photos at



the start and end of the population.

Figure 1. Map of survey points taken during our past *Astragalus tricarinatus* studies from 2017, 2018, 2020 ranked by survey priority based on previous population sizes 0: no plants found, 1: 1-5 plants, 2: >5 plants, 3: unknown number of plants. Area shown is in the western Coachella Valley, CA, San Bernardino and Little San Bernardino Mountains, and the Santa Rosa Mountains (inset).

3 RESULTS

(a)  (b) 

Figure 2 (a) *Astragalus tricarinatus* seedling found growing underneath *Gutierrezia* sp. at the Access Road stand. (b) >1 year old *Astragalus tricarinatus* with fruit growing on a slope at Stone House 1 stand.

Our population results, summarized in Table 1, show the most abundant areas for *Astragalus tricarinatus* to be the farthest western survey areas of the Mission Creek/Whitewater River watershed, and also Martinez Canyon. We observed the most first-year pre-flowering plants, 184 individuals, and 4 >1 year old flowering plants at the Access Road stand (Figure 3). This survey area had low overall shrub cover (approximately 1-5% cover) and several seedlings found under or nearby *Gutierrezia* sp. (Figure 2a.). We found fewer individuals of both first year and older than a year at Wathier's Landing down slope from Access Road. This stand occurs along a canyon ridge with more rugged terrain than Access Road and lower shrub density compared to adjacent ridges where we found no individuals. The site at Deep V had a population of 16 plants made up of almost entirely first year plants with a single >1 year flowering plant. We located this stand on a southeast facing slope of whitish decomposed substrate with low shrub density. We observed one of the highest populations at the Bottom of Road stand with 21 individuals of mostly >1 year old pre-flowering plants. Notably, this site was the only location where we found first-year flowering plants. Martinez Canyon had the second largest population, with 42 total individuals comprised of 35 first-year vegetative plants, four vegetative >1 year old plants, and one flowering >1 year old plant.

