

Appendix B

Formal Public Comments

March 19, 2026

By Email

California Department of Parks and Recreation
Attn: Erik Taylor, General Plan Manager
Strategic Planning and Recreation Services Division
c/o Ocotillo Wells SVRA General Plan Update
P.O. Box 942896
Sacramento, CA 94296-0001
info@planocotillowells.org

*Re: EcoLogic Partners, Inc. Comments on Notice of Preparation for Ocotillo Wells
SVRA General Plan Update Environmental Impact Report*

Dear Mr. Taylor:

This firm represents EcoLogic Partners, Inc. (“EcoLogic”), a non-profit consortium of off-highway vehicle (OHV) organizations dedicated to the preservation and enhancement of recreational access to public lands in the western United States¹. EcoLogic members routinely visit the Ocotillo Wells State Vehicle Recreation Area (SVRA) and have a keen interest in the proposed General Plan Update (GPU) for the SVRA, as it will determine the type of uses allowed at the park. We have reviewed the Notice of Preparation (NOP) issued by State Parks for the GPU Environmental Impact Report (EIR) and offer the following comments on it.

I. Introduction and Purpose

On February 20, 2026, State Parks issued the NOP announcing that it will prepare an EIR for the proposed GPU. The NOP initiates the scoping process under CEQA and invites SVRA agencies and stakeholders to comment on the environmental issues that should be addressed in the forthcoming Draft EIR (“DEIR”).

The purpose of this comment letter is to ensure that the DEIR evaluates issues that are of greatest concern to the OHV community, particularly those relating to recreational access, trail availability, infrastructure, and the long-term viability of OHV recreation within the SVRA.

II. Overview of the Proposed Project

The proposed project consists of an update to the Ocotillo Wells SVRA General Plan, the first since 1982. The SVRA encompasses more than 85,000 acres in the Colorado Desert in Southern California, located near the Salton Sea in Imperial and San Diego Counties. The General Plan

¹ EcoLogic’s member organizations include the American Sand Association, the American Motorcyclist Association District 37, the Off Road Business Association, and the Specialty Equipment Market Association

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Update is intended to provide long-term policy guidance governing the management, development, and operation of the SVRA. The NOP states that the plan will incorporate updated management strategies and address land that has been added to the recreation area since the original plan was adopted. The proposed plan will also establish policies relating to OHV recreation, camping, concessions, special events, and facility development.

The EIR will serve as the program-level CEQA document supporting adoption of the updated General Plan and may be used as a reference for future site-specific projects implemented under the plan. Importantly, the NOP states that the EIR will analyze impacts across a wide range of resource areas, including: biological resources, air quality, cultural resources, land use, noise, transportation, recreation, utilities, wildfire, and others.²

III. Key Issues for Inclusion in the EIR

Based on the scope of the NOP and common issues arising in OHV planning processes, several topics should be emphasized to ensure the EIR adequately addresses the OHV recreational interests.

a. Availability of Riding Areas and Trail Connectivity

A central concern for OHV recreationists is the total acreage available for riding and the connectivity of trail networks within the SVRA. Management changes that restrict access to certain areas or alter trail systems can significantly affect the quality and safety of recreational experiences. The EIR should therefore analyze how proposed management strategies may affect the overall amount of land available for OHV recreation and whether trail connectivity will be maintained or expanded. This analysis should also evaluate the implications of any proposed trail designations, route closures, or changes to access points within the recreation area. The goal of the evaluation in the EIR is to help prevent a situation in which management decisions fragment the trail network or reduce the effective recreational capacity of the SVRA.

b. Potential Area Closures and Restrictions

Environmental management actions, such as habitat protection measures, cultural resource protection zones, or seasonal closures, can sometimes result in the restriction of OHV access to portions of recreation areas. The EIR should analyze the potential effects of any such restrictions on recreational opportunities. This includes evaluating how closures might affect the distribution of riders within the SVRA and whether they could lead to overcrowding or increased safety risks in remaining open areas. Additionally, the EIR should consider whether the displacement of riders

² The full list included in the NOP is as follows: Aesthetics, Air Quality and Greenhouse Gases, Biological Resources, Cultural and Tribal Cultural Resources, Energy, Geology, Soils, and Paleontological resources, Hydrology and Water Quality, Land Use and Planning, Mineral Resources, Noise, Public Services, Recreation, Transportation, Utilities and Service Systems, and Wildfire.

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from restricted areas may lead to increased use pressure in other portions of the park or in other regional OHV recreation areas.

c. Regional Demand for OHV Recreation

Ocotillo Wells SVRA is one of the largest OHV recreation areas in California and serves a significant regional and statewide recreation demand. Given the scale of the SVRA and its importance to the OHV community, the EIR should include an analysis of regional recreation demand and visitation trends. Such an analysis is important because reductions in available riding areas may have broader consequences beyond the boundaries of the SVRA. If access is reduced at Ocotillo Wells, riders may shift to other recreation areas that are already heavily used, potentially leading to increased environmental and safety impacts elsewhere. Accordingly, the EIR should consider the role of the SVRA within the broader network of OHV recreation areas in California.

d. Organized Events and Group Recreation

The SVRA has historically hosted organized OHV events, races, and group gatherings. These activities are important to the OHV community both culturally and economically. The EIR should evaluate how the proposed General Plan Update may affect the ability of the SVRA to host organized events and whether sufficient space and infrastructure will be available to accommodate such activities in the future.

e. Infrastructure and Recreational Facilities

The NOP indicates that the General Plan Update will address facility development and management policies. Infrastructure such as staging areas, campgrounds, restrooms, and support facilities plays a critical role in supporting safe and sustainable OHV recreation. The EIR should evaluate whether additional infrastructure may be necessary to accommodate current and projected visitation levels. This includes considering the adequacy of staging areas, camping facilities, and access points for riders entering the SVRA. From an environmental management perspective, properly designed facilities can help concentrate use in appropriate areas and reduce impacts to sensitive resources.

f. Visitor Safety and Emergency Access

The EIR should examine how management strategies may affect emergency response access, enforcement capacity, and other safety considerations. For example, changes to trail systems or staging areas may influence the ability of emergency responders to reach injured riders or other visitors in remote areas of the SVRA. Similarly, enforcement strategies may affect compliance with safety regulations and overall visitor behavior within the recreation areas. Ensuring that safety considerations are analyzed as part of the EIR will help support management decisions that protect both recreational users and park resources.

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g. Land Ownership and Land Use Compatibility

The SVRA exists within a complex landscape that includes multiple landowners and jurisdictions, including State Parks, the Bureau of Land Management, private landowners, and other governmental entities. Because of this mixed ownership pattern the EIR should analyze potential land use compatibility issues that could affect OHV access or management of the SVRA. This includes considering how adjacent land uses, development pressures, or jurisdictional boundaries may influence recreation patterns within the park. Understanding these interactions will help ensure the General Plan Update accounts for the broader land use context surrounding the SVRA.

IV. Conclusion

By emphasizing the aforementioned topics during the scoping process, our Comment Letter can help ensure that the environmental review provides a balanced analysis that considers both environmental protection and the continued availability of high-quality OHV recreation opportunities within Ocotillo Wells SVRA.

Very truly yours,



David P. Hubbard
of
Gatzke Dillon & Ballance LLP



Matt Kirkland <info@planocotillowells.org>

Ocotillo Wells SVRA General Plan Update - Notice of Preparation of an Environmental Impact Report

Ed Stovin <motoed@hotmail.com>

Sun, Mar 22, 2026 at 10:57 PM

To: Plan Ocotillo Wells <info@planocotillowells.org>

Hi Erik, here are our comments for the general plan. Please contact me anytime with questions or concerns. Our organization would be happy to help the park any way we can

Ed Stovin

858 822 8274

These comments on the Ocotillo Wells SVRA management plan formation are on behalf of the San Diego Off Road Coalition. Hundreds of thousands of people treasure camping in and traveling throughout OWSVRA. I have personally enjoyed hundreds of trips to Ocotillo Wells in the last 49 years. The high recreational resource value of Ocotillo Wells comes both from the wonderful topography in the park as well as the dedicated work of the park staff to maintain a first class recreational destination. I hope these comments can help Ocotillo Wells SVRA create a general plan that will preserve both motorized recreation and the natural environment.

After speaking with a number of SDORC members and other users of Ocotillo Wells SRVA, the overwhelming consensus is that less development is better. The users of the park want no more infrastructure added to the park. We understand that the park has the ability to put all kinds of infrastructure in the park. We don't want any more. No more road signs, shades, restrooms, trash containers, kiosks, interpretive etc. That being said, having a mobile ranger substation available to place in the north is believed to be a good idea. By substation, we don't mean a building, just a large camping trailer that can be parked up there on weekends. Something that would allow law enforcement and safety personnel to escape the elements while not on a call. As visitation in the park has been trending downward, it would be difficult to justify the expense of putting a permanent ranger station building in the north.

"Trails Only" OHV recreation should be limited as much as possible. Users of Ocotillo Wells enjoy trails and mostly recreate on trails, but love having the ability to go where there are no trails and to go on seldom used trails. For visitors who seek trails only recreation, please refer them to Anza Borrego Desert State Park, where there are 500 miles of routes and 10 times the number of acres. Ocotillo Wells was created by legislation to be an open OHV park. Please keep it this way.

Camping areas.

Under no circumstances should the park consider adding developed camping. That can be assumed to mean camping on pads with hookups. This would be contrary to the visual resource goals of the park. It would also make the more rugged campers feel bad (They have power and water, while we don't). It would create problems with getting power, water and sewage to and from the sites and would make reserving sites a challenge. If campers want to camp with hookups, there are private campgrounds across the street to fill that need.

Camping should be allowed in all open OHV areas and up to 200 feet on either side of routes in the limited use areas.

It is strongly felt that permanent concessions have no place in Ocotillo Wells. There are plenty of business's surrounding Ocotillo Wells to satisfy the needs of users. Temporary concessions play a different part in management goals. We believe that vendors should be allowed at special events with no special fees. Any kind of emergency concessions such as private ambulances and towing should be allowed without a permit. Rental RV placement should be allowed with minimal trouble. What we do not want to see is the ice cream man driving around or going camp to camp selling ice, firewood, snacks, gas etc.

Should dust problems arise in Ocotillo Wells, the park should be able to show that large amounts of dust are created when military aircraft land, touch and go and perform low fly by's at the Ocotillo Wells airport. Perhaps video a few occurrences and keep a log of a typical weeks maneuvers.

Cultural Resources

The park should establish a limit as to how much cultural resources are enough. Every old fire mark, bottle cap and empty can does not have to be protected. Interesting artifacts that tell an old story should be preserved, but every little piece of trash from 50 + years ago does not need protection. When cultural resources that need to be protection are found, the park should consider making a report on the site and then burying it under a few feet of soil. This will protect the resource while allowing OHV use to continue.

Fenced Area

Park users are frustrated with fenced areas throughout the park. These fences should be minimized as much as possible. While we don't agree with most of the fences, we have noticed that most fences have close wire weave down to the ground. We know that larger mammals cannot easily cross these fences. We recommend the lower half of fences be removed. This will allow animals to move freely, while still keeping vehicles out of sensitive areas. Our organization would be happy to organize volunteers to come out and help remove lower fence sections.

Inholdings

There are private holdings throughout OWSVRA. Much of this land contains terrain that is of high quality for motorized recreation. The Ocotillo Wells Plan must guide the OWSVRA to develop a procedure to bring this land into the park, should it come up for sale or become available for donation. Several prime parcels have come up for sale in recent years and the State Park was unable to acquire this land. Some of this land has been closed to off-roading and developed. This procedure must guide State Parks to act quickly, as many sellers lack the patience to wait months or years for a sale to close escrow.

Some land to the east of Ocotillo Wells is owned by the BLM. This area is managed by requiring travelers to stay on official routes. OWSVRA needs to designate more routes in this area for motorized use.

There are a variety of threats to recreation in Ocotillo Wells SVRA. OWSVRA must act to minimize these restrictions to motorized recreation. This would include, but are not limited to;

Renewable energy generation

Endangered species designations

Archeological findings

The Ocotillo Wells Plan must include language that states that the park's first priority is to provide maximum motorized off-highway vehicle opportunity. This state park is not a place to make wind, solar, geothermal or other types of energy, renewable or not. The Plan must contain language that states efforts to bring energy generation to Ocotillo Wells must be opposed. If such projects cannot be opposed, their impact to recreation must be minimized as much as possible and mitigation in the form of suitable land for motorized recreation must be provided to the off-road community at a cost entirely carried entirely by the entity bringing the project.

The Ocotillo Wells Plan must include language that states that the park will participate in any public process that attempts to list any species that lives in the park.

The Plan must recommend that solutions other than restriction to recreation be studied and exhausted regarding any species of concern before any restrictions to recreation be agreed upon or recommended by Ocotillo Wells SVRA.

The Ocotillo Wells Plan must include language that states that the park will protect the maximum amount of motorized recreation possible when managing archeological resources within the park.

While off-road opportunities abound in the park, some users enjoy riding motocross on a closed course. The Ocotillo Wells Plan should direct OWSVRA to study the possibility of constructing a pay for use groomed motocross track for motocross practice and racing.

There is a need to have a safe and quick way for Ocotillo Wells SVRA staff to cross the park to reach the north side (near S22) for safety, law enforcement or other issues. Construction of such a route may be recommended to have the least effect on motorized recreation and on the environment. We would like to suggest a route that uses as much existing wash and routes as possible. Take the Shell Reef Expressway to East Bank Wash north. From there a way may be found, and/or improved, to connect to the Arroyo Salada Wash to Crossover Trail and Holly Road. The way north from the Bank Wash area may skirt the border of Anza Borrego Desert State Park. Ocotillo Wells SVRA may want to consult with ABDSP about a route in this area.

Law enforcement

Law enforcement in the past has been something that OWSVRA can be proud of. Peace has been kept and resources have been protected. The role of law enforcement in OWSVRA should continue to prioritize education over enforcement whenever possible. Seldom has the off-road community heard of improper behavior by park rangers. Most visitors consider OWSVRA rangers friendly and helpful. I hope that their role in park management can continue as it has in the past.

Fees

Many off-road vehicle areas charge fees to enter. OWSVRA should oppose charging fees to enter or operate a vehicle within its boundary. There is sufficient money from green sticker fees and fuel taxes to cover operating costs of the park. The collection of fees in other areas has proven to be extremely inefficient. Some prominent areas spend as much as 1/3 of the fee money collected in the collection of fees.

I hope these comments will help to maintain and improve recreation in Ocotillo Wells SVRA. I am very interested in the positive outcome of this project and will make myself available to assist at any stage of these proceedings.

Edward Stovin

858 822 8274

President San Diego Off Road Coalition

From: Plan Ocotillo Wells <info@planocotillowells.org>

Sent: Friday, February 20, 2026 9:49 AM

Subject: Ocotillo Wells SVRA General Plan Update - Notice of Preparation of an Environmental Impact Report

[Quoted text hidden]

California Department of Transportation

DISTRICT 11
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March 23, 2026

11-IMP-78,86

VAR

Ocotillo Wells SVRA GPU

NOP/SCH#2026020853

Mr. Erik Taylor
General Plan Project Manager
California Department of Parks and Recreation
Strategic Planning and Recreation Services Division
P.O. Box 942896
Sacramento, CA 94296-0001

Dear Mr. Taylor:

Thank you for including the California Department of Transportation (Caltrans) in the environmental review process for the Notice of Preparation (NOP) for a Draft Environmental Impact Report on the Ocotillo Wells State Vehicular Recreation Area (SVRA) General Plan Update (GPU) located near State Routes 78 and 86 (SR-78, SR-86) in San Diego and Imperial Counties. The mission of Caltrans is to provide a safe and reliable transportation network that serves all people and respects the environment. The Local Development Review (LDR) Program reviews land use projects and plans to ensure consistency with our mission and state planning priorities.

Safety is one of Caltrans' strategic goals. Caltrans strives to make the year 2050 the first year without a single death or serious injury on California's roads. We are striving for more equitable outcomes for the transportation network's diverse users. To achieve these ambitious goals, we will pursue meaningful collaboration with our partners. We encourage the implementation of new technologies, innovations, and best practices that will enhance the safety on the transportation network. These pursuits are both ambitious and urgent, and their accomplishment involves a focused departure from the status quo as we continue to institutionalize safety in all our work.

Caltrans is committed to prioritizing projects that are equitable and provide meaningful benefits to historically underserved communities, to ultimately improve transportation accessibility and quality of life for people in the communities we serve.

We look forward to working with the Department of Parks and Recreation in areas where the agency and Caltrans have joint jurisdiction to improve the transportation network and connections between various modes of travel, with the goal of improving the experience of those who use the transportation system.

Caltrans has the following comments:

Traffic Impact Study

- A Vehicle Miles of Travel (VMT) based Traffic Impact Study (TIS) should be provided for this project. Please use the Governor's Office of Planning and Research Guidance to identify VMT related impacts.¹ If a Vehicle Miles of Travel (VMT) based Traffic Impact Study (TIS) and/or Local Mobility Analysis is completed, please provide a copy for this project to Caltrans for review.
- The TIS may also need to identify the proposed project's near-term and long-term safety or operational issues, on or adjacent any existing or proposed State facilities.
- For Draft Environmental Impact Report (DEIR) for Ocotillo Wells SVRA GPU, please reference the Caltrans "Local Development Review (LDR) Safety Review Practitioner's Guidance" <https://dot.ca.gov/-/media/dot-media/programs/safety-programs/documents/202402-ldr-safety-review-practitioners-guidance-a11y.pdf> to determine if the project meets both of the screening criteria. If both screening criteria are not met, then a safety review will be needed.
- On all plans, indicate Caltrans' Right-of-Way (R/W) lines. It's important to clearly delineate Caltrans' R/W limits by calling them out on your plans so we can identify any impacts to Caltrans' state facilities. You can access Caltrans' R/W lines/maps by following the link to the Caltrans public website below:

<https://experience.arcgis.com/experience/04ae3745190047c5adf8f33714af9e3a>
- Please clarify and clearly identify on the Site Plan all proposed driveway access points for the proposed project.
- SR-78 and SR-86 in this area are mostly access-controlled. Proposed ingress and egress to the State Highways should be at permitted access points. Please include and clearly indicate the proposed and existing ingress and egress locations in the transportation/traffic study.
- Please explain whether the proposed project plans on using existing driveway access points off SR-78 and SR-86 or if the project is proposing to install any new access points along the State Highway System.
- The proposed project will not be allowed direct access off SR-78 or SR-86 if there is access to the project site through a County of San Diego or Imperial County owned local road. Caltrans District 11 standard practice is not to allow new access onto any state facility if there is access through a local street or road. Allowing new access creates new conflict points for motorists on SR-78 or SR-86 where there was none.

¹ California Governor's Office of Planning and Research (OPR) 2018. "Technical Advisory on Evaluating Transportation Impacts in CEQA." https://opr.ca.gov/docs/20190122-743_Technical_Advisory.pdf

- If the project proposes any new intersections or major modifications to existing intersections on the State Highway System along SR-78 (Anza-Borrego Desert State Park Road) or SR-86, the Caltrans Intersection Safety and Operational Assessment Policy (ISOAP) will be triggered. Please refer to the ISOAP policy for applicable requirements:
<https://dot.ca.gov/programs/traffic-operations/isoap>.
- An encroachment permit will be necessary to make any improvements within the State's R/W if allowed and approved by Caltrans.

Hydrology and Drainage Studies

- Please provide hydraulics studies, drainage and grading plans to Caltrans for review.
- Provide a pre and post-development hydraulics and hydrology study. Show drainage configurations and patterns.
- Provide drainage plans and details. Include detention basin details of inlets/outlet.
- Provide a contour grading plan with legible callouts and minimal building data. Show drainage patterns.
- On all plans, show Caltrans' Right of Way (R/W).
- Early coordination with Caltrans is recommended.
- Caltrans generally does not allow development projects to impact hydraulics within the State's Right-of-Way. Any modification to the existing Caltrans drainage and/or increase in runoff to State facilities will not be allowed.

Design

Caltrans State Highway Operation and Protection Program (SHOPP) Project 11-43194 proposes pavement preservation of approximately 25 miles of southbound SR-86 west of the Salton Sea and adjacent to the Ocotillo Wells SVRA project. This project and other proposed improvements are as follows:

- Pavement preservation, southbound SR-86 (PM R43.035/67.824)
- Drainage Restoration - Replace/Install Culvert – 526.8 Linear Feet - Cure-In-Place Line Culvert – 2379.8 Linear Feet
- Guardrail - 34,183 Linear Feet – Replace guardrail
- Sign Panel Replacement - 30 Each
- Electrical Elements - 12 Each – Lighting Rehabilitation - 3 Each – Census Stations (Minor Work) - 6 Each – Accessible Pedestrian Signal
- Complete Street Elements - 127,844 Linear Feet, Bikeway Class 2 Buffered –Southbound Direction - 8 Conflict Zone Green Paint - Rumble Strip with Gaps for Bicycles

Tentative timelines for this project are as follows:

- Begin Environmental: 8/21/2026
- PA&ED Phase: 3/7/2028
- Begin Design: 5/4/2028
- Ready to List: 12/21/2029
- Approve Construction Contract: 9/3/2030
- Contract Acceptance: 2/9/2033

In addition, Caltrans SHOPP Project 11-43274 proposes a roundabout on SR-86 at the intersection of Black Diamond Road (PM R62.38). This project is in the PID phase.

Another Caltrans SHOPP Project 11-43155 proposes rehabilitation of existing pavement along SR-78 (PM 34.0/41.1).

Other proposed improvements – Please be aware of these existing Caltrans projects:

- On SD-078 at postmiles 80.00/95.30 (near Ocotillo Wells from 3.2 miles east of Yaqui Pass Road to Imperial County Line), work is proposed to take place around July 2026 to provide microsurfacing.
- On IMP-078 at postmiles 0.00/13.20 (near Ocotillo Wells from San Diego County Line to North Junction Route 86), work is proposed to implement microsurfacing, rumble strips, and pavement delineation for pavement preservation.

System Planning

The following documents are helpful resources to reference:

[ICTC Long Range Transportation Plan 2024](#) – The Imperial County Transportation Commission (ICTC) Long Range Transportation Plan may provide further background on regional planning efforts. We encourage further review of the Plan and the following sections that may support your project:

- [Appendices A-G](#) provide additional information regarding the region.
- Appendix E: SR-86 Border Patrol Checkpoint Expansion (SR-86 near intersection of SR-78)

[SCAG Connect SoCal 2024](#) – Connect SoCal 2024 is a plan prepared by Southern California Association of Governments (SCAG) that supports the implementation of transportation projects in a coordinated manner across public agencies. It includes projects, policies, strategies, and investments that contribute towards the region's communities, mobility, environment, and economy.

[SANDAG 2025 Regional Plan](#) – Although the majority of the Ocotillo Wells SVRA is in Imperial County, the western portion of the area is in San Diego County. The San Diego Association of Governments (SANDAG) 2025 Regional Plan may provide further background on state and regional planning efforts.

- [Appendix A: Transportation Projects, Programs, Policies, and Phasing](#) includes one project that is relevant to the Ocotillo Wells SVRA:
 - CC095: SR 78 Transportation Technology

[California Transportation Plan 2050 \(CTP 2050\)](#) – The CTP 2050 provides a common framework for guiding transportation decisions and investments by all levels of government and the private sector. Statutorily mandated federal and state law requires that Caltrans facilitate, develop, and prepare the CTP.

- Please review this guidance for topics on safety and operations, GHG emissions reduction and VMT mitigation, multimodal transportation, land use and more.

[Climate Action Plan for Transportation Infrastructure \(CAPTI\)](#) – The California State Transportation Agency (CalSTA) adopted the CAPTI in 2021, which details how the state recommends investing transportation dollars annually to combat and adapt to climate change while supporting public health, safety and equity. The update, [CAPTI 2.0](#) was released in February 2025.

- Please review this guidance as it relates to goals for reduction of GHG emissions, VMT mitigation, transportation and land use connections, multimodal transportation options, and zero emission vehicle infrastructure.

[Smart Mobility Framework 2010](#) – The Smart Mobility Framework (SMF) was prepared by Caltrans to address both long-range challenges and short-term programmatic actions to implement sustainable transportation strategies in California. The SMF is a planning framework that helps guide and assess how well plans, programs, and projects meet a definition of "smart mobility".

- Please review this guide for details on housing, improved accessibility, social equity, reduction of environmental impacts, and more.
- Please review this guide for information on VMT mitigation, GHG emissions reduction, and open space preservation.

Noise

The applicant must be informed that in accordance with 23 Code of Federal Regulations (CFR) 772, the Department of Transportation (Caltrans) is not responsible for existing or future traffic noise impacts associated with the existing configuration of SR-78 and SR-86.

Environmental

Caltrans welcomes the opportunity to be a Responsible Agency under the California Environmental Quality Act (CEQA), as we have some discretionary authority of a portion of the project that is in Caltrans' R/W through the form of an encroachment permit process. We look forward to the coordination of our efforts to ensure that Caltrans can adopt the alternative and/or mitigation measure for our R/W. We would appreciate meeting with you to discuss the elements of the Environmental Document that Caltrans will use for our subsequent environmental compliance.

An encroachment permit will be required for any work within the Caltrans' R/W prior to construction. As part of the encroachment permit process, the applicant must provide approved final environmental documents for this project, corresponding technical studies, and necessary regulatory and resource agency permits. Specifically, CEQA determination or exemption. The supporting documents must address all environmental impacts within the Caltrans' R/W and address any impacts from avoidance and/or mitigation measures.

We recommend that this project specifically identifies and assesses potential impacts caused by the project or impacts from mitigation efforts that occur within Caltrans' R/W that includes impacts to the natural environment, infrastructure including but not limited to highways, roadways, structures, intelligent transportation systems elements, on-ramps and off-ramps, and appurtenant features including but not limited to fencing, lighting, signage, drainage,

guardrail, slopes and landscaping. Caltrans is interested in any additional mitigation measures identified for the project's Draft Environmental Document.

Sustainability

The Climate Action Plan (CAP) contains several actions and strategies that align with Caltrans' responsibilities and priorities. Caltrans recommends collaboration between our agency and the Department of Parks and Recreation on the proposed transportation related topics including adaptation strategies to help improve the City's resilience to potential climate change impacts and strategies to reduce vehicle miles traveled (VMT), and off-road and on-road greenhouse gas (GHG) emissions.

Caltrans recognizes that transportation is a leading contributor to GHG emissions in the region and is dedicated to reducing and mitigating transportation related emissions. We recommend collaborating with Caltrans on the following measures such as increasing the use of zero emission vehicles, installing electric vehicle (EV) charging stations, identifying right-of-way areas to be used for carbon sequestration, and complete streets.

The existing climate hazards discussed in this document will have an impact of the transportation system. We recommend working with Caltrans on determining the preventative strategies the Caltrans can take to keep roadways operational and ensure their longevity against climate stressors such as increased temperatures, changes in precipitation patterns, wildfire, and flooding. Caltrans recognizes the central role that transportation planning plays in safety and ensuring that when these natural hazards do occur, citizens have a reliable evacuation route.

Mitigation

Caltrans endeavors that any direct and cumulative impacts to the State Highway network be eliminated or reduced to a level of insignificance pursuant to the CEQA and National Environmental Policy Act (NEPA) standards.

Right-of-Way

Per Business and Profession Code 8771, perpetuation of survey monuments by a licensed land surveyor is required, if they are being destroyed by any construction.

Any work performed within Caltrans' R/W will require discretionary review and approval by Caltrans and an encroachment permit will be required for any work within the Caltrans' R/W prior to construction.

Additional information regarding encroachment permits may be obtained by visiting the website at <https://dot.ca.gov/programs/traffic-operations/ep>. Projects with the following:

- require a Caltrans Encroachment Permit
- have completed the Caltrans Local Development Review (LDR) process
- have an approved environmental document

Mr. Erik Taylor, General Plan Project Manager

March 23, 2026

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need to have documents submitted for Quality Management Assessment Process (QMAP) process via email to D11.QMAP.Permits@dot.ca.gov. Early coordination with Caltrans is strongly advised for all encroachment permits.

If you have any questions or concerns, please contact Mark McCumsey, LDR Coordinator, at (619) 985-4957 or by e-mail sent to Mark.McCumsey@dot.ca.gov.

Sincerely,

Kimberly D. Dodson

KIMBERLY D. DODSON, GISP
Branch Chief
Local Development Review



Matt Kirkland <info@planocotillowells.org>

New form submission on Webflow for Ocotillo Wells SVRA General Plan Update

Webflow forms <no-reply-forms@webflow.com>

Sat, Mar 7, 2026 at 4:55 AM

Reply-To: no-reply@webflow.com

To: info@planocotillowells.org

You just received a new form submission on your website Ocotillo Wells SVRA General Plan Update.

Name: James Konugres

Email Address: konugres@gmail.com

Organization:

Comment: Please keep open our public lands at ocotillo Wells SVRA. Longtime mororcyclist (62 y/o) and we pay our taxes to enjoy our land and NOT be on our phones!

Number of submissions received

1/unlimited this month

March 1st – March 31st

Need more submissions?

Please contact your website administrator.

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Matt Kirkland <info@planocotillowells.org>

New form submission on Webflow for Ocotillo Wells SVRA General Plan Update

Webflow forms <no-reply-forms@webflow.com>

Thu, Mar 5, 2026 at 10:35 PM

Reply-To: no-reply@webflow.com

To: info@planocotillowells.org

You just received a new form submission on your website Ocotillo Wells SVRA General Plan Update.

Name: James Rue

Email Address: ruefamily@att.net

Organization: none

Comment: More adventure to the Park. Ocotillo Wells, as you know has some wonderful scenic and interesting area, including history. I would like to see "adventure trails" where the trail provides an adventure with education. Create designated trails, where the adventurer sees an educational path with information about our desert. The trails can be somewhat challenging, but manageable for all ages, so that they move through slowly. There would be more stopping, observing, and learning (may be trail signs with images), similar to what is at other state parks. And/or scheduled adventure rides with "Park guides". Some of the trails should be ride to, and walk to, themes. Maybe, with more "adventures" trails / guides people will stop driving and riding like the park is a raceway. "Stop, Look, Listen and Smell the Desert flowers". Additionally, these trails would naturally have to be updated regularly. What was in east move to the west, what is in the north move to south, etc.... For those who can't get to all the "adventure areas".

Number of submissions received

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Matt Kirkland <info@planocotillowells.org>

New form submission on Webflow for Ocotillo Wells SVRA General Plan Update

Webflow forms <no-reply-forms@webflow.com>

Mon, Mar 2, 2026 at 2:04 PM

Reply-To: no-reply@webflow.com

To: info@planocotillowells.org

You just received a new form submission on your website Ocotillo Wells SVRA General Plan Update.

Name: Beverley jean MANGIMELLI

Email Address: mangimelli@cox.net

Organization: San Diego four wheeler

Comment: Please save our off road areas

[Quoted text hidden]



Matt Kirkland <info@planocotillowells.org>

New form submission on Webflow for Ocotillo Wells SVRA General Plan Update

Webflow forms <no-reply-forms@webflow.com>

Mon, Mar 2, 2026 at 1:21 PM

Reply-To: no-reply@webflow.com

To: info@planocotillowells.org

You just received a new form submission on your website Ocotillo Wells SVRA General Plan Update.

Name: Jeff Radtke

Email Address: bayhiker@yahoo.com

Organization:

Comment: I travel 10 hours to get to this SVRA, to train and then ride in the local desert trails. When these training and recreation areas exist like this, we all benefit in getting more people outdoors to appreciate the special desert landscapes in California. If trails or areas are closed or reduced, the remaining open trails are further eroded and far less desirable due to over use. Please create more trails and recreation areas for this most populous state to recreate in California.

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Matt Kirkland <info@planocotillowells.org>

New form submission on Webflow for Ocotillo Wells SVRA General Plan Update

Webflow forms <no-reply-forms@webflow.com>

Wed, Mar 4, 2026 at 4:42 PM

Reply-To: no-reply@webflow.com

To: info@planocotillowells.org

You just received a new form submission on your website Ocotillo Wells SVRA General Plan Update.

Name: kuuipoaloha p Lawler

Email Address: kuuipoaloha@cox.net

Organization: SDORC

Comment: 1. The 5 Things Riders Are Most Worried About These concerns come up in almost every OHV planning process in California. 1. Gradual Loss of Open Riding Areas Ocotillo Wells is famous because it is one of the last truly open riding parks. The fear is that planners may shift toward: designated trails only restricted riding zones seasonal closures This has happened in other OHV areas like Dumont Dunes and parts of Johnson Valley. Key concern riders have: Open desert riding slowly becomes "stay on marked trails." 2. Habitat Protection Expanding into Riding Areas Environmental pressure often focuses on: Desert tortoise sensitive desert plants archaeological/cultural sites When these protections expand, they can lead to: permanent closures seasonal closures buffer zones around habitats Sometimes closures start small and expand later. 3. Land Acquisitions Being Closed to Riding Since the original 2007 plan, the park has added lands. The big question riders ask: Will new lands become riding areas or conservation zones? Sometimes new acquisitions become "resource protection areas." 4. Increased Regulation and Enforcement Another concern is a shift toward: more designated trails more patrol enforcement speed restrictions noise enforcement These can slowly change the riding experience. 5. Event Restrictions and Visitor Limits Ocotillo Wells hosts large holiday gatherings and events. Possible concerns include: limiting group events permits required for larger gatherings restricting camping areas This affects clubs and riding groups. 2. How to Influence the General Plan Process Effectively Most people show up too late in the process when decisions are already made. To have influence you want to engage early and consistently. Step 1 — Get on the Project Mailing List Make sure you receive: public meeting notices draft plan releases comment periods These are where influence happens. Step 2 — Comment During the "Scoping Phase" This is the most important phase. This stage decides: what issues are studied what alternatives are considered If riders don't comment here, planners assume no one cares about those issues. Step 3 — Support Balanced Language Instead of just saying: ✗ "Don't close riding areas." Say something like: ✓ "The General Plan should prioritize maintaining Ocotillo Wells as a unique open riding area while protecting sensitive habitats through targeted management rather than broad closures." This sounds reasonable to planners and regulators. Step 4 — Show Economic Impact State agencies listen when you mention: tourism local businesses visitor spending Ocotillo Wells supports: gas stations RV parks restaurants repair shops Nearby communities depend on riders. Step 5 — Encourage Rider Stewardship One powerful suggestion is: volunteer cleanup days trail education programs habitat protection awareness This shows the OHV community cares about the land. 3. How Plans Quietly Restrict Riding Areas Restrictions often happen through small wording changes in planning documents. Here are the most common ways. Method 1: "Resource Protection Zones" Plans may create zones labeled something like: Sensitive Resource Area Habitat Protection Zone Cultural Resource Management Area These zones often mean no riding allowed. Sometimes they are large areas. Method 2: "Adaptive Management" This phrase appears often in park plans. Example language: "Management actions may be adjusted over time to protect sensitive resources." This allows future closures without another full public process. Method 3: Conversion to "Designated Route System" This is the biggest change riders fear. Instead of riding anywhere in open desert, riders must stay on: marked trails mapped routes This dramatically reduces riding freedom. Method 4: Seasonal Habitat Closures Plans may say something like: "Seasonal closures may be implemented to protect wildlife during breeding periods." These closures sometimes expand later. Method 5: Gradual Shrinking Through Monitoring Another tactic is: "Areas showing environmental degradation may be closed or restored." Over time this can shrink riding zones. I would like to thank the BLM for helping my family to enjoy 50 years of riding in the parks and open land. You deserve a true Mahalo for all the hard work on making an impact general plan. Kuuipoaloha Lawler

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Matt Kirkland <info@planocotillowells.org>

New form submission on Webflow for Ocotillo Wells SVRA General Plan Update

Webflow forms <no-reply-forms@webflow.com>

Mon, Mar 2, 2026 at 3:53 PM

Reply-To: no-reply@webflow.com

To: info@planocotillowells.org

You just received a new form submission on your website Ocotillo Wells SVRA General Plan Update.

Name: tim thomas

Email Address: timet@sbcglobal.net

Organization: Dirt Devils of Southern California

Comment: Please keep all land available for recreational use. Being able to protect the environment through marking trails, fence lines, signs, and trail routes is a benefit for all to respect the environment and enjoy what is available. As a member of 2 four wheel drive clubs as well as being part of California's CORVA and Cal4wheel, I believe these are organizations that allow us to enjoy the land, trails, OHVs, and other places of interest very responsibly. Thank you

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Matt Kirkland <info@planocotillowells.org>

NOTICE OF PREPARATION-Environmental Impact Report for the Ocotillo Wells State Vehicular Recreation Area General Plan Update

Perez, Vanessa@SLC <Vanessa.Perez@slc.ca.gov>

Fri, Mar 13, 2026 at 1:13 PM

To: "\"info@planocotillowells.org\"" <info@planocotillowells.org>

Cc: "Hall, Christopher@SLC" <Christopher.Hall@slc.ca.gov>

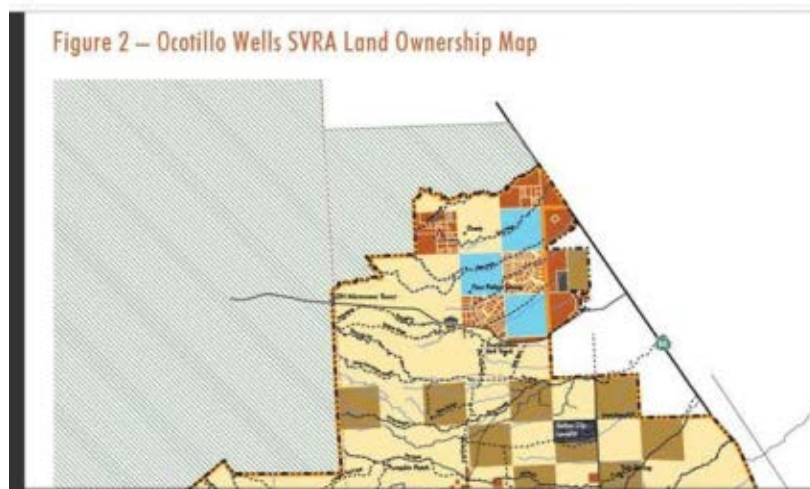
Hello,

For the subject notice, the commission is trying to determine the section, township, and range that you have highlighted in baby blue as Commission-owned lands. I am guessing this area is near the Salton Sea airport but also struggling to read the town names in your map.

Since I am sending a formal inquiry to our boundary staff, so I like to confirm the area. Can you please provide the Section, township, and range or another identifier.

Thank you

of Preparation_Final_20260220.pdf



Since I am sending a formal inquiry to our boundary staff, so I like to confirm the area. Can you please provide the Section, township, and range or another identifier.

Thank you

Vanessa Perez, Senior Mineral Resources Engineer

Mineral Resources Management Division

[CALIFORNIA STATE LANDS COMMISSION](#)

301 East Ocean Blvd., Suite 550

Long Beach, CA 90802

Phone: 562-400-7654

Vanessa.Perez@slc.ca.gov

Work Hours: Mon. – Thurs., 7:30 a.m.- 5:00 p.m. (alternating Fri. 7:30-4:00)



STATE OF CALIFORNIA
DEPARTMENT OF FISH AND WILDLIFE



GAVIN NEWSOM, Governor
MEGHAN HERTEL, Director

Inland Deserts Region
3602 Inland Empire Blvd., Suite C-220
Ontario, CA 91764
wildlife.ca.gov

March 18, 2026
Sent via email

Erik Taylor
General Plan Project Manager
California Department of Parks and Recreation
P.O. Box 942896
Sacramento, CA 94296
info@planocotillowells.org

**Subject: Notice of Preparation of a Draft Environmental Impact Report
Ocotillo Wells State Vehicular Recreation Area General Plan Update Project
State Clearinghouse No. 2026020853**

Dear Erik Taylor:

The California Department of Fish and Wildlife (CDFW) received a Notice of Preparation (NOP) of a Draft Environmental Impact Report (DEIR) from the California Department of Parks and Recreation for the Ocotillo Wells State Vehicular Recreation Area General Plan Update (Project) pursuant to the California Environmental Quality Act (CEQA) and CEQA Guidelines.¹ Thank you for the opportunity to provide comments and recommendations regarding those activities involved in the Project that may affect California fish and wildlife. Likewise, we appreciate the opportunity to provide comments regarding those aspects of the Project that CDFW, by law, may be required to carry out or approve through the exercise of its own regulatory authority under the Fish and Game Code.

CDFW ROLE

CDFW is California's Trustee Agency for fish and wildlife resources, and holds those resources in trust by statute for all the people of the State. (Fish & G. Code, §§ 711.7, subd. (a) & 1802; Pub. Resources Code, § 21070; CEQA Guidelines § 15386, subd. (a).) CDFW, in its trustee capacity, has jurisdiction over the conservation, protection, and management of fish, wildlife, native plants, and habitat necessary for biologically sustainable populations of those species. (*Id.*, § 1802.) Similarly, for purposes of CEQA, CDFW is charged by law to provide, as

¹ CEQA is codified in the California Public Resources Code in section 21000 et seq. The "CEQA Guidelines" are found in Title 14 of the California Code of Regulations, commencing with section 15000.

available, biological expertise during public agency environmental review efforts, focusing specifically on projects and related activities that have the potential to adversely affect fish and wildlife resources.

CDFW is also submitting comments as a Responsible Agency under CEQA. (Pub. Resources Code, § 21069; CEQA Guidelines, § 15381.) CDFW expects that it may need to exercise regulatory authority as provided by the Fish and Game Code. As proposed, for example, the Project may be subject to CDFW's lake and streambed alteration regulatory authority. (Fish & G. Code, § 1600 et seq.) Likewise, to the extent implementation of the Project as proposed may result in "take" as defined by State law of any species protected under the California Endangered Species Act (CESA) (Fish & G. Code, § 2050 et seq.), the Project proponent may seek related take authorization as provided by the Fish and Game Code.

PROJECT DESCRIPTION SUMMARY

The proposed Project is located within the Ocotillo Wells State Vehicular Recreation Area (SVRA) that encompasses more than 85,000 acres and lies just west of the Salton Sea, in the Colorado Desert in Southern California in Imperial and San Diego counties. It is located approximately 90 miles northeast of the City of San Diego, near the intersection of State Route (SR) 78 and SR 86. The community of Ocotillo Wells is adjacent to Ocotillo Wells SVRA to the south, and the community of Salton City is adjacent to the east.

The Project proposes an update to the 1982 Ocotillo Wells SVRA General Plan. This proposed comprehensive update would incorporate new management strategies and include new areas that have been added to Ocotillo Wells SVRA since 1982.

COMMENTS AND RECOMMENDATIONS

CDFW offers the comments and recommendations below to assist the California Department of Parks and Recreation in adequately identifying and/or mitigating the Project's significant, or potentially significant, direct and indirect impacts on fish and wildlife (biological) resources.

CDFW recognizes that the general plan EIR need not be as detailed as CEQA documents prepared for specific projects that may follow (CEQA Guidelines § 15146). CDFW also recognizes that the level of detail should be reflective of the level contained in the plan or plan element being considered (*Rio Vista Farm Bureau Center v. County of Solano* (1992) 5 Cal.App.4th 351). However, please note that the California Department of Parks and Recreation cannot defer the analysis of significant effects of the general plan to later-tiered CEQA documents (*Stanislaus Natural Heritage Project v. County of Stanislaus* (1996) 48 Cal.App.4th 182).

CDFW recommends that the forthcoming DEIR address the following:

Assessment of Biological Resources

Section 15125(c) of the CEQA Guidelines states that knowledge of the regional setting of a project is critical to the assessment of environmental impacts and that special emphasis should be placed on environmental resources that are rare or unique to the region. To enable CDFW staff to adequately review and comment on the project, the DEIR should include a complete assessment of the flora and fauna within and adjacent to the Project footprint, with particular emphasis on identifying rare, threatened, endangered, and other sensitive species and their associated habitats.

The CDFW recommends that the DEIR specifically include:

1. An assessment of the various habitat types located within the project footprint, and a map that identifies the location of each habitat type. CDFW recommends that floristic, alliance- and/or association-based mapping and assessment be completed following *The Manual of California Vegetation*, second edition (Sawyer et al. 2009²). Adjoining habitat areas should also be included in this assessment where site activities could lead to direct or indirect impacts offsite. Habitat mapping at the alliance level will help establish baseline vegetation conditions.
2. A general biological inventory of the fish, amphibian, reptile, bird, and mammal species that are present or have the potential to be present within each habitat type onsite and within adjacent areas that could be affected by the project. CDFW's California Natural Diversity Database (CNDDDB) in Sacramento should be contacted at (916) 322-2493 or CNDDDB@wildlife.ca.gov or <https://wildlife.ca.gov/Data/CNDDDB/Maps-and-Data> to obtain current information on any previously reported sensitive species and habitat, including Significant Natural Areas identified under Chapter 12 of the Fish and Game Code, in the vicinity of the proposed Project.

CDFW's CNDDDB is not exhaustive in terms of the data it houses, nor is it an absence database. CDFW recommends that it be used as a starting point in gathering information about the *potential presence* of species within the general area of the project site.

3. A complete, *recent* inventory of rare, threatened, endangered, and other sensitive species located within the Project footprint and within offsite areas with the potential to be affected, including California Species of Special Concern (CSSC) and California Fully Protected Species (Fish & G. Code, § 3511). Species to be addressed should include all those which meet the CEQA definition (CEQA Guidelines § 15380). The inventory should address seasonal variations in use of the Project area and should not be limited to

² Sawyer, J. O., T. Keeler-Wolf, and J. M. Evens. 2009. A manual of California Vegetation, 2nd ed. California Native Plant Society Press, Sacramento, California. <http://vegetation.cnps.org/>

resident species. Focused species-specific, completed by a qualified biologist and conducted at the appropriate time of year and time of day when the sensitive species are active or otherwise identifiable, are required. Acceptable species-specific survey procedures should be developed in consultation with CDFW and the U.S. Fish and Wildlife Service, where necessary. Note that CDFW generally considers biological field assessments for wildlife to be valid for a one-year period, and assessments for rare plants may be considered valid for a period of up to three years. Some aspects of the proposed Project may warrant periodic updated surveys for certain sensitive taxa, particularly if the Project is proposed to occur over a protracted time frame, or in phases, or if surveys are completed during periods of drought.

Burrowing Owl (*Athene cunicularia*)

On October 10, 2024, the Fish and Game Commission determined that western burrowing owl warrants protection as a candidate species under the California Endangered Species Act (Fish & G. Code, § 2050 et seq.). During the candidacy period, western burrowing owl will be afforded the same protection as threatened and endangered species under CESA. If Project activities, including burrow exclusion and closure, could result in take, appropriate CESA authorization (i.e., Incidental Take Permit under Fish and Game Code section 2081) should be obtained prior to commencement of Project activities.

The Project site has the potential to provide suitable foraging and/or nesting habitat for burrowing owl. Take of individual burrowing owls and their nests is defined by Fish and Game Code section 86, and prohibited by sections 3503, 3503.5 and 3513. Take is defined in Fish and Game Code section 86 as “hunt, pursue, catch, capture or kill, or attempt to hunt, pursue, catch, capture or kill.”

CDFW recommends that the California Department of Parks and Recreation follow the recommendations and guidelines provided in the *Staff Report on Burrowing Owl Mitigation* (Department of Fish and Game, March 2012); available for download from CDFW's website:

<https://www.wildlife.ca.gov/conservation/survey-protocols>. The Staff Report on Burrowing Owl Mitigation, specifies three steps for project impact evaluations:

- a. A habitat assessment;
- b. Surveys; and
- c. An impact assessment

As stated in the Staff Report on Burrowing Owl Mitigation, the three progressive steps are effective in evaluating whether a project will result in impacts to burrowing owls, and the information gained from the steps will inform any subsequent avoidance, minimization, and mitigation measures. Habitat assessments are conducted to evaluate the likelihood that a site supports burrowing owl. Burrowing owl surveys provide information needed to

determine the potential effects of proposed projects and activities on burrowing owls, and to avoid take in accordance with Fish and Game Code sections 86, 3503, and 3503.5. Impact assessments evaluate the extent to which burrowing owls and their habitat may be impacted, directly or indirectly, on and within a reasonable distance of a proposed CEQA project activity or non-CEQA project.

Within the 2012 Staff Report, the minimum habitat replacement recommendation was purposely excluded as it was shown to serve as a default, replacing any site-specific analysis and discounting the wide variation in natal area, home range, foraging area, and other factors influencing burrowing owls and burrowing owl population persistence in a particular area. It hypothesized that mitigation for permanent impacts to nesting, occupied, and satellite burrows and burrowing owl habitat should be on, adjacent or proximate to the impact site where possible and where habitat is sufficient to support burrowing owls present. If mitigation occurs offsite, it should include (a) permanent conservation of similar vegetation communities (grassland, scrublands, desert, urban, and agriculture) to provide for burrowing owl nesting, foraging, wintering, and dispersal (i.e., during breeding and non-breeding seasons) comparable to or better than that of the impact area, and (b) be sufficiently large acreage with the presence of fossorial mammals. Furthermore, the report noted that suitable mitigation lands should be based on a comparison of the habitat attributes of the impacted and conserved lands, including but not limited to: type and structure of habitat being impacted or conserved; density of burrowing owls in impacted and conserved habitat; and significance of impacted or conserved habitat to the species range-wide.

Desert Tortoise (*Gopherus agassizii*)

Portions of the proposed Project occurs within the range of desert tortoise; a state- and federally-listed threatened species and state candidate for uplisting to endangered. CDFW recommends that the California Department of Parks and Recreation complete protocol level surveys over all areas (i.e., 100 percent coverage) proposed to be directly or indirectly affected by the Project, using appropriately qualified biologists, according to protocols in Preparing for Any Action that May Occur within the Range of the Mojave Desert Tortoise (USFWS 2019³). To reduce the likelihood of nonconcurrence with proposed surveys, methodology, and qualifications of biologists, CDFW recommends working with the USFWS and CDFW concurrently to ensure a consistent and adequate approach to planning your work (USFWS 2019).

CDFW recommends that biologists retained to complete desert tortoise protocol level surveys submit their qualifications to CDFW and the USFWS prior to initiation of surveys. Should the California Department of Parks and Recreation desire CDFW to pre-approve

³ USFWS, 2019. Preparing for Any Action that May Occur within the Range of the Mojave Desert Tortoise (*Gopherus agassizii*), United States Fish and Wildlife Service, Desert Tortoise Recovery Office: October 26, 2018
(https://www.fws.gov/sites/default/files/documents/Mojave%20Desert%20Tortoise_Pre-project%20Survey%20Protocol_2019.pdf)

the qualifications of biologists conducting protocol level desert tortoise surveys, CDFW requests information for all biologists participating in survey efforts to the following email address: AskRegion6@wildlife.ca.gov, jacob.skaggs@wildlife.ca.gov.

4. A thorough, recent, floristic-based assessment of special status plants and natural communities, following CDFW's *Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Natural Communities* (CDFW 2018⁴)
5. Information on the regional setting that is critical to an assessment of environmental impacts, with special emphasis on resources that are rare or unique to the region (CEQA Guidelines § 15125[c]).
6. A full accounting of all open space and mitigation/conservation lands within and adjacent to the Project.

Analysis of Direct, Indirect, and Cumulative Impacts to Biological Resources

The DEIR should provide a thorough discussion of the direct, indirect, and cumulative impacts expected to adversely affect biological resources as a result of the Project (including the plan's land use designations, policies and programs). To ensure that Project impacts to biological resources are fully analyzed, the following information should be included in the DEIR:

1. A discussion of potential impacts from lighting, noise, human activity (e.g., recreation), defensible space, and wildlife-human interactions created by zoning of development projects or other project activities adjacent to natural areas, exotic and/or invasive species, and drainage. The latter subject should address Project-related changes on drainage patterns and water quality within, upstream, and downstream of the Project site, including: volume, velocity, and frequency of existing and post-Project surface flows; polluted runoff; soil erosion and/or sedimentation in streams and water bodies; and post-Project fate of runoff from the Project site.
2. A discussion of potential indirect Project impacts on biological resources, including resources in areas adjacent to the project footprint, such as nearby public lands (e.g., National Forests, State Parks, etc.), open space, adjacent natural habitats, riparian ecosystems, wildlife corridors, and any designated and/or proposed reserve or mitigation lands (e.g., preserved lands associated with a Natural Community Conservation Plan, or other conserved lands).