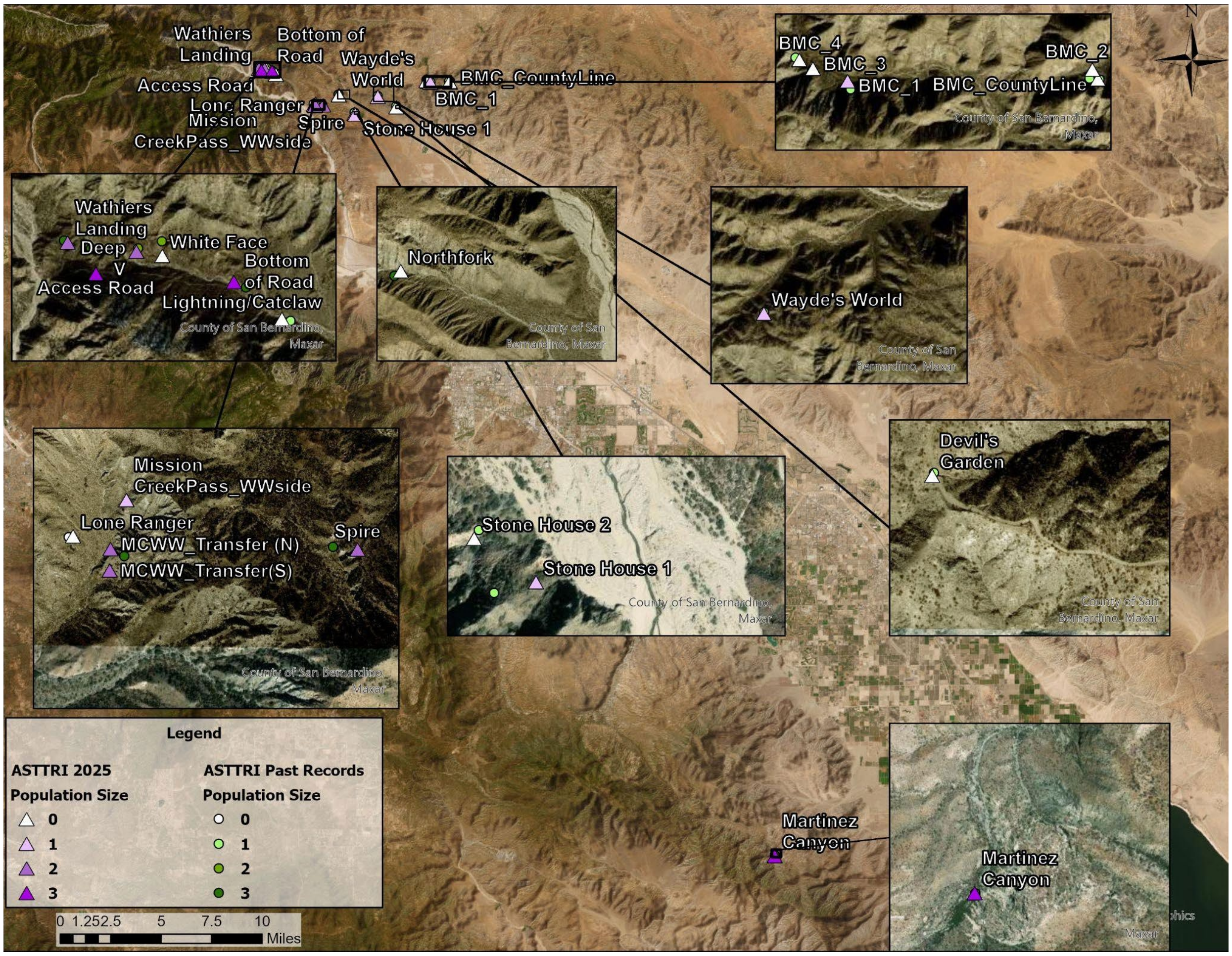


Figure 3. Map of the population surveys, where triangles indicate populations surveyed during spring of 2025 and circles represent populations recorded in 2017, 2018 or 2020. Color ramps indicating the following codes for both green and purple tones: 0: no plants found, 1: 1-5 plants, 2: 5-20 plants, 3: >20 plants.

At Devil's Garden, BMC County Line, BMC 2, 3, 4, White Face, Lightning/Catclaw, Lone Ranger, North Fork, Stone House 2 and WWMC Transfer (S) we found either no individuals or no live individuals. The last time we surveyed the Stone House 2 stand in 2020 we found a small population of three individuals and the dry conditions this year likely contributed to this population being undetectable this year. Similarly, our past surveys show a small population of a few plants at Devils Garden usually occurring along an exposed south facing ridgeline dirt road where, this year, we found the two dead plants. We could not reach the White Face stand because thick shrubs made the approach impossible (possibly due to post-fire vegetation recovery) so we conducted the survey using binoculars from approximately 100 m away. The sparsely vegetated white decomposed granite face had only one dead plant that we identified as *Astragalus tricarinatus*. Lightning/Catclaw had a high density of shrubs and *Bromus* sp. on the east side of the stand but the west side had a freshly eroded steep slope with no vegetation. At North Fork and Lone Ranger, we observed moderate to high *Bromus* sp. cover which likely contributed to the lack of plants at these stands. At all the Big Morongo Canyon sites we saw consistently moderate shrub cover (approximately 5-15% cover) on canyon sides and ridges and found only one live plant at BMC 1 on a north facing slope. In our previous survey of Big Morongo Canyon in 2020, we recorded one individual at all sites except BMC County Line which had five plants and BMC_3 with 30 plants. Big Morongo Canyon stands seem to have overall low and sparse population sizes which would be more vulnerable to not being productive during a dry year like this one. WWMC Transfer S site had a dense *Encelia farinosa* stand covering the slope which made surveying difficult due to the high shrub cover (>15% cover).

At the WWMC Transfer N stand, we found three first year vegetative plants, seven >1 year old vegetative plants, and two >1 year old flowering plants. This stand was within a canyon with gray and pink distressed granite soil composition had low to moderate shrub cover with a low cover of *Bromus* sp. Similarly, at Mission Creek pass WW side, a stand with moderate shrub cover and low invasive species, we found five first year plants, and >1 year old plants that had two vegetated, one flowering and one of three stands that we observed a fruiting individual. We also counted fruiting individuals at Wayde's World and Stone House 1, both of which had a single >1 year old fruiting plant. At the Spire stand we found only one first year plant, and the majority of the remaining plants we saw were >1 year old vegetated plants and two flowering plants all on white decomposed substrate. A large portion of the slope face appeared newly eroded and potentially contributed to a smaller population this year, 11 total, compared to 2020 when we found 30 individuals at this site.

Table 1. *Astragalus tricarinatus* population counts, divided into categories based on phenologys: <1yr live: vegetation, flowering, fruiting; >1yr live: vegetation, flowering, fruiting and total population number and dead plant counts.

Stand Name	Survey Date	<1yr veg	<1yr flr	<1yr frt	>1yr veg	>1yr flr	>1yr frt	Total #	DEAD
Access Road	4/19/2025	184	0	0	10	4	0	198	38
Wathiers Landing	4/20/2025	10	1	0	6	1	0	18	45
Deep V	4/20/2025	15	0	0	0	1	0	16	7
White Face	4/20/2025	0	0	0	0	0	0	0	1
Bottom of Road	4/20/2025	4	2	0	15	0	0	21	29
Lightning/Catclaw	4/20/2025	0	0	0	0	0	0	0	0
Spire	5/6/2025	1	0	0	8	2	0	11	5
Mission Creek Pass WWside	4/29/2025	5	0	0	2	1	1	9	4
Lone Ranger	4/29/2025	0	0	0	0	0	0	0	0
MCWW Transfer (S)	4/29/2025	0	0	0	0	0	0	0	0
MCWW Transfer (N)	4/29/2025	3	0	0	7	2	0	12	0
Northfork	5/14/2025	0	0	0	0	0	0	0	0
Stone House 1	5/14/2025	2	0	0	0	0	1	3	1
Stone House 2	5/14/2025	0	0	0	0	0	0	0	0
Wayde's World	5/1/2025	0	0	0	5	0	1	6	8
Devil's Garden	5/15/2025	0	0	0	0	0	0	0	2
BMC_CountyLine	5/21/2025	0	0	0	0	0	0	0	1
BMC_1	5/21/2025	0	0	0	1	0	0	1	0
BMC_2	5/21/2025	0	0	0	0	0	0	0	0
BMC_3	5/21/2025	0	0	0	0	0	0	0	0
BMC_4	5/21/2025	0	0	0	0	0	0	0	1
Martinez Canyon	4/4/2025	35	0	0	6	1	0	42	1

4 DISCUSSION

This year the Coachella Valley received very little winter or spring rain- collectively about 1.5 inches in Palm Springs and 0.5 inches in Indio (NOAA 2025) which is likely why we saw little recruitment outside of areas with more water availability. Our most western plots likely received higher rainfall due to their geographical position and proximity to the mountains, explaining the higher population numbers we saw at Access Road, Wathiers Landing, Deep V and Bottom of Road, compared to the populations further east. This cluster of plots have a higher elevation and cooler temperatures which may help increase the year-to-year survivorship of individuals that make it to adulthood in the first year, which in turn could aid in maintaining populations even in years with little rain. Martinez Canyon is downstream from the Santa Rosa Mountains, and we noticed a trickle of water at the bottom of the broader canyon that we surveyed for *Astragalus tricarinatus*. While *A. tricarinatus* lives on the canyon walls, not directly benefiting from the small stream of water, there may be some indirect benefit or amelioration of microclimate factors due to, for example, denser shrub cover and increased humidity within a broader area that receives lower amounts of precipitation. Our other eastern plots saw lower population numbers compared to past years, likely a result of dry conditions in those areas.