Please note that the Project area supports significant biological resources and contains

⁴ CDFW, 2018. *Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Sensitive Natural Communities*, State of California, California Natural Resources Agency, Department of Fish and Wildlife: March 20, 2018 (<https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=18959&inline>)

habitat connections, providing for wildlife movement across the broader landscape, sustaining both transitory and permanent wildlife populations. The western boundary and part of the northern boundary connect with the half-million acre Anza-Borrego Desert State Park. CDFW encourages project design that avoids and preserves onsite features that contribute to habitat connectivity. The DEIR should include a discussion of both direct and indirect impacts to wildlife movement and connectivity, including maintenance of wildlife corridor/movement areas to adjacent undisturbed habitats.

3. An evaluation of impacts to adjacent open space lands from both the construction of the Project and any long-term operational and maintenance needs.
4. A cumulative effects analysis developed as described under CEQA Guidelines section 15130. The DEIR should analyze the cumulative effects of the plan's land use designations, policies and programs on the environment. Please include all potential direct and indirect Project related impacts to riparian areas, wetlands, vernal pools, alluvial fan habitats, wildlife corridors or wildlife movement areas, aquatic habitats, sensitive species and other sensitive habitats, open lands, open space, and adjacent natural habitats in the cumulative effects analysis. General and specific plans, as well as past, present, and anticipated future projects, should be analyzed relative to their impacts on similar plant communities and wildlife habitats.

Alternatives Analysis

CDFW recommends the DEIR describe and analyze a range of reasonable alternatives to the Project that are potentially feasible, would "feasibly attain most of the basic objectives of the Project," and would avoid or substantially lessen any of the Project's significant effects (CEQA Guidelines § 15126.6[a]). The alternatives analysis should also evaluate a "no project" alternative (CEQA Guidelines § 15126.6[e]). The no Project alternative should evaluate how the changing environment, such as climate change and drought, may affect the community if a new or revised general plan were not adopted.

Mitigation Measures for Project Impacts to Biological Resources

The DEIR should identify mitigation measures and alternatives that are appropriate and adequate to avoid or minimize potential impacts, to the extent feasible. The California Department of Parks and Recreation should assess all direct, indirect, and cumulative impacts that are expected to occur as a result of the implementation of the Project and its long-term operation and maintenance. When proposing measures to avoid, minimize, or mitigate impacts, CDFW recommends consideration of the following:

1. *Fully Protected Species*: Fully protected species, such as Peninsular bighorn sheep (*Ovis canadensis nelsoni*), may not be taken or possessed at any time and no licenses or permits may be issued for their take except as follows:

- Take is for necessary scientific research,
- Efforts to recover a fully protected, endangered, or threatened species,
- Live capture and relocation of a bird species for the protection of livestock, or
- They are a covered species whose conservation and management is provided for in a Natural Community Conservation Plan (Fish & G. Code, §§ 3511, 4700, 5050, & 5515).

Specified types of infrastructure projects may be eligible for an incidental take permit for unavoidable impacts to fully protected species if certain conditions are met (see Fish & G. Code §2081.15). Project proponents should consult with CDFW early in the project planning process.

Project activities described in the DEIR should generally be designed to completely avoid any fully protected species that have the potential to be present within or adjacent to the Project area. CDFW also recommends that the DEIR fully analyze potential adverse impacts to fully protected species due to habitat modification, loss of foraging habitat, and/or interruption of migratory and breeding behaviors. CDFW recommends that California Department of Parks and Recreation include in the analysis how appropriate avoidance, minimization, and mitigation measures will reduce indirect impacts to fully protected species.

2. *Sensitive Plant Communities*: CDFW considers sensitive plant communities to be imperiled habitats having both local and regional significance. Plant communities, alliances, and associations with a statewide ranking of S-1, S-2, S-3, and S-4 should be considered sensitive and declining at the local and regional level. These ranks can be obtained by querying the CNDDDB and are included in *The Manual of California Vegetation* (Sawyer et al. 2009). The DEIR should include measures to fully avoid and otherwise protect sensitive plant communities from project-related direct and indirect impacts. Sensitive plant communities with ranks S-1 to S-3 have the potential to or have been documented to occur within or adjacent to the project area, including, but not limited to: California fan palm oasis.
3. *California Species of Special Concern (CSSC)*: CSSC status applies to animals generally not listed under the federal Endangered Species Act or the CESA, but which nonetheless are declining at a rate that could result in listing, or historically occurred in low numbers and known threats to their persistence currently exist. CSSCs should be considered during the environmental review process. CSSC have the potential or have been documented to occur within or adjacent to the Project area, including, but not limited to: flat-tailed horned lizard (*Phrynosoma mcallii*), Colorado desert fringe-toed lizard (*Uma notata*), Palm Springs pocket mouse (*Xerospermophilus tereticaudus chlorus*), and Le Conte's thrasher (*Toxostoma lecontei*).

4. *Mitigation*: CDFW considers adverse project-related impacts to sensitive species and habitats to be significant to both local and regional ecosystems, and the DEIR should include mitigation measures for adverse project-related impacts to these resources. Mitigation measures should emphasize avoidance and reduction of project impacts. For unavoidable impacts, onsite habitat restoration and/or enhancement, and preservation should be evaluated and discussed in detail. Where habitat preservation is not available onsite, offsite land acquisition, management, and preservation should be evaluated and discussed in detail.

The DEIR should include measures to perpetually protect the targeted habitat values within mitigation areas from direct and indirect adverse impacts in order to meet mitigation objectives to offset project-induced qualitative and quantitative losses of biological values. Specific issues that should be addressed include restrictions on access, proposed land dedications, long-term monitoring and management programs, control of illegal dumping, water pollution, increased human intrusion, etc.

If sensitive species and/or their habitat may be impacted from the Project, CDFW recommends the inclusion of specific mitigation in the DEIR. CEQA Guidelines section 15126.4, subdivision (a)(1)(8) states that formulation of feasible mitigation measures should not be deferred until some future date. The Court of Appeal in *San Joaquin Raptor Rescue Center v. County of Merced* (2007) 149 Cal.App.4th 645 struck down mitigation measures which required formulating management plans developed in consultation with State and Federal wildlife agencies after Project approval. Courts have also repeatedly not supported conclusions that impacts are mitigable when essential studies, and therefore impact assessments, are incomplete (*Sundstrom v. County of Mendocino* (1988) 202 Cal. App. 3d. 296; *Gentry v. City of Murrieta* (1995) 36 Cal. App. 4th 1359; *Endangered Habitat League, Inc. v. County of Orange* (2005) 131 Cal. App. 4th 777).

CDFW recommends that the DEIR specify mitigation that is roughly proportional to the level of impacts, in accordance with the provisions of CEQA (CEQA Guidelines, §§ 15126.4(a)(4)(B), 15064, 15065, and 16355). The mitigation should provide long-term conservation value for the suite of species and habitat being impacted by the Project. Furthermore, in order for mitigation measures to be effective, they need to be specific, enforceable, and feasible actions that will improve environmental conditions.

5. *Habitat Revegetation/Restoration Plans*: Plans for restoration and revegetation should be prepared by persons with expertise in southern California ecosystems and native plant restoration techniques. Plans should identify the assumptions used to develop the proposed restoration strategy. Each plan should include, at a minimum: (a) the location of restoration sites and assessment of appropriate reference sites; (b) the plant species to be used, sources of local propagules, container sizes, and seeding rates; (c) a schematic depicting the mitigation area; (d) a local seed and cuttings and planting schedule; (e) a description of the irrigation methodology; (f) measures to control exotic vegetation on

site; (g) specific success criteria; (h) a detailed monitoring program; (i) contingency measures should the success criteria not be met; and (j) identification of the party responsible for meeting the success criteria and providing for conservation of the mitigation site in perpetuity. Monitoring of restoration areas should extend across a sufficient time frame to ensure that the new habitat is established, self-sustaining, and capable of surviving drought.

CDFW recommends that local onsite propagules from the Project area and nearby vicinity be collected and used for restoration purposes. Onsite seed collection should be initiated in advance of project impacts in order to accumulate sufficient propagule material for subsequent use in future years. Onsite vegetation mapping at the alliance and/or association level should be used to develop appropriate restoration goals and local plant palettes. Reference areas should be identified to help guide restoration efforts. Specific restoration plans should be developed for various project components as appropriate.

Restoration objectives should include protecting special habitat elements or re-creating them in areas affected by the Project; examples could include retention of woody material, logs, snags, rocks, and brush piles.

6. *Nesting Birds and Migratory Bird Treaty Act*: Please note that it is the Project proponent's responsibility to comply with all applicable laws related to nesting birds and birds of prey. Fish and Game Code sections 3503, 3503.5, and 3513 afford protective measures as follows: Fish and Game Code section 3503 makes it unlawful to take, possess, or needlessly destroy the nest or eggs of any bird, except as otherwise provided by Fish and Game Code or any regulation made pursuant thereto. Fish and Game Code section 3503.5 makes it unlawful to take, possess, or destroy any birds in the orders Falconiformes or Strigiformes (birds-of-prey) to take, possess, or destroy the nest or eggs of any such bird except as otherwise provided by Fish and Game Code or any regulation adopted pursuant thereto. Fish and Game Code section 3513 makes it unlawful to take or possess any migratory nongame bird except as provided by the rules and regulations adopted by the Secretary of the Interior under provisions of the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. § 703 et seq.).

CDFW recommends that the DEIR include the results of avian surveys, as well as specific avoidance and minimization measures to ensure that impacts to nesting birds do not occur. Project-specific avoidance and minimization measures may include, but not be limited to: project phasing and timing (e.g., conducting work outside the peak nesting season), monitoring of project-related noise (where applicable), sound walls, and buffers, where appropriate. The DEIR should also include specific avoidance and minimization measures that will be implemented should a nest be located within the project site. If pre-construction surveys are proposed in the DEIR, the CDFW recommends that they be required no more than three (3) days prior to vegetation clearing or ground disturbance

activities, as instances of nesting could be missed if surveys are conducted sooner. CDFW recommends that disturbance of occupied nests of migratory birds and raptors within the Project site and surrounding area be avoided any time birds are nesting on-site. CDFW therefore recommends the completion of nesting bird surveys *regardless of the time of year* to ensure compliance with all applicable laws pertaining to nesting and migratory birds.

7. *Moving out of Harm's Way*: To avoid direct mortality to any non-listed terrestrial wildlife, CDFW recommends that the lead agency condition the DEIR to require that a CDFW-approved qualified biologist be retained to be onsite prior to and during all ground- and habitat-disturbing activities to inspect the Project area prior to any Project activities. Any individuals found shall not be harassed and shall be allowed to leave the Project area unharmed. If needed, a qualified biologist may guide, handle, or capture an individual non-listed, non-fully protected wildlife species to move it to a nearby safe location within nearby refugium, or it shall be allowed to leave the Project site of its own volition. Capture methods may include hand, dip net, lizard lasso, snake tongs and snake hook. If the wildlife species is discovered or is caught in any pits, ditches, or other types of excavations, the qualified biologist shall release it into the most suitable habitat near the site of capture. Movement of wildlife out of harm's way should be limited to only those individuals that would otherwise be injured or killed, and individuals should be moved only as far as necessary to ensure their safety (i.e., CDFW does not recommend relocation to other areas). Only biologists with appropriate authorization by CDFW shall move CESA-listed species. Furthermore, it should be noted that the temporary relocation of onsite wildlife does not constitute effective mitigation for the purposes of offsetting Project impacts associated with habitat loss.
8. *Translocation of Species*: CDFW generally does not support the use of relocation, salvage, and/or transplantation as mitigation for impacts to rare, threatened, or endangered species as studies have shown that these efforts are experimental in nature and largely unsuccessful.

California Endangered Species Act

CDFW is responsible for ensuring appropriate conservation of fish and wildlife resources including threatened, endangered, and/or candidate plant and animal species, pursuant to CESA. CDFW recommends that a CESA Incidental Take Permit (ITP) be obtained if the Project has the potential to result in "take" (California Fish and Game Code Section 86 defines "take" as "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill") of State-listed CESA species, either through construction or over the life of the project. It is the policy of CESA to conserve, protect, enhance, and restore State-listed CESA species and their habitats.

CDFW encourages early consultation, as significant modification to the proposed Project

and avoidance, minimization, and mitigation measures may be necessary to obtain a CESA ITP. CDFW must comply with CEQA for issuance of a CESA ITP. CDFW therefore recommends that the DEIR addresses all Project impacts to listed species and specify a mitigation monitoring and reporting program that will meet the requirements of CESA.

CDFW Lake and Streambed Alteration Program

Based on review of material submitted with the NOP and review of aerial photography, a range of large to small ephemeral washes traverse the Project area. Depending on how the Project is designed and constructed, it is likely that the Project applicant will need to notify CDFW per Fish and Game Code section 1602. Fish and Game Code section 1602 requires an entity to notify CDFW prior to commencing any activity that may do one or more of the following: Substantially divert or obstruct the natural flow of any river, stream or lake; Substantially change or use any material from the bed, channel or bank of any river, stream, or lake; or Deposit debris, waste or other materials that could pass into any river, stream or lake. Please note that "any river, stream or lake" includes those that are episodic (i.e., those that are dry for periods of time) as well as those that are perennial (i.e., those that flow year-round). This includes ephemeral streams, desert washes, and watercourses with a subsurface flow.

Upon receipt of a complete notification, CDFW determines if the proposed Project activities may substantially adversely affect existing fish and wildlife resources and whether a Lake and Streambed Alteration (LSA) Agreement is required. An LSA Agreement includes measures necessary to protect existing fish and wildlife resources. CDFW may suggest ways to modify your Project that would eliminate or reduce harmful impacts to fish and wildlife resources.

CDFW's issuance of an LSA Agreement is a "project" subject to CEQA (see Pub. Resources Code 21065). To facilitate issuance of an LSA Agreement, if necessary, the DEIR should fully identify the potential impacts to the lake, stream, or riparian resources, and provide adequate avoidance, mitigation, and monitoring and reporting commitments. Early consultation with CDFW is recommended, since modification of the proposed Project may be required to avoid or reduce impacts to fish and wildlife resources. To submit a Lake or Streambed Alteration notification package, please go to <https://wildlife.ca.gov/Conservation/Environmental-Review/EPIMS>.

ADDITIONAL COMMENTS AND RECOMMENDATIONS

Landscaping

To ameliorate the water demands of this Project, CDFW recommends incorporation of water-wise concepts in any Project landscape design plans. In particular, CDFW recommends xeriscaping with locally native California species and installing water-efficient

and targeted irrigation systems (such as drip irrigation). Native plants support butterflies, birds, reptiles, amphibians, small mammals, bees, and other pollinators that evolved with those plants, more information on native plants suitable for the Project location and nearby nurseries is available at CALSCAPE: <https://calscape.org/>. Local water agencies/districts and resource conservation districts in your area may be able to provide information on plant nurseries that carry locally native species, and some facilities display drought-tolerant locally native species demonstration gardens. Information on drought-tolerant landscaping and water-efficient irrigation systems is available on California's Save our Water website: <https://saveourwater.com/>.

Construction Noise

Project-related construction has the potential to generate a substantial temporary or permanent increase in ambient noise levels in the vicinity of the Project. CDFW recommends that the DEIR include an analysis of impacts to wildlife from Project-related construction noise, and appropriate avoidance, minimization, and mitigation measures that will reduce impacts to less than significant.

Construction may result in substantial noise through road use, equipment, and other Project-related activities. This may adversely affect wildlife species in several ways as wildlife responses to noise can occur at exposure levels of only 55 to 60 dB⁵. Anthropogenic noise can disrupt the communication of many wildlife species including frogs, birds, and bats^{6,7,8,9}. Noise can also affect predator-prey relationships as many nocturnal animals such as bats and owls primarily use auditory cues (i.e., hearing) to hunt. Additionally, many prey species increase their vigilance behavior when exposed to noise because they need to rely more on visual detection of predators when auditory cues may be masked by noise^{10,11}. Noise has also been shown to reduce the density of nesting birds¹² and cause increased stress that results in decreased immune responses¹³. The California Department of Parks and Recreation should include measures in the DEIR to ensure the following: restricting the use of equipment to hours least likely to disrupt wildlife (e.g., not at night or in early morning); restricting the use of generators except for temporary use in emergencies; provide power to sites by solar PV

⁵ Barber, J. R., K. R. Crooks, and K. M. Fristrup. 2009. The costs of chronic noise exposure for terrestrial organisms. *Trends in Ecology and Evolution* 25:180-189.

⁶ Sun, J. W. C., and P. M. Narins. 2005. Anthropogenic sounds differentially affect amphibian call rate. *Biological Conservation* 121:419-427.

⁷ Patricelli, G., and J. J. L. Blickley. 2006. Avian communication in urban noise: causes and consequences of vocal adjustment. *Auk* 123:639-649.

⁸ Gillam, E. H., and G. F. McCracken. 2007. Variability in the echolocation of *Tadarida brasiliensis*: effects of geography and local acoustic environment. *Animal Behaviour* 74:277-286.

⁹ Slabbekoorn, H., and E. A. P. Ripmeester. 2008. Birdsong and anthropogenic noise: Implications and applications for conservation. *Molecular Ecology* 17:72-83.

¹⁰ Rabin, L. A., R. G. Coss, and D. H. Owings. 2006. The effects of wind turbines on antipredator behavior in California ground squirrels (*Spermophilus beecheyi*). *Biological Conservation* 131:410-420.

¹¹ Quinn, J. L., M. J. Whittingham, S. J. Butler, W. Cresswell, J. L. Quinn, M. J. Whittingham, S. J. Butler, W. Cresswell, and W. Noise. 2017. Noise, predation risk compensation and vigilance in the chaffinch *Fringilla coelebs*. *Journal of Avian Biology* 37:601-608.

¹² Francis, C. D., C. P. Ortega, and A. Cruz. 2009. Noise pollution changes avian communities and species interactions. *Current Biology* 19:1415-1419.

¹³ Kight, C. R., and J. P. Swaddle. 2011. How and why environmental noise impacts animals: An integrative, mechanistic review. *Ecology Letters* 14:1052-1061.

(photovoltaic) systems, cogeneration systems (natural gas generator), small micro-hydroelectric systems, or small wind turbine systems; ensure the use of noise suppression devices such as mufflers or enclosure for generators; and sounds generated from any means must be below the 55-60 dB range within 50-feet from the source.

Artificial Nighttime Lighting

The Project will introduce new sources of artificial lighting. CDFW recommends that the DEIR include lighting design specifications for all artificial nighttime lighting that will be used by the Project, an analysis of the direct and indirect impacts of artificial nighttime lighting on biological resources, and appropriate avoidance, minimization, and mitigation measures that will reduce impacts to less than significant. The direct and indirect impacts of artificial nighttime lighting on biological resources including migratory birds that fly at night, bats, and other nocturnal and crepuscular wildlife should be analyzed, and appropriate avoidance and minimization measures should be included in the DEIR.

Artificial nighttime lighting often results in light pollution, which has the potential to significantly and adversely affect fish and wildlife. Artificial lighting alters ecological processes including, but not limited to, the temporal niches of species; the repair and recovery of physiological function; the measurement of time through interference with the detection of circadian and lunar and seasonal cycles; the detection of resources and natural enemies; and navigation¹⁴. Many species use photoperiod cues for communication (e.g., bird song¹⁵), determining when to begin foraging¹⁶, behavioral thermoregulation¹⁷, and migration¹⁸. Phototaxis, a phenomenon that results in attraction and movement towards light, can disorient, entrap, and temporarily blind wildlife species that experience it⁸. The California Department of Parks and Recreation should include measures in the DEIR to ensure the following: eliminate all nonessential lighting throughout the Project area; avoid or limit the use of artificial light during the hours of dawn and dusk when many wildlife species are most active; lighting for Project activities is fully shielded, cast downward, reduced in intensity to the greatest extent, and does not result in spill over onto other properties or upward into the night sky (see the International Dark-Sky Association standards at <http://darksky.org/>); the use of LED lighting with a correlated color temperature of 3,000 Kelvins or less; proper disposal of hazardous waste; and recycling of lighting that contains toxic compounds with a qualified recycler.

ENVIRONMENTAL DATA

¹⁴ Gatson, K. J., Bennie, J., Davies, T., Hopkins, J. 2013. The ecological impacts of nighttime light pollution: a mechanistic appraisal. *Biological Reviews*, 88.4: 912-927.

¹⁵ Miller, M. W. 2006. Apparent effects of light pollution on singing behavior of American robins. *The Condor* 108:130–139.

¹⁶ Stone, E. L., G. Jones, and S. Harris. 2009. Street lighting disturbs commuting bats. *Current Biology* 19:1123–1127.

¹⁷ Beiswenger, R. E. 1977. Diet patterns of aggregative behavior in tadpoles of *Bufo americanus*, in relation to light and temperature. *Ecology* 58:98–108.

¹⁸ Longcore, T., and C. Rich. 2004. Ecological light pollution - Review. *Frontiers in Ecology and the Environment* 2:191–198.

CEQA requires that information developed in environmental impact reports and negative declarations be incorporated into a database which may be used to make subsequent or supplemental environmental determinations. (Pub. Resources Code, § 21003, subd. (e).) Accordingly, please report any special status species and natural communities detected during Project surveys to the California Natural Diversity Database (CNDDDB). Information can be submitted online or via completion of the CNDDDB field survey form at the following link: <https://wildlife.ca.gov/Data/CNDDDB/Submitting-Data>. The types of information reported to CNDDDB can be found at the following link: <https://wildlife.ca.gov/Data/CNDDDB/Plants-and-Animals>.

FILING FEES

The Project, as proposed, would have an impact on fish and/or wildlife, and assessment of filing fees is necessary. Fees are payable upon filing of the Notice of Determination by the Lead Agency and serve to help defray the cost of environmental review by CDFW. Payment of the fee is required in order for the underlying project approval to be operative, vested, and final. (Cal. Code Regs, tit. 14, § 753.5; Fish & G. Code, § 711.4; Pub. Resources Code, § 21089.).

CONCLUSION

CDFW appreciates the opportunity to comment on the NOP of a DEIR for the Ocotillo Wells State Vehicular Recreation Area General Plan Update Project (SCH No. 2026020853) and recommends that the California Department of Parks and Recreation address CDFW's comments and concerns in the forthcoming DEIR. Questions regarding this letter or further coordination should be directed to Jacob Skaggs, Senior Environmental Scientist Specialist, at jacob.skaggs@wildlife.ca.gov.

Sincerely,

DocuSigned by:

84F92FFEEFD24C8...

Kim Freeburn
Environmental Program Manager

ec: Heather Brashear, Senior Environmental Scientist (Supervisor), CDFW
Heather.Brashear@wildlife.ca.gov

Office of Planning and Research, State Clearinghouse, Sacramento
state.clearinghouse@lci.ca.gov



Matt Kirkland <info@planocotillowells.org>

New form submission on Webflow for Ocotillo Wells SVRA General Plan Update

Webflow forms <no-reply-forms@webflow.com>

Mon, Mar 2, 2026 at 1:26 PM

Reply-To: no-reply@webflow.com

To: info@planocotillowells.org

You just received a new form submission on your website Ocotillo Wells SVRA General Plan Update.

Name: Alisa Allen

Email Address: alisalawrence@gmail.com

Organization:

Comment: Please consider establishing a designated VHF radio frequency for coordination of emergencies with the public. The frequency could be communicated on signs and would allow visitors to reach out for emergency services when cell service is limited.

[Quoted text hidden]



Matt Kirkland <info@planocotillowells.org>

New form submission on Webflow for Ocotillo Wells SVRA General Plan Update

Webflow forms <no-reply-forms@webflow.com>

Tue, Mar 3, 2026 at 11:08 PM

Reply-To: no-reply@webflow.com

To: info@planocotillowells.org

You just received a new form submission on your website Ocotillo Wells SVRA General Plan Update.

Name: BO NEECE

Email Address: rnbneece@cox.net

Organization: Tierra Del Sol 4x4 Club / San Diego Off Road Collation

Comment: I urge you to consider allowing permitted events in Truckhaven north of Hwy S-22

Number of submissions received

1/unlimited this month

March 1st – March 31st

Need more submissions?

Please contact your website administrator.

If you believe this is a spam submission, please forward to form-spam-reports@support.webflow.com

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VIA ELECTRONIC MAIL

April 3, 2026

Erik Taylor, General Plan Project Manager
California Department of Parks and Recreation
Strategic Planning and Recreation Services Division
P.O. Box 942896
Sacramento, CA 94296-0001
Email: info@planocotillowells.org

**Re: 2026 Notice of Preparation of an Environmental Impact Report for the
Ocotillo Wells State Vehicular Recreation Area General Plan Update, SCH
Number 2026020853.**

Dear Project Manager Taylor,

These comments are submitted on behalf of the Center for Biological Diversity (“Center”) regarding the 2026 Notice of Preparation of an Environmental Impact Report for the Ocotillo Wells State Vehicular Recreation Area General Plan Update, SCH Number 2026020853. The Center sought, and was granted, an extension of time until April 3, 2026, to file these scoping comments due to lack of notice. (See Attachment A.) The Center previously submitted many comments related to this multi-decade process including on February 7, 2008, March 21, 2012, and March 8, 2014. (Attachments B, C, D.) The Center also commented on the Soil Conservation Plan on March 24, 2025. (Attachment E.) Those comments are attached and all comments submitted are also incorporated by reference herein.

The Center has been engaged in efforts to protect the resources of the California deserts including within the Ocotillo Wells State Vehicular Recreation Area (OW SVRA) for decades. The Center has consistently advocated for greater protections across the OW SVRA for sensitive resources. In the Desert Cahuilla Prehistoric area in the northern portion of the OW SVRA that was acquired in 2006 for conservation of cultural and natural resources, the Center filed suit to protect the resources which resulted in a 2007 agreement to ensure full CEQA compliance for any special events and that State Parks would initiate a general plan update process--- that process has now been ongoing nearly 20 years.

Pursuant to California Public Resources Code § 5090.35(f): “The division *shall* protect natural, cultural, and archaeological resources within the state vehicular recreation areas.” (Emphasis added).

OHV use is known to damage resources in open areas and on trails as the Legislature found when adopting measures regarding management of such uses. (Pub. Res. Code § 5090.02(a), (c)(4) [“the indiscriminate and uncontrolled use of those vehicles may have a deleterious impact on the environment, wildlife habitats, native wildlife, and native flora” and “When areas or trails or portions thereof cannot be maintained to appropriate established standards for sustained long-term use, they should be closed to use and repaired, to prevent accelerated erosion. Those areas should remain closed until they can be managed within the soil conservation standard or should be closed and restored.”].)

Public Resources Code § 5019.56(a) provides that state recreation areas “shall be selected for their having terrain capable of withstanding extensive human impact.” In contrast, “areas containing ecological, geological, scenic, or cultural resources of significant value shall be preserved within state wildernesses, state reserves, state parks, or natural or cultural preserves . . .” (*Id.*) Accordingly, the acquired lands where there is a need to protect natural and cultural resources do not meet the criteria for a SVRA and should not be managed as part of the OW SVRA -- those areas should be closed to OHV use going forward and management transferred to more appropriate management. (See Public Resources Code § 5090.43(a).)

For lands that were already considered in the earlier OW SVRA General Plan, State Parks must consider establishment of “sensitive areas” for cultural and natural resources that require protection. (Public Resources Code § 5090.43(b) [“To protect natural and cultural resource values, sensitive areas may be established within state vehicular recreation areas where determined by the department to be necessary to protect natural and cultural resources. These sensitive areas shall be managed by the division in accordance with Sections 5019.71 and 5019.74, which define the purpose and management of natural and cultural preserves.”].) And for areas where OHV use has damaged natural or cultural resources or sensitive areas, those areas should be closed and restored. Public Resources Code § 5090.43(c) [“If off-highway motor vehicle use results in damage to any natural or cultural resources or damage within sensitive areas, appropriate measures shall be promptly taken to protect these lands from any further damage. These measures may include the erection of physical barriers and shall include the restoration of natural resources and the repair of damage to cultural resources.”].)

Nothing in the Public Resources Code or elsewhere allows State Parks to permit the use of off-road vehicles in ecologically or culturally sensitive areas, including many such areas within OW SVRA. These resources on state public land should be protected as a non-motorized cultural and/or natural “special areas” within OW SVRA. The EIR must include alternatives that ensure full protection of sensitive cultural and ecological areas and identify long term funding to restore and protect these public lands for future generations.

1. A Program Level EIR Alone Is Not Sufficient

The NOP contemplates the Updated General Plan would provide support for both program-level and project-level decisions. A program EIR is not sufficient for site specific decisions including how to manage acquired lands in the Desert Cahuilla Prehistoric area which has not previously been addressed in an EIR. A program EIR is particularly applicable and

advantageous where many later site specific decisions will tier off the program or plan being analyzed and is an excellent vehicle to consider cumulative impacts, alternatives to the proposed program procedures, and mitigation requirements for future site-specific proposals. See CEQA Guidelines § 15168. Here, a program EIR could be appropriate for the General Plan Update but not for addressing management of lands acquired after the existing General Plan was adopted in 1982. A project-level EIR analysis is required to support any decisions regarding management of those areas. Indeed, a project-level CEQA analysis should have been undertaken before allowing any impactful uses of those newly acquired lands but was not. The purpose of CEQA is to provide decision-makers and the public with environmental information before decisions are made, not after. As the California Supreme Court observed in *Laurel Heights I*, “[i]f postapproval environmental review were allowed, [CEQA analyses] would likely become nothing more than post hoc rationalizations to support action already taken. We have expressly condemned this [practice].” *Laurel Heights Improvement Ass’n v. Regents of Univ. of Cal.* (“*Laurel Heights I*”), (1988) 47 Cal. 3d 376, 394 (citation omitted). State Parks must undertake that analysis now, without pre-determining the appropriate activities and uses in those areas or limit the alternatives or mitigation measures considered. “[P]ublic agencies shall not undertake actions concerning the proposed public project that would have a significant adverse effect or limit the choice of alternatives or mitigation measures, before completion of CEQA compliance.” CEQA Guidelines § 15004(b)(2). In particular, an agency shall not “take any action which gives impetus to a planned or foreseeable project in a manner that forecloses alternatives or mitigation measures that would ordinarily be part of CEQA review of that public project.” CEQA Guidelines § 15004(b)(2)(B).

Complete and thorough programmatic and project-level EIRs that evaluate and mitigate all of the past and foreseeable future significant impacts associated with allowing off-road vehicle use in the Desert Cahuilla Prehistoric area, other acquired lands, and in sensitive habitats must be prepared.

2. State Parks Should Provide an Updated Proposed Project Description With Updated Resource Maps Taking Into Account New Information and Changed Circumstances

The Center appreciates that this long-overdue planning process is once again moving forward. However, as an initial matter, the Center is concerned that State Parks has not provided an updated draft plan but appears to be relying on a “Proposed Project” outlined in a March 2015 document entitled “DRAFT PREFERRED ALTERNATIVE / PROPOSED ACTION” from the earlier joint State and Federal process and a series of working papers provided in 2013. No effort has been made to revise the General Plan Update or consolidate the information into a single document. That draft was woefully deficient in many ways including by failing to address the need to designate cultural and natural “sensitive areas” to protect at-risk resources as envisioned under the Public Resources Code sections 5090.43, 5019.71 and 5019.74.

Under the statute, OHV use should not have been established in any of the acquired lands where there is a need to protect natural and cultural resources. Public Resources Code § 5090.43(a). For lands that were already considered in the earlier OW SVRA General Plan,

“sensitive areas” should be established in those areas that need protection for cultural and natural resources, which should be managed in the same manner as “preserves.” (Public Resources Code § 5090.43(b) [“To protect natural and cultural resource values, sensitive areas may be established within state vehicular recreation areas where determined by the department to be necessary to protect natural and cultural resources. These sensitive areas shall be managed by the division in accordance with Sections 5019.71 and 5019.74, which define the purpose and management of natural and cultural preserves.”].) And for areas where OHV use has damaged natural or cultural resources or sensitive areas, those areas should be closed and restored. Public Resources Code § 5090.43(c) [“If off-highway motor vehicle use results in damage to any natural or cultural resources or damage within sensitive areas, appropriate measures shall be promptly taken to protect these lands from any further damage. These measures may include the erection of physical barriers and shall include the restoration of natural resources and the repair of damage to cultural resources.”].)

In addition, although the Soil Conservation Plan stated that a Wildlife Habitat Protection Plan (WHPP) was being prepared for OW SVRA to be implemented in 2025, that document (even in draft form) is not available on the SVRA website and does not appear to have been adopted as required under Public Resources Code § 5090.35(c)(1). As the Soil Conservation Plan noted at 5-6: “The District started the Wildlife Habitat Protection Plan (WHPP) in 2022 with implementation anticipated in 2025. The WHPP will address compliance with PRC §5090.35(c)(1) requirements to improve and conserve wildlife habitat. While the SCP and WHPP focus on different resources, they were designed to be complementary as there is overlap between the two documents.”

Similarly, there appears to be no progress towards the required inventory of native plant communities which is intended to inform plan updates. (Public Resources Code § 5090.35(c)(1).) In order to support robust planning to protect wildlife and native plant communities, OW SVRA should prepare and implement the WHPP and native plant inventory in concert with the General Plan Update and the SCP.

Many things have changed significantly in the intervening years including new laws and regulations including, but not limited to: AB 52 (2014) and later legislation regarding consultation with tribes, significance of tribal cultural resources, and providing definitions and procedures; the BLM’s 2016 adoption of the DRECP Plan Amendment to CDCD Plan; an increasing warming and drying climate; and changes in the status of species including the CESA uplisting of tortoise from threatened to endangered and CESA candidate status for Burrowing owls. In addition, we anticipate that Le Conte’s thrasher will become a CESA candidate species in the near future.

BLM’s 2016 DRECP designation of the Ocotillo Wells East Special Recreation Management Area (SRMA) on 21,561 acres of land, the majority of it within the OW SVRA, and designation of Development Focus Area on many of the BLM sections for geothermal development and leasing only. DRECP, Appendix C, SRMA/ERMA, at 110-116. The DRECP anticipated that the OW SVRA General Plan Update would be developed jointly with BLM and provide additional management direction for these lands and provide needed mitigation for

sensitive resources. “This plan will identify potential impacts to sensitive resources within the SRMA and ensure appropriate mitigation from OHV use and camping.” DRECP, Appendix C, SRMA/ERMA, at 112. Although the OW SVRA General Plan Update is no longer being developed jointly with the BLM, State Parks must address potentially significant impacts to all sensitive resources and consider alternatives to avoid those impacts, and measures to minimize and mitigate those impacts under CEQA.

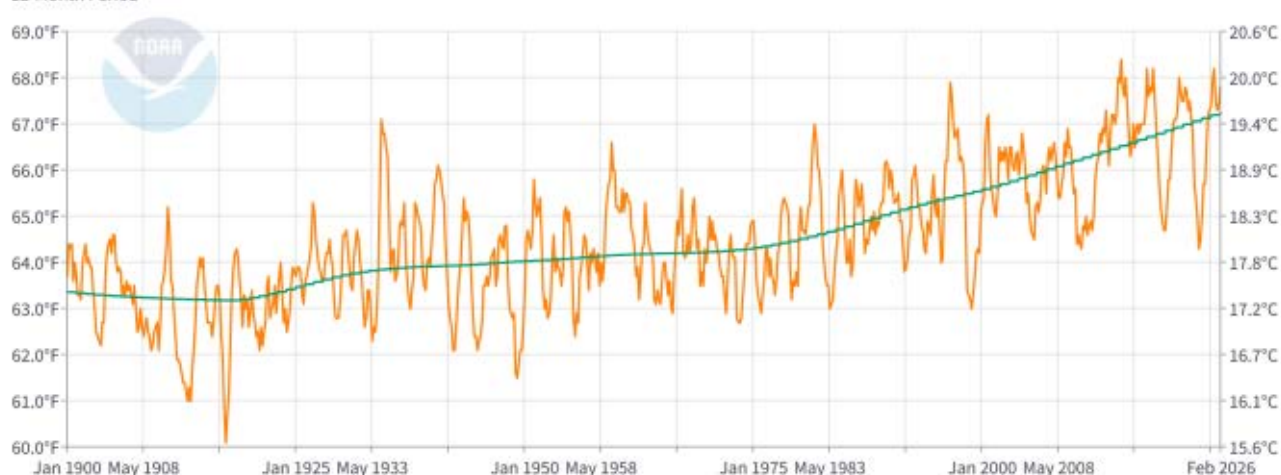
For Peninsular bighorn sheep there are also significant new cumulative impacts to the species from actions to block movement across the southern border.

There is myriad significant new information including impacts persistent drought and climate change on the resources within the OW SVRA including Peninsular bighorn sheep, desert tortoise, burrowing owls, Flat-tailed horned lizards, many resident and migratory birds, rare plants and plant communities including desert drywash woodlands, and air quality.

Average temperatures in the Southwest have been increasing, and annual averages are projected to climb to historically unprecedented levels due to climate change (NECI 2025, p. 2). Average temperatures in California’s southeast desert basin climate region (Climate Division 7) increased nearly 4 degrees F from 1900 to April 2026 (NCEI 2026), which is experiencing a brutal, decades-long “megadrought.”

California, Climate Division 7 Average Temperature

12-Month Period



Average temperatures in California’s southeast desert basin climate region from 1900 to April 2026 (NCEI 2026).

Climate change is also increasing extreme weather events in the southwest, an area already considered one of the most climate-challenged regions in the U.S. (Gonzalez et al. 2018, p. 1104; USGCRP 2023, p. 2-12). Extreme heat waves and prolonged droughts are projected to occur with greater frequency and intensity over the coming decades, and precipitation is

expected to become more variable (Tagestad et al. 2016, p. 392; Gonzalez et al. 2018, p. 1104, 1108, 1143; Hopkins 2018, p. 7, 50). According to a recent study, 42% of the current southwest North American megadrought can be attributed to human-caused climate change (NOAA 2022, p. 1). In the western U.S., human-caused warming from 1979-2020 was responsible for nearly 68% of the increased aridity (USGCRP 2023, p. 2-20).

In the Southwest, the impacts of droughts are further amplified by the increasing variation of year-to-year winter precipitation, as vegetation growth is dependent on winter precipitation and ecosystems have experienced reoccurring whiplash between the “wettest” and “driest” winters on record over a period of 40 years (Tagestad et al. 2016, p. 396; NPS 2017). The increases in average temperatures, extreme heat waves, and prolonged droughts are projected to occur with greater frequency and intensity over the coming decades, and precipitation expected to become even more variable (Gonzalez et al. 2018, p. 1108, 1109, 1112; Hopkins 2018, p. 12).

Ecosystem-level changes caused by climate change will have severe effects on many species and habitat types. Native arid land vegetation is projected to shift northward as temperatures increase, or more worryingly, completely disappear. There is concern that some desert vegetation communities may not be able to adapt to the current pace of climate change (Borgman et al. 2024, p. 48). Climate change vulnerability and sensitivity assessments for vegetation communities in the Sonoran and Mojave Deserts determined multiple desert shrub communities to be highly vulnerable, and most desert shrub and dune communities to be highly sensitive to climate change (Comer et al. 2012, p. 26-27).

3. Current Baseline Information on Resources Is Needed

The EIR must provide *current* baseline information on the status of resources within the OW SVRA. For species and habitats this data should be based on protocol surveys following CDFW and FWS guidelines. The EIR must also include detailed resources maps for all natural and paleontological resources. While mapping cultural resources may need to be kept confidential to protect tribal cultural interests, that mapping should nonetheless be performed as part of the EIR.

The Center is concerned that the current resource data is lacking in several areas. As just one example, Flat-Tailed horned lizard (FTHL) surveys in the OW SVRA are primarily conducted in areas with low or limited ORV use, although significant FTHL habitat occurs in open areas. Because data sampling is not consistent across the area, it can give the false impression that ORVs are not impacting FTHL or its habitat—which is inaccurate.

4. The EIR Must Address All Resources that May Be Significantly Affected By Activities Authorized Under the General Plan

The EIR must evaluate potentially significant impacts on sensitive biological resources, including impacts on all plants, wildlife, habitat corridors, ecological zones, and native habitat values. The evaluation must consider impacts from ongoing OW SVRA activities, increased

impacts on the acquired lands in the OW SVRA, and the cumulative impacts of all off-road vehicle related activities. The cumulative impacts analysis in the EIR must consider the impacts of past, current and future off-road vehicle use at OW SVRA. Additional impacts for regional factors, such as biological habitat corridors other sensitive resources in the region must be added into the cumulative analysis.

Given the unique biological diversity of the OW SVRA, unique cultural and historic resources, and the large project area, the EIR must thoroughly evaluate the potentially significant project impacts at several scales, and for various resources individually and cumulatively. The significant impacts of authorized activities are wide-ranging particularly for OHV use in open areas, on trails, and at special events.

ORV routes have long been documented to cause impacts to desert resources in many ways, through both indirect and direct impacts. For example, by crushing animals on the surface or in burrows, and through indirect impacts such as habitat alteration from soil compaction, noise, vegetation destruction, excessive dust, the promotion of weed invasions that displace native vegetation, and toxins from exhaust. Competitive events or other special events can be particularly damaging to desert resources as they encourage off-route travel for passing, lead to widening of routes, loss of vegetation, soil destruction and air quality impacts, all of which adversely impact wildlife and other resources. (See, *e.g.*, Wilshire, 1983; Webb & Wilshire, 1983; Ouren et al. 2007, with bibliography of resources.) Competitive ORV events have been monitored and documented to negatively impact vegetation and habitat for species. (*Id.*)

a. Air Quality, Soils, Water Quality:

ORV use – both open riding or on trails—leads to soil erosion and air quality impacts that must be considered in the context of the already impaired air basin. When soil structure is damaged in the desert, winds can pick up significant particulate matter (PM). ORV use introduces particulates, and increases fugitive dust and other toxic pollutants into the air. These emissions must also be evaluated in the context of greenhouse gas emissions. All of these impacts must be considered in the EIR at the local scale as well as in the context of the cumulative impacts to the region with already impaired air quality.

Although OW SVRA has stated that a Dust Control Plan was developed in 2013 (Tetra Tech 2013) and is updated biennially, that alone does not mean that air quality issues have been fully addressed even for PM. Additionally, because no CEQA compliance was undertaken for the Dust Control Plan, there is no showing that avoidance was addressed through appropriate alternatives analysis. Accordingly, the OW SVRA General Plan Update must address avoidance of PM and other air quality impacts through a range of alternatives including alternatives that reduce or eliminate ORV use seasonally, by zone, or otherwise.

The Center submitted comments on March 24, 2025 on the soil conservation plan which included citations and links to references regarding impacts to soils and other resources. Those comments and resources remain relevant and must be addressed in the EIR for the General Plan Update including the following:

Impacts from off road or off-highway vehicles has been well documented for decades by studies which have identified numerous deleterious effects to soils, flora and fauna. Soil compaction in arid regions negatively affects soil processes and vegetation (Adams et al. 1982; Webb 1983; Ploughe and Fraser 2022; Al-Dousari et al. 2019; Vollmer et al. 1977), soil erosion (Gillette and Adams 1983; Padgett et al. 2008; Wilshire 1983; Ploughe and Fraser 2022; Heede 1983; Hinkley, Iverson, and Hallet 1983), degraded air quality (Padgett et al. 2008; Buckley 2004), vegetation loss (Switalski 2018; Ploughe and Fraser 2022), cryptobiotic crust loss (Belnap 1995; 2002), habitat loss and impacts to native animals (Berry, Yee, and Lyren 2020; Brattstrom and Bondello 1983; Cheung et al. 2021; Grant and Doherty 2009; Ouren et al. 2007; Papouchis, Singer, and Sloan 2001; Ploughe and Fraser 2022; Tull and Brussard 2007). Research on the number of off-highway/road vehicles also documents ongoing increasing trends in activity and impacts (see Cordell et al. 2005).

(Attachment E at 1, 2-4.)

In addition to emitting hydrocarbons and metals into the air, OHV vehicles create a high risk for toxic oil and gas spills. Even if individual spills may be relatively small, the cumulative impacts to soils, air quality and other resources must be considered along trails, in open areas, and in staging areas.

Water quality must also be addressed including but not limited to increased runoff due to soil compaction and pollution from hydrocarbons.

b. Species, Habitats, and Natural Communities:

Among the resources that may be significantly impacted by the activities authorized under the OW SVRA General Plan Update are many federally and state-listed species, as well as sensitive and species of concern in this area. The EIR must address these impacts along with alternatives that could avoid such impacts, and measures to minimize and mitigate any impacts which cannot be wholly avoided. The species and habitats that should be addressed include, but are not limited to:

- Peninsular Bighorn Sheep (*Ovis canadensis nelsonii*) and its essential habitat (Federal ESA endangered, State Fully-Protected)
- Flat-tailed Horned Lizard (*Phrynosoma mcallii*) and its essential habitat (CDFW Species of Special Concern)
- Pierson's pincushion (*Chaenactis carphoclinia* var. *piersonii*)
- Orcutt's woody aster (*Xylorhiza orcuttii*)
- Mecca woody aster (*Xylorhiza cognata*)
- California fan palm (*Washingtonia filifera*)
- Salton milk-vetch (*Astragalus crotalariae*)
- Prairie falcon (*Falco mexicanus*)

- Golden eagle (*Aquila chrysaetos*)
- Le Conte's thrasher (*Toxostoma lecontei*) (CESA petition in progress)
- burrowing owl (*Athene cunicularia*) (CESA candidate)
- Colorado fringed-toed lizard (*Uma notata*)
- Desert Tortoise (*Gopherus agassizii*) (Federal ESA threatened, CESA endangered, California state reptile)
- Palm Springs pocket mouse (*Perognathus longimembris bangsi*)
- Abrams' spurge (*Euphorbia abramsiana*)
- gravel milk-vetch (*Astragalus sabulonum*)

More common species that occur in the OW SVRA must also be addressed including, for example, Fan Palm oases which are rare in this area.

The natural communities in the OW SVRA include areas of desert scrub, desert succulent shrubs, alkali scrub, and large extents of microphyll woodlands. Impacts to all of these natural communities must be addressed and significant impacts avoided, minimized and mitigated. Microphyll woodlands (also called Desert Drywash Woodlands) are a rare habitat type that provides habitat for many species—all existing areas should be conserved and any degraded areas should be restored.

The EIR must consider alternatives that would avoid harm to these species and habitats and mitigation measures to ensure their persistence in the wild. For example, rare fan palm oases found in the OW SVRA should be protected from damage by motorized vehicles and recreationists through physical barriers.

c. Cultural and Paleontological Resources:

The Desert Cahuilla Prehistoric area and surrounding lands contain rare and fragile resources. The area is within the ancestral lands of the Cahuilla people along the shoreline of the ancient Lake Cahuilla and has significant scenic, ecological, archeological, historical, geological, and paleontological value. Some of the area is now managed by Anza-Borrego Desert State Park, but some of it is within the OW SVRA. The land contains hundreds of documented prehistoric cultural artifacts, including ceremony circles, shaman fire pits, and prehistoric trails along the ancient Lake Cahuilla shoreline that should be preserved for future generations. Other areas of OW SVRA may similarly contain important paleontological, cultural, or historic resources. Complete baseline information must be gathered and potentially significant impacts of activities authorized under the General Plan Update assessed.

d. A Habitat Conservation Plan and a Natural Communities Conservation Plan are Needed:

Because the activities authorized under the OW SVRA General Plan update may cause “take” of some species protected under the Federal ESA, including Peninsular bighorn sheep and desert tortoise, a Habitat Conservation Plan (HCP) is needed. Because the Peninsular bighorn sheep are also a fully-protected species under California ESA, a NCCP is also needed. California

Fish and Game Code § 2835.

The EIR should disclose whether an HCP and/or NCCP is being pursued, and if so, the proposed HCP should be completed and available concurrent with the draft EIR for the project, as the EIR cannot rely on speculative future mitigations (such as a planned HCP) to address needed avoidance in alternatives or to compensate for severe unavoidable adverse impacts. CEQA requires that clear, practical and mandated mitigations be identified during the CEQA process, not deferred to future speculative processes. The public has a right to evaluate any HCP and/or NCCP to determine whether it will adequately mitigate for impacts to imperiled species, habitats and natural communities.

5. *State Parks Must Consider a Broader Range of Alternatives Than Those Presented in 2015/2013*

The EIR alternatives analysis must include alternatives with non-motorized low impact recreation uses, and cultural and natural resource protection. Under CEQA, a lead agency may not approve a project if there are feasible alternatives that would avoid or lessen its significant environmental effects. (Public Resources Code §§ 21002, 21002.1(b).) To this end, an EIR is required to consider a range of potentially feasible alternatives to a project, or to the location of a project, that would feasibly attain the project's basic objectives while avoiding or substantially lessening any of the project's significant environmental impacts. (*Save Round Valley Alliance v. County of Inyo* (2007) 157 Cal.App.4th 1437, 1456.) Here, the stated objective is to update the management plan for the existing OW SVRA. That goal can be achieved without allowing damaging ORV use into the Desert Cahuilla Prehistoric area or other sensitive areas including sensitive species habitats.

As the Supreme Court put it:

The core of an EIR is the mitigation and alternatives sections. The Legislature has declared it the policy of the State to "consider alternatives to proposed actions affecting the environment." (Pub. Resources Code, § 21001(g); *Laurel Heights*, supra, 47 Cal.3d at p. 400.) Section 21002.1, subdivision (a) of the Public Resources Code provides: "The purpose of an environmental impact report is to identify the significant effects of a project on the environment, *to identify alternatives to the project*, and to indicate the manner in which those significant effects can be mitigated or avoided." (Italics added. See also Pub. Resources Code, § 21061 ["The purpose of an environmental impact report is . . . to list ways in which the significant effects of such a project might be minimized; *and to indicate alternatives to such a project.*"].)

(*Citizens of Goleta Valley v. Board of Supervisors* (1990) 52 Cal.3d 553, 564-65 [italics in original].)

The 2013 Alternatives document failed to address a meaningful range of alternatives that would *avoid* impacts to resources in the first instance. Although areas can also be closed after

damage results, *see, e.g.*, Public Resources Code §5090.43(c), the General Plan Update should prioritize ways to avoid impacts and efforts to restore degraded habitats and other resources.

A reasonable range of alternatives to address significant impacts to resources in the OW SVRA should include, but is not limited to:

- at least one alternative that would prioritize protection of cultural and paleontological resources by eliminating ORV use in areas where these resources are present through designation of cultural “sensitive areas” and end open riding, trail riding and special events in these areas. These areas should include, but are not limited to, all of the Desert Cahuilla Prehistoric area and buffer zone (this area is denoted as the “Truckhaven” zone in the 2013 Alternatives document at 17). This alternative would also protect Peninsular bighorn sheep.
- at least one alternative that would prioritize protection of sensitive and imperiled species, habitats, and natural communities by eliminating ORV use in areas where these resources are present through designation of “sensitive areas” and end open riding, trail riding and special events in these areas.
- at least one alternative that would end all open riding in the park and restore those areas of the park.
- at least one alternative that would both end trail riding and open riding in the park and restore habitats and other resources.

Thank you for considering these comments. The Center looks forward to reviewing revised Proposed Project and an EIR that fully considers the current environmental baseline, a range of alternatives including at least one alternative that prioritizes protection of cultural and paleontological resources and sensitive and imperiled species, habitats, and natural communities. Please ensure that the Center is on the notice list for all future updates and notices associated with the OW SVRA General Plan Update and its environmental review, and include the Center in all future stakeholder outreach efforts.