We noticed a potential association between *A. tricarinuatus* and *Gutierrezia* sp. after seeing several occurrences of *A. tricarinatus* seedlings growing underneath *Gutierrezia* sp. (Figure 2a) and adult *A. tricarinatus* plants growing next to the shrub. Where it is present in the more western survey areas, *Gutierrezia* sp. may benefit *A. tricarinatus*. *Gutierrezia* is a dense shrub to shubshrub, with many branches arising from the ground level. This growth form could also be beneficial for capturing *A. tricarinatus* seeds on steep slopes, and then acting as a nurse shrub for vulnerable seedlings. We noted that no *A. tricarinatus* at stands with a moderate to high shrub cover. We know that the presence of invasive species has a negative effect on *A. tricarinatus* populations (Heintz *et al.* 2018) and perhaps this taxon prefers overall less densely vegetated areas, as it is frequently found growing in disturbed areas such eroded slopes and wash bottoms. After a high precipitation year in 2024 the shrubs appeared to be big and healthy, with extensive vegetative cover, especially at cooler higher elevation and westerly areas. Higher shrub cover leads to a more stabilized soil which does not appear to be preferable habitat for *A. tricarinatus*. We continued to see low to zero population numbers in areas with moderate to high *Bromus* sp. cover. While we think dry winter and spring conditions drove these lower population numbers this year, especially for the drier eastern survey areas, and high invasive cover in a few sites, we need to consider other factors such as the effects of shrubs on soil stabilization and the effects of severe slope erosion from major storms. Conversely, there might be unexplored positive plant associations, such as shrubs acting as nurse plants. We still know little about the phenology and dispersal of this plant because they grow primarily on remote, rugged canyon slopes, making surveying difficult and time-consuming.

5 RECOMMENDATIONS

In order to meet the management needs of the CVMSHCP, and to continue to monitor for threats and risks to this species, we recommend that monitors continue intermittent surveys targeting poorly-studied aspects of the plant's biology, including phenology, association with other plant species, soil preferences, animal interactions, and different types of competition- not just from invasive species.

6 ACKNOWLEDGEMENTS

We want to express our gratitude to the Coachella Valley Conservation Commission for funding these projects under the Coachella Valley Multiple Species Habitat Conservation Plan and the Coachella Valley Association of Governments staff, Tony Quiroz and Billy Morrow, for cooperation on these projects. We also wish to thank our partners at The Wildlands Conservancy who allowed us access to Mission Creek Preserve in order to do surveys on their land as well as other agency partners. We would like to recognize Danelle Baronia, Rachel Gallardo, Brenda Fisher and Juniper Graham from our lab who helped conduct surveys.

7 LITERATURE

Barneby, R. C. (1959). Astragalus L. milkvetch. *A California flora. University of California Press, Berkeley, CA*, 855-887.

Barneby, R. C. (1964). *Atlas of North American Astragalus: The cercidothrix, hypoglottis, piptoloboid, trimeniaeus, and orophaca Astragali* (Vol. 13). New York Botanical Garden.

Bell, D. S., Fraga N. S., & De Groot, S. J. (2017). Surveys for *Astragalus tricarinatus* (Fabaceae, triple-ribbed milkvetch) in the Chuckwalla Mountains, Orocopia Mountains, and Santa Rosa Wilderness. Report prepared for Bureau of Land Management, Sacramento, CA. On file at Rancho Santa Ana Botanic Garden, Claremont, CA.

Bell, D. S., & Fraga, N. S. (2021). Newly discovered populations of astragalus tricarinatus (triple-ribbed milkvetch, fabaceae) are found on carbonate soils in the santa rosa mountains, riverside county, california. *Madroño*, *67*(4), 211-217.

ESRI. (2025). ArcGIS Pro. https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview

Fraga, N., & Pilapil, J. (2012). Surveys for Astragalus tricarinatus (Triple -rib milkvetch, Fabaceae). *Bureau of Land Management Cooperative agreement L10AC16219*. Habitat Conservation Plan. www.blm.gov/ca/pdfs/cdd_pdfs/Triplerib1.PDF.

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

Harvard University Herbaria and Libraries. GH: 00366431 *Astragalus tricarinatus* A. Gray USA: California Chuckawalla Mts. M. F. Spencer 1770 1921-4-6. Accessed October 8, 2025.

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

Jepson Flora Project. (2017). Jepson eFlora. Retrieved July 30, 2025, from http://ucjeps.berkeley.edu/eflora/.

NOAA. (2025) U.S. Wind Climatology | National Centers for Environmental Information (NCEI). https://www.ncei.noaa.gov/access/monitoring/wind/

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

U.S. Fish and Wildlife Service (USFWS) (2009). 5-Year review: summary and evaluation. Astragalus tricarinatus (triple-ribbed milk-vetch). https://ecos.fws.gov/docs/tess/species_nonpublish/1458.pdf

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