Sincerely,

Lisa T. Belenky, Senior Counsel
Zeynep Graves, Senior Attorney
Center for Biological Diversity
2100 Franklin St., Suite 375
Oakland, CA 94612
(510) 844-7107
lbelenky@biologicaldiversity.org
zgraves@biologicaldiversity.org

cc: Andrew.Green@NAHC.ca.gov; jacob.skaggs@wildlife.ca.gov;
Heather.Brashear@wildlife.ca.gov

Attachments:

Attachment A: March 24, 2026, Email granting extension of time

Attachment B: February 7, 2008, Comments re: Notice of Preparation for an Environmental Impact Report Truckhaven/Desert Cahuilla and Ocotillo Wells General Plan

Attachment C: March 21, 2012, Comments Re: Input and Feedback on the Development of the Ocotillo Wells State Vehicular Recreation Area's General Plan

Attachment D: March 8, 2014, Comments on Ocotillo Wells SVRA Draft Alternatives

Attachment E: March 24, 2025, Comments on the Draft Ocotillo Wells SVRA Soil Conservation Plan

References (*references that are not available online are provided with these comments except for the book*):

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Attachment A

From: [Plan Ocotillo Wells](#)
To: [Lisa Belenky](#)
Cc: [Zeynep Graves](#); [Erik@Parks](#)
Subject: Re: NOP Ocotillo Wells State Vehicular Recreation Area General Plan Update- Request for extension of time,
Date: Tuesday, March 24, 2026 11:39:51 AM

Hello Ms. Belenky,

Thank you for your interest in the Ocotillo Wells SVRA General Plan Update. This request for extension has been granted for comments from the Center through Friday, April 3rd, 2026.

We will add the contacts noted in this email to the distribution list for future public notices.

Regards,

Ocotillo Wells SVRA Planning Team

On Tue, Mar 24, 2026 at 9:19 AM Lisa Belenky <lbelenky@biologicaldiversity.org> wrote:

Erik Taylor, General Plan Project Manager.

The Center for Biological Diversity (Center) requests an extension of time of 10 days to submit comments on the Notice of Preparation (NOP). The Center has no record of receiving a copy of the NOP and I only learned of it yesterday.

As you are no doubt aware, the Center has engaged with State Parks many times in the past regarding management of the OWSVRA area and is concerned about protection of many species in the OWSVRA. In 2025 we submitted comments on the Draft Ocotillo Wells SVRA Soil Conservation Plan. Among other work, the Center has advocated for protections of flat-tailed horned lizards that occur in the OWSVRA and has advocated for protections for the environmental and cultural resources of the Desert Cahuilla Acquisition area for decades.

Please ensure that the Center is on the notice list for all future updates and notices associated with the OWSVRA General Plan Update and its environmental review.

Please include both of the following on the notice list:

Lisa Belenky lbelenky@biologicaldiversity.org

Zeynep Graves zgraves@biologicaldiversity.org

Thank you for considering this request for an extension of time.

Sincerely,

Lisa Belenky

Lisa T. Belenky, *Senior Counsel*

for

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Attachment B



February 7, 2008

sent via certified mail

Chris Moore, Senior Project Manager
EDAW, Inc
1420 Kettner Boulevard, Suite 500
San Diego, California 92101

Re: Notice of Preparation for an Environmental Impact Report Truckhaven/Desert Cahuilla and Ocotillo Wells General Plan

Mr. Moore,

The Center for Biological Diversity (“the Center”) is a non-profit, public interest environmental organization dedicated to the protection of native species and their habitats through science, policy, and environmental law. The Center has over 40,000 members throughout California and the United States.

The Desert Protective Council (DPC) is a 53-year-old non-profit membership organization. The DPC's mission is to safeguard those desert areas of unique scenic, scientific, historical, spiritual and recreational value for this and succeeding generations, and to educate children and adults to a better understanding of the deserts. The DPC has participated in general plan processes for Anza-Borrego Desert State Park since the 1960s and was a vocal supporter of the formation of Ocotillo Wells SVRA. The DPC continues to be dedicated to the protection of all of the unique natural and cultural resources in the desert areas of Imperial and San Diego Counties.

The Center and DPC submit the following comments on the Notice of Preparation (“NOP”) for an Environmental Impact Report (“EIR”) on behalf of our board, staff, and members of the public with an interest in protecting the native species and habitats of southern California, Anza Borrego State Park and specifically the Desert Cahuilla acquisition area.

The newly acquired Desert Cahuilla Prehistoric area provides spectacular scenery with colorful badlands-type mud hills, secluded washes and rare geological features, dark skies and quiet in densely populated southern California. The area is habitat for endangered species, including designated critical habitat for the Peninsular Bighorn Sheep. It is the ancestral home and hunting grounds of the Cahuilla Indians. This area and its important resources continue to be at great risk from off-road vehicle (ORV) abuse. Conservation groups have made numerous requests to close the property during the NOP/EIR process, however these requests were denied and we were assured there would be no new damage. Recently, we have provided evidence that there is ongoing and new damage and we are becoming increasingly skeptical that the EIR process will result in a management plan that adequately preserves the unique features of the property when that isn't even happening now. If ongoing damage continues as the EIR process drags out, the Department will have allowed a great loss of important resources.

The environmental impacts of this damage and that which may be allowed to continue even after the EIR process is complete, will likely be severe. Given the exceptional ecological and cultural significance of the project area within Imperial and San Diego Counties and the state of California, the project, as it is proposed, presents difficulties that in the Center's view need to be remedied before the environmental review process begins, specifically the way the project is being framed and set up by the Department. In particular, we are concerned with the bundling of this project with the development of the Ocotillo Wells General Plan and the unwillingness of the agencies to protect the area from damage over the next 3 to 5 years during the EIR process. Both of these actions will result in extremely significant impacts to native listed and sensitive species, adjacent wilderness areas, cultural and historical artifacts and air quality, among other things.

We hope that the Department will reconsider this decision and will re-issue an NOP that complies with CEQA and will move forward with a separate planning process for each area. We are asking you to reconsider the EIR process and outline our reasons in further detail below. Regardless, the Center also offers these comments regarding the scope of issues that should be addressed in the EIR. In general, the Draft Environmental Impact Report (EIR) should adequately demonstrate the purpose and need of the proposed project, if and how each project alternative will fulfill the project's purpose and need, and adequately describe how each alternative will impact biological resources and mitigate for those impacts.

Following are specific issues the Center believes must be addressed in a new NOP and the EIR under the California Environmental Quality Act, Public Resources Code §§ 2100 et seq. ("CEQA"). We offer these comments to assist the California Department of Parks and Recreation ("the Department") in avoiding, minimizing and mitigating project impacts to biological resources.

The NOP Does Not Comply With CEQA

In a recent letter submitted to Mr. Moore by the Anza Borrego Foundation, Desert Protective Council and the Center, we requested that the Department reissue the NOP based on a failure to comply with CEQA. We have not yet received a response to our request and the Center would like to reiterate this request formally as part of these comments. Specifically, in the scoping notice, the project is not identified as project having Statewide, Regional or Areawide Significance (CEQA § 15206). CEQA (§ 15082 (c) (1)) requires specific requirements for such projects, including a noticed scoping meeting. Projects of Statewide, Regional or Areawide Significance are defined within CEQA § 15206. We believe that the project does meet the definitions as provided within CEQA § 15206 (b) (5) where a "*Project which would substantially affect sensitive wildlife habitats including but not limited to riparian lands, wetlands, bays, estuaries, marshes, and habitats for endangered rare and threatened species as defined by Section 15380 of this Chapter.*"¹

¹ Rather than reiterate our entire argument please refer to the letter submitted by these groups and dated January 7, 2008, Re: Inadequate Notice of Preparation: Truckhaven/Desert Cahuilla and Ocotillo Wells General Plan.

The NOP is Inadequate: It Fails to Mention State Lands Commission Issues

Destructive ORV use continues to occur on the State Lands Commission properties despite the Commission's expressed prohibition of such activity unless such users "first obtain authorization from the California State Lands Commission."² The NOP does not mention the fact that the CSLC manages some of the parcels of that State Parks is trying to acquire the State Lands Commission inholding lands. This EIR will likely cover that additional acquisition and the NOP should include disclosure of the State Lands Commission acquisition issue. The failure to disclose that issue is another major flaw in this NOP.

The Desert Cahuilla Acquisition Requires a Separate General Plan and EIR

The Department released the NOP for preparation of an EIR for the "the Truckhaven/Desert Cahuilla and Ocotillo Wells General Plan," implying that there will be only one general plan for this entire unit. We do not support the Department's decision to bundle these planning processes and request the creation and analysis of a separate plan for the Desert Cahuilla area.

The planning process itself was supposed to determine whether this area would become part of Anza Borrego Desert State Park (ABDSP) which already has a current general plan, or part of Ocotillo Wells State Vehicle Recreation Area (OWSVRA) which does not have a current plan. During the discussion at the OHV Commission meeting³ where this acquisition was voted on, the following was stated:

As part of this classification and designation process, alternatives will be weighed including, but not limited to, addition of the entire or partial acreage into Anza Borrego State Park and/or Ocotillo Wells State Vehicle Recreation Area or designation of the entire or partial acreage as a separate California State Parks unit.

There was an even explicit statement regarding the fact that purchase of this parcel with funds from the OHV commission would not prejudice its use: Rick LeFlore of the OHV Division answered, "That's correct" when questioned further by Commissioner Willard who asked "... this acquisition isn't prejudiced toward a final use? I think you stated that it could end up in Anza Borrego, Ocotillo Wells or even a separate unit."

The bundling of the units under one general plan in the NOP is contrary to this intent and these statements. It is prejudicial and is being interpreted as a predetermination of the EIR management recommendation, i.e., Desert Cahuilla property will be managed by OWSVRA. One general plan that includes Desert Cahuilla **is not acceptable**. The bundling of these units under one NOP/EIR process narrows the management alternatives relative to Desert Cahuilla.

The Desert Cahuilla Area was acquired by State Parks with the understanding that the area would be collaboratively managed by Anza-Borrego Desert State Park and Ocotillo Wells staff in the period before the finalization of a management plan for the Desert Cahuilla Area. The

² Exhibit 1: Letter w/ Subject 12th Annual Truckhaven Challenge from CSLC to California Off-Road Vehicle Association dated January 17, 2007.

³ Exhibit 2: Minutes from STATE OF CALIFORNIA, OFF-HIGHWAY MOTOR VEHICLE RECREATION COMMISSION, REGULAR MEETING, Friday, May 19, 2006.

natural and cultural resource surveys and inventories of the area have not been completed and the public has not had a chance to voice their concerns or preferences and until these requirements have been completed, it is premature to attempt to evaluate the degree to which, if at all, ORV recreation will be appropriate. This is especially important given that the primary mission of California State Parks is to protect the natural and cultural resources for this and future generations.

While communications and testimony to the OHV Commission stated that equal consideration would be given to a variety of management alternatives for the area, the NOP does not make this clear, and the reality is that the process is already biased toward the area becoming part of Ocotillo Wells. Examples include:

- OHV Division and Ocotillo Wells staff are in control of the resource surveys and management planning process
- Colorado Desert District staff are shut out of contracting with consultants for resource surveys
- No consultation with stakeholders has been conducted, as prescribed in acquisition communications
- Requests for information from conservation stakeholders have been ignored

The OHV Division has combined the general planning process for Desert Cahuilla with the Ocotillo Wells Management Plan Update. This again gives the appearance that Desert Cahuilla is a project of Ocotillo Wells SVRA, not Anza-Borrego State Park. The OHV Division's argument that to treat Desert Cahuilla separately from the Ocotillo Wells update would constitute "piecemealing" only holds true if Desert Cahuilla is considered part of a larger "Ocotillo Wells Project" that could be piecemealed.

We are very concerned that the resources will receive a less than appropriately weighted review/assessment because it appears that the Department has already made their decision to include this as part of OWSVRA, as is evidenced by the bundling of these two planning processes.

This bundling is also not appropriate because resources on this property are uniquely distinct from the Ocotillo Wells or Heber Dunes units including (a) federally designated bighorn sheep habitat overlaying 2/3 of the property, (b) unique geological features, and (c) unique archaeological and paleontological resources including fish traps, milling sites, ancient and fragile lake terraces, desert pavement, concentrations of petrified wood...all framed within the representation by California State Parks that this area would receive separate consideration⁴.

The EIR Must Consider a Range of Alternatives

In general, the EIR should include "a range of reasonable alternatives to the project, or to the location of the project, which would feasibly attain most of the basic objectives of the project but would avoid or substantially lessen any of the significant effects of the project, and evaluate the comparative merits of the alternatives," as required by Section 15126.6 (a) of the

⁴ Exhibit 3 - Letter Dated February 28, 2006 to Alex Tynberg (Trust for Public Land) from Warren E. Westrup, Jr., Chief Office of Acquisition and Real Property Services with the Department of Parks and Recreation

CEQA Guidelines. The alternatives should be limited to ones that would avoid or substantially lessen any of the significant effects of the project [CEQA Guidelines, section 15126.6(1)]. For each alternative, the EIR should provide a discussion on how each alternative would avoid or minimize significant impacts on biological resources.

The EIR should provide a very clear and detailed description of the purpose, goals, and objectives for the project, as this will be critical in determining the most appropriate alternative to address recreational needs and specific biological impacts and to reduce biological impacts to a level less than significant.

The Desert Cahuilla project must be considered separately from the Ocotillo Wells SVRA General Plan and a full range of alternatives must be considered, *including a full and objective analysis of an alternative that would turn over the management of the entire Desert Cahuilla area to Anza-Borrego Desert State Park*. This alternative would have the greatest potential to preserve the area's special features and allow appropriate motorized access for the public to enjoy the area's natural beauty and special features.

An alternative that included these lands into ABDSP would also have the greatest likelihood of meeting the requirements set forth by the bill that designated federal funding for this purchase. The federal funding portion was a congressional earmark by the 51st District Congressman, Bob Filner. The actual bill language reads, "Acquisition of land along California 86 at the Desert Cahuilla Prehistoric site, Imperial County, for environmental mitigation related to reducing wildlife mortality while maintaining habitat connectivity."⁵ The OHV Division reviewed this language in context with its enabling legislation and mission and confirmed with Congressman Filner's office, that "managed off-highway vehicle recreation" was allowed on these lands. However, the key to this is "managed" off-road recreation, meaning that ORVs will not be allowed designated routes or to travel through important habitat or sensitive areas, including washes and palm oases.

An area purchased with money for the purpose of "environmental mitigation" should not be included in an SVRA. The history of resource destruction at OWSVRA shows that resources cannot be protected in an ORV "open play area." For instance, both Shell Reef and Barrel Spring show extensive degradation since acquisition by OWSVRA.

Any alternative that includes the option of non-street legal vehicular travel in the area or opening up parts or all of this area to "open travel off of designated routes" must show how this type of recreation would not harm the areas sensitive geological, plant and animal species, particularly the endangered Peninsular Bighorn. It must consider the impacts of allowing non-street legal vehicles on the quality of other types of quiet recreation in the area and the potential impacts to the resources and recreational quality in Anza-Borrego Desert State Park and on the adjacent wilderness.

⁵ See Exhibit 3: Minutes from STATE OF CALIFORNIA, OFF-HIGHWAY MOTOR VEHICLE RECREATION COMMISSION, REGULAR MEETING, Friday, May 19, 2006. p. 139.

The analysis of any alternative that includes non-street legal vehicle recreation or that allows cross-country travel off of designated routes must specifically answer these questions:

- How would fossils, rare geological features, cultural artifacts (including trails and geoglyphs that are scattered throughout all of the sections, be protected from off road vehicle damage whether unintentional or malicious?
- How would the presence of two stroke dirt bikes and other ATVs affect the Peninsular Bighorn's use of the washes for seasonal foraging?
- With the addition of non-street legal vehicles and/or cross-country travel to the area, how will State Parks protect the mesas and sandstone hills from creation of new tracks and trails throughout the area? New tracks and trails have been created in the Desert Cahuilla Area since it has been acquired by State Parks.
- How would the addition of non-street legal vehicles to the Desert Cahuilla Area affect the air quality of the already impaired Imperial County Air basin and how will the additional particulates pollution affect the air quality in Anza-Borrego Desert State Park and in the local areas such as Salton City and the Borrego Valley?
- In any alternative that includes non-street legal vehicular recreation in the Desert Cahuilla Area, the issue of public safety must be addressed. Currently, off road vehicles create a hazard to the public traveling on highway S22 as they illegally cross the highway from Ocotillo Wells to the Desert Cahuilla Area. How will the potential for increasing this hazard be addressed?

The EIR Must Consider Direct and Cumulative Impacts to Biological Resources

An EIR must be prepared to address the direct and cumulative impacts of the proposed project to threatened, endangered, and sensitive species within the Desert Cahuilla area and in the surrounding areas (including the adjacent Wilderness area).

One of the biggest issues in the Desert Cahuilla area is how motorized recreation will be managed in this fragile desert ecosystem. As explained in the previous section, we would like to see the Department recommend a preferred alternative that will turn over management of the Desert Cahuilla area to Anza Borrego State Park, will minimize or eliminate vehicle use in the entire area, or at least critical habitat and will ultimately preserve the resources.

Regardless the EIR must fully disclose and analyze impacts to any listed, candidate, sensitive, or locally rare species, and discuss alternatives and enforceable mitigation measures to avoid, reduce, and mitigate impacts to the species. The EIR must also fully disclose and analyze impacts to sensitive vegetation types.

The EIR must include a *quantitative, data-based* analysis of the direct impacts of the Desert Cahuilla planning process from the loss of habitat, as well as the indirect impacts resulting from pollution, noise, increase in fire, disturbance, invasion of non-native species, and other effects on biological resources if motorized vehicles are allowed to travel in the area, either

on-routes or off-routes. This analysis must also include the impacts of special events that allow and encourage hundreds or thousands of vehicles to descend on the area for days at a time. These types of events create heavily impacted areas and can be especially detrimental to ecosystems that are fragile and do not revegetate very easily or quickly.

The analyses must not be comprised only of general, qualitative descriptions of potential impacts, but contain quantitative analyses of effects based on population data obtained from field surveys and local conditions. In addition, the EIR must include a detailed analysis of the cumulative impacts of this project together with other completed, current, and reasonably foreseeable projects in the area (including the Truckhaven Geothermal Leasing Project and others).

Wildlife and Plant Species

According to the State of California's California Natural Diversity Database (CNDDB 2007; Truckhaven, Seventeen Palms, Shell Reef and Kane Springs NW 7.5" quadrangle maps), federally and state-listed species, as well as sensitive and species of concern in the vicinity of the Desert Cahuilla project area include, but are not limited to:

- Peninsular Bighorn Sheep (*Ovis canadensis nelsonii*)
- Flat-tailed Horned Lizard (*Phrynosoma mcallii*)
- Pierson's pincushion (*Chaenactis carphoclinia* var. *piersonii*)
- Orcutt's woody aster (*Xylorhiza orcuttii*)
- Mecca woody aster (*Xylorhiza cognata*)
- The California fan palm (*Washingtonia filifera*)
- found The Salton milk-vetch (*Astragalus crotalariae*), a CNPS list 4.3 species, which is found in Palm
- Prairie falcon (*Falco mexicanus*)
- Golden eagle (*Aquila chrysaetos*)
- Le Conte's thrasher (*Toxostoma lecontei*)
- The Colorado fringed-toed lizard (*Uma notata*)

The EIR must consider the impacts of off-road vehicle use on each of these species in the project areas and the cumulative impacts that the anything proposed in the plan will have on these species.

Listed Species

Where "take" of a species listed under the federal or California Endangered Species Act is anticipated, the EIR must document *and quantify* past and reasonably foreseeable future take authorizations for that species issued by the U.S. Fish and Wildlife Service ("FWS") and California Department of Fish and Game ("DFG") in order to evaluate the project's direct and cumulative impact on the species. The Department should work with FWS and DFG to determine existing take authorizations that will assist the Department in its analysis.

The EIR also must consider the project's impacts on the *recovery* of listed endangered and threatened species that may occur on the site. Any potential impairment of species recovery associated with the project must be considered a potentially significant impact.

The endangered Peninsular Bighorn Sheep (*Ovis Canadensis nelsonii*) is a State and Federally listed species that is also a “fully protected species” under California law. Fish & Game Code § 4700(b)(2). The Desert Cahuilla acquisition lands include critical habitat for bighorn sheep in the Peninsular Ranges, which was identified by the U. S. Fish and Wildlife Service’s Recovery Team as habitat essential for the preservation and recovery of this endangered population (66 Federal Register 8650-8677, February 1, 2001). Therefore, by allowing off-road vehicle use in critical habitat, State Parks would be violating the “take” prohibitions of both the California and Federal Endangered Species Acts. *We recommend that the EIR consider closing all critical habitat for the Peninsular Bighorn Sheep to all motorized vehicle traffic.*

Bighorn sheep in the Peninsular Ranges also frequently use alluvial fans, gentle slopes, washes, and springs, such as those found on the Desert Cahuilla acquisition lands, as important foraging and movement areas. How will the habitat connectivity be preserved in the alternatives that include non-street legal vehicular recreation? How will corridors be protected and enhanced? What provisions for ranger and law enforcement presence in this huge area can be made, given the limited numbers of law enforcement personnel available in the area and given the huge need for law enforcement and other rangers at the Ocotillo Wells SVRA?

Sensitive Species

The Center requests that the EIR thoroughly evaluate the impacts of the proposed permitted activities on sensitive and locally rare species (not merely federally and state-listed threatened and endangered species). The preservation of regional and local genetic diversity is very important to the long-term persistence of species. Therefore, we request that all species found at the edge of their ranges or that occur as disjunct locations be evaluated for impacts by the proposed permitted activities.

The Flat-tailed Horned Lizard (*Phrynosoma mcallii*) is found in the area. This rare lizard is a California species of special concern, meaning that the California Department of Fish and Game (DFG) has identified that this species warrants careful observation due to declining habitat availability or a restricted distribution in California. The listing status of the Flat-tailed Horned Lizard (FTHL) changed in 2005. The U.S. District Court for the District of Arizona set aside the January 3, 2003 withdrawal of the proposed rule to list the flat-tailed horned lizard as a threatened species. On December 7, 2005 the U.S. Fish and Wildlife Service published a Federal Register Notice vacating the January 2003 withdrawal and restoring proposed status to the FTHL (70 FR 72776). It is also a BLM species of concern. The reason that the FTHL is not currently listed is based partially on the Flat-tailed Horned Lizard Rangewide Management Strategy, 2003 Revision, which as you know is an interagency agreement to protect the species. The EIR will need to show past actions and compliance and proposed future actions compliance with the Flat-tailed Horned Lizard Rangewide Management Strategy, 2003 Revision in the Ocotillo Wells Management Area, especially in light of the fact that the Ocotillo Wells Recreation Area is a key linkage between West Mesa and Borrego Badlands Management Areas, and is included as a Research Area. Please include all reports of research findings on the FTHL in the CEQA process.

A number of sensitive plant species, known to occur in and along portions of the six major washes in the Desert Cahuilla area could be damaged or destroyed by off-road activity. These include Pierson's pincushion (*Chaenactis carphoclinia* var. *piersonii*) a CNPS list 1B.3 species, Orcutt's woody aster (*Xylorhiza orcuttii*) a CNPS list 1B.2 species found in several of the washes within the Desert Cahuilla area (Dice and Jorgenson 2006) and the Mecca woody aster (*Xylorhiza cognata*) also a CNPS list 1B.2 species (CNDDDB 2007) known from the area. These CNPS designations meet the definitions under Sec. 2062 and 2067 (California Endangered Species Act) of the California Department of Fish and Game code, and are eligible for state listing. Therefore, it is mandatory that they be fully analyzed in California Environmental Quality Act (CEQA) processes. The California fan palm (*Washingtonia filifera*) found, while not a rare species, is considered a rare plant community by the California Department of Fish and Game (2003). Several groupings of California Fan Palms are still located in Palm Wash (Dice and Jorgenson 2006). Rare plant communities must also be fully analyzed in the CEQA process. The Salton milk vetch (*Astragalus crotalariae*), a CNPS list 4.3 species, which is found in Palm Wash, is strongly recommended for inclusion in the CEQA process.

At least two rare raptor species, protected under the Migratory Bird Treaty Act are known to use the Desert Cahuilla as foraging habitat (Dice and Jorgenson 2006). The prairie falcon (*Falco mexicanus*), which was much more common in California in the late 1970's, uses this area for foraging. The golden eagle (*Aquila chrysaetos*) is also a "fully protected" species under California law. Both of these raptors require large foraging areas in the desert due to the natural paucity of prey. Both species are included as Bird Species of Special Concern in California and are considered the highest priority for conservation (Remsen 1978).

Le Conte's thrasher (*Toxostoma lecontei*) is a California species of concern (CNDDDB 2007), known from the hills between Palm and Grave washes and near the Kane Springs area. It is included as Bird Species of Special Concern in California and is considered to be one of the second highest priority birds for conservation (Remsen 1978).

The Colorado fringed-toed lizard (*Uma notata*) is a California species of concern (CNDDDB 2007), known from Ocotillo Wells SVRA and threatened by ORV activities. All of the above California species of concern require mandatory analysis in the CEQA process.

Biological Surveys and Mapping

The Center requests that thorough, seasonal surveys be performed for sensitive plant species and vegetation communities and animal species under the direction and supervision of the resource agencies. Full disclosure of survey methodology and results to the public and other agencies without limitations must be provided to assure full CEQA compliance.

Surveys for the plants and plant communities should follow California Native Plant Society ("CNPS") and California Department of Fish and Game (CDFG) floristic survey guidelines (see Exhibits 4 and 5) and should be documented as recommended by CNPS (Exhibit 6) and California Botanical Society policy guidelines. A full floral inventory of all species encountered must be documented and included in the EIR. Surveys for animals should include an evaluation of the California Wildlife Habitat Relationship System's ("CWHR") Habitat Classification Scheme. All rare species (plants or animals) must be documented with a California Natural

Diversity Data Base form and submitted to DFG (Exhibit 7) as per the State's instructions (Exhibit 8).

The Center requests that the vegetation maps be developed at an appropriate scale to be useful for evaluating the impacts. Vegetation habitat mapping should be at such a scale to provide an accurate accounting adjacent habitat types that will be directly or indirectly affected by the proposed activities. A half-acre minimum mapping unit size is recommended. Habitat classification should follow both CNPS' *Manual of California Vegetation* and the modified version of Cowardin et al. (1979) developed by Ferren et al.(1996).

Additionally the surveys need to be done to assess cryptobiotic soil crusts – where they exist and how to protect them. Cryptobiotic soils are an essential component of healthy desert soils, providing a protective layer that absorbs the scant precipitation events, provides “safe sites” for seed germination and prevents soil erosion. Because this and essential desert soil component is fragile and not easily restored, a full discussion of the impacts needs to be included.

The EIR Must Consider Direct and Cumulative Impacts to Air Quality

The Imperial County Air Pollution Control District (APCD) which is part of the larger Salton Sea Air Basin (SSAB) is currently exceeding the federal standards for the criteria pollutants PM₁₀ and ozone. The area has exceeded federal and state standards for PM₁₀ since 1996. See ¹ Final Environmental Impact Statement for the Imperial Sand Dunes Recreation Area Management Plan and Proposed Amendment to the California Desert Conservation Plan 1980, DOI, BLM/CA/ES-2003-017 + 1790 – 1600, District Manager Linda Hansen (May 2003) at 213. Ozone levels have exceeded federal and state standards in every year from 1996 to 2000, and levels currently exceed state and federal standards. Id. at 213 PM₁₀ consists of fine particulate matter of 10 microns or less that is a mixture of airborne solid particles and liquid droplets from both manmade and natural sources. Id. at 210 PM₁₀ is generally caused by wind blown sources of dust, or interaction of sulfur oxides, nitrous oxides and volatile organic compounds. Id. at 210 Ozone is the primary constituent in smog and is created through the reaction of volatile organic hydrocarbons and nitrogen oxides in the presence of heat and sunlight. Id. at 209

The American Lung Association (2004) reports that there are many adverse health and environmental effects from PM₁₀ and ozone pollution. Inhalable particulate matter (“PM”) is associated with numerous health effects including, but not limited to, aggravation of respiratory conditions such as asthma, increased hospital visits for heart and lung disease, decreased lung function and even premature death. Id. at 210 Ozone has been linked to increased hospital admissions for respiratory causes including, but not limited to, respiratory infection, asthma, chest pain, cough and significant decreases in lung function. Id. at 209 PM and ozone are also responsible for negative impacts on the surrounding environment. PM is the major cause of reduced visibility in many areas of the United States. Id. at 210 Ozone negatively effects vegetation and ecosystems leading to reductions in agricultural and commercial forest yields, increased mortality for seedlings, and increased susceptibility to disease, pests and other environmental stressors. Id. at 209.

ORV use in the Desert Cahuilla and Ocotillo Wells SVRA contributes to existing air quality problems. Emissions from ORV related activities contribute to increased levels harmful

pollutants including, but not limited to, carbon monoxide (“CO”), sulfur oxides (“SO_x”), PM₁₀, and ozone precursor pollutants (reactive organic gases (“ROG”) and oxides of nitrogen, (“NO_x”). Indeed, “the most significant sources of O₃, NO₂, CO, and PM₁₀ in Imperial County APCD are automobiles and OHVs.” *Id.* at 213 The Imperial County APCD also suffers from problems contributed by adjacent areas. Pollution from the South Coast Air Basin, covering most of the Los Angeles metropolitan area, and Mexico worsen existing air pollution problems in the Imperial County APCD. However, a recent Ninth Circuit decision held that emissions from Mexico do not excuse Imperial Valley APCD from meeting NAAQS.⁶

The EIR must fully disclose and analyze the direct and cumulative impacts of additional land set aside for ORV use and the additional accompanying use on the already compromised air quality in the region, and discuss effective alternatives and mitigation measures to avoid, reduce, and mitigate these impacts. The EIR must also analyze the impacts of nitrogen deposition and other air pollutants on the vegetation and wildlife of the surrounding area, as well as the project’s contribution to global warming.

The Department must show how activities permitted in the Desert Cahuilla area will comply with California Ambient Air Quality Standards (“CAAQS”) established by the California Air Resources Board (“CARB”) and *prevent* emissions that will increase the severity of nonattainment. The Department must also show how this plan will comply with the Clean Air Act. The consumptive use of fossil fuels by off road vehicles, the resulting air pollution, and also the enormous dust plumes that come as a result of ORV use in the Desert Cahuilla area must be addressed and minimized

The EIR Must Adequately Describe the Environmental Baseline

The baseline for environmental analysis should not simply be set based on the existing environmental conditions because the environment itself is changing. Instead, the EIR analysis should be based on a dynamic baseline that accounts for recreational trends and population growth in terms of how it will affect the number of visitors to the Desert Cahuilla area and global warming which may particularly affect species survival and air quality trends.

The EIR Should Consider Recreational Needs and Alternatives Should Minimize User Conflicts

It is true that in recent decades, the use of off-road vehicles has increased, however the statistics associated with this growth tend to be misleading, making land managers believe that motorized users outnumber non-motorized users on public lands. Certain sources estimate that by 2010 there will be an estimated 60 million domestic off-road vehicle enthusiasts. Actually, the latest research reveals that the fastest growing outdoor activities are non-motorized. Meanwhile, the participation rate for off-road vehicle recreation is on the decline and ATV sales have dropped.⁷

⁶ This found that the EPA’s decision to classify the Imperial Valley APCD as in “attainment” under the Clean Air Act was arbitrary and capricious as contrary to scientific evidence. See Sierra Club v. United States Environmental Protection Agency, 346 F.3d 955 (9th Cir. 2003), amended by 352 F.3d 1186 (9th Cir. 2003)

⁷ Rudy Schuster, Department of Forestry, Syracuse University. Relating that sales of ATVs declined by 4% in 2003-05 and percentage of off-road vehicle recreationists has declined on a per capita basis since 2003 during a

Hikers alone outnumber ATV and dirt bike riders at a ratio of almost ten⁸ to one⁹; non-motorized winter recreationists (skiers, snowshoers, etc) outnumber snowmobilers ten¹⁰ to one¹¹. Overall, 225 million Americans participate in non-motorized outdoor recreation.¹²

Instead of allowing a perceived “demand” dictate what uses are allowed, the impact of a particular use of the land should limit if and where it is allowed. The impacts of vehicle use on threatened and endangered species like the Peninsular bighorn sheep, Peirson’s pincushion, etc. are far too severe and extensive for such a use to be compatible with the responsibility of agencies to ensure their survival, conservation and recovery.

Motorized vehicle use remains a minority use of public lands, however its impact on natural resources is disproportionate to this fact. If we allocated land use based on demand, we should limit ATVs, dirt bikes, and 4X4s to just three percent of the acres on public lands. Thus, the agencies can not justify keeping these areas open based on the need to serve the public or fill a recreational niche that is not available elsewhere, especially in the Desert Cahuilla area where there is an adjacent 85,000-acre SVRA that contains very similar terrain and experiences.

The EIR should analyze the impact of allowing motorized use in certain areas on muscle-powered recreationists and should identify and analyze potential user conflicts, including the impacts of noise on other users. The property, if entirely included in the OWSVRA management unit, would abut the largest state wilderness unit in California (Santa Rosa Mountains Wilderness), and also property owned by the Torres Martinez Band of Indians. ORV activity along these boundaries very likely would subject these properties to incursions by ORV users, thereby creating conflicts with wilderness users and landowners. This would also create additional patrolling issues for park rangers. An alternative should be developed that will minimize these conflicts and prioritize resource protection.

If “recreational trends” are going to be addressed, all types of recreational trends must be analyzed. The EIR must list a full range of studies available. Analysis of recreational trends and

presentation for the “Off-Highway Vehicle Use & Impacts on Rangelands Symposium” the Society of Range Management (SRM) 60th Annual Meeting and Tradeshow, Reno, Nevada, February 13, 2007.

⁸ Outdoor Industry Foundation, 2005 found that 76.7 million Americans are hikers.

⁹ 8 million ATVs and dirt bikes in existence according to H. Ken Cordell et al. Off-Highway Vehicle Recreation in the United States, Regions and States: A National Report from the National Survey on Recreation and the Environment. 2005. www.srs.fs.usda.gov/trends/Nsre/NSRE200562303.pdf.

¹⁰ 16 million Americans are backcountry winter users according to Outdoor Industry Foundation 2006 report, The Active Outdoor Recreation Economy: A \$730 Billion Annual Contribution to the U.S. Economy. .

¹¹ Just 1.6 million snowmobiles are registered in the United States. (International Snowmobile Manufacturers Association. 2006-2007 United States Snowmobile Registrations. 2007. http://www.snowmobile.org/stats_registrations_us.asp.

¹² Outdoor Industry Foundation 2006 estimates that more than three out of four Americans participate in “active outdoor recreation” (defined non-motorized).

“needs” should be reviewed in the context of the increasing pressures of expanding human populations on our natural lands, water, and air quality in California.

The EIR Must Analyze and Mitigate the Plan’s Impacts on Global Warming

Curbing greenhouse gas emissions to limit the effects of climate change is one of the most urgent challenges of our time. Fortunately, the California Environmental Quality Act (“CEQA”), Cal. Pub. Res. Code §§ 21000 et seq., 14 Cal. Code Regs. § 15000 et seq. (“Guidelines”), set forth a clear and mandatory process to address the Project’s greenhouse gas and global warming impacts. Each alternative in this EIR must be addressed in terms of its probable effect on California’s mandate to reduce the state’s production of greenhouse gasses. The EIR must include a complete and adequate analysis of how all actions associated with the project will influence greenhouse gas emissions, a full discussion of the impacts from those emissions, a finding that these impacts are significant under CEQA, and a thorough and quantitative analysis of alternatives and mitigation measures to reduce those impacts.

CEQA Requires a Full Analysis of a Project’s Greenhouse Gas Emissions

CEQA is “to be interpreted in such manner as to afford the fullest possible protection to the environment within the reasonable scope of the statutory language.” *Laurel Heights Improvement Ass’n v. Regents*, 47 Cal.3d 376, 389 (1988) (“Laurel Heights I”). CEQA contemplates consideration of all potential environmental impacts, including those that may not have been foreseen at the time CEQA was enacted. *See Bakersfield Citizens for Local Control v. City of Bakersfield* (2004) 124 Cal.App.4th 1184, 1196, 1204-1205 (tracing judicial recognition of CEQA application to urban blight impacts and noting that “[w]ater contamination and air pollution, now recognized as very real environmental problems, were once scoffed at as the alarmist ravings of environmental doomsayers.”). Accordingly, a project impact must be assessed if it has “an effect on the environment within the meaning of CEQA.” *See Protect the Historic Amador Waterways v. Amador Water Agency*, 116 Cal.App.4th 1099, 1111 (2004). *See also Cadiz Land Co. v. County of San Bernardino*, 83 Cal.App.4th 74, 85-86 (2000) (an EIR must “evaluate all potential effects on those physical conditions and resources” within the project area). CEQA defines “environment” as “the physical conditions which exist within the area which will be affected by a proposed project, including land, air, water, minerals, flora, fauna, noise, objects of historic or aesthetic significance.” Pub. Res. Code § 21060.5. Global warming affects the “environment” as defined by CEQA because it is and will transform the physical conditions throughout California, including in the project area. As the California Legislature has declared:

Global warming poses a serious threat to the economic well-being, public health, natural resources, and the environment of California. The potential adverse impacts of global warming include the exacerbation of air quality problems, a reduction in the quality and supply of water to the state from the Sierra snowpack, a rise in sea levels resulting in the displacement of thousands of coastal businesses and residences, damage to marine ecosystems and the natural environment, and an increase in the incidences of infectious diseases, asthma, and other human health-related problems.

California Global Warming Solutions Act of 2006 (Heath & Safety Code § 38501(a)). By expressly acknowledging the existence of and adverse impacts associated with greenhouse gas emissions, the State of California recognized that greenhouse gas emissions have a profound environmental effect. Because greenhouse gas emissions impact the environment and CEQA's fundamental purpose is to "demonstrate to an apprehensive citizenry that the agency has in fact analyzed and considered the ecological implications of its action," an assessment of impacts from a project's greenhouse gas emissions falls squarely within CEQA's purview. *Sundstrom v. County of Mendocino* (1988) 202 Cal.App.3d 296, 310.

The legislature recently eliminated any doubt that a global warming analysis is required under CEQA with the passage of SB 97, which requires the Office of Planning and Research to prepare guidelines "for the mitigation of greenhouse gas emissions or the effects of greenhouse gas emissions *as required by* [CEQA], including, but not limited to, effects associated with transportation or energy consumption." (SB 97, codified as Pub. Res. Code § 21083.05). As noted in its legislative analysis, SB 97 "confirm[s] that GHG emissions are a significant adverse effect under" CEQA. Thus, SB 97 constitutes Legislative recognition that an analysis of greenhouse gas emissions, and mitigation for those effects, is required under CEQA. (SB 97 Senate Bill Analysis stating that "The analysis of GHG impacts under laws like CEQA, and its federal counterpart NEPA, is not new, nor did it commence with the passage of the California Global Warming Solutions Act of 2006.")

In order to properly analyze a plan's climate change impacts, the EIR should: 1) provide a regulatory and scientific background on global warming; 2) assess the project's contribution to climate change through an emissions inventory; 3) assess the impacts of climate change on the project; 4) make a significance determination; and 5) mitigate the project's greenhouse gas emissions.

The EIR for the Project Should Provide a Scientific and Regulatory Background on Global Warming

Climate change poses enormous risks to California. In order to provide the necessary context for the assessment of a plan's impacts on global warming, the EIR should first discuss the impact of global warming on California by providing an accurate summary of the scientific literature on climate change. Scientific literature on the impact of greenhouse gas emissions on California (and the world) is well developed and can provide the context for this discussion.¹³ The summary should make a good faith effort at full disclosure and avoid minimizing or discounting the severity of global warming's impacts. See Guidelines § 15151; *San Joaquin Raptor/Wildlife Rescue Center v. County of Stanislaus*, 27 Cal.App.4th 713 (1994).

The California Climate Change Center has evaluated the present and future impacts of climate change to California and the project area in research sponsored by the California Energy Commission and the California Environmental Protection Agency. See, e.g., California Climate Change Center ("CCCC"), Projecting Future Sea Level (2006); CCCC, Climate Change and Electricity Demand in California (2006); CCCC, Public Health Related Impacts of Climate

¹³ See, e.g., CalEPA (2006) and Intergovernmental Panel on Climate Change (IPCC) (2007). Additional reports issued by California agencies are available at <http://www.climatechange.ca.gov>, and IPCC reports available at <http://www.ipcc.ch/>.

Change in California (2006); CCCC, Climate Change and Wildfire In and Around California: Fire Modeling and Loss Modeling. Some of the types of impacts and estimated ranges of severity are summarized as follows:

- A 30-90% reduction of the Sierra snowpack during the next 100 years, including earlier melting and runoff.
- An increase in water temperatures at least commensurate with the increase in air temperatures.
- A 6-30 inch rise in sea level, before increased melt rates from the dynamical properties of ice-sheet melting are taken into account.
- An increase in the intensity of storms, the amount of precipitation and the proportion of precipitation as rain versus snow.
- Profound impacts to ecosystem and species, including changes in the timing of life events, shifts in range, and community abundance shifts. Depending on the timing and interaction of these impacts, they can be catastrophic.
- A 200-400% increase in the number of heat wave days in major urban centers.
- An increase in the number of days meteorologically conducive to ozone (O₃) formation.
- A 55% increase in the expected risk of wildfires

There is also robust, peer-reviewed literature on estimating the social costs of climate change and quantifying the cost of carbon dioxide emissions (Stern 2006). The Stern Review of the Economics of Climate Change, a comprehensive report commissioned by the British government, recently concluded that allowing current emissions trajectories to continue unabated would eventually cost the global economy between 5 to 20 percent of GDP each year within a decade, or up to \$7 trillion, and warned that these figures should be considered conservative estimates (Stern 2006). By contrast, measures to mitigate global warming by reducing emissions were estimated to cost about one percent of global GDP each year, and could save the world up to \$2.5 trillion per year (Stern 2006). If we take no action to control emissions, each ton of CO₂ that we emit now is causing damage worth at least \$85 (Stern 2006). As economic and social costs of a physical change may be used to determine the significance of physical changes to the environment, the EIR should incorporate the costs of the emissions generated by the plan into its analysis. See CEQA Guidelines 15131(b).

Recent peer reviewed works emphasize the urgent need to reduce greenhouse gas emissions immediately: just ten more years of “business as usual” emissions may commit us to climate feedbacks and impacts which would entirely transform the planet as we now know it (Hansen et al. 2007). As aptly noted in a report commissioned by CalEPA:

Because most global warming emissions remain in the atmosphere for decades or centuries, the choices we make today will greatly influence the climate our children and grandchildren inherit. The quality of life they experience will depend on if and how rapidly California and the rest of the world reduce greenhouse gas emissions.

CCCC, Our Changing Climate, Assessing the Risks to California (2006).

The EIR should also include a brief discussion of other laws to address climate change, including California's mandate to reduce emissions to 1990 levels by 2020 and goal of further reducing emissions to 80% below 1990 levels by 2050. Achievement of state mandated emissions reductions will be severely impeded if agencies across the state continue to approve *new* projects without incorporating measures to reduce the added emissions created by these projects.

The EIR for the Plan Must Include an Inventory and Analysis of the Project's Projected Greenhouse Gas Emissions

The first step in determining a project's greenhouse gas pollution impact is to complete a full inventory of all emissions sources. In conducting such an inventory, all phases of the plan and actions to be sanctioned under the plan must be considered. See 14 Cal. Code Regs. § 15126. A basic requirement of CEQA is that "[a]n EIR should be prepared with a sufficient degree of analysis to provide decision-makers with information which enables them to make a decision which intelligently takes account of environmental consequences." 14 Cal. Code Regs. § 15151. The greenhouse gas inventory for this plan must include a complete analysis of all of the area's substantial sources of greenhouse gas emissions, including those from increased use of off-road vehicles on the property, increased traffic in the area, vehicle trips to and from the area while towing trailers, emissions from law enforcement vehicles, etc.

A greenhouse gas inventory for the project must include the project's direct and indirect greenhouse gas emissions. See 14 Cal. Code Regs § 15358(a)(1) ("Indirect or secondary effects may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density, or growth rate, and related effects on air and water and other natural systems, including ecosystems.").

Without a complete inventory, the EIR cannot adequately inform the public and decision-makers about the Project's impacts and adequately discuss alternatives, avoidance, and mitigation measures to reduce those impacts. The EIR must include a full and adequate inventory of the Project's greenhouse gas emissions.

The Project's Greenhouse Gas Contribution Will Be Cumulatively Significant Impact

A project's impacts require a mandatory finding of significance if they are "cumulatively considerable." Cal. Pub. Res. Code § 21083(b). "'Cumulatively considerable' means that the incremental effects of an individual project are significant when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects." 14 Cal. Code Regs. § 15064(h)(1). Climate change is a classic example of a cumulative effects problem; emissions from numerous sources combine to create the most pressing environmental and social problem of our time. These sources may "appear insignificant when considered individually, but assume threatening dimensions when considered collectively with other sources with which they interact." *Los Angeles Unified School Dist. v. City of Los Angeles*, 58 Cal.App.4th 1019, 1025 (1997). The solution to climate change lies not in any one single action, but in systematically reducing emissions from all possible sources.

Courts have flatly rejected the notion that the incremental impact of a project is not cumulatively considerable because it is so small that it would make only a *de minimis* contribution to the

problem as a whole. See *Communities for a Better Environment v. California Resources Agency*, 103 Cal.App.4th 98, 117 (2002). An EIR may not use “the magnitude of a current problem to trivialize the project’s impacts.” *Kings County Farm Bureau v. City of Hanford*, 221 Cal. App. 3d 692, 719 (1990). Rather, “the greater the existing environmental problems are, the lower the threshold should be for treating a project’s contribution to cumulative impacts as significant.” *Communities for a Better Environment*, 103 Cal. App. 4th at 120. Not only is global warming arguably the greatest environmental problem of our time, but as federal courts have repeatedly recognized, “[t]he fact that global warming will not be solved by any one industry or by regulation of any one source of emissions . . . points to the necessity of responses, however incomplete when viewed individually, on any number of fronts.” *Green Mountain Chrysler v. Crombie*, 2007 U.S. Dist. Lexis 67617, at * 64 (D.Vt. Sept. 12, 2007); *Massachusetts v. EPA*, 127 S.Ct., 1438, 1457 (2007) (U.S. Environmental Protection Agency arguments for not regulating carbon dioxide from vehicles under the Clean Air Act “rests on the erroneous assumption that a small incremental step, because it is incremental, can never be attacked in a federal judicial forum [. . .] Agencies, like legislatures, do not generally resolve massive problems in one fell regulatory swoop.”).

Consistent with CEQA’s treatment of cumulative impacts, lead agencies have repeatedly determined that *any* increase in greenhouse gases above existing levels is a significant impact under CEQA. A lead agency need not have adopted thresholds to make a determination regarding the significance of global warming impacts. Where there is no universally accepted methodology as to what constitutes a significant impact, a lead agency must still meaningfully attempt to quantify a particular impact and determine whether the impact is significant. *Berkeley Keep Jets Over the Bay Committee v. Board of Port Commissioners*, 91 Cal.App.4th 1344, 1370-71 (2001). In the case of climate change, there is nothing speculative about the fact that: 1) new sources of greenhouse gases add to existing levels; and 2) the state has determined existing levels are unacceptable and must be reduced within a fixed timeframe. Accordingly, the lack of adopted greenhouse gas thresholds does not shield a lead agency from making a significance determination on global warming impacts. Where, as here, the legislature has determined that California’s current greenhouse gas baseline is so high that it requires significant reductions, and the proposed project will exacerbate existing conditions, it is difficult to see how a new source, even a small one, can be insignificant cumulatively. In light of the magnitude and scope of the climate change impacts facing California, the impacts from any project adding additional amounts of greenhouse gases to the environment should be considered cumulatively significant.

The California Air Pollution Control Officers Association (CAPCOA) recently released guidance on the evaluation of greenhouse gases under CEQA. CAPCOA Guidance is available at <http://www.capcoa.org/index.php> and should be used in evaluating the impact of the Project’s greenhouse gas emissions.

Off-road vehicles contribute significantly to emissions in the country and in California. In 2002, the EPA stated that “Recreational vehicles by themselves account for about 6 percent of national mobile source [HydroCarbon] emissions and about 2 percent of national mobile source [Carbon Monoxide] emissions. The California Air Resources Board (2003) acknowledged that off-road motorcycles and ATVs produce 118 times as much smog-forming pollutants as modern automobiles on a per-mile basis. Clearly, a planning process like this one, which will consider

alternatives that will include increasing the amount of land open to off-road vehicles will add to greenhouse gas emissions.

Because of the potential and likelihood that this plan will allow, encourage and promote the Desert Cahuilla area as a destination for off-road vehicle recreation, resulting in significant greenhouse gas emissions, the EIR must move on to the critical step of analyzing alternatives and measures to mitigate or avoid those impacts. As discussed below, there are numerous measures available to greatly reduce the Project's greenhouse gas emissions.

The EIR Must Analyze and Adopt Feasible Mitigation Measures to Reduce the Project's Greenhouse Gas Emissions

Because the plan's greenhouse gas emissions may cumulatively contribute to global warming, "the EIR must propose and describe mitigation measures that will minimize the significant environmental effects that the EIR has identified." *Napa Citizens for Honest Gov't v. Napa County Bd. of Supervisors*, 91 Cal.App.4th 342, 360 (2001). CEQA requires that agencies "mitigate or avoid the significant effects on the environment of projects that it carries out or approves whenever it is feasible to do so." Pub. Res. Code § 21002.1(b). Mitigation of a project's significant impacts is one of the "most important" functions of CEQA. *Sierra Club v. Gilroy City Council*, 222 Cal.App.3d 30, 41 (1990). Therefore, it is the "policy of the state that public agencies should not approve projects as proposed if there are feasible alternatives or feasible mitigation measures which will avoid or substantially lessen the significant environmental effects of such projects." Pub. Res. Code § 21002; *See Laurel Heights I*, 47 Cal.3d at 400-401.

Thank you for your consideration of these comments. Please add us to the distribution list for the EIR and all notices associated with the project.

Sincerely,



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List of Exhibits

Exh 1. Letter with Subject: 12th Annual Truckhaven Challenge from CSLC to California Off-Road Vehicle Association dated January 17, 2007

Exh 2. Minutes from State of California, Off-Highway Motor Vehicle Recreation Commission, Regular Meeting, Friday May 19, 2006.

Exh 3. Letter Dated February 28, 2006 to Alex Tynberg (Trust for Public Land) from Warren E. Westrup, Jr., Chief Office of Acquisition and Real Property Services with the Department of Parks and Recreation.

Exh 4. California Native Plant Society ("CNPS") floristic guidelines

Exh 5. California Department of Fish and Game (CDFG) floristic survey guidelines

Exh 6. CNPS documentation guidelines

Exh 7. California Natural Diversity Data Base form

Exh 8. California Natural Diversity Data Base form Instructions

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Attachment C



March 21, 2012

Tina Robinson
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RE: Input and Feedback on the Development of the Ocotillo Wells State Vehicular Recreation Area's General Plan

Ms. Robinson and Mr. Shea,

On behalf of the 350,000 members and supporters of the Center for Biological Diversity, we submit the following “input and feedback” on the development of the Ocotillo Wells State Vehicular Recreation Area's General Plan. I did submit some of these comments via the website, however, the complexity of some of these issues required explanations that far exceed the extremely limited 140 characters allowed on the website. I have grouped them by issue area as follows:

Visitor experience and opportunities

- **Flat-tailed horned lizard Research Area**

The OWSVRA is identified in the Flat-tailed Horned Lizard Rangewide Management Strategy (2003) as a Research Area. This Research Area is the only connectivity between the Borrego Badlands Management Area and the West Mesa Management Area. Because the SVRA is identified as a Research Area, the General Plan should incorporate specific goals and objectives for research on the flat-tailed horned lizard. The General Plan needs to include clearly identified protected connectivity linkages for flat-tailed horned lizard, where visitors can go to see the flat-tailed horned lizard. In order to enable research in the Research Area, these connectivity areas should be preserved as scientific “control” areas for experimental purposes in other part of the SVRA.

Resource management

- **GP must incorporate the 2008 Soil Conservation standard and demonstrate compliance with it throughout the plan area.**

Public Resources Code Section 5090.35 (a) states that “The protection of public safety, the appropriate utilization of lands, and the conservation of land resources are of the highest priority in the management of the state vehicular recreation areas; and, accordingly, the division shall... *anticipate and prevent accelerated and unnatural erosion..*” (emphasis added). The 2008 Soil Conservation Standards and Guidelines identifies the Standard as “Off-highway vehicle (OHV) recreation facilities shall be managed for sustainable long-term prescribed use *without generating soil loss that exceeds restorability*, and without causing erosion or sedimentation which significantly affects resource values beyond the facilities.” (emphasis added). The General Plan needs to set our specific metrics for annually evaluating compliance with the 2008 Soil Conservation Standard.

- **The GP must require air quality monitoring inside/outside the boundary of the OWSVRA**

Because off-road vehicle activity destabilizes soil structure and causes airborne dust particles that are a known health hazard under the Clean Air Act, the General Plan needs to identify an air quality monitoring protocol and implementation plan. The monitoring plan should include multiple monitoring sites both within and outside of OWSVRA. Triggers need to be included that would require limiting vehicular recreation activities if unhealthful PM10 levels are exceeded.

- **Full Investigation of Whistleblower Complaint**

The Center supports a full investigation of the issues raised in the Whistleblower Complaint I2011-1275, Illegal Operation of a California State Park with Resulting Destruction of Public Lands. The Whistleblower Complaint raises serious issues regarding the failure of the California Department of Parks and Recreation to protect State Park resources at the Ocotillo Wells State Vehicular Recreation Area including rare and imperiled plant and wildlife species, fragile soils, paleontological and cultural resources, and air quality under existing management. The revised management plan must address ways to ensure that the many fragile resource of the OW SVRA will in fact be protected under the plan.

- **Flat Tailed Horned Lizard Research Area**

Pursuant to the Flat-tailed Horned Lizard Rangewide Management Strategy,¹ the OWSVRA includes an area of 8,936 acres designated as the Ocotillo Wells Flat-tailed Horned Lizard Research Area to be managed in accordance with that strategy document to conserve the species. The damage detailed in the Whistleblower Complaint raises serious questions as to whether the

¹ Prepared by the Flat-Tailed Horned Lizard Interagency Coordinating Committee. Documents available at <http://www.fws.gov/southwest/es/arizona/Flat.htm>

Department is complying with its obligations under the MOU for the FTHL Rangewide Management Strategy – these issues should be addressed and management changes made to ensure protection and conservation of the species in this area.

- **Other Species that Must be Considered and Protected**

The plan should ensure conservation of all federally and state-listed species, as well as sensitive and species of concern in this area which include, but are not limited to:

- Peninsular Bighorn Sheep (*Ovis canadensis nelsonii*) and its essential habitat
- Flat-tailed Horned Lizard (*Phrynosoma mcallii*) and its essential habitat
- Pierson's pincushion (*Chaenactis carphoclinia* var. *piersonii*)
- Orcutt's woody aster (*Xylorhiza orcuttii*)
- Mecca woody aster (*Xylorhiza cognata*)
- California fan palm (*Washingtonia filifera*)
- Salton milk-vetch (*Astragalus crotalariae*)
- Prairie falcon (*Falco mexicanus*)
- Golden eagle (*Aquila chrysaetos*)
- Le Conte's thrasher (*Toxostoma lecontei*)
- Colorado fringed-toed lizard (*Uma notata*)

In addition, all fan palm oases should be protected from damage by motorized vehicles and recreationists through physical barriers.

- **Protect the Lake Cahuilla Shoreline and other Archaeological Resources**

The OWSVRA also contains portions of the ancient western shoreline of Lake Cahuilla and fish traps and other archeological resources associated with the shoreline. The GP must protect resource along with other fragile soils in the area.

Interpretation and Education

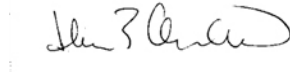
- Natural Resource education needs to include information on flat-tailed horned lizards, Peninsular bighorn sheep, values of riparian areas, palm oases and other rare plants and animals, as well as cultural and archaeological resources that occur within the OWSVRA including the Lake Cahuilla Shoreline

Area-Specific Goals

- Annexed lands north of the Salton Seaway, routes should be designated in Palm Canyon Wash. Other washes north of Palm Canyon should be closed to motor vehicles to protect the PBS, rare plants and cultural resources. If non-compliance with vehicular designated routes occurs, then the area should be closed.

Thank you for the opportunity to submit more detailed comments on the proposed General Plan. Please feel free to contact me with any questions at ianderson@biologicaldiversity.org or 323-654-5943

Sincerely,

A handwritten signature in dark ink, appearing to read 'Ilene Anderson', written in a cursive style.

Ilene Anderson
Biologist/Public Lands Desert Director
Center for Biological Diversity

Attachment D



March 8, 2014

Tina Robinson
General Plan Project Manager
California Department of Parks & Recreation
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By email to: tina.robinson@parks.ca.gov

Comments on Ocotillo Wells SVRA Draft Alternatives

Dear Ms. Robinson:

We submit this comment letter “off line” rather than using the Department’s “input forum” web page because of the limited opportunity provided there for the public to comment on the OWSVRA General Plan. We have three main points to make:

1. The Draft Planning Alternatives document is narrowly focused on use and facilities under three alternatives for each planning zone and the “input forum” doesn’t provide for comments beyond those narrow categories.
2. The Working Papers lack sufficient information and analysis of environmental issues to inform public comment.
3. The request for the public to choose alternatives now, without the required analysis, is arbitrary and delays the CEQA and General Plan processes unnecessarily, allowing violations of law and regulation to continue and the ongoing damage to park resources to go unchecked.

We have reviewed the available General Plan working documents, including:
Working Paper #1: Major Themes from Initial Public Outreach;

Working Paper #2: Existing Conditions;
Working Paper #3: Draft Issues and Analysis;
Working Paper #4: Draft Planning Alternatives.

A link identified as “Environmental Documents” takes one to a list of these same documents, none of which can credibly be called an environmental document. Working Paper #3, titled Draft Issues and Analysis, in fact, includes no analysis; it is simply a list of issues and assumptions. Working Paper #2, despite being titled Existing Conditions, is wholly inadequate presenting quantitative data sets on the existing conditions in Ocotillo Wells. Perhaps those data exist, in which case they should be available as part of this process for public review.

You are asking the public to recommend alternatives when you have yet to provide any general or site-specific information regarding how those alternatives will affect natural or cultural resources. This flies in the face of environmental planning laws, which intend that the public be presented with a project and alternatives that are provided in the context of their environmental impacts and benefits. Indeed, CEQA requires a lead agency to explore all feasible alternatives that would avoid or lessen significant environmental effects. (Public Resources Code §§ 21002, 21002.1(b).) To this end, an Environmental Impact Report (EIR) will be required to consider a range of potentially feasible alternatives, that would feasibly attain most of the project’s basic objectives while avoiding or substantially lessening any of the project’s significant environmental impacts. (Save Round Valley Alliance v. County of Inyo (2007) 157 Cal.App.4th 1437, 1456.) The Department, in this case, is way off base to ask the public to choose alternatives without any information and analyses at all about those environmental impacts, including how the alternatives comply with local, state and federal laws. Since these, or other, alternatives must be analyzed in an EIR, we have to wonder what is the purpose of asking the public to choose alternatives now, except to promote expectations for a decision that allows use to continue pretty much as it does currently. Or, is it simply to add steps to a process that is already years overdue, in order to delay making a decision at all, while natural and cultural resources continue to be destroyed?

By identifying only three alternatives in each zone, the input forum discourages any comment outside those alternatives, even if none of those three alternatives appeals to the commenter. A full range of alternatives would include ending all ORV use and restoring the park, or ending open riding and restoring the park. Only one zone (Lake Shore) would prohibit both open and trail riding, in Alternative 2 (Rugged) for that zone. One zone (Gas Domes) proposes to end open riding under all alternatives, but permits trail riding under all alternatives. A single alternative (Rugged) in the Palo Verde, Arroyo and Truckhaven zones prohibits open riding. Trails-only riding is proposed in one or more alternatives in fewer than half of (5 of the 11) zones. Trail riding only is not proposed in the other 6 zones, under any alternative. The public is not given any information as to the rationale behind these alternatives.

In zones (Headquarters, OW South, Shell Reef, Pumpkin Patch, Tarantula and Hot Springs) where every alternative provides for both open and trail riding, how will someone know which policy applies in the area in which they are currently riding? Will the plan include even smaller subzones? Currently, riding is limited to “trails only” east of Pole Line Road, yet the park staff appears unable to enforce that policy. How will it enforce a management strategy infinitely more complex? The multiple proposals will create a management nightmare, and are unlikely to result in the protection of yet-identified natural and cultural resources. As a practical matter, how would a user know when he moved from one planning zone to another? Within a zone in which open riding and trail riding are both permitted, how would a user know which was permitted in a particular area of that zone? Working paper #3 identifies the complexities of managing the area as an issue, yet the management strategy that appears to be emerging will be many times more complex and difficult...and unmanageable.

The State is asking the public to make site-specific recommendations but provides no site-specific information to inform those recommendations. The information provided to the public on the “input forum” and General Plan documents lacks sufficient detail regarding many important issues the General Plan must address. Lead agencies must ensure adequate environmental information is gathered and that the environmental impacts of a proposed action are fully identified and analyzed. “To conclude otherwise would place the burden of producing relevant environmental data on the public rather than the agency and would allow the agency to avoid an attack on the adequacy of the information contained in the report simply by excluding such information.” (Kings County Farm Bureau v. City of Hanford (1990) 221 Cal. App. 3d 692, 724.) Environmental review documentation

is more than a set of technical hurdles for agencies and developers to overcome. [Its] function is to ensure that government officials who decide to build or approve a project do so with a full understanding of the environmental consequences and, equally important, that the public is assured those consequences have been taken into account.” (Laurel Heights I, supra, 47 Cal.3d at pp. 391-392.) For the [environmental review documentation] to serve these goals it must present information in such a manner that the foreseeable impacts of pursuing the project can actually be understood and weighed, and the public must be given an adequate opportunity to comment on that presentation before the decision to go forward is made. (Vineyard Area Citizens for Responsible Growth, Inc. v. City of Rancho Cordova (2007) 40 Cal.4th 412, 449-450.)

The environmental review documents in which these alternatives and others will be included must “contain facts and analysis, not just the agency's bare conclusions or opinions.” (Laurel Heights Improvement Assn. v. Regents (1989) 47 Cal. 3d 376, 404 [and cases cited therein].) The environmental review documents “must include detail sufficient to enable those who did not participate in its preparation to understand and to consider meaningfully the issues raised by the proposed project.” (Id.)

While we recognize that these “working papers” are not CEQA documents, they are being used to inform the CEQA process and should therefore comply with the CEQA standards. Intensity and manner of use in a particular planning zone must be constrained according to the environmental and cultural resources in that zone, yet the planning documents provided to date fail to provide resource information, zone-specific or otherwise, on which a commenter may construct comments. The descriptions of the zones often include a boundary simply identified as an “existing trail.” How is the public supposed to discern which of many unnamed existing trails is referenced? There is no description of non-ORV recreational resources that may exist in each zone, or which should serve as a constraint to use in any particular zone. The shape and nature of each zone may make sense to the planners, but they have yet to share that information with the public.

The OWSVRA General Plan update has many significant issues to address, including impacts to sensitive plant and wildlife species, serious air quality challenges in counties that are in non-attainment for particulate matter, decimation of vegetation that provides crucial wildlife habitat, and inadequate road and trail maintenance. The Planning documents merely allude to the above resource concerns, without any serious attempt to analyze how the various alternatives will address these issues. Continued current and increased use is likely not in compliance with the Public Resources Code §5090.35. The Department must ensure compliance with the PRC when making management decisions; in this case, that will likely require restricting vehicle use to designated routes. Sensitive soils, wildlife and cultural resources of OWSVRA cannot be protected or sustained when open riding continues to be allowed in the park. The EIR must include at least one alternative that limits all riding to designated routes throughout the OWSVRA. OWSVRA should also consider the alternative of completely shutting down those areas of the park that have received considerable damage and need to be rehabilitated and those areas with at –risk cultural and historical resources.

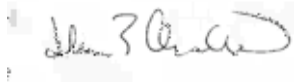
In summary, we believe this solicitation of “votes” for limited alternatives in these zones is an unnecessary and arbitrary step in the General Planning and CEQA process. Given the Department’s claim of insufficient resources to manage OWSVRA currently, we urge you to stop wasting the Department’s money by dragging out the General Plan process with unnecessary and unproductive exercises, and to complete the required and long-overdue environmental analysis and allow the public to comment on alternatives in the context of adequate information to make reasoned choices.

Sincerely,

A handwritten signature in blue ink that reads "Karen Schambach".

Karen Schambach
California Field Director

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cc: Garratt Aitchison, Supervisor, OWSVRA
Christopher Conley, Deputy Director, OHMVR Division

Attachment E



via email

March 24, 2025

OHMVR.EnvComp@parks.ca.gov

RE: Comments on the Draft Ocotillo Wells SVRA Soil Conservation Plan

To whom it concerns,

These comments are submitted on behalf of the Center for Biological Diversity (“Center”) regarding the draft Ocotillo Wells SVRA Soil Conservation Plan (SCP) circulated for public comment on February 20, 2025. The Center is concerned that the draft SCP does not adequately address the crucial components required to show whether Ocotillo Wells SVRA is achieving the 2020 Soil Conservation Standard. The 2020 Soil Conservation Standard states that “Off-highway vehicle recreation facilities shall be managed for sustainable long-term prescribed use *without generating soil loss that exceeds restorability, and without causing erosion or sedimentation which significantly affects resource values beyond the facilities.*” 2020 Soil Conservation Standard and Guidelines at 6 [emphasis added]). More detail is needed in the SCP to understand whether and/or how Ocotillo Wells SVRA is complying with the standard and Public Resources Code, Sections 5090.2, 5090.35, and 5090.53.

The Center is a nonprofit, public-interest environmental organization dedicated to the protection of native species and their habitats through science, policy, and environmental law. The Center has over 1.7 million members and online activists throughout California and the United States. The Center has worked for many years to protect and preserve the California Desert ecosystem, including working to specifically minimize harm to desert flora and fauna from numerous threats including off road vehicles.

Impacts from Off-Highway Vehicles Overview

Impacts from off road or off-highway vehicles has been well documented for decades by studies which have identified numerous deleterious effects to soils, flora and fauna. Soil compaction in arid regions negatively affects soil processes and vegetation (Adams et al. 1982; Webb 1983; Ploughe and Fraser 2022; Al-Dousari et al. 2019; Vollmer et al. 1977), soil erosion (Gillette and Adams 1983; Padgett et al. 2008; Wilshire 1983; Ploughe and Fraser 2022; Heede 1983; Hinkley, Iverson, and Hallet 1983), degraded air quality (Padgett et al. 2008; Buckley 2004), vegetation loss (Switalski 2018; Ploughe and Fraser 2022), cryptobiotic crust loss (Belnap 1995; 2002), habitat loss and impacts to native animals (Berry, Yee, and Lyren 2020; Brattstrom and Bondello 1983; Cheung et al. 2021; Grant and Doherty 2009; Ouren et al. 2007; Papouchis, Singer, and Sloan 2001; Ploughe and Fraser 2022; Tull and Brussard 2007). Research on the number of off-highway/road vehicles also documents ongoing increasing trends in activity and impacts (see Cordell et al. 2005).

Draft Soil Conservation Plan

While we appreciate that the OW SVRA has drafted a SCP, it seems not yet fully developed. For example it states, “A compliance report and action plan will also be incorporated as part of the SCP to document activities and projects undertaken to comply with the Standard and to detail planned actions and projects aimed at improving soil conservation efforts at the OHV recreational facility.” (at pg. 5). The Action Plan would be essential to focus on OW SVRA’s priorities and should be included in an updated draft of the SCP. The compliance report needs further clarification on what it actually is. Is it

compliance with SCP or the 2020 State Soil Conservation Standards? Or is it compliance with the draft General Plan or the draft Wildlife Habitat Protection Plan – neither of which are publicly available. Compliance reports typically are tied to identified requirements and follow field evaluations of the success of compliance with requirements. Please clarify the timeline for the Action Plan to be developed and adopted. Please clarify the specifics of the compliance reports.

While Appendix 6 lays out a draft monitoring plan, a final monitoring plan needs to be adopted. The final SCP requires significant additions in order to utilize the monitoring data, as follows:

- The SCP must evaluate if soil degradation has occurred or is occurring, is restoration even feasible. This evaluation should be done by soil-type. Soils in the California deserts can be damaged for decades, centuries or even permanently as exemplified by [Patton's tank tracks](#) which are clearly visible on the landscape from World War II training that occurred over 80 years ago. No scientific studies were provided that support successful soil restoration despite the OW SVRA having been established in 1979. Surely there have been efforts to conserve soils within the SVRA over the last forty years. The ongoing disturbance engenders skepticism that restoration is even feasible.
- The SCP must identify, by soil type, the triggers that would activate protective measures. Extensive monitoring is useless unless it leads to a cessation and restoration of the degrading soil condition.
- The SCP needs to establish success criteria for soil restoration in order evaluate if restored areas are meeting the criteria.
- The SCP needs to include a list of remedial measures based on soil type would aid in identifying opportunities for impacted soils to be restored.

These basic restoration components are essential to any restoration activities, and to not have them identified in the SCP is shocking.

The SCP identifies that currently only the East of Poleline Management Unit (MU) has designated trails that recreationalists can use, while the rest of the SVRA is open to riding everywhere. The Catshead MU is 6,255 acres and currently designated as open riding, with the draft General Plan considering a trails only riding designation (at pg. 33). Additionally the SCP states “Restoration efforts in this [Catshead] MU have occurred in prior years as this area has a higher density of vegetation, provides habitat for many species (e.g., flat-tailed horned lizard, LeConte's thrasher, burrowing owl), and may possibly become a trails only riding area in the future.” (at pg. 34). While the “restoration” is referenced above it is unclear if it was soil or vegetation restoration (typically they are closely tied anyway), the results of the restoration efforts need to be included in the SCP in order to evaluate if restoration is effective and feasible. (see above). In the Catshead MU, clearly cessation of open riding is being contemplated, presumably to due resource impacts including soil impacts. Cessation of open riding needs to be included as one of the restoration approaches. “The Truckhaven MU is 7,818 acres and currently designated as open riding, with the draft General Plan proposing a trails-only designation.” (at pg. 38). While the draft General Plan is not available for public review at this time, the trails-only designation appears appropriate based on the rugged landscape, erosive soils potential and cultural resources.

The SCP identifies that it currently uses watering as a method to control dust (at pg.7). There is no information provided about any impacts of this approach. Providing water can bring native desert animals into harms way as has been reported for [flat-tailed horned lizards on solar developments](#). More detail is needed to assess the impacts of watering, and if retained in the SCP, monitoring for imperiled animals needs to be done in conjunction with watering.

The SCP also identifies that a Wildlife Habitat Protection Plan (WHPP) has been prepared and will be implemented in 2025 (at pg. 5). However it is not available on the SVRA website even as a draft

document. The Center has submitted constructive comments on other SVRA WHPP and we look forward to commenting on this one when it becomes publicly available.

While the OW SVRA has put dust control measures in place and “Based on historical monitoring, the ICAPCD was able to show that all exceedances of the 24-hour PM10 threshold were during exceptional events” (at pg. 51), the SVRA is more highly utilized on weekends and holidays particularly during the cooler seasons. It is unclear if the high-use times have coincided with the “exceptional events.” Poor air quality affects wildlife as well as humans causing respiratory problems, reduced reproductive success, and weakened immune systems, with effects ranging from direct mortality to changes in species distribution and ecosystem disruption. Because PM10 are associated with soil particles, the SCP should identify additional measures to be put in place to reduce air pollution even during “exceptional events.”

Thank you for the opportunity to provide these comments and we look forward to a revised SCP for public review and comment in the near future.

Sincerely,

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Conservation Strategy for Bendire's and LeConte's Thrashers

(Toxostoma bendirei and Toxostoma lecontei)

Version 1.0, 2024



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LeConte's Thrasher (top, photo credit: J. Tinsman), Bendire's Thrasher (bottom, photo credit: J. Tietz)

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Introduction

Bendire's Thrasher (*Toxostoma bendirei*, Figure 1) and LeConte's Thrasher (*Toxostoma lecontei*, Figure 2); hereafter collectively referred to as "Desert Thrashers", are among the fastest declining avian taxa in North America (Rosenberg et al. 2016, Sauer et al. 2020). Their populations are decreasing across their ranges according to Breeding Bird Survey (BBS) data, with annual population declines in the United States of -3.12%/year for Bendire's Thrashers and -2.77%/year for LeConte's Thrashers over the last 50 years (Sauer et al. 2020, Figure 3, Tables 1 and 2), resulting in 86% and 67% declines, respectively, over the same time period. BBS data is imperfect, and the details of the trend data are discussed below. Partners in Flight (2024) estimated worldwide population sizes for both species are already small, between 31,000 and 93,000 Bendire's Thrashers and 16,000 to 92,000 for LeConte's Thrashers, making continued declines detrimental.



Figure 1. Bendire's Thrasher (*Toxostoma bendirei*)
Photo credit: C. McCreedy.

The conservation concern of both species has been recognized by Federal and State agencies, as well as non-governmental organizations (Table 3). Both species are considered Species of Greatest Conservation Need (SGCN) or of Special Concern in every State Wildlife Action Plan where they occur (Wildlife Action Plan Team 2012, CDFW 2015, Utah Wildlife Action Plan Joint Team 2015, NMDGF 2016, AZGFD 2022). Both species are U.S. Fish and Wildlife Service (USFWS) Birds of Conservation Concern (USFWS 2021), and Birds of Management Concern; Bendire's Thrasher is included as a focal species (USFWS 2011), and additionally is listed as "Vulnerable" by the IUCN (IUCN 2022). Both species are rated "Red" on the Partners in Flight Watchlist (Rosenberg et al. 2016) and are included on the Department of Defense's Mission Sensitive Species list (DOD 2021). However, neither species is currently listed on Mexico's species-at-risk list, the NORMA Oficial Mexicana NOM-059-SEMARNAT (Domínguez-Sánchez 2020). Following up on widespread anecdotal evidence of Desert Thrasher declines, as well as survey data, The Desert Thrasher Working Group (DTWG) was established in 2011 to begin addressing overall downward trends.



Figure 2. LeConte's Thrasher (*Toxostoma lecontei*) perched on a shrub.
Photo credit: J. Tinsman.

Both thrasher species occupy flat, sparse deserts, grasslands, and shrublands of the southwest United States and adjacent northwest Mexico. Both species present challenges to research and monitoring in that they nest earlier than most other land birds, they are scarce and patchily scattered across large swaths of landscape, they occur across numerous habitat types, they are cryptic in coloration and habits, and they use ephemeral food resources, often altering

timing and location of breeding activities to sync with these resources.

Despite recent advancements in our understanding of the biology and ecology of the two desert thrasher species, there are still significant data gaps that need to be filled. These include comprehensive information on their breeding season and winter distributions, habitat associations, demographics, and population-limiting factors. A better understanding of Desert Thrasher's biology and ecology are needed to provide informed conservation actions for these unique desert thrasher species.

Desert Thrasher populations are threatened by numerous practices that have led to loss and degradation of vast tracts of habitat. Populations are losing habitat due to expansion of urban areas, conversion of habitat to farmland, renewable energy development, and infrastructure projects. Habitats are further degraded by unsustainable grazing practices and an influx of invasive plant species that alter fire regimes. Finally, threats from climate change play a direct role in limiting survival and productivity of Desert Thrashers, and climate change impacts exacerbate habitat degradation through impacts from prolonged droughts, increasing temperatures, and other stochastic weather events such as floods and fires. Understanding the role these factors play in population declines is critical to reversing current population trends and conservation of these species.

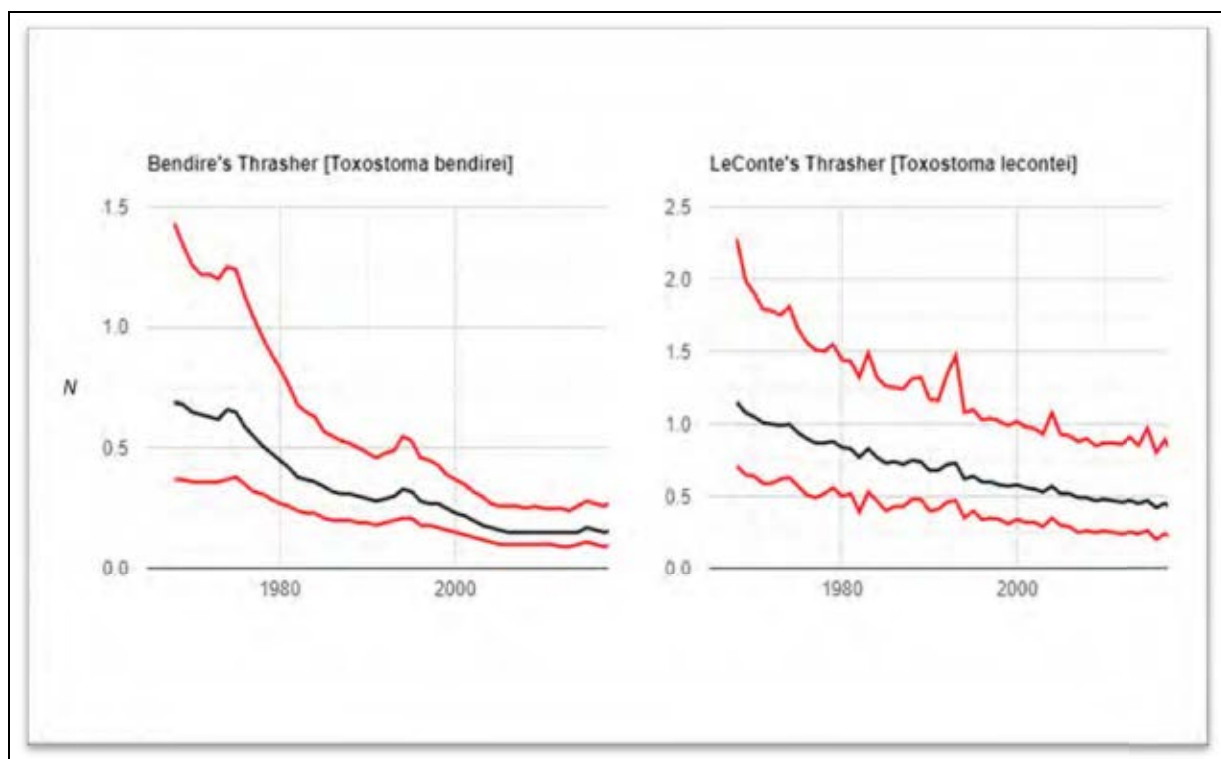


Figure 3. Population trends for Bendire's and LeConte's Thrashers from Breeding Bird Survey results 1968-2019 (Sauer et al. 2020). *N* = annual index of relative abundance. Solid black lines show trends in annual indices of relative abundance over the survey period; red lines indicate 95% credible intervals (2.5 and 97.5%). Bendire's Thrashers show a survey-wide trend of -2.75% annually, and LeConte's Thrashers show a survey-wide trend of -1.69% annually. See also Tables 1 and 2.

This plan summarizes the current state of knowledge of these birds, identifies data gaps that impede meaningful recovery, summarizes range-wide threats, and provides beneficial management practices that are designed to help land and wildlife managers maintain thrasher populations. It is anticipated that this plan will be updated to reflect new knowledge, changes in population trends, and other important new developments. The plan will highlight actions that can be taken to address current threats and narrow data gaps. The conservation targets of this plan are to have a 10% population increase over 10 years for both Bendire's and LeConte's Thrashers as well as to define Bendire's Thrasher habitat requirements. This plan addresses both LeConte's and Bendire's Thrashers; these species have comparable life histories and similar habitats, making the threats and conservation actions similar to each other in many cases. When there are differences, they will be treated separately.

Population Estimate, Status, and Trends

The global population of Bendire's Thrashers is currently estimated at 83,000, 95% CI [31,000, 93,000] with 56,000 of those birds estimated to be in the United States, and the remaining 27,000 in Mexico (Partners in Flight 2024). The Bendire's Thrasher population is declining with a significant negative survey-wide population trend of -3.14%/year, 95% CI [-4.3, -1.6] since BBS began in 1968 (Sauer et al. 2020). Population trends are also negative in all but one Bird Conservation Regions (BCR), with the greatest declines in the Southern Rockies BCR and New Mexico, as well as survey-wide (Table 1). Trends over the last 30 years are similar, with an overall significant negative trend of -2.8%/year, and greatest downward trends in the same regions (e.g., Southern Rockies BCR, New Mexico, and survey-wide). There are limitations to BBS data, especially for these species, both in coverage and robustness, which are discussed in more depth below, but that are especially apparent when considering subsets of the already limited data. Additionally, BBS data only reflect trends in the United States; trends in Mexico are unknown. Though BBS data are the only long-term and large-scale survey data available for estimating population trends for these species, there have been recent advances using community science data to estimate bird population abundance and trends (Fink et al. 2023). However, owing to the difficulties in detectability, stemming from their cryptic coloration and behavior, and under-visited habitats, data were not robust enough to provide trend estimates for Bendire's Thrasher. The DTWG has also developed survey methods and has conducted surveys across the range of both species to start better understanding of overall distributions, trends, and habitat associations, but these data are still being accumulated. These surveys have confirmed a low probability of detection (~20%), even when surveys are focused on Desert Thrashers (DTWG, unpublished data). Population goals outlined in the 2016 Partners in Flight Landbird Conservation Plan are to increase the population size by 75–100% between 2016 and 2046 (Rosenberg et al. 2016).

The global population of LeConte's Thrasher is currently estimated at 71,000, 95% CI [16,000, 92,000], with 46,000 of those birds estimated to be in the United States, and the remaining 25,000 in Mexico (Partners in Flight 2024). There is a significant negative BBS survey-wide trend of -2.77 %/year, 95% CI [-4.4, -1.2] since 1968, and a significant trend of -3.42 %/year, 95% CI [-5.9, -1.3] since 1993 (Sauer et al. 2020, Table 2). Trends are significantly downward in all regions except Nevada, where few routes detect the species and trends are negative but not statistically significant. BBS data only reflect trends in the United States; trends in Mexico are unknown. Unlike Bendire's Thrashers, abundance trends for LeConte's Thrasher based on community science data were robust enough to produce trend estimates. Abundance trends show a -15.3% decline between 2012 and 2022, 95% CI [-5.3, -28.5] in the United

States, and -10.4%, 95% CI [20.2, -20.6] decline in Mexico (Fink et al. 2023). These trends are much greater than trends estimated by BBS data. The 2016 Partners in Flight Landbird Conservation Plan calls to increase the population by 75–100% between 2016 and 2046 (Rosenberg et al. 2016). Other studies have shown downward trends in local LeConte’s Thrasher populations which are better fit by non-linear trends (Sheppard 2018).

There are limitations in using BBS data for these species. These species have a low likelihood to be recorded with conventional point counts (Weigand and Fitton 2008). Further, the BBS survey period can be mismatched with Desert Thrasher breeding phenology, with onset of nesting typically beginning long before the beginning of the BBS survey period. In some states or BCRs there are few routes where either species may be detected (e.g., Bendire’s Thrasher in BCR 9, see Table 1). Despite these sampling limitations in certain areas or timeframes, both Bendire’s and LeConte’s Thrashers are sampled well enough overall to provide reasonable downward trend estimates, though in some regions with fewer detections, there is greater uncertainty about the magnitude of trends.

Breeding bird surveys for both species have no greater than a “yellow” credibility score, reflecting data deficiencies. Yellow credibility scores reflect low abundance (< 1.0 bird/route), and small samples sizes (< 14 routes) where the species is detected, and in general are considered incapable of detecting trends of < 3% annually (Sauer et al. 2020). Regions with a “red” credibility score result from overall very low abundance (< 0.1 bird/route) of the target species, or very few routes (< 5) where the species is detected. For Bendire’s Thrasher, this occurs in regions on the edges of the range (e.g. BCR 9) or where abundance is particularly low. Trends estimates in these regions are considered imprecise and incapable of detecting trends < 5% annually. Caution should be exercised in interpreting trends in regions especially with red trends. However, while individual regions may not have enough power to detect precise trends, survey-wide trends typically have greater power. For Desert Thrasher species, which are low density and scarce on the landscape, even survey-wide trends have a “yellow” credibility score, which should be interpreted carefully, especially if trends are less than 3%/year.

Table 1. Bendire’s Thrasher population trends from 1968–2022 and the most recent analyzed 30-year BBS period (1993–2022) by Bird Conservation Region, State, and Breeding Bird Survey Route area. Note that information from Mexico is not available from these surveys. For the BBS trends, N = number of survey routes on which the species was encountered during the entire survey period. BBS trends are presented as yearly percentage changes. Numbers in parentheses are the 95% credible intervals for the trend estimate; the values represent the 2.5% and 97.5% percentiles of the posterior distribution of trend estimates (Sauer et al. 2020). Trends for which credible intervals do not include zero are considered statistically significant, and bold text represents a significant negative trend. BBS credibility scores also indicate the power of surveys to detect changes in population sizes, R = red, Y = yellow, and B = blue. Y indicates higher power, and R indicates lower power (see Sauer et al. 2020 and discussion above).

Bendire’s Thrasher		1968–2022		1993–2022		
	<i>N</i>	Trend (percent/ year)	95% CI	Trend (percent/ year)	95% CI	Credibility Score
Great Basin (BCR 9)	2	-0.23	(-4.28, 3.95)	1.46	(-4.28, 7.68)	R
Southern Rockies/Colorado Plateau (BCR 16)	24	-4.29	(-6.78, -1.77)	-5.15	(-9.0, -1.15)	Y
Sonoran and Mojave Deserts (BCR 33)	28	-2.74	(-4.92, -0.75)	-1.85	(-4.85, 0.97)	Y
Sierra Madre Occidental (BCR 34)	9	0.51	(-3.14, 4.39)	-0.322.73	(-5.08, 4.5)	R
Chihuahuan Desert (BCR 35)	5	-1.36	(-4.82, 2.35)	-0.33	(-4.92, 4.8)	R
Arizona	33	-2.64	(-4.71, -0.74)	-1.68	(-4.51, 0.97)	Y
California	7	-2.74	(-5.8, -0.11)	-0.84	(-5.533.81)	R
Nevada	4	-0.37	(-3.86, 3.14)	0.03	(-4.5, 5.05)	R
New Mexico	19	-4.59	(-6.78, -2.45)	-5.86	(-9.18, -2.43)	Y
Utah	5	-2.22	(-8.24, 2.89)	-4.34	(-11.97, 1.51)	R
Survey-wide/United States	68	-3.14	(-4.63, -1.6)	-2.8	(-4.91, -0.6)	Y

Table 2. LeConte’s Thrasher population trends from 1968–2022 and the most recent analyzed 30-year BBS period (1993–2022) by Bird Conservation Region, State, and Breeding Bird Survey Route area. Note that information from Mexico is not available from these surveys. For the BBS trends, N = number of survey routes on which the species was encountered during the entire survey period. BBS trends are presented as yearly percentage changes. Numbers in parentheses are the 95% credible intervals for the trend estimate; the values represent the 2.5% and 97.5% percentiles of the posterior distribution of trend estimates (Sauer et al. 2020). Trends for which credible intervals do not include zero are considered statistically significant, and bold text represents a significant negative trend. BBS credibility scores also indicate the power of surveys to detect changes in population sizes, R = red, Y = yellow, and B = blue. Y indicates higher power, and R indicates lower power (see Sauer et al. 2020 and discussion above).

LeConte’s Thrasher		1968–2022		1993–2022		
	<i>N</i>	Trend (percent/ year)	95% CI	Trend (percent/ year)	95% CI	Credibility Score
Coastal California (BCR 32)	2	-8.69	(-13.13, -3.40)	-8.86	(-13.94, -3.33)	R
Sonoran and Mojave Deserts (BCR 33)	39	-2.64	(-4.31, -0.97)	-3.38	(-5.83, -1.22)	Y
Arizona	8	-3.79	(-6.93, -0.30)	-3.59	(-5.83, -1.22)	R
California	29	-2.77	(-4.54, -1.12)	-3.59	(-6.31, -1.34)	Y
Nevada	4	-0.39	(-7.6, 6.56)	-0.81	(-10.52, 6.51)	R
Survey-wide/United States	41	-2.77	(-4.41, -1.16)	-3.42	(-5.85, -1.26)	Y

Table 3. The status of Bendire’s and LeConte’s Thrashers on various lists of Conservation Concern held by different agencies and organizations.

	Bendire’s Thrasher	LeConte’s Thrasher
Arizona ¹	SGCN – Tier 2	SGCN – Tier 2
California ²	Species of Special Concern	Species of Special Concern
Nevada ³	Species of Conservation Priority G4G5S1	Species of Conservation Priority G4S2
New Mexico ⁴	SGCN – Category 1 (Immediate Priority)	NA (not present)
Utah ⁵	SGCN (threat impact 1)	NA (rarely occurs)
USFWS ^{6, 7}	Bird of Conservation Concern, Bird of Management Concern, Focal Species	Bird of Conservation Concern, Bird of Management Concern
Sonoran Joint Venture ⁸	Continental Concern	Continental Concern
BLM Sensitive Species ⁹	California, Nevada, New Mexico	Arizona, California, Nevada
IUCN ¹⁰	Vulnerable	Least Concern
Partners in Flight ¹¹	Red List, Half-life: 18 years	Red List, Half-life: 27 years
DOD PIF ¹²	Mission Sensitive Species	Tier 2 Species
Road to Recovery ^{13, 14}	Red Alert Tipping Point Species	Red Alert Tipping Point Species

1. Arizona Wildlife Conservation Strategy Tier 2 species are deemed vulnerable but do not match criteria for tier 1, which are generally ESA listed species or former ESA listed species (AZGFD 2023).

2. California State Wildlife Action Plan (CDFW 2015)

3. Nevada Wildlife Action Plan (Wildlife Action Plan Team 2012)

4. State Wildlife Action Plan for New Mexico (NMDGF 2016)

5. Utah State Wildlife Action Plan (Utah Wildlife Action Plan Joint Team 2015)

6. USFWS Birds of Conservation Concern (U. S. Fish and Wildlife Service 2021)

7. USFWS Birds of Management Concern (U.S. Fish and Wildlife Service 2011)

8. Sonoran Joint Venture Bird Conservation Plan (Sonoran Joint Venture Technical Committee 2006)

9. See individual state Bureau of Land Management Sensitive Species lists

10. International Union for Conservation of Nature Red List of Threatened Species (IUCN 2022)

11. Partners in Flight Landbird Conservation Plan: 2016. (Rosenberg et al. 2016)

12. Department of Defense Partners in Flight Mission Sensitive Species (DoD PIF 2021)

13. <https://r2rbirds.org/tipping-point-species/>

14. Partners in Flight. 2024. Avian Conservation Assessment Database, version 2024. (Partners in Flight 2024)

Natural History

Bendire's Thrasher

Bendire's Thrashers occur in Arizona, California, Nevada, New Mexico, and Utah in the United States, and Chihuahua, Sonora, and northern Sinaloa in Mexico (Map 1). They typically occupy areas of little relief and sparse vegetation across desert scrub, grassland, and savanna habitats at elevations between sea level and 1,800 meters (England and Laudenslayer Jr. 2020). This species is adaptable and can also be found in the periphery of rural agricultural land, ranches, and adjacent to low-density residential areas.

Like most thrashers, they primarily forage on the ground for insects including ants, termites, grasshoppers, beetles, various larvae and pupae (England and Laudenslayer Jr. 2020), as well as seeds and berries from small trees and shrubs such as *Lycium* spp. and desert mistletoe (*Phoradendron californicum*), though there has been little formal study on Bendire's Thrasher diet. On rural edges they have been observed feeding on livestock feed and at seed feeders.

Bendire's Thrashers usually begin to sing in early January at lower elevations and late March to early April in higher elevation habitats within their breeding range. However, singing can begin as early as December in southern portions of the breeding range, and they may continue singing through June, although singing activity declines after breeding (England and Laudenslayer Jr. 2020). This species has a complex melodic song, described by Dawson (1923) as reminding him of a Catbird, saying it "...is something of a ventriloquist, too, and on such occasions drops liquid notes like beaded custard for richness". The song was described by Herbert Brown as a continuous warble with a double quality, as if singing two songs (Phillips et al. 1983). Songs may be given at length, often from high perches, but also from less conspicuous perches.

Bendire's Thrashers construct a bowl-shaped stick nest lined with grasses, hair, fur, and other soft materials, placed in a cactus, shrub, or short tree (Figure 4). Herbert Brown (Brown 1901) found that of 200 nests studied, the nests include much finer materials and "workbirdship" than those of most thrashers; they are smaller, more compactly built and very symmetrical in their cupped shape. Finer twigs are used on the outside and are fitted closely together. The lining is variously composed of horsehair, thread, twine, pieces of cloth, grass, weeds, rootlets, fine bark, wool, and cotton from bed quilts (Bent 1948). Both sexes construct the nest (Kondrat 2019).

Eggs are 25 mm in length and laid in a clutch of three to four, and rarely five eggs (Brown 1901, England and Laudenslayer Jr. 2020, Salas 2021). Average clutch size at the Chemehuevi Wash in California was 3.2 eggs ($n = 9$ nest; Point Blue Conservation Science, unpublished data), and 3.3 eggs in southern New Mexico ($n = 75$; Salas 2021). They may attempt up to three clutches a season, but two are common (England and Laudenslayer Jr. 2020, Salas 2021). Most eggs are irregularly spotted and blotched with well-defined markings of tawny red fawn color and vinaceous buff. These markings are generally heaviest about the larger end of the egg. The female is the primary incubator. When she leaves the nest, the male, or even a young bird from a previous clutch, has been observed watching closely over the eggs or nestlings on the nest's edge (Kondrat 2019). Incubation and nestling periods are not well defined, but according to the North American Nest Record Card Program, fledglings leave the nest approximately 12 days after hatching. In southern New Mexico, incubation averaged 13 days, and the nestling period averaged 15 days (Salas 2021).



Figure 4. Bendire's Thrasher nest. Photo credit: J. Tietz.

In southern New Mexico, nests are commonly found in soaptree yucca (*Yucca elata*) or honey mesquite (*Neltuma glandulosa*, formerly *Prosopis glandulosa*); Salas and Desmond 2018, Salas and Desmond 2019). In central Arizona and Sonora, nests are commonly found in honey mesquite, palo verde (*Parkinsonia* spp.), cholla cactus (*Cylindroptunia* spp.), Joshua tree (*Yucca brevifolia*), and juniper (*Juniperus* spp.). In Nevada and California, blue palo verde (*Parkinsonia florida*), *Lycium* spp., *Rhus* spp., cholla, and Joshua tree are frequently used (Ammon et al. 2020, Figure 5). In blue palo verde xeric riparian habitat on the Chemehuevi Wash in California, nine of ten nests were built in blue palo verde (Point Blue Conservation Science, unpublished data). Nests are often well concealed and placed in dense clumps of vegetation, such as limbs infected with desert mistletoe, or where Russian thistle has accumulated against shrubs, or other dense vegetation. They will also regularly nest near human dwellings or agricultural structures. Nest heights range from 0.7 meters to 4.6 meters (Bent 1948, Corman and Wise 2005, Ammon et al. 2020).

Migration and dispersal patterns, nonbreeding locations, and nonbreeding habitats are understudied or unknown, but a recent study has begun to provide insight (Borgman and Kondrat, *in prep*). The study found that individuals sampled in southern Arizona remained in their territories year-round (100%, $n = 4$), while individuals from northwestern Arizona, southwestern and central New Mexico were migratory (94%, $n = 17$); Borgman and Kondrat, *in prep*). Migratory birds primarily wintered in Sonora, with a few individuals wintering in southern Arizona; one individual remained on its breeding territory in southwestern New Mexico. The distance traveled by birds varied from 274 km to 740 km. Most birds in the nonbreeding season were found within Sonoran desertscrub (described in Brown 1994) habitats and centered around the broad area (approximately 130 km radius) surrounding Hermosillo, Sonora. A recent survey effort has also shown that Bendire's Thrashers in areas around Hermosillo are present during both breeding and nonbreeding periods (GBBO unpublished data, *in prep*).



Figure 5. Cholla with Bendire's Thrasher nest in Mojave Desert. Photo credit: J Tietz.

The study also found that birds from different sites-initiated migration at different times; birds in northwestern Arizona departed in late July (average July 24, $n = 8$), birds in central New Mexico departed in late August (average August 27, $n = 3$), and birds from southwestern New Mexico departed in late September (average September 25, $n = 5$). Nonbreeding site fidelity and any annual variation in departure timing are still not known. A better understanding of the migratory behavior, including factors that drive the selection of nonbreeding locations and habitats is necessary. Breeding site fidelity has been observed from a color-banding study in southern and central Arizona (Kondrat, unpublished data), and 61% of birds tagged during the migration study returned to their original trapping locations (Borgman and Kondrat, *in prep*); the factors that contribute to this behavior are not fully understood. To gain a more comprehensive understanding, further research is necessary to investigate the factors that influence nest site fidelity and nest site selection.

In general, birds at southern latitudes and low elevations breed earliest, but overall timing of breeding may vary widely and appears to be dependent on precipitation, elevation, and latitude (McCreedy and van Riper 2015). Resident birds at low elevations in central and southern Arizona and California initiate breeding in late January to mid-February, with earlier breeding dates coinciding with wet years. In Arizona, atlas data show peak nesting period in April, but nesting efforts continue through mid-June, and as late as mid-July (Corman and Wise 2005). In southwestern New Mexico, nest initiation varied by approximately one month annually, from late March to late April, with later nesting occurring in the drier year (Salas 2021); fewer nests were attempted during the drier year. Arrival and nest initiation in

central New Mexico was observed from early April through May. At locations on the Colorado Plateau, breeding occurs from May into July.

Nest survival in southwestern New Mexico ranged between 40% and 69% ($n = 75$) during the two-year study (Salas 2021). Nest survival was modeled at various scales. Temporally, nest survival was strongly influenced by time of year, with nests initiated later in the year having reduced survival, but with a strong effect from year as well (Salas 2021). At the nest site and territory scales, no variable had a statistically significant effect, though nest concealment, distance to nearest edge, canopy gap sizes, and arthropod abundance all had positive influences on nest survival (see Salas 2021 for full discussion). Predation caused most of the nest failures; the most common predators were Chihuahuan Ravens (*Corvus cryptoleucus*) and coyotes (*Canis latrans*; Salas 2021). Apparent nest survival in Chemehuevi in California was 71%, with five of seven nests fledging young and two nests deserted during hot conditions in June. Three additional nests ($n = 10$ total nests monitored between 2003 and 2008) had unknown outcomes but were still active at the end of the monitoring season in June (Point Blue Conservation Science unpublished data). Nest survival in other parts of the range have not been reported. Parasitism by Brown-headed Cowbirds (*Molothrus ater*) does not appear to be common; none were observed in southwestern New Mexico, but there are a few records from Arizona (England and Laudenslayer Jr. 2020, Salas 2021).

At this same southwestern New Mexico site, post-fledging survival was estimated using radio telemetry at 38% for a 30-day period, with 10 of 25 individuals surviving. Most died within five days of fledging (Salas 2021). Transmitter effect was not considered, and transmitters may have a minimal negative effect on survival (Barron et al. 2010). Juveniles stayed on their breeding territories during this time, with early movements (first five days) within 100 m of nest sites and increasing to 300 m over time (up to 40 days). They used areas with more tall shrubs, greater shrub cover, and bare ground for foraging, but when modeled, only the effect of year was significant, and habitat characteristics did not have a significant influence on juvenile survival (Salas 2021). Suspected predators of fledglings included coyotes and raptors, but also snakes and rodents as some transmitters were recovered from burrows. Thirty-eight percent survival is low for a bird this size, but within the range of reported survival for passerines for post-fledging survival (Cox et al. 2014). However, juvenile survival below 40% may be implicated in population declines in some scenarios, so this measure is important to consider for future studies. Adult survival has not been estimated on breeding or nonbreeding grounds, but according to the Bird Banding Laboratory, there is a longevity record for Bendire's Thrasher currently aged at 10 years (Kondrat, unpublished data).

Average territory size in southwestern New Mexico was 1.7 ha over three years of study and ranged between 1.3 ha and 2.3 ha between years (Sutton 2020). Territory size did not vary across different habitat types, but it did vary between years, and precipitation drove this variation to some degree (Sutton 2020). At a territory scale, occupied territories had more bare ground, taller shrubs, and greater vegetation density than random sites. At a landscape scale, occupied territories had a higher number of small patches, and higher edge density, translating to territories that have high levels of heterogeneity, with plenty of bare ground for foraging and surrounding dense vegetation for cover. Tall shrubs may play a role in offering potential nest sites and singing perches (Figure 6). Bendire's Thrashers avoid areas of contiguous cover, such as open grasslands and dense stands of creosote (*Larrea tridentata*), mesquite, or other woody cover. They are also often associated with desert washes, which can provide structural complexity against a backdrop of homogenous upland habitats used for foraging. Thrasher's breeding territories are well-spaced, ranging from approximately 400 m of separation in densely populated clusters to a kilometer or more in apparently less suitable habitats.



Figure 6. Typical breeding habitat in the Chihuahuan Desert in southwestern New Mexico. Photo credit: A. Stein.

LeConte's Thrasher

LeConte's Thrashers were considered by early ornithologists to be among the rarest and most elusive birds. This species is a year-round resident species of the Mojave and Sonoran deserts of southeast California, including the San Joaquin Valley, the Mojave Desert in California, southern Nevada, the extreme southwest corner of Utah, and the Sonoran and Mojave deserts of western and southwestern Arizona, northeast Sonora, and Baja California (Map 2). They are residents of hot, flat, desert habitats, low on slopes in valleys, drainages, or basins, from the floor of Death Valley in California up to 1,600 m in the northern parts of its range. Maximum annual precipitation is < 20cm and the species rarely occurs where snowfall is greater than 15 cm annually (Sheppard 2018). LeConte's Thrashers require large swaths of habitat that include bare, sandy ground for foraging and some shrubs or cacti adequately sized for nesting (Sheppard 2018). Important features usually include saltbush (*Atriplex* spp.), cholla, and stands of taller shrubs and trees such as *Yucca* spp. and ocotillo (*Fouquieria splendens*; Sheppard 2020). LeConte's Thrashers forage on the ground, primarily for arthropods, as well as small vertebrates such as lizards and rodents; small amounts of seeds may also be consumed. All necessary water is obtained from prey consumption.

Singing occurs throughout the year, but typically peaks in December and January and often through February (Sheppard 2020) in the southern part of the range, and January through February in the northern part of the range. LeConte's Thrashers sing sporadically and are not known to devote large portions of their daily budget to singing (Sheppard 2020). Typically, nesting occurs between February and the middle of June (Sheppard 2018). However, in the southern portions of the range, nesting may begin in December (Sonora and Baja California) or January (southern Arizona) (summarized in Sheppard 2018). Nests are stick nests with four distinct layers: the outer layer is constructed of larger twigs, the next layer of smaller twigs, a third layer of finer materials, such as grasses and rootlets, and the definitive inner layer, which is well-padded and insulated with soft vegetation. This padded inner lining is unique to any other nest of its approximate size in the desert southwest (Sheppard 2020, Figure 7).



Figure 7. LeConte's Thrasher nest. Photo Credit: J. Tobin.

LeConte's Thrashers require a nest shrub that is adequately dense to support and protect a nest, and the presence of suitable nest substrates may be a limiting factor in defining suitable habitat (Sheppard 2018, Hargrove et al. 2019), such that nest site selection may be more driven by vegetation structure than species or diversity in sparsely vegetated habitats (Blackman et al. 2012). In a sample of about 700 nests, 82% were in cholla or saltbush, but other plant species that provide dense branching were also used. Nests are typically well concealed.

Artificial structures are also used occasionally (Sheppard 2018). In California, silver cholla (*Cylindropuntia echinocarpa*) or pencil cholla (*C. ramosissima*) were most used, as well as honey mesquite afflicted with mistletoe growth (Hargrove et al. 2019, Ammon et al. 2020). In Nevada, cholla are also most commonly used, especially buckhorn (*C. acanthocarpa*) and silver cholla (Figure 8). Other favored nest substrates in Nevada include Mojave yucca (*Yucca schidigera*), *Lycium* spp., and catclaw acacia (*Senegalia greggii*) with mistletoe (Ammon et al. 2020). For 23 nests in southern Arizona, paloverde species ($n = 5$), teddy bear cholla (*Cylindropuntia bigeloveii*, $n = 5$), ironwood (*Olneya tesota*, $n = 6$), crucifixion thorn (*Canotia holacantha*, $n = 3$), and velvet mesquite (*Neltuma velutina*, formerly *Prosopis velutina*, $n = 4$) were used (Blackman and Diamond 2015). In saltbush associations, the favored substrate is cattle saltbush (*Atriplex polycarpa*) (Sheppard 2018). Nest heights range from 0 to 4.5 meters, and the average nest height is 0.8 m ($n = 343$; Sheppard 2020). Clutch sizes are generally two to five eggs, average is 3.3 eggs ($n = 655$, Sheppard 2018). LeConte's Thrashers typically have two to three clutches per season (Sheppard 2018). Average incubation period is 15.8 days (range 14–19 days, $n = 18$), and fledging occurs after 15.9 days on average (range 12–20 days, $n = 51$, Sheppard 2020).

In Maricopa, California, 64% of nests fledged at least one young ($n = 139$), and successful nests fledged an average of 2.98 per nest (Sheppard 2018). Apparent nest success of 42% was recorded in California in



Figure 8. LeConte's nest site in cholla (center) in typical LeConte's habitat in Avi Kwa Ame National Monument in Nevada. Photo credit: L. Harter.

2019 ($n = 26$, Hargrove et al. 2019), though estimating nest survival was not the goal of the study. No nest survival estimates have been made that account for sources of detection bias (e.g., Mayfield (1975) or Program Mark (Dinsmore et al. 2002)); estimates derived from these measures are typically lower than apparent success, and factors influencing nest success have not been investigated. Individual nests were most commonly lost to predation, however, failure of eggs to hatch, nestling starvation, and weather events were also significant factors in nest loss (Sheppard 2018).

A radio-telemetry study conducted at Barry M. Goldwater Range in southern Arizona revealed large post-fledging dispersal distances and large home-ranges of contiguous habitat for a bird of this size (Blackman and Diamond 2015). Juvenile home ranges were on average 364.6 ha ($n = 7$, range 222.4–747.5 ha), and core areas covered 87.3 ha. Movements were on average 678.9 m (range 441.9–825.2 m) from their nests within 50 days of fledging. Home ranges of birds from adjacent territories all overlapped to some degree (Blackman and Diamond 2015). In another study area, with significant differences in study area, study design, and study goals, average breeding territory size for adults was 7.34 ha, ranging from 4-12 ha in Maricopa, California (Sheppard 2018). Total cumulative habitat utilized by the same marked pairs over several years ranged from about 10-40 ha, averaging 27 ha in optimum habitat. These are considered minimal territory sizes. In less optimal habitats cumulative home ranges may cover significantly larger areas. The measures from these two studies vary drastically, but also investigated different measures (e.g., home range versus territory size). More study is needed to understand the true home range or territory size requirements for this species.

Juvenile survival was estimated at 46.13% (SE ± 7.69 , $n = 7$) during the first 58 days of the post-fledging period, and survival probability was inversely related to fledgling age, as survivorship decreased with greater time spent out of the nest (Blackman and Diamond 2015). Blackman and Diamond evaluated a fairly small sample ($n = 7$) of post-fledging juveniles using radio telemetry. Transmitter impacts were not assessed. However, Sheppard (2018) also estimated a low apparent juvenile survival of 20% for the first 90-days post-fledge ($n = 242$) by resighting color bands. Approximately 20% of the young survive to the following year. More investigation is needed into juvenile survival as a potentially limiting factor in population growth. Like Bendire's Thrashers, these juvenile survival rates are low compared to other species (Cox et al. 2014) and could be implicated in population declines. Annual survival rate for adults

was approximately 60%, and maximum life expectancy for adults is seven to eight years (Sheppard 2018).

Taxonomy

Bendire's Thrasher

Since its first description by Western ornithologists, Bendire's Thrasher (Figure 9) has been shrouded in uncertainty. Major Charles E. Bendire collected the first specimen of this species in 1872 near Camp Lowell, in current-day Tucson, Arizona. The specimen was examined by Robert Ridgway and Elliott Coues. It was eventually determined to be a new species, distinct from the similar Curve-billed Thrasher (*Toxostoma curvirostre*, Coues 1873, Brandt 1951, American Ornithologists' Union 1957).

There are three subspecies currently recognized by the AOU (1957): *T. b. bendirei* is found from southeastern California, southern Nevada, southern Utah and southern Colorado southward to N. Sonora. *T. b. candidum* is confined to west-central Sonora, and *T. b. rubricatum* is confined to interior southern Sonora. Among the *Toxostoma* thrashers, Bendire's Thrashers are most closely related to Gray Thrasher of Baja California (*T. cinereum*), according to genetic studies, and separate from Curve-billed Thrashers, a widespread and very similar species in appearance (Zink et al. 1999).



Figure 9. Bendire's Thrasher. Photo Credit: C. Kondrat..

Bendire's Thrasher's overall appearance of plumage is of a light sand color with triangular marks on the breast. The bill of an adult Bendire's Thrasher is mostly grayish brown. The maxilla is slightly curved, and the mandible is straight with a pale patch at the base (Figure 9). This pale patch is present in all life

stages of the bird (hatchlings, recently fledged young, and adults). In contrast, the similar Curve-billed Thrasher's bill is a dark grayish brown, with distinct long curves to both the maxilla and mandible, there is no pale patch at the base of the mandible (Kondrat 2022), and markings on the breast are rounded rather than triangular.

LeConte's Thrasher

The LeConte's Thrasher (Figure 10) was first collected by Dr. John LeConte near Fort Yuma, Arizona in 1851. As with the Bendire's Thrasher, it is rare and elusive, and one of the last North American bird species to be formally described. Only five specimens of this species were collected in the 30 years following its "discovery" by modern ornithology (Bent 1948). Currently, there are three recognized subspecies (Dickinson and Christidis 2014): *Toxostoma lecontei lecontei*, the most widespread subspecies, is resident across the Mojave and Sonoran Deserts of Arizona, Nevada, and California; *Toxostoma lecontei arenicola*, a resident of the Vizcaino Desert of Baja California; and *Toxostoma lecontei macmillanorum*, found in the southern San Joaquin Valley of California. However, evidence for subspecies status of *T. l. macmillanorum* is weak, with multiple authors providing evidence against including it as a separate subspecies (Zink et al. 1999, Sheppard 2018). Genetic studies show the LeConte's Thrasher is most closely grouped with Crissal Thrashers (*T. crissale*, Zink et al. 1999).



Figure 10. LeConte's Thrashers. Photo Credit: M. Brady.

LeConte's Thrashers are similar in size to other thrashers, with a distinctly unmarked breast, dark iris, strongly decurved bill, buff-colored vent, and contrasting dark tail. LeConte's Thrashers are unique in that they occupy especially harsh environments, exhibit a preference for running over flying, and are extremely reclusive (DTWG 2018).

Appearance and Identification

It can be difficult for untrained observers to differentiate between similar Thrasher species. For instance, Bendire's and Curve-billed Thrashers can be difficult to identify, especially during parts of the year where juvenile Curve-billed Thrashers may appear short-billed. To bring awareness of and aid in identification of similar Thrashers, The Desert Thrasher Working Group (DTWG) has provided reference Desert Thrasher (Figure 11) [identification materials](#).



Figure 11. Example of Thrasher identification materials available from DTWG.

Range and Distribution

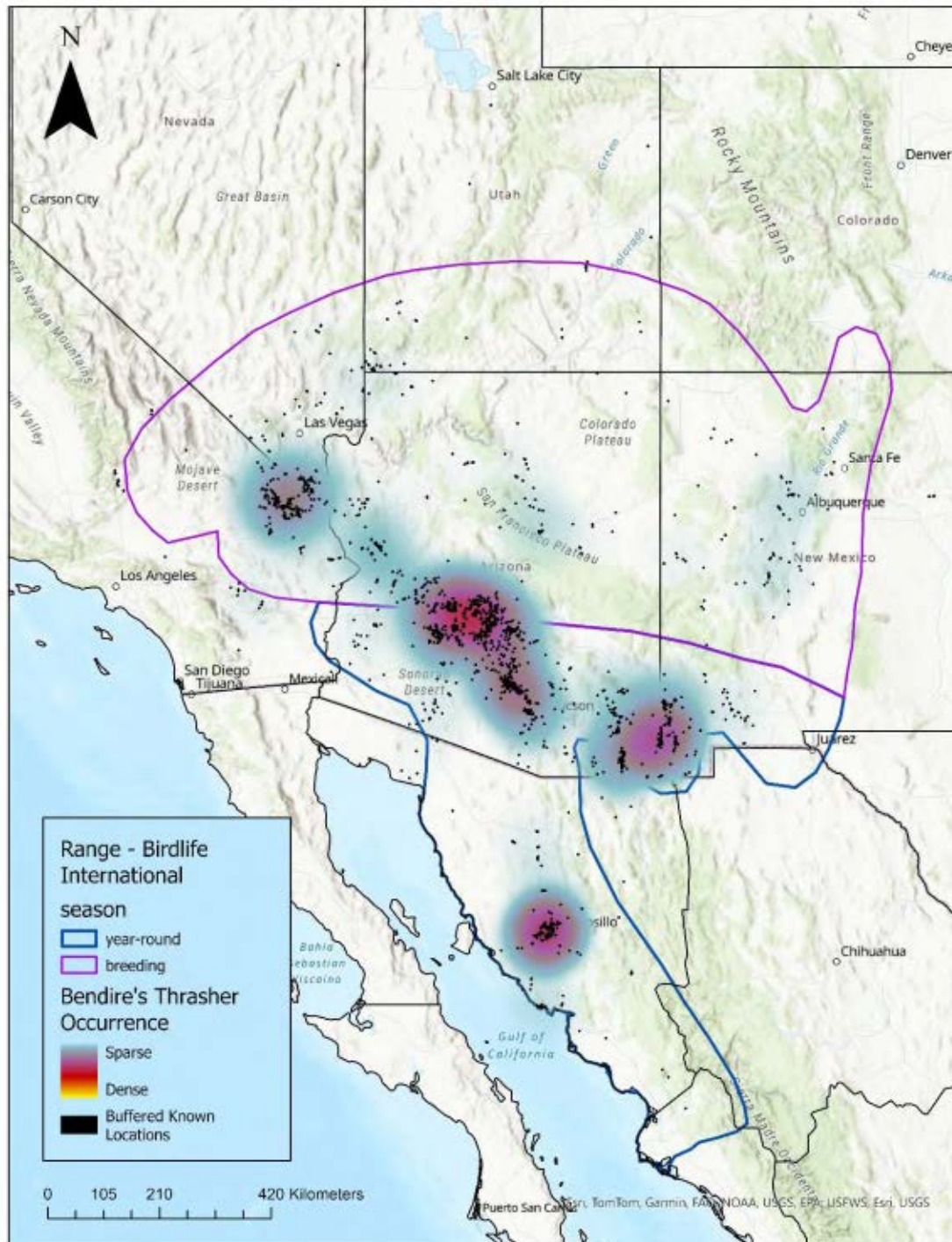
Bendire's Thrasher

Bendire's Thrashers are limited to the southwestern United States and northwestern Mexico (Map 1). They range from approximately the Rio Grande in New Mexico westward through the Mojave Desert in Southern California and Nevada. They occur from sea level near Guaymas, Sonora, Mexico (mostly in the winter) to approximately 1,800 m near Escalante, Utah, with some occurring at over 2,000 m in New Mexico (Gilman 1909, England and Laudenslayer Jr. 2020, Sutton 2020). They extend from southern Sonora to northern New Mexico, northern Arizona, and southern Utah, with a few historical detections in southwestern Colorado. The core of their range occurs in southwestern New Mexico, through Arizona and into parts of Southern California, Nevada, and Sonora. The species occurs rarely in locations outside of its normal range, with extralimital detections in southwestern Colorado, east-central Utah, the greater Los Angeles area, the Farallon islands, and the mountains outside of Bakersfield, California (DeSante and Ainley 1980).

Some changes to the distribution of the species have occurred. In New Mexico, numerous historic locations in the eastern part of the state have not had follow-up detections despite survey efforts (Baumann 2015), and detections are rare east of the Rio Grande. There is some indication of northward range expansion in Nevada with confirmed breeding near Wendover, Nevada. (eBird 2024, Great Basin Bird Observatory unpublished data). In California, the species has undergone some range contractions as habitats have disappeared and shifted.

Bendire's Thrashers are distributed primarily across six Bird Conservation Regions (<https://nabci-us.org/resources/bird-conservation-regions/>). These include the Great Basin (9), Southern Rocky Mountains (16), Coastal California (32), Sonoran and Mojave Deserts (33), Sierra Madre Occidental (34), and the Chihuahuan Desert (35). Additionally, because there is significant planning focused at an ecoregional scale, we also consider here the breadth of occurrence across North American Level III ecoregions (Wiken 2011) (See habitat section below for complete list).

Map 1. Bendire's Thrasher range map. Known Bendire's Thrasher presence from various data sources including eBird (eBird Basic Dataset), Desert Thrasher Working Group surveys, and other research and monitoring efforts. Presence is depicted as a density heat map, with buffered detection points (black polygons). The Birdlife International range map is also included for reference. Note that the presence points included herein represent known locations, but are not comprehensive, and due to use of eBird data, detections are likely skewed toward higher densities in populated areas (e.g., Phoenix, Arizona).



LeConte's Thrasher

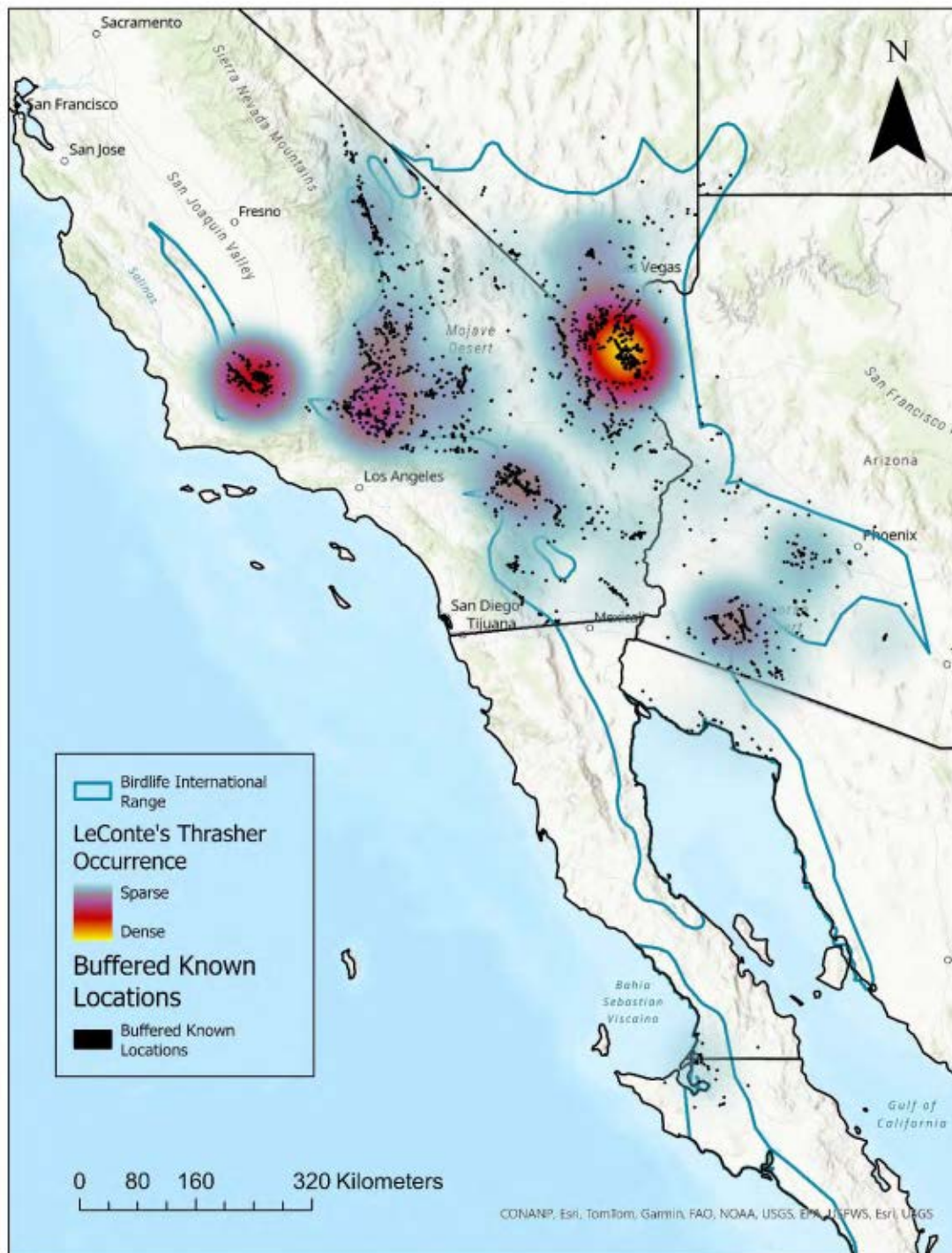
LeConte's Thrashers (Figure 12) are found in some of the driest portions of the Mojave and Sonoran Deserts of Southern California, southern Nevada, southward around the Gulf of California to about central coastal Sonora and eastern Baja California, and throughout Arizona eastward to Phoenix (Map 2). The *T. l. arenicola* subspecies occurs as an isolated subpopulation on the west coast of the Baja California peninsula.

Local changes to the overall distribution have occurred in many parts of the range. The population in the San Joaquin Valley of California has retracted due to habitat loss and fragmentation (Shuford and Gardali 2008), and the population in the Coachella Valley, California has likely been extirpated (Hargrove et al. 2019) due to land use changes and habitat loss and degradation. LeConte's Thrashers are primarily found in two Bird Conservation Regions: Sonoran and Mojave Deserts (33), and Desierto de Baja California (40). Researchers from the Comision de Ecologia y Desarrollo Sustentable de Estado de Sonora (CEDES), conducted surveys in 2021 to investigate the distribution of Bendire's and LeConte's Thrashers with the Comcaac community in areas near Puerto Libertad and Puerto Lobos, Sonora and found that previous populations of LeConte's Thrashers were no longer observed (CEDES personal communication).



Figure 12. LeConte's Thrasher Photo Credit: J Tinsman.

Map 2. LeConte's Thrasher range map. Known LeConte's Thrasher presence from various data sources including eBird (eBird Basic Dataset), Desert Thrasher Working Group surveys, and other research and monitoring efforts. Presence is depicted as a density heat map, with buffered detection points (black polygons). The Birdlife International range map is also included for reference. Note that the presence points included herein represent known locations, but are not comprehensive, and densities may be skewed toward areas with more survey effort or populated areas.



Habitat – Breeding and Nonbreeding

Ecoregional Habitat Descriptions

Specific plant associations and habitat characteristics for these two species vary regionally. We use the Commission for Environmental Cooperation (CEC) Level III Ecoregions (Wiken et al. 2011) as logical cut-points for habitats and include a discussion by Bird Conservation Region (BCR; Bird Studies Canada and NABCI 2014). Habitat descriptions are included below for each of the ecoregions where Bendire's and LeConte's Thrashers occur. We chose to evaluate habitat based on ecoregions because they closely match Bird Conservation Regions, and because some land managers, such as the Bureau of Land Management (BLM), manage many of the key areas where both LeConte's and Bendire's Thrashers (Figure 13) occur, and use these designations for planning.



Figure 13. Bendire's Thrasher Photo Credit: C. McCreedy.

Map 3. Bird Conservation Regions (BCR; Bird Studies Canada and NABCI 2014) and Level III Ecoregions (US EPA 2013) across range of Bendire's and LeConte's Thrashers. BCRs are shown in black outlines, ecoregions are colored according to the legend.



Bendire's Thrasher

Breeding

Bendire's Thrashers prefer desert habitats with open ground, including short grasslands with a significant shrub component, open shrublands, or shrubby woodlands with scattered shrubs and trees (Figure 14). Vegetated desert washes are important habitat features across the many different habitat types. Bendire's Thrashers are found in flat areas with less than six percent slope (Sutton 2020) from near sea level to 2,000 m and prefer firmly packed soils (Shuford and Gardali 2008). Bendire's Thrashers are not found in large blocks of dense vegetative cover such as riparian woodlands nor monotypic shrub or grassland communities, but they have been recorded using the edge habitat of broken woodlands adjacent to large tracts of open brush and shrublands (Phillips et al. 1983, Corman and Wise 2005, England and Laudenslayer Jr. 2020). In lower elevation desert grasslands and shrublands, representative vegetative species are a variety of cacti such as cholla, Joshua tree, and other yuccas, mesquite, palo verde, acacias (*Senegalia* spp.), agaves (*Agave* spp.), ironwood, *Lycium* spp., and netleaf hackberry (*Celtis reticulata*). At higher elevations, the preferred dominant vegetative cover can include a variety of sagebrush species (*Artemisia* spp.) and junipers within a broken mosaic of cholla cacti or shrubland and



Figure 14. Sonoran Desert Bendire's Thrasher habitat. La Paz Co., Arizona. Photo Credit: L. Harter.

grassland (Corman and Wise 2005, England and Laudenslayer Jr. 2020). England (1998) found that in the Mojave Desert of southeastern California, the species is found in the highest densities in habitats which had a higher incidence of Mojave yucca, Joshua tree, and cholla cactus. Bendire's Thrashers appear to prefer large heterogeneous landscapes with varying degrees of past disturbance and found on floodplains, such as the Gila River in Arizona (Rea 1983).

Nonbreeding

Vegetative characteristics of suitable nonbreeding habitat are poorly known and are conspicuously lacking in the literature (England and Laudenslayer Jr. 2020). It is believed that they are attracted to similar vegetative structure and species composition in the nonbreeding season as on the breeding grounds for the resident or short-distance migrants (AOU 1983, England and Laudenslayer Jr. 1998, Russell and Monson 1998). Howell and Webb (1995) described the thrasher's habitat preferences as arid to semiarid open or semi-open country, sometimes with a broken grassland component, with scattered bushes, cacti, and shrublands present. Birds tagged during a migration study spent the nonbreeding season primarily in Sonora and used Sonoran desertscrub habitats (Borgman and Kondrat, *in prep*). Plant composition was similar to breeding habitat in the Sonoran Desert, and included mesquite species,

ironwood, and palo verde, as well as jumping cholla (*Cylindropuntia fulgida*) and organ pipe cactus (*Stenocereus thurberi*). Year-round residents tagged during this study stayed on their breeding sites throughout the winter.

Bendire's Thrasher Habitat by Ecoregion

Arizona/New Mexico Plateaus and Mountains

Arizona/New Mexico Plateaus (10.1.7) are within the Southern Rockies/Colorado Plateau BCR (16), and Arizona/New Mexico Mountains (13.1.1) are within the Sierra Madre Occidental BCR (34) and Southern Rockies/Colorado Plateau BCR (16). Bendire's Thrashers are known from Arizona, New Mexico, and Utah in this ecoregion. Within these two ecoregions, Bendire's Thrashers use similar habitat types. While high-elevation pine and mixed-conifer forests are present, these forest types are not used;

Bendire's Thrashers sparsely inhabit lower elevations in pinyon and/or juniper savannas (Figure 15) during the breeding season, often with a dominant cholla cactus component or with other shrub species including four-wing saltbush (*Atriplex canescens*), barberry (*Berberis* spp.), *Lycium* spp., as well as grama grasses (*Bouteloua* spp.). Invasive annuals such as Russian thistle (*Salsola* spp.) are also common.



Figure 15. Juniper savanna habitat in central New Mexico. Photo credit: C. Borgman.



Figure 16. Vegetated desert wash habitat in central New Mexico. Photo credit: C. Borgman.

Vegetated desert washes are a common and important habitat feature in these ecoregions (Figure 16). Bendire's Thrashers occur at the highest elevations in these ecoregions (up to 2,000 m). Bendire's Thrashers in these ecoregions are primarily migratory.

Mojave Basin and Range

This ecoregion (10.2.1) is included within the larger Sonoran and Mojave Desert BCR (33). Bendire's Thrashers in this ecoregion are found in Arizona, California, Utah, and Nevada. In the Mojave Desert, the Bendire's Thrasher is most often found in areas containing a moderate density of Joshua tree, as well as big galleta (*Hilaria rigida*) or other bunchgrass species. Smaller shrubs are typically present in moderate to high density and include a diversity of species such as Mojave buckwheat (*Eriogonum fasciculatum*), blackbrush (*Coleogyne ramosissima*), white bursage (*Ambrosia dumosa*), ephedra (*Ephedra* spp.), and winterfat (*Krascheninnikovia lanata*). Mojave yucca and banana yucca (*Yucca baccata*) and large to medium size chollas (*Cylindropuntia acanthocarpa* and *C. echinocarpa*) are usually present in medium to high densities (Figure 17). Occasionally, the Bendire's Thrasher is found in areas lacking Joshua tree when large Mojave yuccas are present. Bendire's Thrashers in this ecoregion are primarily migratory.



Figure 17. Bendire's Thrasher habitat in Mojave Basin and Range ecoregion. A nest is present in the cholla in the foreground. Photo credit: J. Tietz.

Sonoran Basin and Range



Figure 18. Sonoran Basin and Range. Pima Co., Arizona. Photo Credit: A. Hannuksela.

This ecoregion (10.2.2) is in Arizona, California, Baja California, and Sonora and is included within the larger Sonoran and Mojave Desert BCR (33). Bendire's Thrashers in this ecoregion are primarily year-round residents. Breeding and nonbreeding populations (both migratory and resident) occur throughout the floodplains and valleys. The vegetation community in the Sonoran ecoregion where Bendire's Thrashers regularly occur is commonly composed of creosote, *Lycium* spp., graythorn (*Ziziphus obtusifolia*), desert tree species such as mesquite, palo verde, and ironwood, as well as large yucca and cholla (Figure 18). In

altered habitats, Bendire's Thrashers can be commonly found utilizing mesquite tree and shrub-lined edges of agricultural fields and large livestock operations within the Sonoran ecoregion, as well as small rural farm and ranch communities (Figure 19).



Figure 19. Bendire's Thrasher habitat in Sonoran Basin and Range adjacent to housing in Avra Valley, Arizona. Photo credit: C. Borgman.

Chihuahuan Desert

Found in New Mexico and Chihuahua, the Chihuahuan Desert ecoregion (10.2.4) includes the Chihuahuan Desert BCR (35). Bendire's Thrashers are known in this ecoregion in New Mexico, with expected but unconfirmed occupancy in parts of Chihuahua. In the Chihuahuan Desert, Bendire's Thrashers can be found in desert scrub and desert grassland habitat types (Figure 20), on generally flat slopes and elevations below 1,200 m. They are often found toward the bottom of bajada slopes, and in closed basins. Regardless of plant associations, the amount of bare ground and average shrub height were positive drivers of Bendire's Thrasher occurrence within the Chihuahuan Desert (Sutton 2020). Areas with greater proportion of bare ground and taller than average shrubs were more likely to be occupied by Bendire's Thrashers. They are associated with shrubs such as soaptree yucca, honey mesquite, little-leaf sumac (*Rhus microphylla*), catclaw acacia, and creosote. However, Bendire's Thrashers are not found in homogeneous patches of dense creosote or mesquite. Desert washes are an important feature for Thrashers in this ecoregion. Bendire's in this ecoregion may be resident or migratory.



Figure 20. Bendire's Thrasher habitat in the Chihuahuan Desert in southwestern New Mexico. Photo credit: C. Borgman.

Madrean Archipelago

This ecoregion (12.1.1) includes parts of the Sierra Madre Occidental BCR (34). Bendire's Thrashers in this ecoregion are found in New Mexico, Arizona, Sonora, and Chihuahua. The Madrean Archipelago, often referred to as the "Sky Islands", are made up of basin and range topography. Within this region, Bendire's Thrashers are found within the low-lying basins and low hills. These broad, low-lying valleys are dominated by deserts and desert grasslands, with tobosa grass (*Pleuraphis mutica*) and grama grasses, mesquite, yucca, and creosote (Figure 21). Bound by the Chihuahuan Desert to the east and the Sonoran Desert to the west, this ecoregion shares plant associations with both adjacent ecoregions. Bendire's Thrashers in this ecoregion may be resident or migratory.



Figure 21. Bendire's Thrasher habitat in Madrean Archipelago ecoregion.
Photo credit: C. Rubke.

Sinaloa Coastal Plain with Low Thorn Tropical Forest and Wetlands



Figure 22. Bendire's Thrasher habitat in Sinaloa Coastal Plain, Sonora. Photo Credit: A. Hannuksela.

This ecoregion (14.3.1) is within Sonoran and Mojave Desert BCR (33) in Sinaloa and Sonora. Bendire's Thrashers seem to prefer disturbed areas in this ecoregion (Figure 22). At low elevations, this ecoregion has dense thornscrub and high abundance of columnar cactus (*Stenocereus* spp. and *Pachycereus* spp.) and dense shrubs. Higher elevations have taller trees and thorn forest, though Bendire's do not occur in these habitat types. The low elevations have some of the most expansive agricultural development in Mexico. Birds in this ecoregion are known with few records from Sonora and Sinaloa during the winter in disturbed areas.

LeConte's Thrasher

Breeding and Nonbreeding

Year-round residents of the driest deserts, LeConte's Thrasher habitat is the same throughout the year. Habitat is typically distributed within alluvial fans, desert flats, dunes, or the margins of river drainages or dry lakes (Sheppard 2018). They prefer habitats with scattered cholla and saltbush plant associations (Grinnell 1933, Zeiner et al. 1990, Sheppard 2018). In general, the species occupies desert scrub habitat (Zeiner et al. 1990, Sheppard 2018), and Mojave yucca and Joshua tree dominated woodlands (Garrett and Dunn 1981, Zeiner et al. 1990). They can occur in areas of nearly pure creosote and bursage (*Ambrosia* spp.) if there is a minimal amount of cholla or other dense shrubs present to serve as nesting substrate habitats. Areas of ample soil, sand, or leaf litter are necessary for vegetation and shelter for their prey. They are often associated with dunes, and rarely with locations where bedrock is close to the surface. Shrubs, including cholla, rarely exceed two meters in height, with scattered larger trees and yucca often present. Surface water is almost never present. LeConte's thrashers are often found in heterogeneous shrub cover; they can often be found near desert washes or arroyos that typically offer a wider variety of shrubs and at slightly greater sizes and densities than their surrounding flats (Figure 23, and where larger shrubs can support nests (Grinnell 1933, Engels 1940, Sheppard 2018). Roadways across washes and lower depressions often have increased shrub sizes due to increased runoff, and therefore can be important features for this thrasher as well.

They are found in flat areas of less than five percent slope (Fletcher 2009). They can be found in higher relief areas with smaller, flat valleys and low rolling hills (Sheppard 2018). A nest was recently found in a juniper, indicating thrashers may be moving up in elevation as result of drought or climate change (Sheppard 2018). This species tends to occur in substrates that thrive in alkaline soils (Grinnell and Miller 1944, Sheppard 1970, 1973).



Figure 23. LeConte's Thrasher habitat in a vegetated desert wash on the Carrizo Plain of California. Photo credit: J. Tietz.

Ecoregional Habitat Descriptions

Mojave Basin and Range

This ecoregion (10.2.1) is included within the larger Sonoran and Mojave Desert BCR (33). LeConte's Thrashers in this ecoregion are found in Arizona, California, and Nevada. In the Mojave Desert, the LeConte's Thrasher is most often found in areas of little topographic relief. This species is often associated with the creosote and white bursage cover types which make up the majority of the Mojave Desert, but only when occurring in conjunction with larger plants that offer



Figure 24. LeConte's Thrasher habitat in Mojave Basin and Range ecoregion. Photo credit: D. Fletcher.

appropriate structure for nesting. Within this habitat type, LeConte's Thrashers are typically found in areas containing at least one of the following species: Mojave yucca, silver cholla, or buckhorn cholla (Fletcher 2009, Figure 24). Other important species include desert willow (*Chilopsis linearis*), desert almond (*Prunus fasciculata*), and catclaw acacia, which are often associated with desert washes or arroyos. Additionally, the LeConte's Thrasher can be found nesting in saltbush-dominated cover types, specifically in cattle saltbush (Fletcher 2009, Sheppard 2018).

Sonoran Desert

This ecoregion (10.2.2) is in Arizona, California, Baja California, and Sonora. This ecoregion is included within the larger Sonoran and Mojave Desert BCR (33). It is a dry subtropical climate marked by hot summers and mild winters. Most of the precipitation occurs during summer monsoons, and light winter rains. Common vegetation includes small-leaved trees such as palo verde, mesquite, and ironwood. Shrubs



Figure 25. Typical LeConte's Thrasher habitat in Sonoran Desert ecoregion. Photo credit: C. Kondrat.

and cactus, such as creosote, brittlebush (*Encelia farinosa*), and cholla are common (Figure 25).

The ecoregion contains alluvial valleys and fans, fault block mountains, and lower mountains/hills. Sand dunes, large open dry washes, and arroyos are important for this thrasher and other wildlife. LeConte's Thrashers commonly occur in such areas with sparse vegetation. Typical desert habitat consists of open, flat to gently rolling hills and shallow braided washes (Figure 26). Saguaros are typically absent where LeConte's can be found. The vegetation community is commonly composed of saltbush, bursage, and *Lycium* spp. Trees and larger desert shrubs are very sparse (Corman and Wise 2005).



Figure 26. Aerial photograph of LeConte's Thrasher habitat in the Sonoran Desert. Photo credit: M. Reigner.

10.2.3 Baja California Desert/Desierto de Baja California (40)

The ecoregion includes southern two-thirds of the Baja California peninsula. It contains the coastal plains and mountain ranges of the peninsula. Desert vegetation is the dominant type, gaining significant moisture from ocean fog on the west coast. Xeric shrubs, including several endemics, make up the majority of the ecoregion, which is superficially similar to Sonoran Desert vegetation. Common species include: Vizcaíno agave (*Agave vizcainoensis*), cirio (*Fouquieria columnaris*), creeping devil cactus (*Stenocereus eruca*), sour pitaya (*Stenocereus gummosus*) and red barrel cactus (*Ferocactus peninsulae*). Large areas have been converted to vineyards and other agriculture. High elevation mountain ranges host communities of oak and tropical deciduous forests but no LeConte's Thrashers, which inhabit the lowlands.

Causes of Decline

Both Bendire's and LeConte's Thrashers have experienced significant population declines over the last 50 years (Sauer et al. 2020, Rosenberg et al. 2019, Rosenberg et al. 2016). We assessed current threats to thrasher populations and include a detailed discussion of those threats. Historically, land use

practices have reduced habitat availability and quality. Both thrasher species prefer flat, sparsely vegetated habitats and desert washes. The physical features of these habitats make these areas desirable for land conversion and recreational uses that include urban, agricultural, infrastructural, energy development, and off-highway vehicle (OHV) travel. The intersection between thrasher habitat needs and competing land uses such as urban development has resulted in habitat loss, range reduction, and overall population decline over the last 50 years.

Both species have small overall population sizes and patchy distributions, increasing their vulnerability to extirpation, local and otherwise, and the suite of threats to these species are often interrelated. Land uses such as grazing practices and OHV use, may result in degradation of habitat or disturbances that may result in decreased survival or productivity. Overstocking of cattle, especially during drought, may lead to the proliferation of invasive annuals, woody plant encroachment (in some regions), reduced cover, compacted soils, and other landscape impacts that reduce the viability of habitat and increase fire risk. Finally, impacts from climate change are compounding and can negatively impact survival and productivity for thrashers as well. Prolonged droughts reduce primary productivity, impacting food availability, and can exacerbate threats from agricultural practices, invasive plants, and fires, thus leading to reduced breeding attempts or reduced nest survival, plant mortality, as well as direct mortality of thrashers. Increasing high temperatures exacerbate drought conditions by increasing water deficits through increased evapotranspiration, and place additional physiological demands on both thrashers and their food resources. Extreme and unpredictable weather events may also cause rare but significant impacts to thrashers resulting from floods and erosion, early or severe low temperatures, droughts, and prolonged heat waves.

Threats Assessment

Threats to both Bendire's and LeConte's Thrashers were assessed across the range of each species by experts in each region. Threat rankings were conducted according to the methods outlined in Salafsky et al. (2008). Threats were assessed individually for each species in every state and Bird Conservation Region where they occur, then overall rankings were combined across the range of the species for an overall threat ranking. Because both Bendire's and LeConte's Thrasher distributions overlap in many areas, and because they share similar habitat types undergoing similar threats, we present the results of the threats assessment for both species within Table 4 (below).

Threats are ranked according to three criteria: scope, severity, and irreversibility (Salafsky et al. 2008). In summary, this ranks threats based on the proportion of thrasher populations affected by each direct threat, the level of damage caused by each direct threat, and the degree to which effects from a threat can be reversed. Direct threats as assessed through this process are anthropogenic by nature and have negative effects on bird populations. For full discussion and definitions about the process of ranking threats, see Salafsky et al. (2008). The Desert Thrasher Working Group broke level two threats into more specific "level three" threats that impact thrashers. Below, threats are discussed according to level two and three threats as defined within. Numbers correspond to definitions from Salafsky.

Table 4. Direct threat rankings for both Bendire's and LeConte's Thrashers as ranked by members of the Desert Thrasher Working Group. Seventeen direct threats were identified and ranked as Medium (M), High (H), or Very High (VH). Threats that were ranked Low for both species are not included. Table is broken up and used as headings for threats descriptions discussed below.

Salafsky Level Two Threat	Level Three Threat	Bendire's Thrasher	LeConte's Thrasher
1: Residential and commercial development	1.1: Urban sprawl	H	H
	1.2: Ranchettes	M	L
	1.3: non-housing related development	M	M
2: Agriculture and aquaculture	2.1: Conversion of habitat to cropland	M	M
	2.2: Conversion of habitat to orchards, vineyards, cannabis farms	M	M
	Improper grazing - current	M	M
	Improper grazing - historic	H	H
3: Energy production and mining	Solar power facilities	M	H
	Wind power facilities	M	M
4: Transportation and service corridors	roads and railways	M	M
6: Human Intrusions and disturbance	Legal OHV use	M	M
	Illegal OHV use	M	M
7: Natural systems modifications	7.1: Fire and fire suppression	H	H
8: Invasive plant species	8.1 Invasive non-native/alien species	M	H
11: Climate change and severe weather	11.1: Habitat shifting and alteration	VH	VH
	11.2: Droughts	H	H
	11.3: Temperature extremes	H	H
12: Other	12.1: Data gaps	H	H

Discussion of Direct Threats:

1: Residential and Commercial Development

Salafsky Level Two Threat	Threat	Bendire's Thrasher	LeConte's Thrasher
1: Residential and commercial development	1.1: Urban sprawl	H	H
	1.2: Ranchettes	M	L
	1.3: non-housing related development	M	M

Both Bendire's and LeConte's Thrashers occupy flat desert and semi-desert habitats that continue to be targeted for urban and suburban development. The southwestern United States (Arizona, California, Colorado, Nevada, New Mexico, Utah) is the fastest-growing region of the country and is expected to continue along a similar trend (Theobald et al. 2013, Beavers et al. 2022). Phoenix is the fifth largest city in the U.S., and five of the 15 fastest-growing U.S. cities (> 50,000) are in the greater Phoenix area (U.S. Census Bureau 2020). The human population of Maricopa County (Phoenix) has increased from 971,000 in 1970 when Breeding Bird Survey efforts began to 4.4 million in 2020 (U.S. Census Bureau 2020). While Maricopa County is one of the greatest and largest urban centers in the habitats of desert thrashers, Pima County, Arizona, Clark County, Nevada, and Riverside County, California have also experienced rapid urbanization. As the populations have grown, urban land cover in the southwest has also increased by 45% since 1973, with a projected doubling of urban cover from 4.1 million acres in 2010 to 9.3 million acres by 2050, and the footprint of exurban development is expected to increase from 13.6 million acres in 2010 to 19.1 million acres by 2050 (Theobald et al. 2013). Land type conversion has primarily been from grass or shrublands to urban (Theobald et al. 2013). There is significant overlap between the fastest-growing urban centers and historical Thrasher distributions, in the Sonoran and Mojave deserts (e.g., Phoenix and Tucson, Arizona, Las Vegas, Nevada, Coachella Valley and Apple Valley, California). Loss of habitat due to urban expansion has very likely caused declines in Thrasher populations, and in the case of Coachella Valley, historic LeConte's Thrasher populations have largely been extirpated (Hargrove et al. 2019). Direct threats to thrashers from urban expansion also include increased predation risk from outdoor cats, increased collision risk (e.g., vehicles, buildings, roadways, powerlines) and reduced food resources in many cases.

Much the same to urban expansion in nature, the expansion of the anthropogenic footprint related to the development of commercial properties similarly impacts thrasher habitat targets. Development of data centers, factories, shopping centers, indoor cannabis farms, etc. contribute to the expansion of building footprints and habitat loss and fragmentation. Included under agricultural threats, the proliferation of cannabis farms can be locally problematic, especially in BCR 33 in California where large indoor farms require an expansion of building footprints. This also creates a large water demand that impacts groundwater.

However, not all development necessarily excludes these thrasher species. Bendire's Thrashers in particular will occupy low-density exurban housing and rural edges around "ranchettes" where suitable habitat is adjacent or where landscaped or other woody vegetation provides structure and cover for nesting. Both thrashers commonly nest near houses or other development such as corrals and farmhouses in these scenarios (Dawson 1923, Kondrat pers. comm., England and Laudenslayer Jr. 2020, Sheppard, pers. comm.). Bendire's Thrashers may be attracted to taller and more dense vegetation that benefits from irrigation and resultant increased food resources. Threats from increased predation and collision risks, and how nesting in proximity to housing impacts demographics such as nest survival, productivity, or adult and juvenile survival are unknown. The density of development tolerated by thrashers is also unknown, though thrashers do not occupy urban or suburban areas where adjacent native or other suitable habitat is not present. The extent of suitable habitat (minimum patch size) required for Bendire's Thrasher occupancy is also unknown. The trend of subdividing larger rural parcels into smaller "ranchettes" may create some habitat suitable for Bendire's Thrashers but may also eventually result in development at a density that is unsuitable for thrashers; more research is required on patch size requirements, fecundity, and survival for thrashers in these habitats.

A big difference between these two thrashers is their general mobility. Bendire's Thrashers are migratory over much of their U.S. range, while LeConte's Thrashers might not move more than 5-8 km in a lifetime. Dispersal into isolated patches of suitable habitats is greatly restricted for the latter, while the former has a greater likelihood of finding other suitable nesting habitats with changing habitat conditions.

LeConte's Thrashers are generally more sensitive to disturbance and are less likely to tolerate urban development, though as stated above, will make use of man-made structures for nesting or will nest near low density development in certain scenarios (Sheppard 2018). They have large minimum patch size requirements. In the San Joaquin Valley of California, patches of habitat less than 160 ha in size were not occupied despite typical use of 10–30 ha per pair (Sheppard 2018). Post-fledging juveniles in southern Arizona also used very large swaths of habitat (average 365 ha; Blackman and Diamond 2015). In addition, they have weak dispersal capabilities and patchy distributions that make it difficult for them to adapt to urbanization (Fletcher 2009, Sheppard 2018). In the Coachella Valley of southern California, which has changed from open desert scrubland to housing and agriculture since the 1950s (Figure 27), LeConte's Thrashers were relatively abundant according to historic records (pre-1940). However, during surveys in 2004 and 2005, few LeConte's Thrashers were noted (Hutchinson 2005), and in 2019 no LeConte's Thrashers (Hargrove et al. 2019) were detected, despite detections occurring in the surrounding areas, representing extirpation or near extirpation of LeConte's Thrashers in this former stronghold.

Threats from urban expansion were most relevant in the Mojave Desert regions (BCR 33) of California and Nevada including Riverside, Coachella Valley, Victorville, California and Clark County, Nevada.



Figure 27. LeConte's Thrasher habitat (top) in Desert Hot Springs, California taken in 1970 (Photo credit: J. Sheppard), versus cleared habitat and housing at the same location taken in 2015 (bottom, photo credit: L. Hargrove).

2: Agriculture and Aquaculture

Salafsky Level Two Threat	Threat	Bendire's Thrasher	LeConte's Thrasher
2: Agriculture and aquaculture	Conversion of habitat to cropland	M	M
	Conversion of habitat to orchards, vineyards, cannabis farms	M	M
	Improper grazing - current	M	M
	Improper grazing - historic	H	H

Agricultural conversion

Agricultural conversion from rangelands and desert scrub to irrigated crop land also results in habitat loss for thrashers and can contribute to threats by reducing foraging resources (Figure 28). Agriculture is not as prevalent in the southwestern United States as in other parts of the county (e.g., the plains states or south) due primarily to aridity and water scarcity. However, there is still significant agricultural conversion in areas that can be irrigated. Cropland in the arid southwest and Mexico is mostly situated along river valleys and the coast <https://www.croplands.org/app/map>. Cropland as a land cover type has marginally increased in Arizona, Nevada, and California since 1973, while it has decreased significantly in New Mexico (Theobald et al. 2013). Agricultural conversion has also been significant in Sonora and parts of Baja California. Locally, agricultural conversion may conflict with available habitat for thrashers. Again, because thrashers are often found in sparsely vegetated and flat slopes, often in valleys, agricultural conversion occurs in areas likely to hold suitable Thrasher habitat. Conversion occurs for orchard crops such as pecan and almond, vineyards, and corn, cotton, alfalfa, wheat, and vegetable crops (primarily vegetable crops in the lower Colorado River Valley in Arizona, California, Sonora, and Baja California). Southern Sonora has large areas of irrigated wheat, but Bendire's Thrasher occurrence is generally sparse and during the winter.



Figure 28. Agricultural expansion in Sonora. Photo Credit: A. Hannuksela.

LeConte's Thrashers in the Coachella, San Joaquin, and Imperial Valleys in California, as well as the Gila Valley in Arizona, have lost large swaths of habitat to agricultural expansion since the 1960s (Sheppard 2018). LeConte's Thrashers do not occur in farmed habitats, nor are they observed in areas immediately adjacent to heavy agricultural use (Sheppard 2018). These areas that had previously been strongholds for LeConte's Thrashers have seen declines or extirpations (San Joaquin Valley). Agricultural expansion

in Sonora, Mexico has been prevalent for many years and continues to grow. In some areas, such as between Hermosillo and the Pacific coast, some fields have been abandoned, but expansion is still occurring in other parts of the state. Although aquaculture ranked as a low threat overall for both species, it was identified as a significant threat locally in parts of Sonora and Baja California where shrimp farms cover large footprints of upland habitat conflicting with suitable thrasher habitat. Other threats from agriculture and aquaculture aside from habitat loss and fragmentation include potentially reduced food resources for thrashers, and the introduction of pollutants from herbicides, pesticides, and effluents.

In some areas of the southwest, sites previously converted to irrigated crops are being abandoned as water availability becomes less reliable. Along the Gila River, Bendire's Thrashers were once abundant among indigenous farmland and in floodplains (Rea 1983). In Avra Valley and other areas, abandoned farmland presents opportunities for mitigation and restoration planning.

Grazing Impacts from current and historic practices

Bendire's and LeConte's Thrashers occur across grasslands and shrublands on private, tribal, and public lands that are frequently used for grazing cattle and other livestock. The arid southwestern United States and northwestern Mexico are often characterized by variable and frequently low annual precipitation, and stocking rates for cattle are often inappropriately high for environmental conditions. Additionally, arid grasslands have not evolved in the presence of large grazing mammals, and plants lack adaptations to livestock grazing. Overstocked range lands can result in several habitat degradations including increased soil compaction and run-off, proliferation of invasive annual plant species and dense, monotypic stands of native shrub species (e.g., mesquite and/or creosote), loss of plant cover, and occasional direct mortality of bird nests from livestock (Nack and Ribic 2005).

Grazing can be more prevalent in Bendire's Thrasher habitat than LeConte's, although occasional rotation of cattle, usually at low densities, does occur in LeConte's Thrasher habitat. Historic grazing

practices were identified as a high threat whereas current grazing was ranked as a medium threat for both species. Historic grazing practices (overstocking) resulted in landscape changes including changed hydrology, increased shrub and tree cover, and increased invasive plant species. Bendire's Thrashers do not occur in areas of dense monotypic shrub cover such as creosote or mesquite. Invasive annuals are evident on most plots occupied by Bendire's (77%) and LeConte's Thrashers (93%) in range-wide surveys (Ammon et al. 2020), so presence of invasives does not result in avoidance by either thrasher species, though the impacts on foraging suitability and overall productivity or survival are unknown. Increases in invasive annuals can contribute to increased fire risk, changing fire frequency and resulting in permanent conversion of preferred shrub/woody habitat to annual grasses (discussed below in section 8 and 9). Bufflegrass (*Cenchrus ciliaris*) is used as livestock forage in Sonora, where native vegetation is cleared for bufflegrass pasture. It is an invasive species throughout southern Arizona. Because both species require bare ground for foraging, increased ground cover from invasive annuals likely has an additional negative impact.

However, livestock grazing is a common land use where thrashers, and especially Bendire's Thrashers, occur and can be compatible with thrasher presence. Evidence of livestock use was present on 53% of occupied plots, range wide, and had a minor but positive statistically significant effect on occupancy; evidence of livestock was only present on eight percent of occupied LeConte's Thrasher plots (Ammon et al. 2020). At nest sites in California, occupied sites had less soil compaction than unoccupied sites (Hargrove et al. 2019). In some cases, limited grazing can have a positive impact on foraging by LeConte's and Bendire's Thrashers. Thick grasses can impede thrasher access to their prey, a minor reduction by grazing in non-native grasses allowed the thrashers more access to substrate preferred by arthropod prey (Sheppard 2018). Bendire's Thrashers are commonly detected at infrastructure related to grazing such as stock tanks, windmills, and corrals, and may be attracted to the increased structure, larger trees and shrubs associated with these sites, as well as increased foraging opportunities related to increased water availability and cow manure. The impacts of grazing on nest survival, productivity, or other measures are largely unknown, but there is some evidence of negative associations.

3: Energy Production and Mining

Salafsky Level Two Threat	Threat	Bendire's Thrasher	LeConte's Thrasher
3: Energy production and mining	Solar power facilities	M	H
	Wind power facilities	M	M

As alternative sources of energy to fossil fuels are sought to slow the impacts of climate change, renewable energy production will continue to grow. In the southwestern United States and northwestern Mexico, renewable energy development occurs primarily as wind and solar energy. Within the ranges of these thrasher species, oil and gas extraction is rare, but renewable energy development is becoming more common. Direct threats to thrashers from renewable energy development include mortality from collision or singeing in the case of concentrating solar-thermal power (CSP) facilities. Collision may occur from wind turbines, solar panels, as well as gen-tie lines, fencing, and other infrastructure. Because Desert Thrashers spend most of their time on the ground, collision risk from

wind turbines is expected to be relatively low. Collision risk with solar panels is less well understood but is also probably low, though neither of these risks have been formally studied. However, the loss and fragmentation of thrasher habitat has the potential to occur at large scales and pose a significant threat to Thrasher populations. Areas cleared of vegetation for development will result in habitat loss for Thrashers, and whether Thrashers will use habitat adjacent to disturbance, how close, and what minimum size of retained habitat is needed for occupancy are unknown. Fragmentation and infrastructure development often result in increased predation risk and may also affect food and water resources. Both solar and wind facilities require development of infrastructure such as gen-tie lines, fencing around electrified components, and construction of roads and pads that also increase risks from habitat fragmentation and degradation, and risk of collision, entrapment, and predation increase. In particular, Common Ravens (*Corvus corax*) can have significant negative impacts on numerous bird species as predators of nests and young, and their predicted occurrence was positively influenced by transmission lines, roads, and edge habitats (Coates et al. 2014). Specific impacts from increased predation, decreased productivity, and survival (nest, juvenile, and adult) related to habitat loss and fragmentation are all data gaps.

Solar

In the United States, the greatest solar energy resource potential coincides with the southwestern states (Arizona, California, Colorado, New Mexico, Nevada, and Utah; NREL

http://www.nrel.gov/gis/data_solar.html), and indeed, most operational solar facilities are found in this region (in Walston et al 2016). Photovoltaic (PV) solar has increased by 41% from 2009-2020 and is expected to increase tenfold again by 2040 (Kruitwagen et al. 2021). Both Bendire's and LeConte's Thrashers will be impacted by these increases in solar energy build-out. Solar facilities are in areas of low relief and sparse

vegetation where solar resources are highest and where costs are lowest to prepare sites for installation (Figure 29).

Utility-scale solar requires large footprints ranging from 1.4–6.2 ha/MW. As solar development continues to grow, it is projected that 370,000 to 1,400,000 ha will be needed to meet projected needs (Hernandez et al. 2015a, Walston et al. 2016). In the United States and Mexico, targeted land cover types are primarily



Figure 29. Google Earth image of solar facilities near Desert Center, California, outside of Joshua Tree National Park. Red line is 1 km for scale.

aridlands (Figure 30), followed by agricultural areas and grasslands (Kruitwagen et al. 2021).

Solar development occurs on private lands and public lands. On BLM lands, areas have been specifically designated for solar development (Solar Energy Zones; SEZ). In 2012, 13 SEZ were established across six states, totaling 285,000 acres (Bureau of Land Management and U.S. Department of Energy 2012). In 2023, the BLM proposed to expand the existing SEZ from six states to 11 states. The final proposed plan makes 31 million acres available for solar development across 11 states (Bureau of Land Management 2024), illustrating the scale of the potential conflict. Development will be focused within 15 miles of existing or proposed transmission lines or existing energy corridors and may extend beyond this 15 mile footprint when occurring on previously disturbed lands. Development may be proposed on sites up to 10% slope, with Desert Thrashers occupying slopes of less than 5-6%.

In the final 2012 designation for SEZ, lands were excluded for various reasons, including sensitive habitats, cultural resources, as well as land with greater than five percent slope (Bureau of Land Management and U.S. Department of Energy 2012). LeConte's and Bendire's Thrashers probability of occurrence declines at slopes greater than five to six percent (Fletcher 2009, Sutton 2020), highlighting the overlap between developable areas for solar and suitable thrasher habitat. The



Figure 30. Image of Aqua Caliente Solar Project near Gila Bend, Arizona.
Photo Credit: <https://clui.org/ludb/site/agua-caliente-solar-project>

Environmental Impact Statement (EIS) for these SEZ does include consideration of LeConte's and Bendire's Thrashers, including pre-construction surveys in some cases (Bureau of Land Management and U.S. Department of Energy 2012). However, as analyzed within the EIS, effects are generally considered to be low, citing the extent of potentially suitable habitat available elsewhere. Unfortunately, specific habitat characteristics that define Thrasher occupancy, including structural characteristics, soil properties, plant species, and disturbance are not well understood, and are not captured by habitat layers. The EIS considers that all desert or desert scrub habitat types are suitable for Thrashers and does not consider the actual occupancy of Thrashers at individual sites. Based on evaluation of publicly available data such as eBird and DTWG survey data, of the current 13 SEZs (as of 2024), four are outside of either Thrashers' expected range, four have had previous Thrasher occupancy, and five have had nearby Thrasher occupancy (eBird 2024, DTWG unpublished data). No formal surveys were conducted to evaluate Thrasher occupancy or density. Solar development is expected to have a greater impact on LeConte's Thrashers than Bendire's Thrashers based on the location of current and expected solar build-out, as well as LeConte's Thrasher's need for large swaths of undisturbed habitat. However, any utility-scale solar within occupied Thrasher range could have potential negative impacts.

Solar expansion is also increasing in Sonora and is expected to grow exponentially in the coming years. In 2023, the Mexican government introduced the "Plan Sonora de Energias Sostenibles" that aims to invest seven billion U.S. dollars into renewable energy growth, including developing photovoltaic facilities and transmission infrastructure, as well as lithium exploitation. This plan has the state of

Sonora leading Mexico in developing renewables. Some areas proposed for development include areas known to be occupied by Desert Thrashers. Meanwhile, construction has started on the first phase of a one-gigawatt solar development near Puerto Peñasco in northwest Sonora (Cabanillas 2022) on a site that contained habitat occupied by LeConte's Thrashers (eBird 2024).

It is recommended that new solar energy be focused on local distributed power production. Additionally, it is recommended that development is directed to already compromised areas such as former landfills, parking lots, rooftops, over canals, and roadway/interstate rights-of-way, or other previously degraded landscapes rather than through land-use changes of native or intact desert habitats. In California, for example, developed areas offer ample opportunity to achieve significantly more energy production than energy demands (Hernandez et al. 2015b).

When development of utility-scale solar occurs within native or intact habitats, design features can also help minimize damage to landscapes by leaving vegetation and soils intact between panel rows and around development. Because of the potential conflicts between solar development and thrasher habitat, the Desert Thrasher Working Group has developed "[Recommendations for Conserving Bendire's and LeConte's Thrashers at Utility-Scale Solar Sites](#)", to outline beneficial practices and to minimize impacts from development and operations to Thrashers. Additional research is necessary to pinpoint Thrasher response to the habitat loss, fragmentation, and disturbance caused by solar installations and to identify and recommend effective minimization measures that can be taken to reduce the adverse effects on these species.

Wind

Current wind build-out within either Thrasher's range is relatively minimal as of 2024, though locally some facilities do occur within the Imperial and Coachella Valleys in California, the northwestern corner of Arizona, and scattered sites north of the Mogollon Rim in Arizona, equaling approximately 1,850 MW (Hoen et al. 2018). However, an increase in wind development is expected, though wind resources are only marginal for development across most of these thrashers' ranges (NREL 2017, Boggie et al. 2023). The best potential for wind build-out is localized along the northern interior of the Baja Peninsula, and at scattered locations throughout their range (NREL 2017, considered wind resource at 80 m), though improvements in technology should allow expansion into lower wind resource areas in the future. Development is being investigated in more areas within thrasher range, primarily in Arizona north of the Mogollon Rim, but also some locations in southern Arizona and California (FAA database, <https://www.fws.gov/library/collections/federal-aviation-administration-faa-wind-turbine-location-data>).

Mining

Mining for gold and rare earth minerals was ranked low overall but may have impacts locally. There are several large-scale mines planned for eastern Sonora. Lithium and other minerals may be targeted in Imperial County, California near the Salton Sea, Willcox Playa in Cochise County, Arizona, and casual prospecting in thrasher hotspots such as the Coolgardie Mining District may also negatively impact habitat occupied by LeConte's and Bendire's thrashers.

4.1: Transportation and Service Corridors

Salafsky Level Two Threat	Threat	Bendire's Thrasher	LeConte's Thrasher
4: Transportation and service corridors	Roads and railways	M	M

Expansion of roadways within thrasher habitat is another source of habitat loss and fragmentation. The level of impacts from expansion will be dependent upon selected routes. Residential road expansion can increase risks from collision with vehicles and further fragment habitat but can be compatible to some degree with thrasher presence, especially in the case of Bendire's Thrasher that are more tolerant of low-density development. LeConte's Thrashers would be more heavily impacted by this type of development.

Other expansion could be more detrimental, as in the case of the proposed expansion of Interstate 11 (I-11) to connect Nogales to Phoenix and Las Vegas. Some segments would include construction of new interstate facilities through known areas of significant Bendire's Thrasher occupancy within the Hassayampa Plains near Wickenburg, Arizona, and Avra Valley, outside of Tucson, Arizona. The corridor that was approved in the Arizona Department of Transportation's (ADOT's) Tier One programmatic EIS can be found on page five of the [Final Tier 1 EIS](#). An [interactive map](#) of the route is also available. Arizona Department of Transportation will proceed with a Tier 2 NEPA analysis (i.e., project level analysis) for the northern section of I-11 (Wickenburg to Interstate 10); NEPA analysis is expected to begin in 2024. The other segments of I-11 will proceed with Tier 2 NEPA analysis as funding becomes available.

Additionally, impacts from low-use gravel roads, especially those with undersized culverts in wilderness areas and other protected areas include significant erosion impacts that remove woody vegetation. Removal and decommissioning of these existing features would likely reduce the negative impact of flood events and erosion on washes and surrounding woody vegetation (e.g. saltbush) used by thrashers. It would also reduce access and use of illegal OHVs in protected areas (see section 6 below).

4.2 Utility lines and service lines

At the time of ranking, threats in this category did not rank medium or high for either species overall but have the potential for significant local impacts where developments are planned in areas known or likely to have significant numbers of Thrashers. Numerous transmission lines are planned or are under construction currently (2024), and to meet current renewable energy goals, at least a doubling of capacity is needed. Renewable energy development will preferentially occur in proximity to transmission lines. For example, the final EIS for solar development includes lands only within 15 miles of transmission lines (Bureau of Land Management 2024). There is no understanding of how this fragmentation or collision risk will impact either thrasher species.

6.1: Recreational Activities

Salafsky Level Two Threat	Threat	Bendire's Thrasher	LeConte's Thrasher
6: Human Intrusions and disturbance	Legal OHV use	M	M
	Illegal OHV use	M	M

Off-highway vehicles (OHV) have the potential to cause direct and indirect issues for Thrashers through habitat destruction and disturbance. The distinction between illegal and legal OHV use is difficult to draw, as in most areas law enforcement is minimal even if use is largely illegal, and in other areas, a lack of regulation for OHV users exists. Management of OHV-established areas varies by state and land managers.

Regulation is variable but most OHV use is legal, and off-trail use can be common in some areas. On BLM land in Nevada, only off-road use within Areas of Critical Environmental Concern (ACEC) is illegal. In California, there are minimal plans for additional OHV use areas to be added, but existing footprints are sufficiently large. Impacts are expected to be most pronounced in areas where thrashers are known to occur, such as Sloan Canyon, Ivanpah Valley, and Hidden Valley, Nevada, and Apple Valley and Barstow, California, or in areas where illegal OHV use is prevalent, such as at the Naval Petroleum Reserve #2 near Taft, CA.

In Mexico on the Baja peninsula, many formal off-road races are hosted each year (e.g., Baja 1000, but also numerous shorter races each year). Races are held throughout the year, and courses change annually. The level of impacts will be dependent on whether races coincide with LeConte's Thrasher breeding season and overlap with occupied habitat.

Illegal activities occurring along the international border between the United States and Mexico (e.g., drug trafficking, undocumented migrants) and associated law enforcement activities can disturb wildlife and create illicit trails and roads which can lead to damage to vegetation and erosion. Use of OHV by Border Patrol is unregulated. Threats may be higher locally, especially in areas proximate to the border and particularly south of Interstate 10.

7.1: Fire and Fire Suppression

Salafsky Level Two Threat	Threat	Bendire's Thrasher	LeConte's Thrasher
7: Natural systems modifications	7.1: Fire and fire suppression	H	H

Arid regions historically have had a low propensity to burn in wildfires due to their relatively sparse vegetation which prevents fire from spreading. The lack of wildfire in this environment has caused the native vegetation to evolve mostly without fire adaptations. However, the introduction of exotic vegetation, especially annual grasses, has made the landscape more fire prone by creating a more continuous layer of vegetation. Climate change is exacerbating the situation by thoroughly drying out

fuels during the summer, so when fires ignite, they are difficult to control and consume nearly all vegetation in their paths.

In August of 2020, the lightning-caused Dome Fire burned 43,273 acres of Joshua tree habitat on Cima Dome within the Mojave National Preserve. From 2021–2023, a study was conducted to determine the effect of the fire on Bendire’s Thrasher occupancy. At study sites within the fire footprint, 93% of the Joshua trees were killed and 98% of the shrub/annual vegetation was burned. Bendire’s Thrasher occupancy averaged across years and sites equaled 29% at sites outside the fire perimeter, 26% at sites straddling the fire perimeter, and two percent at sites entirely within the fire perimeter (Tietz and Geupel 2023). The fire left very few patches of unburned vegetation within its perimeter. The natural recruitment of Joshua trees into large areas of denuded vegetation is a slow process. Even if Joshua tree recruitment is augmented through the planting of seedlings, it will take several decades for the trees to grow tall enough to become suitable nesting habitat for Bendire’s Thrashers.

Fire risk is elevated following wet periods with above average precipitation that spurs proliferation of non-native vegetation at sites that support Thrashers. For example, following a relatively wet winter and spring, the York fire burned 93,078 acres in the eastern Mojave National Preserve in July and August of 2023 (Figure 31). Like the Dome Fire, the York Fire footprint consisted largely of Joshua tree habitat and left few unburned patches. Considering the threat posed by wildfires to Desert Thrashers and their habitats, it may be necessary to consider various methods of reducing the risk, such as installing fire breaks and managing the non-native vegetation, especially after wet years, with mechanical or biological means. Fire management planning should also consider important Desert Thrasher habitats and elevate protections or actions in these areas to benefit Desert Thrashers and preserve their habitats.



Figure 31. Burned Joshua Trees from York Fire. Photo credit: S. Gieseemann.

8.1: Invasive plant species

Salafsky Level Two Threat	Threat	Bendire's Thrasher	LeConte's Thrasher
8: Invasive plant species	8.1 Invasive non-native/alien species	M	H

The threats to Bendire's and LeConte's Thrashers from invasive plant species are largely tied to the increased risk of catastrophic fire (discussed above in Section 7), reduced foraging opportunities, and in some cases, conversion of habitat to types incompatible with thrasher presence. Invasive annual plant species are common on occupied thrasher plots for both species (73% of Bendire's Thrasher plots and 93% of LeConte's Thrasher plots, Ammon et al. 2020, Figure 32). Despite thrashers occurring where invasive annuals are common, which likely reflects the prevalence of, rather than the selection for invasive annuals, the impacts of how invasive annuals impact foraging opportunities and food resources are unknown. Typically, invasive annuals, particularly grasses such as red brome (*Bromus rubens*), and cheatgrass (*Bromus tectorum*), offer few food resources to wildlife and otherwise outcompete native vegetation that have higher food resource value. Buffelgrass (*Pennisetum ciliare*) is valued as a forage species for cattle and sheep, but easily colonizes and invades surrounding areas, outcompeting native vegetation. It is prevalent across Arizona and Sonora and is still actively planted in Sonora where it is estimated to occur on over 400,000 ha, and where its expansion has been accompanied with woody plant removal to provide cattle forage (Marshall et al. 2012, Lyons et al. 2013). While Bendire's Thrashers occupy desert grasslands, they still require a shrub component for

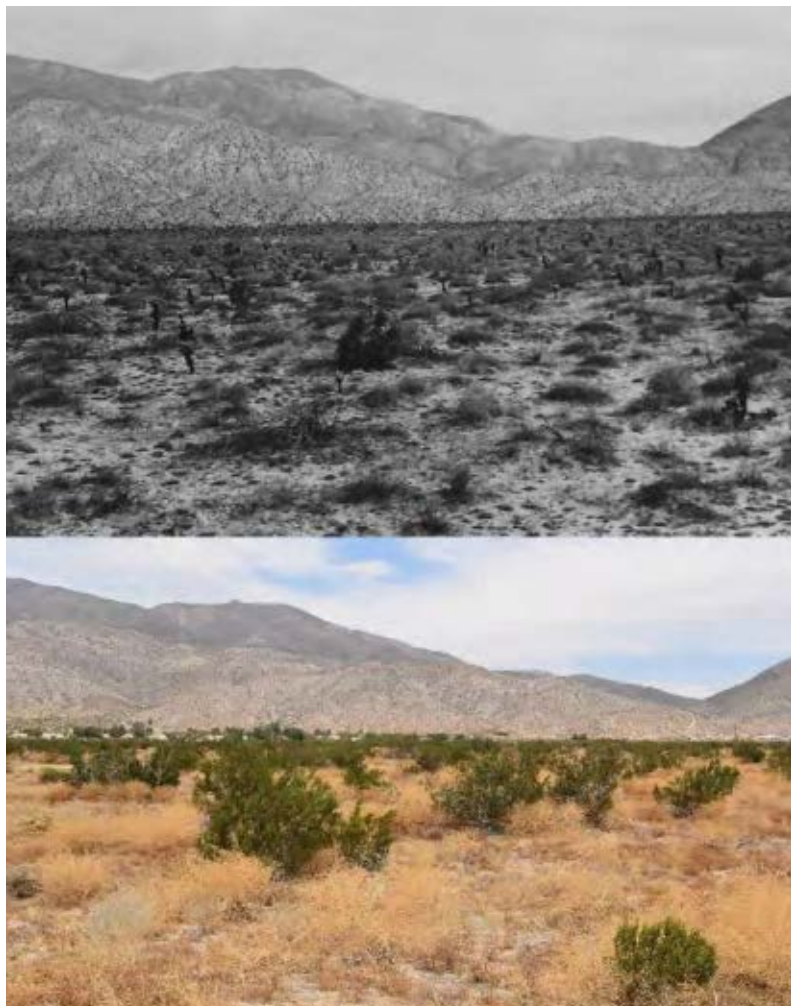


Figure 32. Former LeConte's Thrasher habitat (top photo, taken 1970, photo credit: J. Sheppard), versus current state in 2015 (bottom photo, photo credit: L. Hargrove). Note plant community changes with increased invasive annuals and creosote.

nesting and cover. Additionally, both thrasher species require extensive bare ground or leaf litter for foraging; an abundance of ground cover comprised of invasive grasses such as those mentioned above, or other invasives such as stinknet (*Oncosiphon piluliferum*) may also hinder foraging opportunities.

This threat received locally higher risks for Bendire's Thrasher in BCR 33 in Nevada, as well as in Sonora.

11: Climate Change and Severe Weather

Salafsky Level Two Threat	Threat	Bendire's Thrasher	LeConte's Thrasher
11: Climate change and severe weather	11.1: Habitat shifting and alteration	VH	VH
	11.2: Droughts	H	H
	11.3: Temperature extremes	H	H

Impacts on thrashers from climate change are expected to be significant and are already occurring (Iknayan and Beissinger 2018). Aridland vegetation communities are predicted to shift northward, or, in some instances, disappear entirely from large portions of LeConte's and Bendire's thrashers' current ranges (Cole et al. 2011). LeConte's and Bendire's thrasher distributions are in turn predicted to shift northward (Wilsey et al. 2019, National Audubon Society 2023 a, b), yet vegetation communities' capacity to keep pace with changes in climatic conditions may be untenable (McLachlan et al. 2005, Loarie et al. 2009, Cunze et al. 2014). Impacts to LeConte's Thrashers might be even more dramatic due to their overall low dispersal capabilities.

Increased drought frequency and severity will produce immediate effects on thrasher populations (McCreedy and Van Riper 2015, Albright et al. 2017). LeConte's Thrashers rely on their prey for water (Sheppard 1996) and reduced secondary production can constrain individuals' ability to thermoregulate during extreme temperatures (McKechnie et al. 2021). Reduced secondary production can also delay nesting phenology (McCreedy and van Riper 2015) and shorten the length of the breeding season (Seavy et al. 2018). Thrashers have been found to have reduced fecundity in years of low precipitation, occasionally foregoing breeding altogether (McCreedy 2012a, 2012b, Sheppard 2018, Salas 2021). In turn, low rates of fecundity will burden any conservation efforts to restore populations.

In addition to other climate change impacts, Radchuk et al. (2019) found that "incomplete adaptive responses to ongoing changing climate may already be threatening the persistence of species". To this point, Youngflesh et al. (2022) observed that from just 1989 through 2018 many bird species are reducing body size to adapt to warming temperatures. Birds with smaller body sizes are better equipped to meet water demands associated with thermal homeostasis (Riddell et al. 2019). Larger bodied birds, and those that obtain water through prey, such as Desert Thrashers, are least capable of meeting water needs (Riddell et al. 2019) and risk lethal dehydration and hyperthermia associated with a hotter and drier climate. Cooling costs have increased nearly 20% relative to historic, and these increased water demands for desert species were linked to overall declines in occupancy for numerous species in the

Mojave Desert (Riddell et al. 2019). Species that live in arid habitats are already at the limits of endurable temperatures and will not be able to adapt in sufficient time.

12: Data Gaps/Research Needs.

Salafsky Level Two Threat	Level Three Threat	Bendire's Thrasher	LeConte's Thrasher
12: Other	12.1: Data Gaps	H	H

There are numerous data gaps that exist for both Thrasher species that hinder our ability to enact meaningful conservation actions. For both species, we have incomplete knowledge of full distributions, breeding and nonbreeding season habitat requirements, factors influencing demographic parameters across their range, impacts from development and disturbance. Using a list of potential data gaps adopted from the Utah State Wildlife Action Plan (Utah Wildlife Action Plan Joint Team 2015), members of the DTWG ranked the top five most crucial data needs to enact conservation for these thrasher species. Level three data gaps were ranked, and Salafsky level two data gaps are included for context. These top five broad data gaps are outlined below (Table 5), while many other data needs exist or have been identified since these gaps were ranked. See also Suggested Conservation Actions/Strategies below for additional discussion and needs.

Table 5. Top five most crucial data gaps as identified and ranked by the Desert Thrasher Working Group. The specificity of threats increases from Level Two to Level Three threats, and rankings were conducted at the most specific level (Level Three Threats).

Rank	Crucial Data Gaps	
	Salafsky Level Two Threats	DTWG Level Three Threats
# 1	12.1: Inadequate understanding of ecology and life history - poor knowledge of target species and their relationship to their environment complicates or retards effective conservation	12.1.1: Lack of clarity regarding habitat components at territory and nest scale, as well as nonbreeding season habitat requirements
# 4	12.2: Imperfect understanding of distribution or range - poor knowledge of location, extent, timing, and/or seasonal variation of occurrence complicates or retards effective conservation	12.2.2: Lack of knowledge about breeding season distribution
# 2	12.3: Inadequate inventory and monitoring methods - inability to sample or characterize condition of individuals or population complicates or retards effective conservation	12.3.1: Sampling efforts are hindered by low density and detectability
# 3	12.7: Inadequate restoration tools - lack of adequate restoration materials or methods complicates or retards effective conservation	12.7.1: Difficulties with implementing or designing successful habitat improvement or restoration projects
# 5	12.8: Lack of awareness by public or agencies - target is relatively unknown by members or the public or agencies and may not receive attention or funds needed to achieve effective conservation	12.8.2: Lack of awareness or planning for species in development planning (urban, roads, energy, agricultural, etc.)

Suggested Conservation Actions and Strategies

We present the following conservation strategies and actions needed to conserve Desert Thrashers. These strategies and actions are outlined so that stakeholders and interested parties can consider prioritizing their actions to support meaningful conservation for Desert Thrashers. Much of the current or ongoing research, monitoring, and conservation has been conducted or coordinated through the DTWG, but all efforts to address these strategies and actions by any party are encouraged. The DTWG is available to provide insight, advice, or coordination with interested parties to engage in Desert Thrasher conservation. The DTWG consists of species experts for Bendire's and LeConte's Thrashers and can identify targets. The main targets are arresting population declines and increasing Desert Thrasher populations. We used the Open Standards for the Practice of Conservation to create a conceptual model and identify and rank threats. The group used the conceptual model, results chains, and expert opinion to develop actions and strategies to increase populations, address threats, and address the gaps in knowledge of these enigmatic species. In contrast to species that are better studied, there are actions we have chosen that will fill in our knowledge of the habitats and biology of LeConte's and Bendire's Thrasher.

The following 9 conservation actions were identified to benefit Desert Thrasher populations:

1. Compile habitat requirements.
2. Enhance monitoring methods.
3. Identify and prioritize research and monitoring to address key knowledge gaps.
4. Increase funding for research and monitoring.
5. Identify areas of climate resiliency
6. Develop Beneficial Management Practices (BMPs) for thrasher habitat.
7. Restore abandoned farmland
8. Encourage stakeholders to consider thrashers in planning and increase awareness.
9. Increase regulation/enforcement of OHV use.

Strategy 1: Compile habitat requirements

Without a clear understanding of the components that define breeding and nonbreeding season habitat, we are unable to predict where Desert Thrashers are likely to occur on the landscape, nor provide land managers with the tools they need to manage habitat for Bendire's or LeConte's Thrashers. This information is also needed to incorporate thrashers into planning for infrastructure and energy projects, and to develop habitat restoration projects. Some pre-existing data are already available for analysis (e.g., habitat data collected during area search monitoring by the DTWG from survey locations) and offer a logical starting point for evaluating habitat requirements and outlining common habitat characteristics. Initially analyzed data from 2017 and 2018 (Ammon et al. 2020), showed some commonalities, but also some important differences between ecoregions. Analysis should be completed again with the full set of data, which includes numerous additional years. Nonbreeding habitat characteristics are even less understood, with initial qualitative habitat assessments being conducted in Sonora currently (2024). Compiling habitat requirements is a critical first step for other strategies listed here (e.g., Strategy 3: Data gaps, Strategy 6: Develop beneficial management practices, Strategy 7: Restore abandoned farmland).

Actions:

- 1) Compile habitat requirements.
 - a) Use existing data to summarize current knowledge of habitat.
 - i) Analyze full suite of habitat data collected during area search monitoring from all years.
 - (1) Outline important habitat features associated with Thrasher presence.
 - (2) Include analysis by ecoregion whenever possible.
 - b) Create vegetation protocol for assessing nonbreeding habitat.
- 2) Assess whether existing data provide sufficient power to describe Thrasher habitat.
 - a) If no, evaluate what next steps are needed to adequately describe habitat requirements for Thrashers.

Strategy 2: Enhance monitoring efforts.

Desert Thrashers have challenges to monitoring related to their low detectability, early and variable phenology, and overall limited baseline data regarding their distribution. To address these challenges, the DTWG has developed monitoring protocols that satisfy several different monitoring goals. These include 1) the area search survey protocol, 2) discovery survey protocol, and 3) clearance survey protocol (summarized in Table 6). Use of these protocols is encouraged for current and future research and monitoring. This portion of the strategy has received significant attention and the monitoring protocols in place are adequate but can be adapted as additional information is obtained or as different goals are identified.



Figure 33. Thrasher Surveyors. Photo Credit D. Fletcher

The three protocols were created to address different issues for different objectives and regions. The area search protocol includes plot-based surveys that are sampled multiple times over the breeding season to help identify occupancy and include vegetation sampling at plot centers to identify important habitat features. Species distribution models have been used in the past for site selection, but strata for selection can be modified to fit various objectives. These surveys require more resources to conduct than the other two methods, but also garner the most rigorous data for analysis. The discovery survey protocol was developed to allow for greater coverage of potential Desert Thrasher distribution, especially for areas with little or no previous location data, such as much of Mexico and remote regions. Though these surveys typically provide a greater volume of data at lower costs, they are less rigorous due to the inherent biases. Still, they provide valuable baseline information about the distribution of the

species and their occurrence in a specific area. The clearance survey protocol was developed from the discovery protocol to address the growing need for partners to conduct pre-construction surveys in areas planned for significant habitat modification (e.g., solar site development).

Through cooperation of multiple partners and agencies, area search protocol-based monitoring was conducted throughout the United States portion of the range in 2017 and 2018. Area search monitoring occurred in Arizona, California, Nevada, New Mexico, and Utah (summarized in Ammon et al. 2020). Since 2019, additional surveys have been conducted in all U.S. states at varying intervals. Surveys based on the discovery protocol have been conducted in Sonora in 2021 and 2024, and in Nevada in 2023. In Sonora, there are very few data points for either Thrasher species, land access can be difficult due to the high prevalence of private lands and safety concerns, and discovery surveys are a cost-effective way to gather baseline data.

A range-wide monitoring plan should be established to determine overall monitoring goals, extent, and implementation schedule, as well as identifying potential funding sources and partners. Evaluation of existing data is needed to determine population trends or other metrics as determined through a range-wide monitoring plan. Area search monitoring also includes evaluation of vegetation metrics, which need to be evaluated and integrated into Strategy 1: Compile habitat requirements.

Actions:

- 1) Improve/refine monitoring methods.
 - a) Update protocols as new information becomes available.
- 2) Develop a range-wide monitoring plan.
 - a) Establish monitoring goals and schedule.
 - b) Increase capacity, funding, and implementation of surveys across the range, but especially in Sonora and Baja California in breeding and nonbreeding seasons.
 - i) Identify Mexican partners to conduct surveys.
 - ii) Provide training opportunities to increase capacity.
 - c) Implementation of monitoring
 - i) Identify funding sources.
 - d) Evaluate monitoring data.
 - e) Disseminate results of monitoring data

Table 6. Comparison of different survey protocols developed by the Desert Thrasher Working Group. Protocols, training materials, mp3 files, and datasheets are available at <https://borderlandsbirds.org/projects/desert-thrasher/>

Protocol	General Description	Objective	Intended User
Area Search Survey Protocol	- Statistically rigorous survey method for both population monitoring and fine scale modeling assessments. - Provides quantitative measurements. - Standardized survey method that can be applied range-wide for Desert Thrashers. - Survey plots are stratified and surveyed 3 times throughout the breeding season.	Estimate distribution, determine occupancy, determine population trends, account explicitly for detectability, identify habitat preferences	Researchers or partners conducting monitoring work
Discovery Survey Protocol	- Establish presence of the species in each area - Provide qualitative estimates of abundance in that area.	Gain a better understanding of thrasher distribution through a non-random survey method covering a large area at relatively low costs.	Researchers or partners conducting monitoring work
Clearance Survey Protocol	Recommended by the DTWG to use for pre-clearance survey purposes.	Determine presence of LeConte's and/or Bendire's thrashers within a given area prior to construction or other landscape alterations.	Pre-construction monitors for solar, wind, transmission line, pipeline, or other construction projects

Strategy 3: Identify and prioritize research and monitoring to address key data gaps.

As both Desert Thrasher species are relatively under-studied there remain significant gaps in our knowledge of several key aspects of the annual life cycle and habitat relationships. The DTWG identified and prioritized five knowledge gaps and steps to address each (see Threats: Data Gaps/Research Needs). Additional research needs have been added to reflect current needs by the DTWG. Though other research needs exist, addressing these prioritized needs first should have the greatest conservation benefit for Desert Thrashers.

Actions:

- 1) Improve clarity regarding habitat components at territory and nest scale.
 - a) See Strategy 1: Compile habitat requirements.
- 2) Design or enhance sampling efforts to account for target occurring in low densities, and with low detectability.
 - i) Monitoring efforts need to be designed to explicitly address low detectability and sufficient in scale to address low density.
 - ii) Include explicit measures of detectability in monitoring designs when appropriate.
 - iii) See Strategy 2: Enhance monitoring efforts.
- 3) Identify, design, and implement successful habitat improvement or restoration projects.
 - a) See Strategy 1: Compile habitat requirements and Strategy 7: Restore abandoned farmland.
 - b) Identify farmland to be abandoned and consult with restoration experts to create restoration protocols.
 - c) Investigate enhancement of nesting substrates (primarily cholla) where they have become a limiting factor, such as in areas impacted by former farming, grazing, or OHV practices, or where fires have occurred.
 - d) Study arthropod food availability in native and non-native dominated habitats.
- 4) Increase knowledge about breeding season distribution
 - a) Further implement discovery surveys to provide baseline information about Desert Thrasher presence where few or no previous data are available.
 - b) See Strategy 2: Enhance monitoring efforts.
 - c) Refine distribution models.
- 5) Advance awareness of species in development planning (urban, roads, energy, agricultural, etc.)
 - a) See Strategy 8: Encourage stakeholders to consider thrashers in planning/increase awareness.
- 6) Gain knowledge about nonbreeding season movements
 - a) Create a plan that uses Motus, the Bird Genoscape Project, satellite tags, data loggers, nonbreeding surveys, and other methods to expand nonbreeding range knowledge base.
 - b) Identify important areas, landforms, or habitat characteristics that are used by Thrashers on migratory or nonbreeding grounds.

- 7) Characterize impacts of various disturbance regimes on Thrashers
 - a) Evaluate responses of Thrashers to solar development
 - i) Using Satellite tags, Motus, and/or pre- and post-construction surveys to determine whether Thrashers:
 - (1) use habitat adjacent to or within solar developments,
 - (2) determine minimum patch sizes, address changes in survival and productivity, assess collision risk, or other metrics.
 - (3) evaluate Thrasher use within different solar facilities that employ different design features.
 - b) Evaluate responses of Thrashers to wind, transmission lines, or other infrastructure.
 - c) Design and implement a study to evaluate impacts to Thrashers from different grazing methods and comparing to ungrazed habitat.
 - d) Evaluate responses of Thrasher to disturbance from OHV use
 - e) Evaluate specific impacts of invasive annuals on factors influencing survival, such as food availability.

Strategy 4: Increase funding for research and monitoring.

The need for more funding and associated research and monitoring is perhaps the most common need in conservation planning and species recovery. Most previous conservation accomplishments are the direct result of increased funding, along with legislation. This strategy is tied to and necessary for all other strategies, see Strategy 3 in particular.

Desert Thrashers are no exception, and these little-understood species still require more research and monitoring to complete our understanding of population distributions, habitat needs, and other knowledge gaps, which were identified as a “high” threat, and are prioritized above in crucial data gaps. This will require new and previously used funding sources to address these needs. Though we encourage all interested parties to engage in increasing funding to address Desert Thrasher conservation, the DTWG can serve an important role in defining research needs, matching funding with researchers, facilitating opportunities for collaboration, and directing conservation actions.



Figure 34. Researcher examining a Bendire's Thrasher wing for aging. Photo credit: A. Stein.

Action:

1. Identify potential funding sources.
2. Maintain an active list of funding needs.
 - a. Match needs to different funding opportunities.
 - b. Encourage stakeholders to pursue funding.

Strategy 5: Identify areas of climate resiliency.

Climate change impacts were rated as “very-high” threats to both Bendire’s and LeConte’s Thrashers. Range shifts may be expected to occur over time for both species, as indicated by numerous climate models; both species may be expected to occur in areas further north than their ranges currently extend. Some extralimital records for both species indicate this may be starting to occur already. However, most climate models predict range shifts based on climatic conditions (temperature and precipitation), leaving uncertainty to how and if vegetation shifts will follow. Identifying areas of resiliency where vegetation species, structure, and food resources required by Thrashers are likely to persist through predicted climatic changes can prioritize locations for Desert Thrasher conservation efforts.

Actions:

- 1) Use existing models and maps to identify, map, and protect the most likely areas of resiliency for vegetation, food species, and thrashers.
- 2) Observe and track both elevational and latitudinal range shifts in real time while studying local habitat conditions, which will allow adaptable alterations to fluctuating thrasher ranges.

Strategy 6: Develop “Beneficial Management Practices” (BMPs) for Thrasher habitat.

It is necessary to draft BMPs using increased understanding of Thrashers’ biology and ecology accomplished through other strategies (such as Strategy 1: Compile habitat requirements, as well as how disturbance regimes impact Thrasher occupancy, productivity, and survival and Strategy 3: particularly Actions 4, 6, and 7). Land managers, industry partners, and other stakeholders are encouraged to incorporate BMPs when planning and working within occupied or suitable thrasher habitat to minimize negative impacts and provide benefits to thrashers and their habitats.

Actions:

- 1) Apply established Beneficial Management Practices for solar and renewable energy development and use this as a starting point for other applications and additional BMPs.
- 2) Crosswalk knowledge of known habitat requirements (Strategy 1) and thrasher distributions (Strategies 2 and 3) to common management practices.
- 3) Work with agencies, landowners, and other land stewards to assess needs and ways to complement existing stewardship activities.
- 4) Disseminate BMPs to partners.
- 5) Share recommendations for development of solar sites: [Conservation of Bendire’s and LeConte’s Thrashers at Solar Development Sites: Site Evaluation, Selection, and Design Considerations to Benefit Desert Thrashers](#)
 - a) The DTWG developed recommendations to address issues that arise between Desert Thrasher habitat and sites being evaluated for development of utility-scale solar. The threat of renewable energy development, and particularly solar, was ranked “very high” for LeConte’s Thrashers and “high” for Bendire’s Thrashers as discussed above in the threats section. Because of the likely overlap between Desert Thrasher habitat and sites desirable for solar development, the DTWG

established a process to evaluate sites for Desert Thrasher presence, identify priority areas known to be used by thrashers, presents measures to avoid impacts to Desert Thrashers, and provides some design features that can be employed to minimize impacts to Desert Thrashers if construction does occur in areas where these species are present. Additionally, it gives some examples of conservation opportunities for those partners wishing to provide benefit to Desert Thrashers.

Strategy 7: Restore abandoned farmland.

The key to recovering Desert Thrashers is the recovery and conservation of habitat. The first step in recovery of species is to preserve intact desert habitat. Desert habitat can be more difficult to restore than other habitats due to limited water resources, slow-growing species, and increased risk of invasive plants. With the reduction in the Colorado River and other water sources in the American southwest, agriculture will likely be one of the first areas to experience significant cuts to water allotment. This may result in abandonment of farmland, with lower quality and more remote farmland likely the first to be abandoned. Abandoned sites present an opportunity to reclaim previously converted native desert habitat.

Actions:

- 1) Use results of Strategy 1: Habitat requirements, and Strategy 6: Develop beneficial management practices for thrasher habitat inform restoration goals.
- 2) Evaluate changes in land use and Bendire's Thrasher occupancy in Avra Valley, Arizona as an example of abandoned farmland reverting to Bendire's Thrasher habitat.
 - a) Evaluate history of the site to understand which practices were used to restore habitat, or if restoration was passive.
- 3) Identify potential sites for restoration.
 - a) Restore selected sites.
 - b) Evaluate success of restoration efforts

Strategy 8: Encourage stakeholders to consider Thrashers in planning and increase awareness.

Awareness is an important step for conservation and recovery; as habitat associations and requirements are better understood and BMPs are developed, the DTWG will be able to provide better information to partners to minimize negative impacts and promote beneficial practices.

Actions:

- 1) Associate Desert Thrashers with other species of concern in the planning process.
- 2) Prepare a plan for strategic communications and outreach.
- 3) Implement clearance survey protocol prior to activities that may negatively impact occupied Desert Thrasher habitat.
- 4) See Strategy 6: Develop beneficial management practices.
 - a) See: [Conservation of Bendire's and LeConte's Thrashers at Solar Development Sites: Site Evaluation, Selection, and Design Considerations to Benefit Desert Thrashers](#)

- b) Develop and disseminate BMPS for solar facilities and other applications (completed 2024)
- 5) Work towards inclusion of Bendire's and LeConte's Thrashers on the NOM-059 in Mexico to raise awareness and protection within Mexico.

Strategy 9: Increase regulation/enforcement of off-highway vehicle (OHV) use.

With the increased prevalence of off-highway vehicles by the public and Customs and Border Patrol, and the impacts of unregulated or poorly enforced regulations, the effects of OHV use can have negative impacts to thrashers and their habitat. By strengthening regulations and enforcement of regulations on OHV use, Thrashers and other wildlife will benefit from decreased fragmentation and disturbance.

Actions:

1. Identify areas where OHV use has significant overlap with Desert Thrasher presence.
 - a. Focus efforts to increase regulation in these areas.

Summary and Next Steps

This conservation plan has accumulated much of the known information regarding Desert Thrashers biology and ecology and has identified many of the key unknowns for these species. Threats are identified and discussed, and conservation strategies and actions are identified as well. The intent of this plan is that actions will be taken within the conservation strategies, so by nature this plan is intended to be fluid. Threats may change through time in scope or location, and novel threats may emerge. Knowledge gaps are intended to be filled. As such, this plan should be revisited or amended at points in the future to ensure that actions taken by stakeholders to address Desert Thrasher conservation are novel or consistent with other completed or ongoing actions.

As a group of individuals and entities dedicated to the conservation, research, and monitoring of Desert Thrashers, the DTWG is likely to play an important role in coordination of actions outlined in this plan. However, this plan is intended for all entities with stake in maintaining Desert Thrasher populations and their habitats. Additionally, the DTWG is open to addition of new interested parties, see <https://borderlandsbirds.org/projects/desert-thrasher> for current contact information.

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Climate Change Vulnerability and Adaptation Strategies for Natural Communities

Piloting methods in the Mojave and Sonoran deserts



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Executive Summary

The earth's changing climate is forcing reconsideration of strategies for conserving natural resources. Managers need to understand where and when the resources they manage might be vulnerable to climate change. They also need a better understanding of the factors that contribute to that vulnerability. This knowledge is essential to determine which management actions will be suitable over the coming decades.

NatureServe worked with a number of federal, state, and NGO partners in the United States and Mexico to conduct a climate change vulnerability assessment of major natural community types found within the Mojave and Sonoran Deserts. The project focused on ten major upland, riparian, and aquatic community types, including pinyon-juniper woodlands, Joshua tree-blackbrush scrub, creosote-bursage scrub, salt desert scrub, Palo Verde-mixed cacti scrub, semi-desert grassland, desert riparian and stream, riparian mesquite bosque, and desert springs. This effort piloted a new Habitat Climate Change Vulnerability Index (HCCVI) approach being developed by NatureServe, as a companion to an existing index for species. The project utilized existing data, much of which had been recently developed through the Bureau of Land Management's rapid ecoregional assessments, or by ongoing research efforts with FWS, NPS, and USGS. Once vulnerability assessments were drafted, an expert workshop was held to review and revise the assessments, and then apply the findings to identify climate change adaptation strategies applicable across managed lands within each ecoregion.

Components of the Climate Change Vulnerability Index for Ecosystems and Habitats (HCCVI)

The HCCVI aims to implement a series of measures addressing climate change sensitivity and ecological resilience for each community type for its distribution within a given ecoregion (in this case, the Mojave vs. Sonoran Desert). Since quantitative estimates may not be feasible for all measures, both numerical index scores (*normalized 0.0-1.0 scores*) and qualitative expert categorizations may be used in the HCCVI. The combined relative scores for **sensitivity** and **resilience** determine the categorical estimate of climate change vulnerability by the year 2060 (i.e., 50 years into the future) for a community type. While the overall index score for each community should be useful for regional and national priority-setting and reporting, the results of these individual analyses should provide insight to local managers for climate change adaptation. Index measures are organized within categories of **direct effects**, **indirect effects**, and **adaptive capacity**. A series of 3-5 measures, each requiring a separate type of analysis, produces sub-scores that are then used to generate an overall score for **sensitivity** (*from direct effects*) vs. **resilience** (*indirect effects + adaptive capacity*).

Direct effects can be addressed through several measures, depending on the natural characteristics of the community type. For example, analysis of downscaled global climate forecasts for temperature and precipitation variables provides an indication of the relative intensity of climate-induced stress. For upland vegetation, climate envelope models can be used to correlate and map current plant community distributions with a suite of key climate variables from a 20th century baseline. Then, the location of that same climate envelope as predicted for 2060 using climate forecasts, provides an indication of the directionality, magnitude, and overlap of geographic shift for species from the community. These can also provide insight about plausible patterns for successional dynamics and transitions across major vegetation on the regional landscape. Dynamic simulations of fire regime or hydrologic regime may be used to forecast trends in the alteration or 'departure' from expected conditions for upland vs. riparian/aquatic communities, respectively.

Indirect effects include trends in ecological integrity. These can indicate the potential for resilience to climate change. Analyses may include spatial models aiming to characterize the degree of landscape fragmentation or other anthropogenic impacts (such as invasive species) in the landscapes supporting a given community type. Dynamic simulations of fire regime or hydrologic regime may be used here, not for forecasting, but instead to characterize the past and current degree alteration or ‘departure’ from expected conditions for upland vs. riparian communities, respectively.

Adaptive capacity includes inherent characteristics of a natural community that make it more or less resilient to climate change. Attributes can include diversity within groups of species playing key functional roles. It could also include analysis of climate change vulnerability for species that may provide ‘keystone’ functions in the community. Additionally, the relative breadth of bioclimatic and elevation range that characterizes a community's natural distribution can indicate inherent capacity to cope with climate change.

For the HCCVI, climate-change vulnerability is expressed in four categories, including Very High, High, Moderate, and Low vulnerability. Therefore, the index ratings are quite general, but this is because predictive uncertainty is often high, and our overall intent is a generalized indication of vulnerability. This is analogous to a scoring of “endangered” or “threatened” for a given species, but here focused specifically on climate change vulnerability, and applied to community types.

This pilot analysis resulted in six type/ecoregion combinations being categorized high for climate-change vulnerability. These included Mojave Mid-Elevation [Joshua tree-Black brush] Desert Scrub (Mojave Desert), North American Warm Desert Riparian Woodland and Stream (Mojave and Sonoran deserts), North American Warm Desert Mesquite Bosque (Mojave and Sonoran deserts), Sonora-Mojave Creosotebush-White Bursage Desert Scrub (Sonoran Desert). All other types were categorized as moderate for climate-change vulnerability. No types from this pilot analysis were categorized as either very high or low for climate-change vulnerability.

Given the **direct effects** measures aiming to gauge climate-change sensitivity, all but three types in the analysis resulted in the high-sensitivity category. The three types found to be in the moderate sensitivity category included Sonora-Mojave Creosotebush-White Bursage Desert Scrub (Mojave Desert), Sonora-Mojave Mixed Salt Desert Scrub (Mojave Desert), and Apacherian-Chihuahuan Semi-Desert Grassland (Sonoran Desert). Climate envelope shift and dynamic process forecast scores determined these results.

Indirect effects scores fell between a low resilience score of 0.46 (North American Warm Desert Riparian Woodland and Shrubland (Mojave) and a high resilience score of 0.84 (North American Warm Desert Active and Stabilized Dunes (Sonoran)). Eleven of 16 type/ecoregion combinations fell within the medium resilience range for their average scores. On the whole, average resilience scores tended to be pulled lower by either low scores for current landscape condition, current invasive species effects, current dynamic regime departure, or some combination of these three.

Adaptive capacity scores tended to contribute to higher overall resilience scores, with their averages ranging from a medium resilience score of 0.56 (North American Warm Desert Active and Stabilized Dunes- Sonoran) to a high resilience score of 0.83 (Desert Springs and Seeps – Mojave and Sonoran). On the whole, average resilience scores tended to be pulled lower by either low diversity within identified functional species groups (e.g., desert springs, mesquite bosque, mixed salt desert scrub), keystone

species vulnerability (e.g., creosote-bursage scrub, semi-desert grassland), or where types occur across a relatively narrow elevation range (6 types).

Overall resilience scores ranged from medium (8 types) to high (8 types); but these scores all fell into a narrow range between 0.63 and 0.74. A moderate climate-change vulnerability assessment resulted from the combination of 1) high sensitivity with high resilience (7 types), medium sensitivity and medium resilience (2 types) and 3) medium sensitivity and high resilience (1 type) combinations for a given community type.

Climate Change Adaptation includes actions that enable species, systems and human communities to better cope with or adjust to changing conditions. Some have categorized adaptation strategies into three areas, including resistance, resilience, and facilitated transformation. *Resistance* strategies aim to prevent the direct effects of climate change. *Resilience* strategies aim to secure the capacity to cope with the effects of climate change by ensuring that critical ecological process – as currently understood – are restored to a high level of function or integrity. *Facilitated Transformation* strategies anticipate the nature of climate-change induced transitions and, working with these anticipated trends, include actions that facilitate transitions that are congruent with future climate conditions, while minimizing ecological disruption.

There is also critical temporal dimension to climate-change adaptation. While traditional natural resource management has been ‘retrospective’ – utilizing knowledge of past and current conditions to inform today’s management actions – planners are increasingly required to rigorously forecast future conditions. It is no longer sufficient to assess “how are we doing?” and then decide what actions should be prioritized for the upcoming 5-15 year management plan. One must now ask “where are we going, and by when?” and then translate that knowledge back into actions to take in the near-term, or medium-term, or those to monitor and anticipate taking over longer planning horizons.

The link between climate change vulnerability assessment and adaptation strategies was facilitated in this effort by a) selection of major natural communities as our units of analysis, and b) organizing local expert review within each ecoregion, where decisions across jurisdiction pertain to many of the same community types. The latter step was facilitated by a 2-day expert workshop. Workshop participants reviewed and refined each vulnerability assessment, and then most readily identified components of indirect effects scores (e.g., landscape condition, invasive species, dynamic process alteration) as forming the focus of many “no regrets” adaptation strategies that could be pursued by managers. In most cases, these factors relate to the stressors that are best known and are currently being addressed within managed areas. Where indirect effects stressors were less well known, and/or interactions with climate change were less clear, strategies tended to be categorized as “anticipated actions” within the 5-15 year timeframe, where additional information will be required to move forward, but participants could foresee their implementation.

Direct effects, such as climate stress and climate envelope shifts, challenged workshop participants to identify novel climate-change stressors for each community type, such as effects of heat stress or changes in seasonality of precipitation and their potential effects on functional species groups, such as pollinators. Given the limits to current knowledge in these areas, the strategies identified tended to fall in the “wait and watch” category, where research questions are specified and investment will be required over upcoming decades in order to determine appropriate management actions.

Introduction and Project Overview

Climate change represents a globally pervasive stress on natural ecosystems. Temperature and precipitation regimes drive ecosystem productivity and natural dynamics, such as the rate of plant growth, the frequency of natural wildfire, and the seasonal flow of streams. Paleoecology has shown that past episodes of climate change triggered ecosystem change at regional and local scales with varying speed and intensity (e.g., Wells 1983, Betencourt et al. 1990). As the current rate of global change increases, society can expect profound shifts in key ecological processes to cascade through natural systems, resulting in altered productivity, changes to species composition, local extinctions, and many instances of ecological degradation or collapse (IPCC 2007).

We are scarcely prepared for these changes. While the modern scientific study of ecosystems dates back over a century, we do not sufficiently understand the many linkages between key climate variables and ecosystem dynamics across diverse landscapes. Nor do we fully understand the effects of other stressors, such as those tied to land use, that have already reduced the resiliency of many natural ecosystems. One certain conclusion that we can draw from our experience is that *ecosystems will not simply ‘move’ as climate changes, but will instead transform* in unprecedented ways because of the controlling link between climate and many ecosystem processes (Fagre et al. 2009); including the individualistic responses of species (Gleason 1926, Finch 2012). In any given place, we need to better understand and assess the relative vulnerability of ecosystems, natural communities, and habitats to the specific climate-induced stressors that are most likely to occur there. We also need to integrate this assessment with knowledge of other existing stressors, such as land & water use change, non-native species invasions, and pollution effects. An integrated assessment will be needed to directly inform investments in adaptation strategies by all stakeholders.

The task then, is to develop tools that build on our current understanding of ecosystem processes, structure, and composition so that we can begin to evaluate possible vulnerabilities in a transparent way. Transparency is absolutely essential because it allows for measuring key inputs and outputs, documenting uncertainty, and revising assessments as new information becomes available (Nichols et al. 2011).

In sum, the challenges of climate change for conservation science in the coming decades are:

- to develop transparent, scientifically grounded forecasts of ecosystem characteristics that may enhance or inhibit their transformation under anticipated climate regimes;
- to clarify conservation strategies that strengthen ecosystem resilience and minimize the potential for ecological degradation or collapse through a loss of ecological integrity;

- to facilitate the natural transformation of ecosystems in ways that maximize retention of biodiversity and food-web dynamics, and;
- to identify adaptation action that has the greatest probability of success.

In order to address these challenges, NatureServe worked within the context of the Desert Landscape Conservation Cooperative (LCC) and with a number of federal, state, and private partners in the U.S. and Mexico, to pilot a climate change vulnerability assessment of major ecological community types found throughout the Mojave and Sonoran deserts. With advice and assistance from a project advisory committee¹ we identified high-priority community types for analysis. This pilot assessment addressed ten major upland, riparian, and freshwater types. The analysis drew largely on existing data from the Bureau of Land Management's (BLM) Rapid Ecoregional Assessments in the region, and from ongoing research efforts with FWS, NPS, USGS, and others. Managed areas that were represented in the effort included National Wildlife Refuges, Wilderness Areas, National Park units, other lands managed by BLM and by state agencies, and protected areas in Mexico as defined by the National Commission for Protected Natural Areas.

The primary aim of this effort was to characterize relative climate-change vulnerabilities of each community type, and then bring the results to local specialists to review, refine, and use in identifying adaptation strategies. As the project was initiated, an online survey was used to document the community types, climate change threats, and information needs that field specialists from the region perceived as most important. Once vulnerability assessments were drafted for the selected community types, regional specialists were gathered in a workshop to review and refine the assessment results, prioritize non-climate and novel climate-change stressors, and to clarify plausible climate-change scenarios for upcoming decades. Workshop participants then identified an initial, pragmatic list of adaptation strategies that might be pursued across multiple managed lands.

Assessment of climate change vulnerability for ecosystems and habitats can directly inform key conservation and resource management decisions in the 2012-2060 timeframe. It helps to determine those ecosystem types that, in all or part of their distribution, are most at risk of specific climate change effects; and assist with targeting species-based assessments. This information provides the baseline for developing scientifically grounded strategies for climate change adaptation. It also provides decision makers with the information to determine which adaptation options might have a higher probability of maintaining ecosystem resilience.

This project should contribute to the Desert LCC's mission of enhancing communications among agencies to facilitate achieving individual agency missions and goals through landscape scale approaches to resource conservation and stewardship. The vulnerability assessments, resulting adaptation strategies, and other recommendations by regional specialists were documented here for further consideration and development by partners of the Desert LCC.

¹ See Acknowledgements section for full listing of project advisory committee members and affiliated agencies.

Defining Climate-Change Vulnerability and Adaptation Strategies

The societal response to climate change involves much new science. Along with new science, comes new terminology. Here we define and summarize some key terminology and concepts applied throughout the project. First, the notion of vulnerability to climate change has been succinctly defined by the Intergovernmental Panel on Climate Change (IPCC 2001, 2007) as:

Climate Change Vulnerability - The degree to which a system is susceptible to - and unable to cope with - adverse effects of climate change; including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC 2007).

This overall definition points to several contributing components of climate change vulnerability commonly used in current science. These include concepts of climate-change exposure, sensitivity, and adaptive capacity. These terms have been defined as:

- **Exposure** – The degree of climate stress upon a particular unit analysis; it may be represented as either long-term change in climate conditions, or by changes in climate variability, including the magnitude and frequency of extreme events.
- **Sensitivity** – The degree to which a system will be affected by, or responsive to climate stimuli.
- **Adaptive Capacity** - the potential or capability of a system to adjust to climate change, including climate variability and extremes, so as to moderate potential damages, to take advantage of opportunities, or to cope with consequences.

Gauging climate change exposure involves evaluation of climate information, including past, current, and forecasted future conditions, in areas relevant to the resource of concern. These analyses may be applied at continental, or more local, spatial scales tailored to the distribution of the resource of concern. Gauging climate change sensitivity requires knowledge of the ecology of communities, and/or biology of component species, in order to measure the potential effects of climate change exposure. Gauging adaptive capacity builds on knowledge of the ecology of communities to consider factors that may – or may not – mitigate climate change sensitivities that have been identified.

By understanding the components of climate change vulnerability for a given resource of concern, resource managers and decision makers are better positioned to evaluate alternative actions to respond to climate change, even in the face of considerable uncertainty (Nichols et al. 2011). These alternative actions are known as climate change adaptation strategies.

Climate change adaptation strategies

Climate Change Adaptation includes actions that enable species, systems and human communities to better cope with or adjust to changing conditions. These strategies may take a number of forms. Some have categorized strategies into three areas, including resistance, resilience, and facilitated transformation (Biringier et al. 2003, Millar et al. 2007, McLachlin et al. 2007). *Resistance* strategies for adaptation aim to prevent the direct effects of climate change. Frequently cited examples include building sea walls and coastal hardening to prevent effects of coastal sea-level rise (Klein and Nicholls 1999). Preventive measures to head off effects of invasive species, or uncharacteristic landscape-scale fires, could also fall

into this category. *Resilience* strategies aim to secure the capacity to cope with the effects of climate change by ensuring that critical ecological process – as currently understood – are restored to a high level of function or integrity. For example, by securing large and interconnected natural landscapes, patterns of species dispersal and migration are secured to protect food-web dynamics. *Facilitated Transformation* strategies anticipate the nature of climate-change induced transitions and, working with these anticipated trends, include actions that facilitate transitions that are congruent with future climate conditions, while minimizing ecological disruption. Somewhat radical expressions of these strategies might include assisted migration of sensitive species from current habitats to locations where changing climates might provide new habitat into the future (McLachlin et al. 2007, Milly et al. 2008). Some have characterized these *resistance* and *resilience* strategies as ‘retrospective’ because they emphasize utilization of knowledge about historical or current ecological pattern and process; i.e., protection and restoration of natural conditions as they are currently understood. *Facilitated Transformation* is therefore a ‘prospective’ set of strategies in that they are based on the hypothesis of future conditions (Magnuss et al. 2011).

Finally, there is a critical temporal dimension to adaptation strategies. Conservation decisions are made by people, often within the policy constraints of current law and institutions. While traditional natural resource management has been ‘retrospective’ – utilizing knowledge of past and current conditions to inform today’s management actions – planners are increasingly required to rigorously forecast future conditions (see e.g., Comer et al. 2012). This forecasting must strive to determine the nature and magnitude of change likely to occur, and translate that knowledge to current decision-making. It is no longer sufficient to assess “how are we doing?” and then decide what actions should be prioritized for the upcoming 5-15 year management plan. One must now ask “where are we going, and by when?” and then translate that knowledge back into actions to take in the near-term, or medium-term, or those to monitor and anticipate taking over multiple planning horizons. Considerable new science and policy will be required to support this new type of natural resource decision making.

Scales of Ecological Organization

Climate change vulnerability assessments can be aimed at different scales of ecological organization, including species, communities, or landscapes, just as conservation planning can target these same scales (Groves et al. 2002). Species, as well as subspecies, varieties, and populations, are concepts intuitively understood by the conservation community despite academic disagreement over just what they represent (de Quieroz 2007). Communities could include a variety of units (e.g., habitats for one or more species, vegetation communities, aquatic communities, etc) that have been defined in different ways but generally refer to assemblages of species that co-occur in space and time and interact with each other and their local environment. Landscapes (as units of analysis) typically describe recurrent patterns of communities and occupy geographical areas of varying size.

Regardless of the scale of ecological organization, climate change vulnerability assessments can and should address exposure, sensitivity, and adaptive capacity; the three main components of vulnerability. Different approaches are called for depending on the level in question. The **species** is perhaps the most common focus for vulnerability assessment and consequently has received extensive attention in the literature (e.g., Thomas et al. 2004, Laidre et al. 2008, Rowland et al. 2011). Trait-based approaches examine projected climate change where the species occurs, aspects of the genetic variation, natural history, physiology, and landscape context to assess sensitivity and adaptive capacity (Foden 2009, Young et al. 2012). Bioclimatic modeling approaches how climatic “envelopes” of suitable climate

conditions might change and move over time (Peterson et al. 2002, Thomas et al. 2004, Thomas et al. 2012, Comer et al. 2012). Species-based vulnerability assessments are particularly useful where a relatively small number of individual species form the focus of conservation effort.

Assessments of **landscapes** often center on producing spatially explicit results at regional scales. Evaluation of exposure may result in maps showing where climate stress is projected to be greatest, whereas examination of the potential climate-change effects on disturbance regimes or invasive species, can address sensitivity (Enquist and Gori 2008, Swantson et al. 2010, Rustad et al. 2011). Adaptive capacity can be measured through examination of the heterogeneity of topography, moisture gradients, or microclimates under the assumption that more diverse landscapes provide more opportunities for organisms to find climate refugia than homogeneous ones. Assessments of landscape vulnerability are useful when examining the potential effects of climate change on land use patterns and on biodiversity that is influenced by large-scale processes such as riparian systems where mountain headwaters affect lowland rivers.

A vulnerability assessment of a **community type** requires understanding of the ecological processes such as fire regime, hydrological regime, or food web dynamics that define the community at relatively local scales. As for species, exposure estimates relate to the magnitude of projected changes in temperature and precipitation over the area where the community occurs. Sensitivity estimates can include how the defining ecological processes are affected by changing climates, and synergies between climate and non-climate stressors of the community. Adaptive capacity estimates of a community can include the roles of component guilds of organisms, the vulnerability of important component species, and the natural biophysical variability across the range of the community. Assessing the vulnerability of communities can provide a useful compliment to both landscape and species assessments. Where landscape assessments indicate a high potential for climate-change impacts in certain subregional areas, analysis of component communities could be the next logical step to identify practical adaptation strategies. Assessment of communities also presents the opportunity to avoid time-consuming analyses of long lists of sympatric species, or when the community itself is an effective focus for conservation.

Coping with Uncertainty

While uncertainty is inherent in climate change vulnerability and adaptation planning, it is important to clarify areas of uncertainty so that users may appropriately interpret, and investments in new knowledge to reduce uncertainty can be effectively focused (Risbey and Kandlikar 2007, Swart et al. 2009). Given that all climate change assessments thus far bring together data, models, and expert knowledge, the approach taken for this effort concentrated on identifying the various sources of uncertainty (e.g., in available data, in current models, and in limits to current knowledge) and then attempted to describe the relative confidence throughout the vulnerability assessment with probability statements (i.e., “high” confidence implies a >70% certainty of being correct, “moderate” = 30-70% certainty, and “low” = <30% certainty).

Survey of Field Specialists

A major goal of the project is to develop methods and outcomes useful for natural resource managers. To better understand the needs, concerns, and interests of managers in the Desert LCC, and therefore enhance the chances of creating products useful for them, we initiated the project with a survey of the potential

user audience. The survey sought to understand the natural communities managed, the most important stressors to these systems, the communities perceived to be most vulnerable to climate change, the climate change factors causing these stresses, and the greatest needs for scientific information about climate change. Besides providing a general picture of managers' needs and perceptions about climate change, the survey also allowed us to choose ten plant community types to focus our pilot study on vulnerability of desert habitats to climate change.

See Appendix 1 for discussion of survey methods and results. Thanks to a healthy response rate, the survey succeeded in providing a snapshot of Mojave and Sonoran Desert land managers' perceptions about climate change in the larger context of stressors to the biodiversity they manage. Climate change is but one of numerous stressors that the respondents are confronting, ranking noticeably behind invasive species in importance. Managers are concerned about climate change affecting a wide range of communities via mechanisms that relate to increased water stress, isolation of mountaintops, loss of keystone or endemic species, and storm surge in coastal systems. Their top climate change-related information needs are vulnerability assessments of communities and species as well as predictions of how climate change will influence hydrological cycles. Finally, the survey allowed us to select for vulnerability assessment 10 community types that are relevant to a broad spectrum of land managers.

Overview of Methodology for Vulnerability Assessment

The methods developed for this Habitat Climate Change Vulnerability Index (HCCVI) will be applicable to any given ecosystem or community type that the user might select. For this pilot, we used NatureServe's terrestrial ecological systems classification. The advantage of using this classification system to test the approach is that it represents an established nationwide classification of several hundred upland and wetland types mapped for use by federal and state resource managers (Comer et al. 2003, Comer and Schulz 2007). However, the HCCVI methods are consciously designed to support other ecosystem or community concepts as well; for example, habitats described for individual bird or ungulate species of conservation concern. The 10 selected types for this pilot effort are listed in Table 1. A map of these types is included in Figure 2 later in this report.

Table 1. Focal Natural Communities and Primary Desert of Occurrence.

Type Name	Desert
North American Warm Desert Riparian Woodland and Shrubland and Stream	both
North American Warm Desert Mesquite Bosque	both
Mojave-Sonoran Desert Springs and Seeps	both
Apacherian-Chihuahuan Semi-Desert Grassland and Steppe	Sonoran
Sonoran Paloverde-Mixed Cacti Desert Scrub	Sonoran
Sonora-Mojave Mixed Salt Desert Scrub	both
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	both
North American Warm Desert Active and Stabilized Dune	Sonoran
Mojave Mid-Elevation Mixed Desert Scrub	Mojave
Great Basin Pinyon-Juniper Woodland	Mojave

Index Framework

An index approach to documenting climate change vulnerability aims to organize a series of sub-analyses in a coherent structure that will shed light on distinct components of vulnerability, so that each can be evaluated individually, or in combination. This approach follows a number of related indexing approaches to documenting at-risk status of biodiversity (Faber-Langendoen et al. 2007), or climate change vulnerability for species (Young et al. 2010). The structure implemented here organizes the components of climate change vulnerability in to three main categories: Direct Effects, Indirect Effects, and Adaptive Capacity (Figure 1). These are defined as follows:

Direct Effects encompass the current and forecasted exposure to climate change and their likely effects on ecosystem-specific processes. Analyses of direct effects consider climate forecasts themselves, and their likely implications for increasing ecosystem stress, changing dynamic processes such as wildfire or hydrological regime; and for changing species composition.

Indirect Effects encompass predisposing conditions affecting ecological resilience, with ecological resilience as initially defined by Holling (1973) and Gunderson (2000), and later Walker et al. (2004). Walker et al. (2004) defined it as “the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks.” Analyses of indirect effects consider human alterations to characteristic pattern and process, such as landscape fragmentation, effects of invasive species, or human alterations to dynamic processes. Here, these human alterations are considered independent of climate change, but once identified, have some potential interactions with forecasted climate change. These analyses also include a temporal dimension, considering both legacies of past land use along with current conditions.

Adaptive Capacity encompasses natural characteristics that affect the potential for ecological resilience in light of climate change. Analyses of adaptive capacity for climate change consider the inherent variability in climate regime or geophysical features that characterize the distribution of a given ecosystem or community. They also consider aspects of natural species composition, such as the relative diversity within groups of species that provide functional roles, or the relative vulnerabilities of individual species that provide “keystone” functions.

Authors of this index drew inspiration from Magnuss et al. (2011) and others in structuring analyses with a logic model to combine information in two stages, with the first analyses gauging relative ecological resilience by matching results from indirect effects against adaptive capacity. The direct effects of climate exposure and sensitivity are then considered to arrive at an overall gauge of climate change vulnerability (Figure 1).

Numerical and Categorical Summaries of Vulnerability

The index aims to use component analyses to consistently arrive at a 3-level series of scores; i.e., High, Medium, and Low (Figure 1). Where quantitative data are available, numerical scores should aim to be normalized to a 0.0 to 1.0 scale. Numerical results for component analyses are then averaged. However, where quantitative models are unavailable for a given analysis, expert categorization for each score is sufficient (with documented justification). The H/M/L result for resilience is the average of scores for indirect effects and for adaptive capacity. The H/M/L result for sensitivity is the average of scores for

direct effects. From this point, a simple logic model combines categorical results for resilience and sensitivity to arrive at an overall categorization of climate change vulnerability.

Very High climate change vulnerability results from combining high sensitivity with low resilience. These are circumstances where climate change stress and its effects are expected to be most severe, and relative resilience is lowest. Ecosystem transformation is most likely to occur in upcoming decades.

High climate change vulnerability results from combining either high or moderate sensitivity with low or medium resilience. Under either combination, climate change stress would be anticipated to have considerable impact.

Moderate climate change vulnerability results from a variety of combinations for sensitivity and resilience; initially with circumstances where both are scored as moderate. However, this also results where resilience is scored high, if combined with either high or medium sensitivity. Where both resilience and sensitivity are low, some degree of climate change vulnerability remains.

Low climate change vulnerability results from combining low sensitivity with high resilience. These are circumstances where climate change stress and its effects are expected to be least severe or absent, and relative resilience is highest.

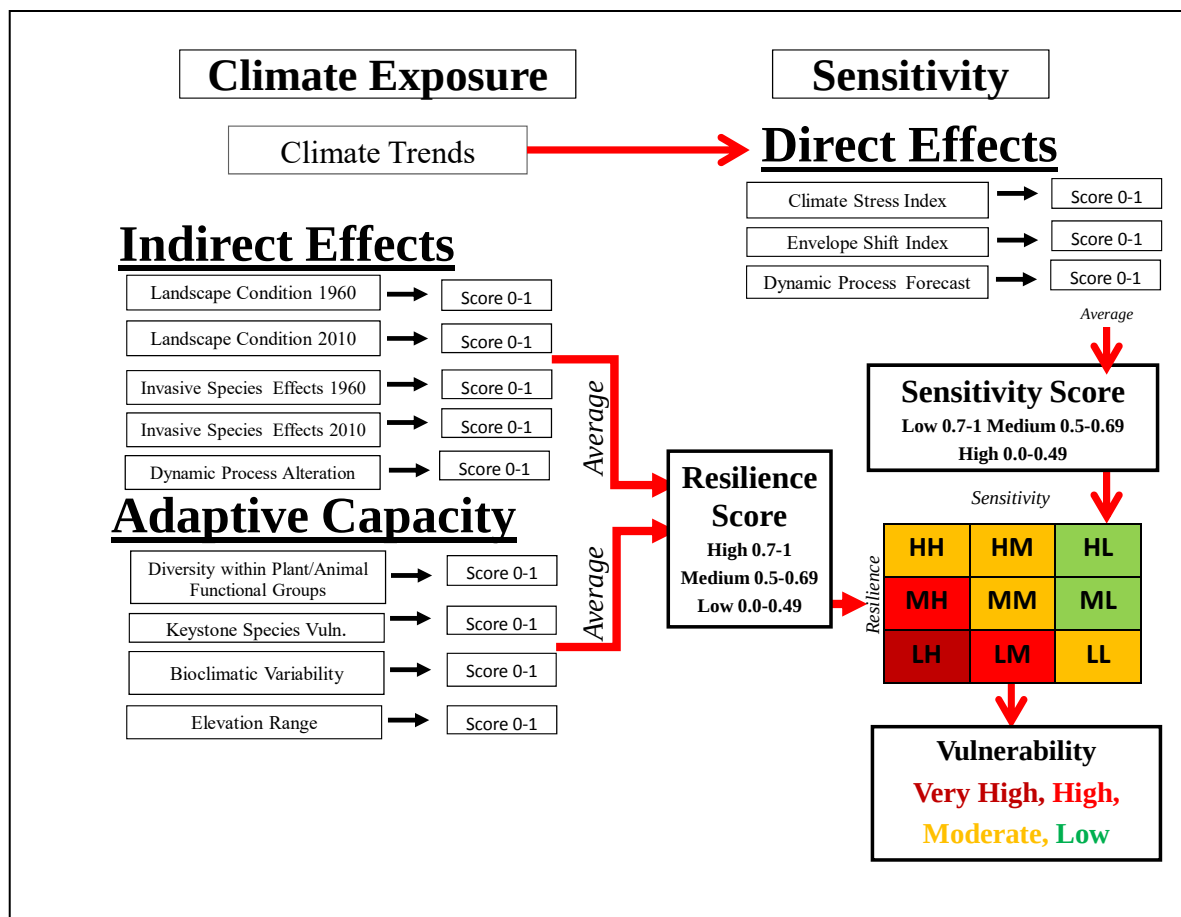


Figure 1. Flow Chart for Habitat Climate Change Vulnerability Index (HCCVI).

Spatial and Temporal Dimensions for Documenting Vulnerability

Climate change vulnerability for ecosystems and habitats was placed here within an explicit spatial and temporal framework. Spatially, a vulnerability assessment initially applies to the distribution of the type within an EPA Level III ecoregion². Across North America, these equate with Level III ecoregions from the Commission for Environmental Cooperation (CEC). Scores for each type are summarized for each applicable ecoregion of their natural distribution. For this project, we focused on the distribution of each target community type within the Mojave and/or Sonoran Desert ecoregions (Figure 2).

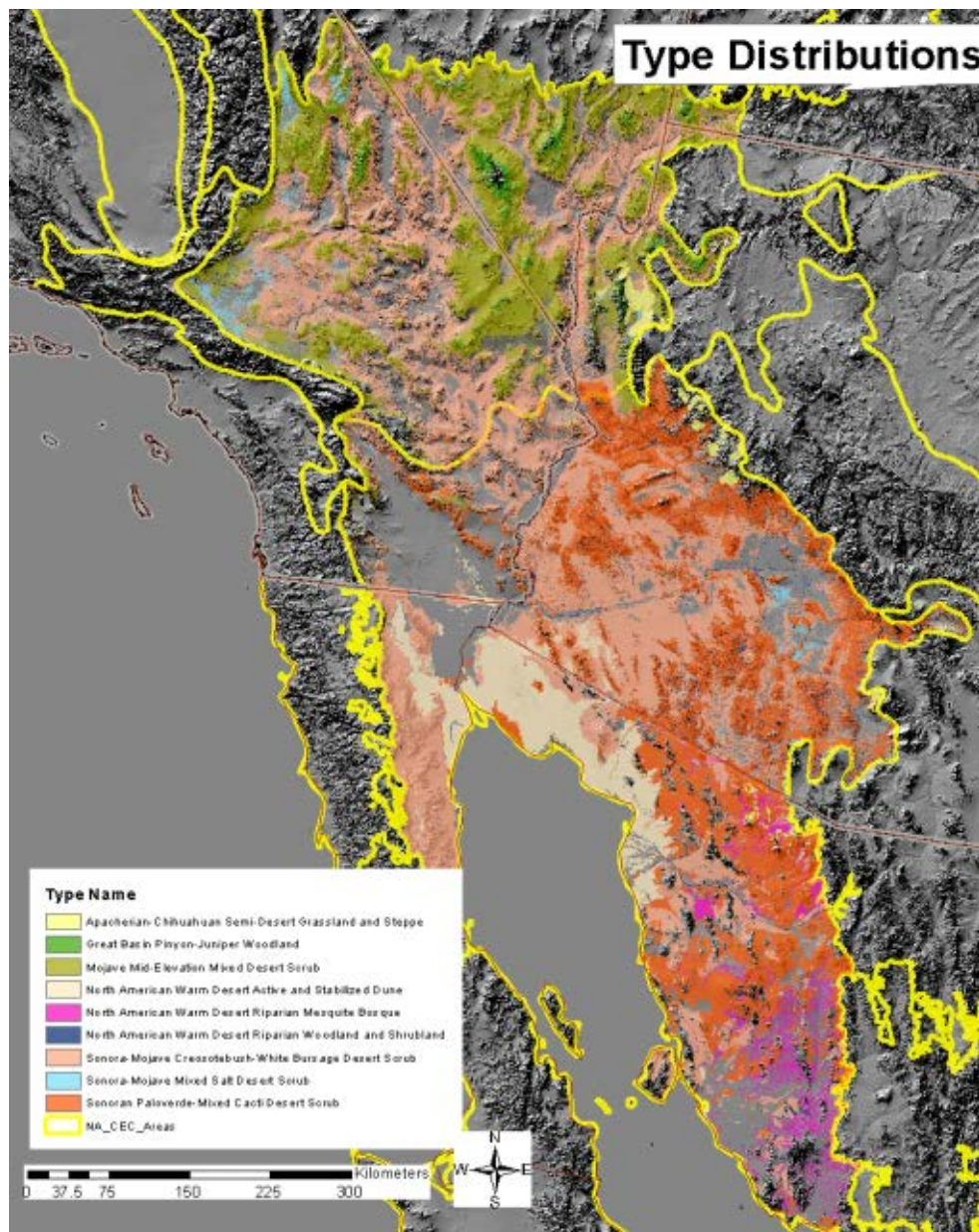


Figure 2. Level III ecoregions and focal community distribution for HCCVI pilot in the Mojave and Sonoran deserts.

² http://www.eoearth.org/article/Ecoregions_of_the_United_States-Level_III_%28EPA%29

One might apply the same analyses and gauge vulnerability for narrower or broader distributions of a given community type, but this level of ecoregionalization was selected because it likely reflects regional pattern of climate-change exposure and effects. It therefore should provide a practical starting point for efforts to systematically document climate change vulnerability at national or regional scales.

Similarly, one must explicitly consider the temporal dimension of climate change vulnerability, as the magnitude of climate exposure varies over the upcoming decades. By utilizing forecasts of climate exposure and sensitivity over a 50-year timeframe (e.g., between 2010 and 2060) provides a practical time period where realistic climate trends can emerge within acceptable bounds of uncertainty.

Climate Exposure in the Mojave and Sonoran Deserts

Where available, historical climate data can and should be used to characterize a given community types 'climate baseline' over the 20th century. This enables meaningful comparisons of climate trends from subsequent time periods to clarify the significance of measurable change. In the United States, PRISM data (Daly et al. 2004) include monthly maximum and minimum temperature and monthly total precipitation, and are available at 4km² spatial resolution from 1900 to the present. An analysis of these monthly variables for the 1900-1980 intervals can then characterize the "expected" variability of historical conditions. That time period is useful because a) it includes the oldest available climate records suitable for developing a climate baseline, and b) around 1980 was the point at which a human influence on climate change was detectable (Lee et al. 2006, Solomon et al. 2007). One can then compare with this baseline summaries of the same climate variables since 1980, and/or climate forecasts, to identify the likely location and magnitude of climate-induced stress across the areas that define the range of the community type.

Here we summarize this analysis taking results from the Rapid Ecoregional Assessment for the Mojave Desert (Comer et al. 2012). See Appendix 2 for detailed explanation of methods and results relative to these analyses, including summaries used for the Sonoran Desert. Again, monthly averages for maximum and minimum temperatures, along with total monthly precipitation, encompass the climate variables used. *For each month and each variable, the mean and standard deviation was calculated, characterizing 80 years of climatic variability.* Then, using an ensemble mean from 6 Global Circulation Models (GCMs) forecasting climate for the decade of 2050-2059 (www.ecoclim.org), we analyzed every 4 km² pixel in the Mojave Desert to identify where forecasted values exceeded this measure of 20th century baseline variability.

Overall forecasted climate trends for the Mojave Desert in 2060 can be summarized in a map (Figure 3). This map indicates the pervasive nature of forecasted climate change anticipated for the Mojave Desert, where almost no area escapes a >2 stdv departure in at least one monthly climate variable. Statistically, a >2 stdv departure indicates that forecasted climate variables fall outside of 95% of the 20th century baseline values. This map also displays a count for each pixel where up to 12 of the 36 monthly temperature variables (maximum and minimum temperature, each x 12 months) and total precipitation (x12) are forecasted to depart by at least 2 standard deviations from the 20th century baseline mean values. This analysis provides an initial suggestion of areas where climate-change impacts might be more or less intense. Table 2 provides a concise summary of these results. Each row included in the table represents the monthly variable where forecast models indicate that the variable will exceed 95% (two standard deviations) of the values that occurred during the 1900-1979 baseline period. The second column of Table

2 includes the proportion of the ecoregion affected by significant climate change; with **bolded numbers** indicating where forecasted proportions are above 50% of the ecoregion surface. Other columns indicate the ecoregion-wide averages for each variable, in terms of their forecasted difference (i.e., departure) from the 20th century baseline. Both maximum (daytime) and minimum (nighttime) temperatures (F) stand out from this analysis, with the months of June through October concentrating forecasted change. For midcentury summers, models predict 80-95% of the Mojave Desert will experience elevated temperatures, with extremes reaching a 9.6 degree F increase in some areas. Monthly total precipitation is forecasted to significantly depart from the 20th century baseline only in the month of August. However, natural variability in precipitation is quite high, and climate forecast models are least reliable with precipitation, so caution is required for interpretation of this particular forecast. These climate forecasts provide a foundation for both estimating future climate stress, and for describing plausible climate-change scenarios relevant to communities in the Mojave Desert.

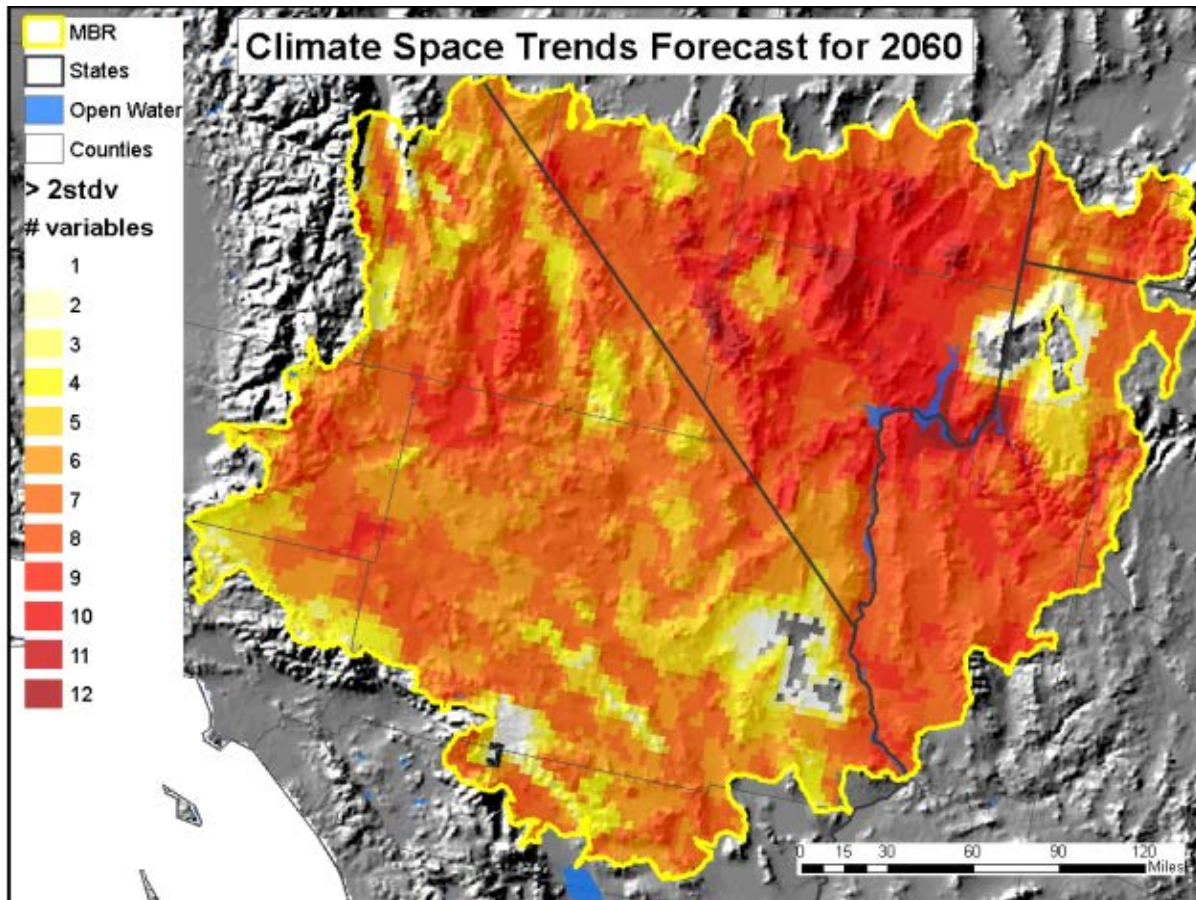


Figure 3. Composite 2060 forecast where climate variables depart by > 2 standard deviations.

Table 2. Summary of areal extent of climate change for individual variables which have at least 2 standard deviations of projected change (2050-2059) from the baseline (1900-1979) mean.

Variable (Month, 2050s forecast)	% of Area with Value >2 stdv departure	Grid Cells > 2 Stdv departure forecast 2050s (degrees F, Precip in Inches)		
		Mean Departure from Baseline	Min	Max
January Min Temp	3.7%	5.9	5.3	7.1
May Min Temp	6.2%	4.8	4.1	5.9
June Min Temp	57.2%	5.7	4.4	8.4
June Max Temp	17.1%	6.2	5.2	9.1
July Min Temp	96.4%	6.4	4.9	9.0
July Max temp	91.1%	5.5	3.9	8.7
August Min Temp	95.9%	6.9	5.1	9.6
August Max Temp	93.8%	5.9	4.5	8.6
August Tot. Precip	11.3%	0.9	0.3	3.0
Sept. Min Temp	91.6%	6.6	4.6	8.8
Sept. Max Temp	7.1%	5.7	5.0	7.5
October Max Temp	4.7%	7.2	6.6	8.5
October Min Temp	81.3%	6.5	4.9	8.3
November Min Temp	8.3%	5.4	4.3	7.1
December Min Temp	0.2%	5.3	4.8	6.1

Describing Climate Stress and its Direct Effects

The first three climate-change analyses for the HCCVI aim to measure the overall magnitude of climate-induced stress and its likely effect on the type across the ecoregion (Figure 1). Each analysis produces an index value either in qualitative categories of High, Medium, or Low Sensitivity, or a numerical 0.0-1.0 result, with scores approaching 0.0 indicating higher climate change sensitivity; i.e., with trends in climate forecasted out for 50 years suggest higher ecological impact. Summarized below, these first three measures of climate-change direct effects include a climate stress index, and climate envelope shift index, and a dynamic process forecast.

Climate Stress Index

Ideally, this can be measured using the proportion of the community distribution where the climate is forecasted to depart significantly from 20th century conditions. Using the analysis from the Mojave Desert described above, an index of climate stress was calculated using the weighted average score of climate forecasts for 2060 (in a 4km² grid) overlain on the current distribution of each community type. As noted above, up to 12 of 36 monthly variables for maximum temperature, minimum temperature, and total precipitation were forecasted for 2060 in the Mojave Desert to depart by >2 stdv from the 20th century baseline. The number of significantly departed monthly variables for monthly maximum temperature (x12) monthly minimum temperature (x12) or total precipitation (x12) per grid cell formed the basis for weighted averaging. Major upland communities for this project had weighted averages around 7.0. Their resulting index score is therefore $1-7/36 = 0.8$. Unfortunately, this type of calculation has yet to be completed for a wide diversity of North American communities, and so the relative

significance of a 0.8 index score remains unclear. However, given comparison of results from Table 1 with generalized results published elsewhere (e.g., US Global Change Research Program 2009); an initial categorization of “High” sensitivity for Mojave and Sonoran desert communities in this project is warranted.

Climate Envelope Shift Overlap Index

A second way to gauge climate-change effects on communities is to predict how climate change may shift the suitable climatic conditions for a given upland type over the upcoming decades. While one should not presume that upland communities will move as a unit with changing climate, this analysis can provide an indication of the direction and magnitude of forecasted change to be experienced by component species of the community type (Pearson and Dawson 2003). In order to complete this analysis, one can first define the characteristic ‘climate envelope’ for the community by correlating its current range with 20th century averages of climate variables. The identified climate envelope can then be projected into the future using climate forecasts for 2060. In this project, distribution modeling algorithm Maxent (Phillips et al. 2006, Phillips and Dudik 2008) was used in conjunction with spatial climate data from PRISM and EcoClim 4 km² (Hamilton, pers. comm. 2012) to model current and future bioclimate of each upland vegetation type within either the Mojave or Sonoran Desert. Maxent is a correlative niche model that uses the principle of maximum entropy to estimate a set of functions that relate environmental variables and known vegetation type occurrences in order to approximate its bioclimate niche and potential geographic distribution. Maxent was chosen because of its established performance with presence-only data relative to alternative niche modeling techniques, and its built-in capacity to deal with multi-colinearity in the environmental variables (Elith et al. 2006, Elith and Leathwick 2009, Elith et al. 2011).

A map of both current and forecasted 2060 distributions was developed and compared for each upland vegetation type (see results and Appendix 2 for map examples). Overlay of map outputs identify where forecasts indicate an overlap between current and 2060 bioclimate distributions. Where forecasted distribution does not overlap current distributions, these indicate a potential ‘contraction’ or ‘expansion’ by 2060. Since six forecast models were developed, results were summarized where least two outputs from 2060 climate forecasts were in agreement. The proportion of calculated overlap forms an index score between 0.0 and 1.0. For the upland vegetated types treated in this project, results ranged from 0.12 (High sensitivity) to 0.91 (Low sensitivity).

Dynamic Process Forecasts

Localized hydrologic or fire regime models for aquatic and upland ecosystems, where available, can help account for past alterations, and then provide insight for projected future climate regimes, applying those estimates as a third measure of direct effects or climate-change sensitivity. See Appendix 2 for detailed discussion of methods from these analyses.

Potential effects of climate change on the hydrologic regime were based on 1) ecological literature identifying the key surface water, groundwater, and hydrogeomorphic dynamics that affect the aquatic/wetland/riparian systems of interest; 2) hydrologic and meteorological literature identifying the key climate variables that have the greatest effect on the ecologically important surface water, groundwater, and hydrogeomorphic dynamics, including studies of prehistoric and historic conditions; and 3) hydrologic and geologic literature identifying the specific ways in which changes in these climate

variables would affect the surface water, groundwater, and hydrogeomorphic dynamics of concern, including studies of prehistoric and historic conditions. Given limitations on the availability of quantitative hydrologic models of use for our purposes in the Mojave and Sonoran deserts, estimates of climate sensitivity were qualitative, scaled between 0.0 and 1.0 for each community type within each desert. In this project, all aquatic/riparian types were scored as “High” sensitivity.

Fire regimes are characterized quantitatively using state-and-transitions models that describe various successional stages and the transitions between them. Using estimates of fire frequency and successional rates, fire regime models predict the relative proportion of natural successional stages one might expect to encounter for a community type across a given landscape. Comparison of the observed vs. predicted aerial extent of successional stages is then used to gauge relative departure from expected proportions (measured in % departure). Models for each upland vegetation type characterizing its expected or “natural” range of variation were compared against current conditions to describe current fire regime departure (see subsequent discussion under Indirect Effects – Dynamic Regime Alteration). The same model, updated to describe current conditions (e.g., with introduced invasive species included) were then run out over several decades to provide a realistic forecast of trends in ecological departure as of 2060. Forecasted departure scores for each upland vegetation type were normalized to a 0.0-1.0 relative score. For the upland vegetated types treated in this project, results ranged from 0.12 (High sensitivity) to 0.72 (Low sensitivity).

Accounting for the Indirect Effects of Climate Stress

Indirect effects address the potential interacting effects of climate-induced stress on the landscape conditions within and surrounding the habitat across its distribution. For example, if the analysis of direct effects indicates the strong need for component species to migrate towards higher elevations or latitudes, and the landscape is fragmented, the relative vulnerability of a community type could increase. In many instances, communities occur in landscapes that were already highly fragmented by the mid-20th century, and are therefore the associated land use legacies make them all the more vulnerable to current and future stressors. Similarly, the introduction of non-native species may also alter natural food-webs or compromise key dynamic processes, such as wildfire regimes, and have high potential for interactions with likely climate stress.

Literature review, and where available, regional maps of landscape condition, land use, invasive species, and fire regime departure, where possible reflecting 1960 and 2010, can provide measures for these effects.

Landscape Condition

Ecological condition commonly refers to the state of the physical, chemical, and biological characteristics of natural ecosystems, and their interacting processes. Many human land uses affect ecological condition, (e.g., through vegetation removal or alteration, stream diversion or altered natural hydrology, introduction of non-native and invasive species, etc.). Landscape condition assessments apply principles of landscape ecology with mapped information to characterize ecological condition for a given area (e.g., USEPA 2001, Sanderson et al. 2002). Since human land uses - such as built infrastructure for transportation or urban/industry, and land cover such as for agriculture or other vegetation alteration – are increasingly

available in mapped form, they can be used to spatially model inferences about ecological stress and ecological condition.

The spatial models of landscape condition used in this project built on a growing body of published methods and software tools for ecological effects assessment and spatial modeling; all aiming to characterize relative ecological condition of landscapes (e.g., Knick and Rotenberry 1995, Forman and Alexander 1998, Trombulak and Frissel 1999, Theobald 2001, Seiler 2001, Sanderson et al. 2002, Riitters and Wickham 2003, Brown and Vivas 2005, Hansen et al. 2005, Leu et al. 2008, Comer and Hak 2009, Theobald 2010, Rocchio and Crawford 2011). The intent of these models is to use regionally available spatial data to transparently express user knowledge regarding the relative effects of land uses on natural ecosystems and communities. For this project, the authors' expert knowledge forms the basis of stressor selection, and relative weightings, but numerous examples from published literature have been drawn upon to parameterize the model for application in this ecoregion. Independent data sets were drawn upon for subsequent model evaluation. This current model has been developed and evaluated for the entire western United States, and then customized for use within each desert ecoregion. Western regional model development and evaluation was completed in cooperation with the Western Governors Association landscape connectivity working group (J. Pierce, pers. comm.).

See Appendix 2 for a detailed description of the models used in the Mojave and Sonoran deserts. Each input data layer is summarized to a 90m grid and, *where the land use occurs*, given a **site impact score** from 0.05 to 0.9 reflecting presumed ecological stress or impact. Values close to 1.0 imply relatively little ecological impact from the land use. For example, a given patch of 'ruderal' vegetation – historically cleared for farming, but recovering towards natural vegetation over recent decades, is given a Very Low (0.9) score for site impact as compared with irrigated agriculture (High Impact 0.3) or high-density urban/industrial development (Very High Impact 0.05). Certainly, there are some ecological values supported in these intensively used lands, but their relative condition is quite limited when compared with areas dominated by natural vegetation.

A second model parameter – *for each input data layer* - represents a **distance decay** function, expressing a decreasing ecological impact with distance away from the mapped location of each feature with Euclidian Distance. Mathematically, this applies a formula that characteristically describes a "bell curve" shape that falls towards plus/minus infinity (Appendix 2). Those features given a high decay score (approaching 1.0) result in a map surface where the impact value dissipates within a relatively short distance. Those features given a low decay score (approaching 0.0) create a map surface where the per-pixel impact value dissipates more gradually with distance away from the impacting feature.

The result is a map surface indicating relative scores per pixel between 0.0 and 1.0 (Figure 4). This provides one composite view of the relative impacts of land uses across the entire ecoregion. Darker blue areas indicate apparently least impacted areas and orange to red areas most impacted.

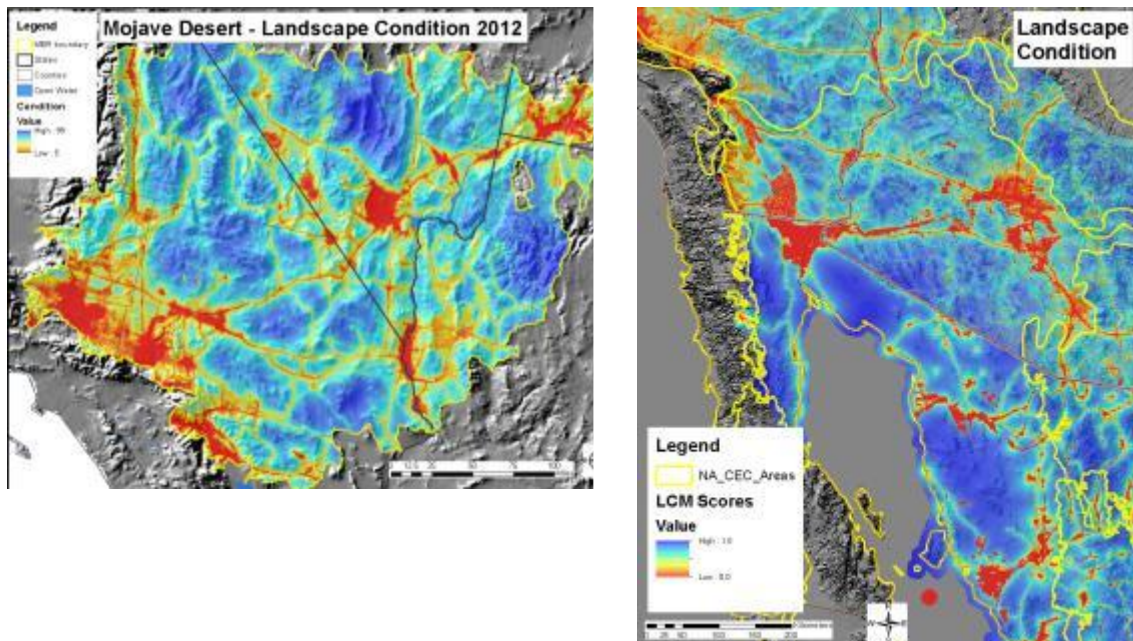


Figure 4. Landscape Condition model (90 m) for the Mojave and Sonoran deserts

Current Landscape Condition (2010): Current Landscape Condition of each community distribution was assessed using the NatureServe (LCM). This indicator is measured by intersecting the community distribution map with the LCM layer and reporting the average per-pixel LCM index value within each ecoregion. The average per-pixel score provides a relative index for landscape condition resulting with a score from 0 to 1 with 1 being very high landscape condition and values close to 0 likely having very poor condition.

Past landscape condition (1960): Historical data were lacking for spatial analysis using an LCM so landscape conditions for 1960 were researched and summarized (0.0-1.0 scale) based on estimated extent of roads and other development and various anthropogenic disturbances. Examples of disturbance include historic ranching (since mid -1800's), which has significantly affected most ecosystems and transportation system of highways and roads have fragmented many areas. Additionally, water diversions and ground water pumping has affected springs and surface flows in riparian ecosystems, and local disturbance from agriculture, urbanization and mining have converted many sites.

Invasive Species

The effects of invasive species on natural communities are well known and there is considerable concern for their interactions with climate change (e.g., Abatzoglou and Kolden. 2011). For example, few annual grasses are native to the region and most of the annual grass cover is from invasive non-native grasses; especially *Bromus tectorum*, *B. madritensis*, *B. rubens* and *Schismus barbatus*. Invasive woody riparian species (e.g., *Tamarix ramosissima*) impact focal riparian communities throughout these deserts, while a variety of invasive aquatic species impact freshwater bodies. Potential effects of these species were assessed using spatial models for invasive annual grasses and woody riparian species in the Mojave

Desert (Comer et al. 2012) and Sonoran Desert (Conservation Biology Institute 2012) developed for the BLM rapid ecoregional assessments. These models leverage existing location records of invasive species, spatial models of potential presence and/or abundance were developed for each invasive floristic group (annuals and woody riparian). See Appendix 2 and appendices in Comer et al. (2012) and CBI 2012 from Mojave and Sonoran REAs for further explanation of these models. Using the master database of plant locality records with a suite of environmental variables and inductive modeling with Maxent and CART methods, the resultant surfaces represent their potential presence. Within the Mojave Desert, since georeferenced samples for invasive annual grasses tended to include relative cover values, five distinct models were developed to indicate the potential for their presence in a series of abundance levels (<5%, 5-10%, 10-25%, 25-45%, and >45%). (Figure 5).

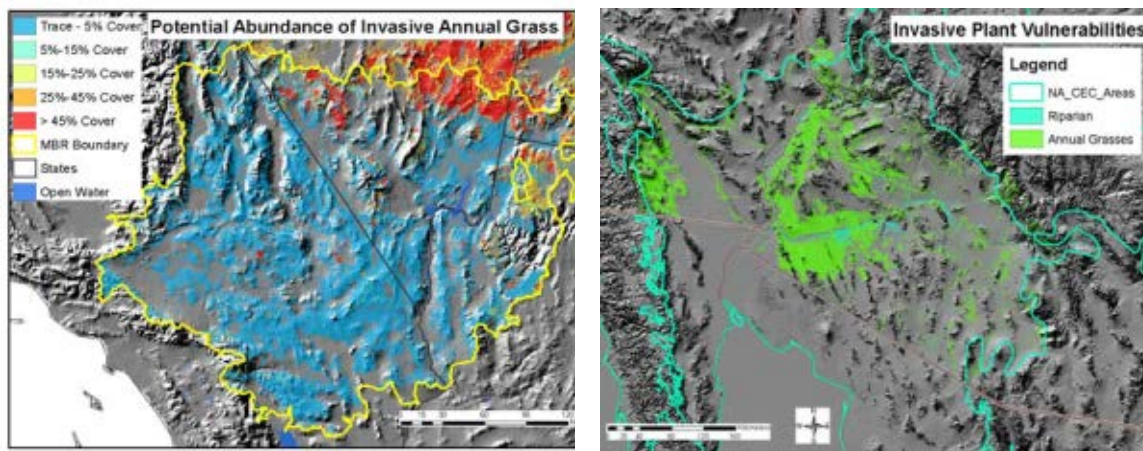


Figure 5. Potential abundance and/or presence models of invasive plant species in the Mojave and Sonoran deserts (from BLM REAs).

Invasive Species Effects (2010): Like the landscape condition model, potential invasives effect is measured by intersecting the community distribution map with the invasives model output and reporting the average per-pixel invasives index value. The invasives index is a scaled from 0 to 1 with 0 representing high potential of lands in the pixel to experience annual grass encroachment and 1 representing no encroachment. Within the US portion of the Sonoran Desert, since presence/absence information is all that is available, the index results from calculating the percentage of the community type distribution overlapping the invasive map. Building from these overlays, qualitative estimates were derived for Mexican portions of the Sonoran Desert. Because invasive annual grass models in the Mojave Desert included relative abundance values, the per-pixel scores also represent a potential abundance of invasive grasses as follows: <5% = 1.0, 5-10% = 0.9, 11-20% = 0.8, 21-40% = 0.6, 41-60% = 0.4, 60-80% = 0.2, and >80% = 0.1. Across upland types, annual grass model scores ranged from 0.4 to 1.0.

Past Invasive Species Effects (1960): Given a lack of historical mapped information on invasive species, an expert estimate built upon a review of available literature and evaluation of the 2010 results. Across all types, scores ranged from 0.5 to 1.0.

Dynamic Process Alterations

As noted previously under Dynamic Process Forecasts, localized hydrologic or fire regime models for aquatic and upland ecosystems can provide insight for projected future climate regimes. They apply equally for characterizing current conditions. Given limitations on the availability of quantitative hydrologic models of use for our purposes in the Mojave and Sonoran deserts, estimates of 2010 hydrologic regime alterations were qualitative for each community type, scaled between 0.0 and 1.0 for each community type within each desert. In this project, all aquatic/riparian types were scored at the “medium” to “low” threshold (0.5) for current resilience. For fire regime models mentioned previously, the same model for each upland type, updated to describe current conditions (e.g., with introduced invasive species included) were used to describe current departure relative to the ‘expected’ proportions of successional stages (see Appendix 2 for detailed explanation). Departure scores for each upland vegetation type were normalized to a 0.0-1.0 relative score. For the upland vegetated types treated in this project, results ranged from 0.23 (Low resilience) to 0.72 (High resilience).

Adaptive Capacity for Responding to Climate Stress

As described previously, adaptive capacity is the potential or capability of a system to adjust to climate change, including climate variability and extremes, so as to moderate potential damages, to take advantage of opportunities, or to cope with consequences (IPCC 2007). As climate changes, community types with the capacity to support more gradual ecological transformation will have a higher likelihood of maintaining essential ecological relationships than those where transformations are more abrupt. Natural characteristics of ecosystems and communities therefore can make them more or less vulnerable to abrupt transformation brought on by rapid climate change. This inherent adaptive capacity may be initially measured in terms of natural composition and environmental variability characterizing the given community type across its distribution. Below are described four measures of adaptive capacity.

Diversity *within* characteristic functional groups

Natural communities may include a number of functional groups, or groups of organisms that pollinate, graze, disperse seeds, fix nitrogen, decompose organic matter, depredate smaller organisms, or perform other functions (Rosenfeld 2002, Folke et al. 2004). Experimental evidence gathered over the last two decades supports the theoretical prediction that communities with functional groups made up of increasingly diverse members tend to be more resilient to perturbations (Walker et al. 2004, Folke et al. 2005, Nyström et al. 2008). Since individual species respond differently to disturbances, where there is high species diversity within a given group, as individual species are lost over time, it is more likely that the community will retain key functions and therefore have greater resilience to stressors. The more diverse the group, the greater the likelihood that at least one species will have characteristics that allow it to continue to perform its function in the community even if, say, precipitation patterns or the fire regime changes. For example, a study of semi-arid grasslands showed where sites with a diversity of grass species, including some seemingly “redundant” ones, was more resilient to changing states because different grass species dominated under different grazing and precipitation conditions (Walker et al. 1999). Thus a factor contributing to the adaptive capacity of a community is the diversity within its component functional groups.

However, the challenge remains to reliably describe functional groups of species for a given community type. Common approaches center on analysis of plant growth forms or specific traits in response to

environmental constraints (Lavorel et al. 1997; Diaz and Cabido 2001). In this pilot effort, plant functional groups were initially identified by evaluating characteristic growth forms among plant species, and specific groups related to plant responses to drought. Pollinator diversity was also identified as an important functional species group to evaluate; although information on within-group diversity was limited. In each instance, expert knowledge was brought to bear in order to document each group, and score them along a 0.0 to 1.0 scale; with 1.0 indicating high species diversity within a functional group. Results from multiple functional groups were averaged together for an overall estimate. Estimates for types within this pilot ranged from 0.3 to 1.0.

CC Vulnerability among keystone species

Assessing the vulnerability of all species in a community would be a daunting task. A more pragmatic approach is to assess the vulnerability of the species playing the most important functional roles in the community. These species, when lost or reduced in abundance, will cause significant cascading effects on the populations of other species. We use the term “keystone species” to describe these species, recognizing that this use might be interpreted as different from some definitions in the ecological literature that equates keystone species with those that affect communities in a manner disproportionate with their abundance or biomass (Power et al. 1996). The Power et al. (1996) definition excludes dominant structural species, yet assessing the capacity of a community to adapt to climate change may require knowledge of how these dominant species might respond. Here keystone species refer to any species that, when extirpated or reduced in abundance, could cause disproportionate effects on the populations of other species that characterize the community.

Determining which species can be considered keystone requires an understanding of the natural history of many species in the community being assessed. Although there are quantitative means of identifying keystone species via food web analysis (Ebenman and Jonsson 2005), these methods can be time and data intensive. However, identification of potential keystone species may follow directly from the above process to clarify functional groups of species. That is, if an important ecosystem function is represented by just one species, that species is likely providing some ‘keystone’ function for purposes of this analysis.

Alternatively, species can be selected by answering a series of questions about which species play dominant roles in the community. Threatened and endangered species, although frequently the targets of conservation action are often too rare to qualify as keystone species. Exceptions are endemic but locally common species that structure communities or top predators. Questions, to ask when identifying keystone species to assess include:

- 1) Which species provide essential community structure?
- 2) Are there ecosystem engineering species that create habitat to others, such as beavers, cavity-excavating woodpeckers, or prairie dogs?
- 3) Are there specific pollinators required for dominant plants?
- 4) Are there species that are primarily responsible for seed predation?
- 5) Are there species that provide limiting nutrients in the community?
- 6) Is there a top predator that keeps meso-predators in check?

- 7) Are there plants that produce unusually large amounts of nectar, fruits, or nuts that support populations of several animal species during times of scarcity?
- 8) Is there a fungus or disease agent that keeps populations in check?
- 9) Is there a species that influences fire frequency and intensity through its growth?
- 10) Is there an herbivore or grazer that prevents rapid expansion of plant populations?

A number of methods are available to then determine the climate change vulnerability of the keystone species once they are determined. As mentioned above, these methods can be grouped into trait-based and bioclimatic envelop modeling approaches. For the HCCVI, we assessed species vulnerability using the NatureServe Climate Change Vulnerability Index (CCVI), a trait-based tool that allows relatively rapid assessment of suites of species and is applicable to all terrestrial and aquatic plant and animal species (Young et al. 2012). The CCVI places species on a categorical scale from being extremely vulnerable to being likely to benefit from climate change. For this effort, the CCVI was applied to the distribution of each species within each ecoregion. The CCVI categories were translated to a numerical scale, and where multiple species were identified and treated for a given community type their resulting scores were averaged to arrive at a single index score (0.0-1.0 scale) for use in the HCCVI.

Characteristic Bioclimate Variability

Natural communities occur across a range of macro and micro-climates. For example, some vegetation types form the upland ‘matrix’ of an ecoregion. Their distribution responds to regional scale patterns of temperature and precipitation. Other community type might occur in relatively limited climates, such as alpine communities that only occur in limited high-elevation area of a ‘basin-and-range’ ecoregion. The variability in climate expressed by the distribution of a given communities can provide another useful indication of adaptive capacity. As compared to community type occurring in a limited range of climates, those types occurring across a wide range of climates have a higher likelihood of coping with the likely climate change of the upcoming decades.

The task then is to characterize bioclimate, the climate that characterizes the distribution of the community, and comparing that to the bioclimates of other community types to arrive at a relative score (high/medium/low). Fortunately, bioclimate classifications exist for much of the world. These maps effectively hold climate variability constant in an established set of classes and allow for comparison among overlain community type distributions. One map and approach utilized in the conterminous United States (Sayre et al. 2009) used climate station data from across the country and applied classifying criteria established by Rivas-Martinez et al. (1999). The combination of ombrotypes (precipitation-base classes) and thermotypes (temperature-based classes) define over 120 unique isobioclimates for the nation. Overlay of a given community distribution on this map surface provides one initial measure of bioclimate variability. In order to provide a relative measure, several hundred terrestrial ecological system types for the western United States were overlain to establish a plausible range of characteristic isobioclimates for community types treated in this project. From one to 20 isobioclimates characterize the range for all of western ecological system types. The result from each of the focal community types in this project was divided by 20 to arrive at a 0.0 – 1.0 relative score. Results varied from 0.4 to 1.0.

Characteristic Elevation Range

Following a similar logic to measuring isobioclimates, elevation range can serve as an additional and distinct measure of biophysical variability that characterizes the distribution of a given community type. Elevation belts of 500 foot (152 meters) intervals were used for this measurement. Elevation belts of this interval may help to indicate local-scale microclimatic variation not well expressed by isobioclimates. Again, with an overlay of several hundred terrestrial ecological system types for the western United States, a maximum score of 12 elevation belts (i.e., 6,000 ft/ 1829 m) was established for comparison with the elevation range measured for each community type. Results ranged from 0.3 to 1.0.

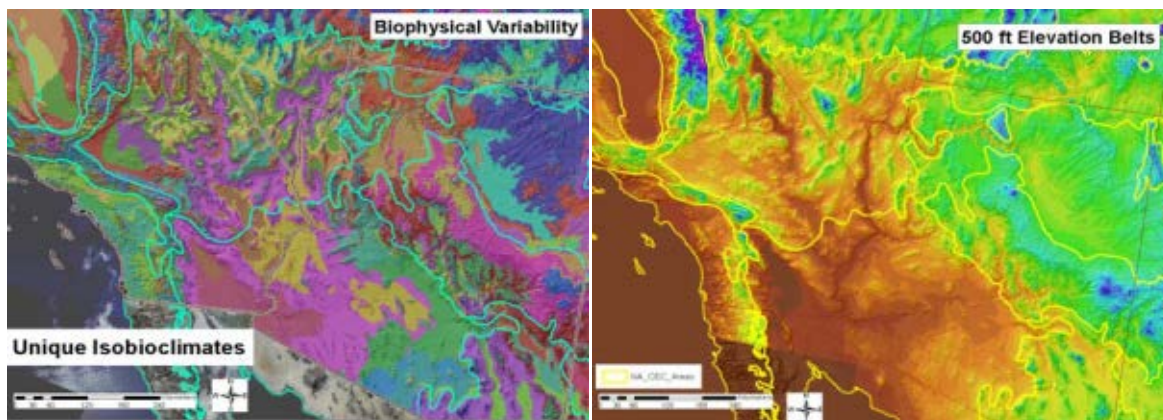


Figure 6. Isobioclimates and elevation belts used to gauge relative biophysical variability for each community type.

Workshop Process for Adaptation Strategies

To identify strategies that could facilitate adaptation of the focal communities to climate change, we held a two-day workshop with the participation of land managers and protected area biologists from the Mojave and Sonoran deserts. Workshops are an effective means of developing these strategies because they bring together a wide range of knowledge and experience, promote stimulating discussion, and engage important stakeholders, paving the way for future implementation (Cross et al. 2012). Planning for the workshop covered three areas: defining the overall goal, objectives, and major activities of the workshop to create a workshop description; recruiting participants; and developing a detailed agenda and workflow.

The overall goal of the workshop was to facilitate interactions among land managers within each ecoregion that support these major community types. The aim of this interaction was to collaboratively identify management strategies that can be readily implemented to promote adaptation of natural communities and associated species. Through discussions with the project advisory team, we enumerated five specific objectives for the workshop. These objectives reflected not only our desire to achieve results in terms of naming management strategies to address climate stressors and their synergistic effects on non-climate stressors, but also the need to receive feedback on the methods used to assess community vulnerability and create awareness among the participants about how climate change might play out in desert communities. The final set of objectives was:

- Communicate the results of climate change vulnerability assessments of ten focal community types of the Sonoran and Mojave deserts to biologists and managers of U.S. and Mexican protected areas that contain these communities.
- Receive feedback on the methods employed and results obtained in the vulnerability assessments.
- Document ecological stressors commonly affecting these communities within managed lands.
- Discuss and identify specific strategies that can be employed on the ground in protected areas to reduce climate change impacts on the characteristic mosaic of natural communities.
- Create awareness about climate change in desert ecosystems, potential synergies among non-climate and climate-induced stressors, and the options for managing for change, as well as resources available for managers.

To achieve these objectives, we determined that the first day should be devoted to explaining the methods and discussing the results of the community vulnerability assessments, and encouraging participants to contribute their knowledge and experience to enhance the analyses prepared in advance. A key activity would then be to document and prioritize synergies between climate and non-climate stressors. During the second day, the participants would build on the outcome of the first day to identify adaptation strategies as well as to clarify monitoring and research needs to lower uncertainty around identified strategies. Because the participants would need to complete these tasks for 10 communities, we determined that they would need to break into three working groups to complete the task. Using this information, we drafted a workshop description to send with invitations.

We worked through the project advisory team to recruit participants. Each member sent invitations to appropriate staff at their institutions. Appropriate staff included (1) areas managers with on-the-ground management experience and authority, and (2) managed area biologists, ecologists, wildlife biologists, vegetation managers, hydrologists, and wildfire managers. Because we had a target number of participants and needed specific expertise represented, we could not open invitations to anyone interested in attending the workshop. We considered requests to attend from those not specifically invited on a case by case basis, considering familiarity with one or more of the community types and space availability.

To plan the agenda, we took into consideration the relative inexperience that many of the participants would have in the fields of climate change vulnerability assessment and adaptation planning. These areas of conservation research and practice are rapidly expanding and taking on their own specialized vocabularies. We therefore scheduled introductory talks in plenary to explain terms and concepts as well as presentations on the methodology itself. We also considered effective means of catalyzing discussion and capturing input. To organize the discussion on synergies between climate and non-climate stressors, we developed a spreadsheet to fill out for each community type. The final agenda listed the talks and activities as well as the charges for the working groups each day (Appendix 4). To further prepare participants (Appendix 5), we sent them two fact sheets developed by EcoAdapt on vulnerability assessment and adaptation planning and recommended two papers (Rowland et al. 2011, Cross et al. 2012) and two books (Glick et al. 2011, Hansen and Hoffman 2011) on these topics one week in advance of the workshop.

Results

The complete set of summarized results for climate change vulnerability assessment and adaptation strategies is found in Appendix 3. Here we provide an overview of these results and include three examples from the full set of community types. These three examples provide a characterization of typical results found across all types. Table 3 includes a high-level summary of analysis scores and overall results for each community type as they occur within either the Mojave or Sonoran desert. When considering the unique combination of type by ecoregion, a total of 16 types are summarized here; one for each row of Table 3.

Six types were categorized high for climate-change vulnerability. These included Mojave Mid-Elevation [Joshua tree-Black brush] Desert Scrub (Mojave), North American Warm Desert Riparian Woodland and Stream (Mojave and Sonoran), North American Warm Desert Mesquite Bosque (Mojave and Sonoran), Sonora-Mojave Creosotebush-White Bursage Desert Scrub (Sonoran). All other types were categorized as moderate for climate-change vulnerability. No types from this pilot analysis were categorized as either very high or low for climate-change vulnerability.

Given the **direct effects** measures aiming to gauge climate-change sensitivity, all but three types in the analysis resulted in the high-sensitivity category. For all types, scores ranged from 0.32 (high sensitivity) to 0.58 (medium sensitivity). The three types found to be in the moderate sensitivity category included Sonora-Mojave Creosotebush-White Bursage Desert Scrub (Mojave), Sonora-Mojave Mixed Salt Desert Scrub (Mojave), and Apacherian-Chihuahuan Semi-Desert Grassland (Sonoran). Climate envelope shift and dynamic process forecast scores determined these results.

Indirect effects average scores fell between a low resilience score of 0.46 (North American Warm Desert Riparian Woodland and Shrubland (Mojave) and a high resilience score of 0.84 (North American Warm Desert Active and Stabilized Dunes (Sonoran). Eleven of 16 fell within the medium resilience range for their average scores. On the whole, average resilience scores tended to be pulled lower by either low scores for current landscape condition, current invasive species effects, current dynamic regime departure, or some combination of these three.

Adaptive capacity scores tended to contribute to higher overall resilience scores, with their averages ranging from a medium resilience score of 0.56 (North American Warm Desert Active and Stabilized Dunes- Sonoran) to a high resilience score of 0.83 (Desert Springs and Seeps – Mojave and Sonoran). On the whole, average resilience scores tended to be pulled lower by either low diversity within identified functional species groups (e.g., desert springs and seeps, mesquite bosque, mixed salt desert scrub), keystone species vulnerability (e.g., creosote-bursage scrub, Apacherian grassland), or where types occur across a relatively narrow elevation range (6 types).

Overall resilience scores ranged from medium (8 types) to high (8 types); but these scores all fell into a narrow range between 0.63 and 0.74. A moderate climate-change vulnerability assessment resulted from the combination of 1) high sensitivity with high resilience (7 types), medium sensitivity and medium resilience (2 types) and 3) medium sensitivity and high resilience (1 type) combinations for a given community type. Because no types score low for sensitivity, no types were scored overall as low vulnerability. Likewise because no types scored low for resilience, no types were scored overall as very high vulnerability.

Table 3. Summary of climate change vulnerability scores for terrestrial ecological system types treated for the Mojave and Sonoran Deserts.

Type Name	Ecoregion	Direct Effects			Sensitivity Score		Indirect Effects						Adaptive Capacity					Resilience Score		CC Vulnerability
		CC Stress	Climate Envelope	Dynamics Forecast			LC 1960	LC 2010	IS 1960	IS 2010	Dynamics Current	Average	Diversity within Functional Group	Keystone Species Vuln.	Bioclim	Elev.	Average			
Great Basin Pinyon-Juniper Woodland	Mojave	0.35	0.17	0.49	0.34	H	0.9	0.76	0.8	0.65	0.35	0.69	0.5	0.9	0.9	0.5	0.70	0.70	H	Moderate
Mojave Mid-Elevation (Joshua Tree-Blackbrush) Mixed Desert Scrub	Mojave	0.35	0.12	0.44	0.30	H	0.7	0.6	0.7	0.45	0.7	0.63	0.9	0.78	0.7	0.5	0.72	0.68	M	High
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	Mojave	0.35	0.8	0.57	0.57	M	0.8	0.73	0.8	0.59	0.1	0.60	0.7	0.6	0.7	0.6	0.65	0.63	M	Moderate
Sonora-Mojave Mixed Salt Desert Scrub	Mojave	0.35	0.91	0.48	0.58	M	0.9	0.72	0.8	0.54	0.26	0.64	0.7	1	0.7	0.8	0.80	0.72	H	Moderate
North American Warm Desert Active and Stabilized Dunes	Mojave	0.35	NA	NA	0.35	H	0.9	0.77	1	0.54	NA	0.80	0.9	0.75	0.4	0.3	0.59	0.70	H	Moderate
North American Warm Desert Riparian Woodland and Stream	Mojave	0.35	NA	0.3	0.33	H	0.6	0.4	0.5	0.4	0.4	0.46	0.8	1	0.8	0.6	0.80	0.63	M	High
North American Warm Desert Riparian Woodland and Stream	Sonoran	0.45	NA	0.3	0.38	H	0.6	0.4	0.7	0.5	0.4	0.52	1	0.85	0.8	0.6	0.81	0.67	M	High
North American Warm Desert Mesquite Bosque	Mojave	0.35	NA	0.3	0.33	H	0.7	0.6	0.5	0.5	0.5	0.56	0.6	0.85	0.7	0.7	0.71	0.64	M	High
North American Warm Desert Mesquite Bosque	Sonoran	0.45	NA	0.3	0.38	H	0.7	0.6	0.7	0.5	0.5	0.60	0.6	0.85	0.7	0.7	0.71	0.66	M	High
Desert Springs and Seeps	Mojave	0.35	NA	0.3	0.33	H	0.8	0.7	0.7	0.5	0.5	0.64	0.5	NA	1	1	0.83	0.74	H	Moderate
Desert Springs and Seeps	Sonoran	0.45	NA	0.2	0.33	H	0.8	0.7	0.7	0.5	0.5	0.64	0.5	NA	1	1	0.83	0.74	H	Moderate
Sonoran Palo Verde – Mixed Cacti Desert Scrub	Sonoran	0.45	0.21	0.62	0.43	H	0.8	0.7	0.9	0.84	0.72	0.79	0.7	0.7	0.7	0.4	0.63	0.71	H	Moderate
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	Sonoran	0.45	0.39	0.6	0.48	H	0.9	0.6	0.9	0.7	0.38	0.70	0.7	0.63	0.7	0.6	0.66	0.68	M	High
Sonora-Mojave Mixed Salt Desert Scrub	Sonoran	0.45	0.21	0.6	0.42	H	0.9	0.7	0.9	0.4	0.38	0.66	0.5	1	0.7	0.8	0.75	0.70	H	Moderate
North American Warm Desert Active and Stabilized Dunes	Sonoran	0.45	NA	NA	0.45	H	0.9	0.85	0.9	0.7	NA	0.84	0.85	0.7	0.4	0.3	0.56	0.70	H	Moderate
Apacherian-Chihuahuan Semi-Desert Grassland	Sonoran	0.45	0.24	0.86	0.52	M	0.6	0.5	0.9	0.8	0.43	0.65	1	0.5	0.7	0.4	0.65	0.65	M	Moderate

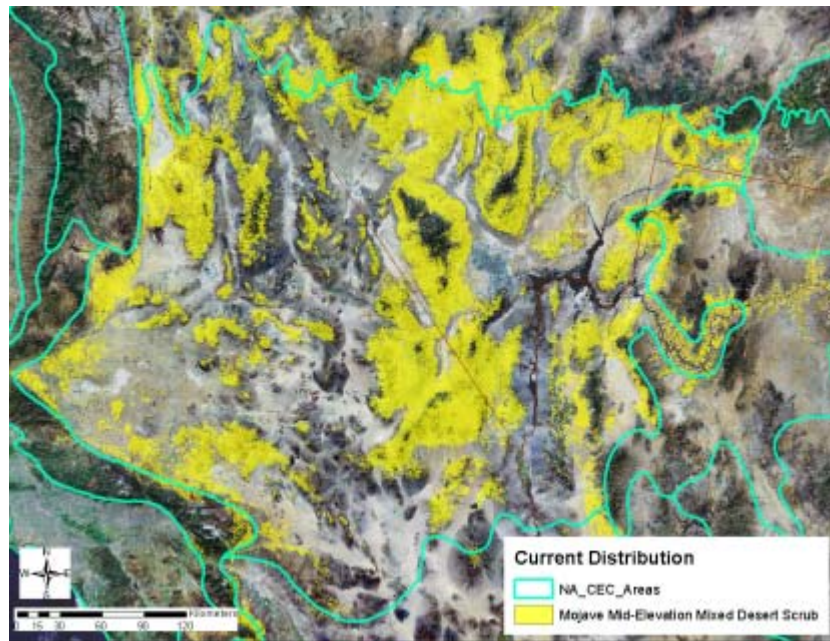
Type Summaries

Here are included three examples of summaries of the natural community types treated in this effort. These examples include Mojave Mid-elevation Mixed Desert Scrub, North American Warm Desert Riparian Woodland and Shrubland, and Sonoran Palo Verde Mixed Cacti Scrub. These three types represent a cross-section of treated types, and well characterize the range of results for both vulnerability assessment and for adaptation strategy development. All type summaries are found in Appendix 3.

Mojave Mid-Elevation (Joshua Tree-Blackbrush) Desert Scrub

CONCEPT

This ecological system represents the extensive desert scrub in the transition zone above Creosote-Bursage desert scrub and below the lower montane woodlands (700-1800 m elevations) that occur in the eastern and central Mojave Desert. It is also common on lower piedmont slopes in the transition zone into the southern Great Basin. The vegetation in this ecological system is quite variable. Codominants and diagnostic species include *Coleogyne*



ramosissima, *Eriogonum*

fasciculatum, *Ephedra nevadensis*, *Grayia spinosa*, *Lycium* spp., *Menodora spinescens*, *Nolina* spp., *Opuntia acanthocarpa*, *Salazaria mexicana*, *Viguiera parishii*, *Yucca brevifolia*, or *Yucca schidigera*.

Less common are stands with scattered Joshua trees and a saltbush short-shrub layer dominated by *Atriplex canescens*, *Atriplex confertifolia*, or *Atriplex polycarpa*, or occasionally *Hymenoclea salsola*. In some areas in the western Mojave, *Juniperus californica* is common with the yuccas. Desert grasses, including *Achnatherum hymenoides*, *Achnatherum speciosum*, *Muhlenbergia porteri*, *Pleuraphis jamesii*, *Pleuraphis rigida*, or *Poa secunda*, may form an herbaceous layer. Scattered *Juniperus osteosperma* or desert scrub species may also be present.

Overall Climate Change Vulnerability Score: High

DIRECT EFFECTS

Forecasted Climate Stress Index

Result 0.35 **High Sensitivity**

For the distribution of this community type within the Mojave Desert, 2060 forecasted temperatures in the months of July-September define this stress, with increases reaching extremes of 9 degrees F. Climate

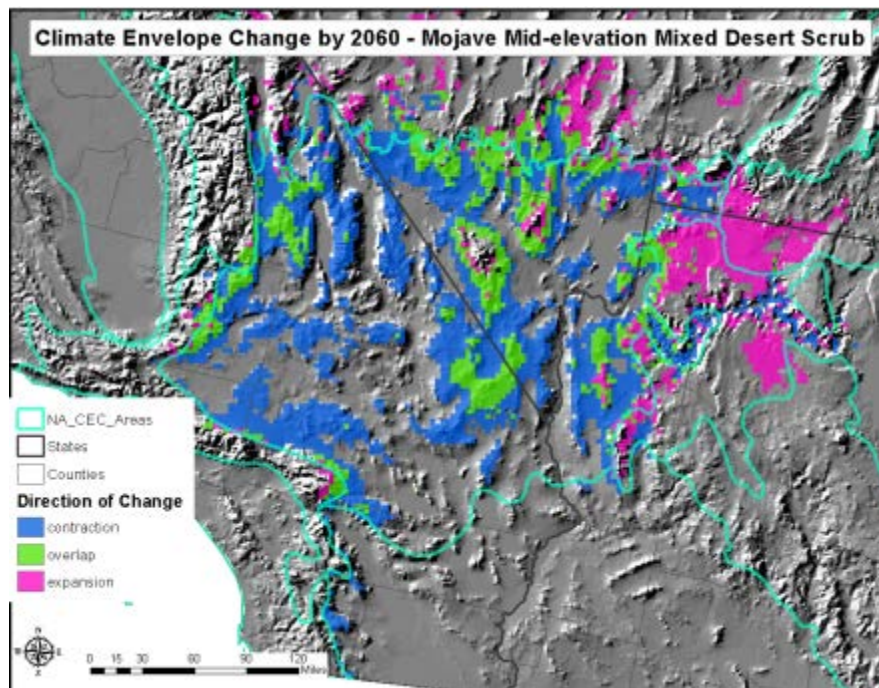
models indicate that the Mean Maximum (daytime) Temperatures for July-August and Mean Minimum (night-time) Temperatures for June-September will increase by approximately 6 degrees F) for the majority of the Mojave Desert. The increased aridity from additional evapo-transpiration will likely cause decline in vegetation cover especially at the lower, hotter elevation sites. The model results also indicate a 0.9 inch (0.3-3.0 inch) increase in mean precipitation in August for the Spring Mountains and other nearby ranges.

The stress of increased mid-summer temperatures could take several forms. While many plants are already dormant, there may be interacting effects from wildlife if isolated springs dry up sooner. If additional moisture does occur in August, it could locally favor pinyon-juniper woodlands and other higher elevation communities commonly located adjacent to this desert scrub. There could also effects on cryptobiotic soil crusts, which are vulnerable to wetting without time to recover carbohydrate losses. They are adapted to arid summers and can get killed by multiple wetting. They are stabilize soils and could form a key functional group of species for soil stabilization.

Forecasted Climate Envelope Shift Index

Result **0.12 High Sensitivity**

A substantial shift from the current climate envelope suggests potential movement of species from this community into the higher elevation pinyon-juniper woodlands and invasion from lower elevation stands of creosotebush desert scrub. This lower elevation conversion could be composed of shorter-lived, faster colonizing species such as *Ambrosia dumosa*, and years later, *Larrea tridentata*.



Dynamic Process Forecast

Fire Regime Departure Index 2060:

Result **0.44 High Sensitivity**

While currently this community is somewhat departed from natural conditions (see indirect effects), largely by increase fire frequency resulting from invasion of non-native annual grasses, simulation models indicate a continued trend toward significant fire regime departure by 2060.

INDIRECT EFFECTS

Landscape Condition 1960:

Result **0.70 High Resilience**

In 1960, land conversion from urbanization had begun. Impacts from the transportation infrastructure (fragmentation) consisted of a several highways and railroad lines and a sparse network of unimproved roads. Major economic activities with ecological impacts were mining (high intensity localized disturbance), cattle grazing (variable intensity, concentrated in areas), and military training and development near Las Vegas. Intensive cattle grazing dates back to the 1920s, with many Mojave yuccas were pulled or otherwise impacted.

Landscape Condition 2010:

Result **0.60 Medium Resilience**

Fragmenting effects of urbanization have increased since 1960; primarily in concentrated areas surrounding established development (e.g., Las Vegas). Current ecological impacts from transportation (fragmentation), mining (high intensity localized disturbance), and recreation use (ORVs) has also increased. Increase in off-highway vehicles and urbanization and less grazing has occurred since 1990 due to protection of tortoise. Overall though, this type remains the most heavily used type for cattle grazing in the Mojave Desert (Keeler-Wolf 2007).

Invasive Species Effects 1960:

Result **0.7 High Resilience**

Invasive, non-native plant species such as annual grasses *Bromus rubens* and *Schismus barbatus* invaded much of the Mojave Desert largely introduced from historic cattle grazing. While present and established by 1960, its relative impact was presumed to be limited.

Invasive Species Effects 2010:

Result **0.45 Low Resilience**

Current spatial models suggest a massive expansion of introduced, non-native plant species since 1960. Invasion of non-native grasses have increased fire frequency and led to destruction of fire sensitive desert scrub (Sawyer et al. 2009).

Dynamic Process Alteration

Fire Regime Departure Index 2010:

Result **0.70 High Resilience**

Introduction of fine fuels have an increasing effect on this types throughout many portions of the Mojave Desert. While significant departure has occurred in concentrated areas throughout the ecoregion, overall scores for the ecoregion keeps this score just within the range of 'high' resilience.

ADAPTIVE CAPACITY

Diversity within Plant/Animal Functional Groups:

Result **0.9 High Resilience**

The key species functional group is species that are tolerant to severe drought (severity and length). The diversity of characteristic dominant species is high (33 species). *Additional consideration should be given for treatment of cryptobiotic soil crusts within this category.*

Keystone Species Vulnerability:

Result **0.78 High Resilience**

Species were tentatively identified as those that could likely have cascading ecological impacts on community function. Selection criteria included dominant plant species and pollinators for *Yucca*. Once selected, a climate change vulnerability index was scored for their distribution within the ecoregion. Categorical scores were transformed to a 0.0 – 1.0 scale and averaged together for an overall index score.

Blackbrush (*Coleogyne ramosissima*) (0.7 High)

This species might be moderately vulnerable to climate change effects in the region, despite its high genetic variation and reliance on a variety of methods for seed dispersal. The increased vulnerability may be the result of changes in the moisture availability within the assessment area. Given these caveats, a 0.7 score still placed it within the high resilience range.

Black-throated Sparrow (*Amphispiza bilineata*) (1.0 High):

This bird may not be vulnerable to climate change in the region. Although it may be negatively affected by possible land use changes resulting from human responses to climate change and could experience detrimental effects from projected changes in moisture availability, it is a good disperser and ecologically versatile.

Yucca moth (*Tegeticula synthetic*) (West Mojave) (0.7 High)

Although this species may be a fairly good disperser and is associated with common geological features or derivatives, it may be negatively affected by projected changes in moisture availability. It is dependent on just one plant species (Joshua tree) for habitat and food, and that plant may be highly vulnerable to climate change within the assessment region. It could be negatively affected by land use changes resulting from human responses to climate change. Overall, it may be moderately vulnerable to climate change, but its borderline score of 0.7 places it with the high resilience category.

Yucca moth (*Tegeticula altiplanella*): (East Mojave) (0.7 High)

Although this species may be a fairly good disperser and is associated with common geological features or derivatives, it may be negatively affected by projected changes in moisture availability. It could be negatively affected by land use changes resulting from human responses to climate change. It is dependent on just one plant genus (*Yucca*) for habitat and food (in this assessment, yuccas were assumed to be at least somewhat vulnerable to climate change within the assessment region). Overall, the moth may be moderately vulnerable to climate change, but its borderline score of 0.7 places it with the high resilience category.

Bioclimate Variability:

Result **0.7 High Resilience**

This type occurs in a moderately high number of isobioclimates (14/20) which is expected for a widespread type. It therefore is placed into the high resilience category.

Elevation Range:Result **0.5 Medium Resilience**

Number of 500' (152 m) elevation belts that encompass the type distribution is 6 of 12. It therefore is placed into the medium resilience category.

Expert Workshop: Ecosystem Stressor Worksheet

Non-Climate Stressor	Current Scope	Current Severity	2060 Climate Scenario	Description of linkages to CC scenarios	Mgmt Opportunity
Altered fire regime, invasive plants Rank 1	High	moderate	Increased summer temp, possible summer moisture through storm events	likely with range where invasives will not be limited by increasing aridity	Same as creosote-bursage
N deposition, ozone Rank 2					low
Livestock grazing Rank 3	Hi – mod locally	Hi-mod locally			High
Military training Rank 3	L	L			Same as above

Climate Stressor	Current Scope	Current Severity	2060 Climate Scenario	Description	Mgmt Opportunity
Summer precipitation effects on cryptobiotic soil crusts	low	low	Increased summer temp, possible summer moisture through storms		Mod. protections from all forms of surface disturbance

Potential Climate Change Adaptation Strategies**Agency Management Goals related to this community type:**

FWS: keep intact for desert tortoise and plant recovery, water development for game species

USFS: Recreation opportunities

“No-regrets” actions to take within the next 5 years:

- Invest resources into minimizing effects of fire using strategic planning – reduce response time to fires in year after high rains in Nov/Dec
- Soil stabilization
- Control of off road vehicles
- Restore hydrological function e.g., improve culverts, restore flows, remove diversions, prevent soil compaction, maintain natural litter fall, restore natural channels where altered, ensure herbicide application allows biomass to remain

- Closer management of grazing intensity
- Fine fuel reduction
- Prevention and control of invasive plants
- Reduce drought stress through thinning in PJ
- Reduce drought stress by preventing soil compaction in salt desert and creosote and blackbrush

Anticipated actions over the coming 5-15 years:

- Consider water developments where springs are drying up.
- Consider earthwork modifications that increase residence time of water in an area (check dams, low long berms)
- Encourage discussions among botanists, entomologists, etc. to develop indicators of ecosystem health and use these to guide adaptive management of all these habitats.
- Develop decision support system and adaptive management for when not to intervene and how to intervene
- Land Fire improvement: complete field verification of existing map and model outputs and monitor with aim to evaluate their predictions
- Downscaling CC modeling to a useful scale; need to determine what scales are useful for which purposes.
-

Wait and watch actions: Potential actions to anticipate over the 15-30 timeframe, with indicators to monitor and inform that future decision

- #1 How successful are re-vegetation efforts and mitigations that have been used?
- #2 Soil crust impacts, succession, function, under changes in rainfall pattern

Research and Monitoring Priorities

- Monitor effectiveness of mitigations for renewable energy impacts
- Research how to use mitigations to alleviate climate change – opportunistic, open ended
- Impacts of retiring grazing allotments – not only to protect desert tortoise, contrast where still in effect, and controlled livestock in vegetation near conservation areas.
- Monitor extent of nitrogen and ozone deposition and impacts to vegetation & nutrient cycling.
- Large scale fuel reduction strategies for adjacent creosote scrub, and use of additional pathogens.
- Monitor invertebrates that are key to ecosystem services and processes
- Research – focus on plant pollinator relations (rare plants)
- Pollutant/toxic impacts under climate change
- We talk about what we are losing, but not about what we are gaining. May want to manage for the changes. Is it all going to become desert pavement? What do we want to facilitate that provides the ecological services?
- Do we have our monitoring set up to pick up the shifts in functional groups?

North American Warm Desert Riparian Woodland, Shrubland and Stream

CONCEPT

This ecological system consists of low-elevation (<1200 m) riparian corridors along medium to large perennial streams throughout canyons and desert valleys of the southwestern United States and adjacent Mexico. Major rivers include the lower Colorado (into the Grand Canyon), Gila, Santa Cruz, Salt, lower Rio Grande, and the lower Pecos. The vegetation is a mix of riparian woodlands and shrublands.



Dominant trees include *Acer negundo*, *Fraxinus velutina*, *Populus fremontii*, *Salix gooddingii*, *Salix lasiolepis*, *Celtis laevigata* var. *reticulata*, *Platanus racemosa*, and *Juglans major*. Shrub dominants include *Salix geyeriana*, *Shepherdia argentea*, and *Salix exigua*. Woody vegetation is relatively dense, especially when compared to drier washes, and phreatophytes draw alluvial groundwater from below the streambed elevation when surface flows stop. Alluvial groundwater levels depend on seasonal precipitation and runoff, and on basin-scale hydrogeology including connections between the alluvial aquifer and surrounding basin-fill and bedrock aquifers. Vegetation depends for growth and reproduction upon annual or periodic flooding and associated sediment scour and/or on annual rise in the water table, with this rise driven by precipitation. The system thus depends on both surface and groundwater regimes, and is sensitive to changes in both.

Overall Climate Change Vulnerability Score: High (Mojave Desert)

Overall Climate Change Vulnerability Score: High (Sonoran Desert)

DIRECTS EFFECTS

Forecasted Climate Stress Index:

Mojave Desert Result **0.35 High Sensitivity**

Sonoran Desert Result **0.45 High Sensitivity**

Sonoran Desert may warm by, on average, 2-4 degrees F; whereas the Mojave Desert is predicted to have a 4-9 degree F increase. Precipitation is less predictable. If precipitation increases significantly, this may change the timing or magnitude of peak and low stream flows which may be beneficial to some species and detrimental to others. Given the higher probability of warming, the stress on component species is high for drought and heat intolerant species. With the higher uncertainty on how precipitation may change, it is difficult to rate the stress this may have on this ecosystem. The direct effect on the hydrologic regime is considered separately.

Dynamic Process Forecast

Hydrologic and Fire Regime Change 2060:

Mojave Desert Result **0.3 High Sensitivity**

Sonoran Desert Result **0.3 High Sensitivity**

Current and forecasted trends in both deserts show potential for moderate increases in precipitation in July and August months; although some models show a decrease or no change in the amount of moisture. The latter could result in:

- **higher evapo-transpiration rates** leading to an earlier, more rapid seasonal drying-down of stream/riparian communities;
- **increased water stress** in nearby basin-floor phreatophyte communities (e.g., Mesquite Bosque), and later, less frequent, briefer wetting of nearby playas;
- **shrinkage of areas of perennial flow/open water**, coupled with higher water temperatures at locations/times when water temperatures are not controlled by groundwater discharges or snowmelt;
- persistence of these hydrologic conditions later into the fall or early winter; and
- **reduced groundwater recharge** in the mountains and reduced recharge to basin-fill deposits along the mountain-front/basin-fill interface.
- Where increases in precipitation, especially in July and Aug, might occur this may result in:
- Increased soil erosion from increased surface flows, which may negatively impact water quality;
- Increased stream flow magnitude in summer time;
- No change, as these results from Sonoran have not yet been compared to historic variation in precipitation.
-

Increased fire frequency and intensity in the watersheds of these systems will have enormous post-fire effects on riparian systems.

- Increased winter precipitation causes increased fire in low/mid elevation shrublands, which causes decreased short-term evapotranspiration. This leads to increased groundwater recharge, which increases post-fire runoff, changing riparian geomorphology and water chemistry.
- Long-term decreased precipitation (e.g., drought) causes increased fire in woodlands and forests, which causes decreased evapotranspiration. This leads to increased groundwater recharge, which increases post-fire runoff, changing riparian geomorphology and water chemistry.
- Example 1: Mogollon Rim. Decreased precipitation caused increased fire intensity/size/frequency, which led to increased post fire watershed effects to downstream riparian and spring systems.
- Example 2: Increased August precipitation in high-elevation woodlands caused increased intensity post-fire watershed events following June fires.

Fires also have direct effects on these systems, changing water chemistry, increasing invasive spp. spread, and increasing inflammability.

Primary concerns include:

- **Increased flammability** due to tamarisk and fountain grass causes increased fire frequency and fuel continuity, which results in changes in species composition and structure.
- Many of the hydrological regime changes could be exacerbated by fire.
- Compounding effects of in situ climate change on **post-fire regeneration of dominant species** (e.g., mesquite regeneration by seed germination).

INDIRECT EFFECTS

Landscape Condition 1960:

Mojave Desert Result 0.6 Medium Resilience

Sonoran Desert Result **0.6 Medium Resilience**

Ample evidence suggests Native American impacts in the Salt/Gila basin from their own irrigation systems. Ranching and farming have been drawing groundwater and diverting surface water from the relevant streams/rivers since the late 1800s. Maps of the extent of perennial flow in Arizona, for example, show a drastic decline that started in the late 1800s, due to diversions and groundwater withdrawals. Physical collapse of basin-fill aquifers due to the groundwater removal, date to the mid-1900s; along with the effects of domestic livestock grazing. This would have significantly altered the distribution of this community type, greatly reducing its extent.

Landscape Condition 2010:

Mojave Desert Result **0.4 Low Resilience**

Sonoran Desert Result **0.4 Low Resilience**

The Sonoran Desert has a very similar footprint to the Mojave Desert with several large urban and agricultural areas along with many relatively unfragmented watersheds. Long-distance canals and impoundments feed water to urban areas and cause impacts from a great distance. There are also cumulative effects of groundwater withdrawals from ranches and numerous small towns. Intensive farming along the riparian corridors fragments floodplain and riparian habitat. Riparian corridor areas are impacted by domestic livestock grazing that reduces bank stability and causes high soil erosion, channel widening and increased in-channel water temperatures. In addition there are watershed-scale impacts of domestic livestock grazing, including soil compaction and removal of runoff-retaining vegetation.

Invasive Species Effects 1960:

Mojave Desert Result **0.5 Medium Resilience**

Sonoran Desert Result **0.7 High Resilience**

Historic cattle grazing introduced invasive plant spp. Late-19th -early 20th century. Deliberate introductions of tamarisk, Russian olive, and annual grasses in residential areas and grazing lands brought these species into riparian corridors.

Invasive Species Effects 2010:

Mojave Desert Result **0.4 Low Resilience**

Sonoran Desert Result **0.5 Medium Resilience**

The current extent of exotic species is incompletely mapped, however spatial models of areas within the United States likely to contain significant amounts of tamarisk, Russian olive, and annual grasses indicate >50% of the riparian areas are affected. In addition, there are aquatic invasive species such as mollusks, non-native fish, bullfrogs and crayfish, which could completely change the aquatic food chain dynamics and eliminate native aquatic species.

Dynamic Process Alteration

Hydrologic Change 2010:

Mojave Desert Result **0.4 Low Resilience**

Sonoran Desert Result **0.4 Low Resilience**

Agricultural and residential/urban use has dropped groundwater levels significantly, already reducing or eliminating many gaining reaches. This began in the late 1800s, and the effects were coupled with a climate-change episode and/or impacts of cattle grazing on watershed runoff (the debate is ongoing) that resulted in a period of significant channel downcutting during the 1930s across the Sonoran region. This resulted in the death of large riparian woodlands on what became hydrologically stranded elevated terraces, and re-establishment of the system on new lower terraces that the entrenched streams carved out.

ADAPTIVE CAPACITY

Diversity within Plant/Animal Functional Groups:

Mojave Desert Result **0.8 High Resilience**

Sonoran Desert Result **1.0 High Resilience**

These communities include a variety of plant and animal life, from woody phreatophytes to warm season grasses, and freshwater and alkaline tolerant species. Within each functional group there are a moderate number of species such as several warm season grasses that are alkaline tolerant, several broad-leaf woody tree and shrub species although none are nitrogen fixers, and multiple nutritious forb species.

Keystone Species Vulnerability:

Mojave Desert Result **1.0 High Resilience**
Sonoran Desert Result **0.85 High Resilience**

American Beaver (*Castor canadensis*) (tbd)

This species plays an obvious ‘keystone’ role in stream and riparian ecosystems where they occur. They would only be expected to occur in the largest portions of this system along the eastern margins of the Sonoran Desert. Evaluation of their relative vulnerability to climate change within this ecoregion has yet to be completed.

The following two species were selected for their relative structural contributions to these communities, with cottonwoods forming primary tree canopy constituents, and indicative of functioning hydrodynamics. Gilded flicker was chosen due to its cavity-nesting behavior and related influence on other species habitat requirements.

Fremont's cottonwood (*Populus fremontii*) (1.0 High)

This species might be potentially stable (with high confidence) in the region despite climate change effects. This may be a result of high genetic variation in Fremont cottonwood that affects whole-tree physiological processes which help adapt a tree to its environment including whole-tree water use and also net primary productivity.

Gilded flicker (*Colaptes chrysoides*) (1.0 High)

This species exhibits characteristics that both increase and decrease its vulnerability to climate change, but overall it may not be vulnerable to climate change and might actually expand its range in the region. It relies heavily on a small number of species that are critical in providing suitable habitat, and land use changes resulting from human responses to climate change could affect it, but these may be overcome by the bird's good dispersal abilities and other aspects of its ecological versatility.

Bioclimate Variability:

Mojave Desert Result **0.8 High Resilience**
Sonoran Desert Result **0.8 High Resilience**

This community could occur throughout all local climate regimes that characterize the Mojave, Sonoran, and Chihuahuan deserts. This type occurs in a high number of isobioclimates (16/20).

Elevation Range:

Mojave Desert Result **0.6 Medium Resilience**
Sonoran Desert Result **0.6 Medium Resilience**

Type is limited to elevations <1200 m (3950 ft). This community occurs within a relatively narrow elevation range. Number of 500ft (152m) elevation belts that encompass the type distribution is 8 of 12.

Expert Workshop: Ecosystem Stressor Worksheets

Non-Climate Stressor	Current Scope	Current Severity	2060 Climate Scenario	Description of linkages with CC scenario	Mgmt Opportunity
Human overpopulation Recreational uses	H	H	Y = potential interaction	Hotter temps means that people will aggregate more in cool, wet places.	M

Non-Climate Stressor	Current Scope	Current Severity	2060 Climate Scenario	Description of linkages with CC scenario	Mgmt Opportunity
			with increased aridity and unpredictability in precipitation events	Warming temps will make riparian areas more restricted, so recreation will be more concentrated.	
Land use change (development, energy, agriculture)			Y	Solar panels require a lot of water for washing.	
Surface water withdrawal			Y	Less water will remain in perennial streams due to increased evapotranspiration.	
Groundwater depletion			Y		
Non-native herbivorous ungulates	M	H	Y	Will concentrate more around water. Legal cattle grazing may decrease because increased temps may make the activity no longer economically viable.	M/L US/Mex
Fire and post-fire watershed effects	L /but increasing	H	Y	Increasing variability in precipitation will increase fire frequency.	M
Invasive species -plants -animals (includes honey bees)	H	H	Y	Dry conditions can promote the growth of invasives.	Variable (site and sp specific)
Water flow control (dams, aqueducts) – Mainstem (includes trans-basin transport of water, e.g., Col. Riv. water going to LA)	H	H	Y	Climate change will influence the activities and maintenance of dams, which will have an influence on downstream riparian communities.	L
Water flow control (dams, aqueducts) - Tributaries	H	H	Y	Same as for mainstem dams, but severity of the impact is greater.	M
Resource extraction (logging, mining)	L	H	N		H
Contamination/water quality	H	H	Y	Extreme storm events will wash more contaminants from urban areas and upper water sheds into riparian areas. Increased	H

Non-Climate Stressor	Current Scope	Current Severity	2060 Climate Scenario	Description of linkages with CC scenario	Mgmt Opportunity
				evapotranspiration will lead to lower water levels and therefore greater concentrations of contaminants.	
Air Pollution/nitrate deposition & acid rain	M	L-M	Y	Higher temps can lead to greater dust deposition.	

Novel Climate Stressor	Current Scope	Current Severity	2060 Climate Scenario	Description
Increased Water Temperature				Can be greater than physiological tolerances and therefore cause distributional shifts or contractions. Increase in metabolism and decrease in dissolved oxygen.
Increased in mean and maximum air temperature				Can be greater than physiological tolerances and therefore cause distributional shifts or contractions. Increase in metabolism. Increased evaporation and evapotranspiration. Increase in stress to plants and therefore lower vigor. Can cause de-synchronization of interspecific events. Some springs/seeps may go dry.
Shift in timing of precipitation events.				Plant regeneration could be threatened if there are no spring rains.
Shift in intensity of precipitation events.				Runoff, plant response and insect hatches are all related to rain intensity.
Shift in amount of precipitation.				Influences hydrogeology that maintains these systems. Can cause increased sp-specific mortality. Some springs/seeps may go dry.
Increase in extreme events (freezes, floods, heat waves, droughts, wind, and combinations of these)				Can cause shift in species composition and structure of habitat. Can exacerbate other nonclimate stressors (such fire, invasives).
All Climate Stressors				Climate events in watersheds beyond where these systems occur have a major influence on this system.
Context				These systems have many migratory species that are subject to climate and nonclimate stressors during stages of their life cycle occurring elsewhere.

Potential Climate Change Adaptation Strategies

Generalized strategies and notes:

- Protect and enhance riparian areas and the listed species that depend on them
- Preservation of remnant riparian areas to support migratory birds
- Protect upper watershed
- Reduce invasives
- Maintain biodiversity and processes (such as flooding)
- Maintain and enhance connectivity for fish
- Preserve scenery, water-based natural and cultural resources for public enjoyment
- Identify information needs of land managers, conduct research, and provide information

****This workshop breakout group had no fish advocate so didn't identify any fish-specific strategies, although they suggested ways to restore riparian habitat that will in turn benefit fish.*

“No-regrets” actions to take within the next 5 years:

- Water flow controls on tributaries
- Fully exercise water rights pertaining to protected lands (various legal mechanisms)
- Work with tribes to fully exercise water rights for mutual benefits.
- Work with agricultural water users to adjust timing and use of diverted water to benefit stream inflows.
- Explore management options for existing dams to maintain downstream riparian processes (e.g., controlled floods)
- Explore opportunities to manage return flows (e.g., stormwater, irrigation return, wastewater effluent) to benefit riparian resources and/or processes (geomorphology)
- Comprehensive aquifer mapping to better understand temporal and spatial connectivity between surface and groundwater.
- Improve engineering practices for diverting/allocating flows to maintain more in stream flow.
- Monitor surface flows and losses.
- Fix laws to better maintain in stream flows.
- Fire and invasives
- Increase resistance to fire by removing/controlling fire-tolerant invasive plants (e.g., buffelgrass, tamarisk)
- Selectively transition riparian forest species composition to meet target conservation species while reducing fire hazard (e.g., planting willow/cottonwood pockets to increase after tam beetle)
- Increase and maintain availability of plant propagules for restoration after fire/invasive species treatment (willow, cottonwood, grasses, others)
- Research drought and temperature tolerant genotypes for restoration.
- Education and management to prevent unplanned human ignitions in riparian and adjacent uplands
- Pre-plan post-fire response to minimize impacts of water impacts of watershed effects (EG debris flows, floatable debris, ask, etc) (site specific)
- Pre-plan for invasive species control and post treatment restoration (in general)
- Explore/research restoration techniques

- Monitor – ecological monitoring and treatment effectiveness to define baselines and implement adaptive management

Actions to anticipate over the coming 5-15 years:

- Manage water control structures at the system level to meet multiple demands (including in stream flows).

“Watch and Wait” Potential actions to anticipate over the 15-30 timeframe, with indicators to monitor and inform that future decision:

- All actions were categorized as research and monitoring priorities.

Research and Monitoring Priorities (numbers refer to number of votes by participants indicating priorities)

A. Invasives and restoration

- Modeling of spread through regions of greatest risk (with projected new climates)
- Invasive effects of system? (2)
 - Feral animal impacts on systems
 - Synergies, such as cattle/livestock grazing and buffleggrass and fountain grass invasions
- Identification of spring/seep species best for propagation and reintroduction
- Monitor treatment effectiveness (1)
- Monitor past disturbance restoration
 - early invasion
 - establishment of natives
- Research drought and temperature tolerant genotypes and species (1)
- Research restoration techniques to improve efficiency and effectiveness (6)
 - How to improve restoration of agricultural lands to mesquite bosques
- Ecological monitoring to define baselines (1)

B. Hydrology

- Need for spatial information linking recharge zones with springs and riparian systems (3)
- Where are the aquifers and which springs are dependent on which aquifers (1)
- How does recharge effect aquifer levels (2)
- What makes particular springs or riparian areas more vulnerable to climate change
- Better groundwater monitoring
- Better general understanding of hydrological regimes (7)
- Explore management options for existing dams to maintain riparian processes
- Explore opportunities to manage return flows (e.g., storm water, irrigation return, wastewater effluent) to benefit riparian resources and/or processes (geomorphology)
- Monitor surface flows and losses.
- Monitor flows, seasonality and temperature and water chemistry in springs. (1)
- How do we establish buffers around recharge areas?
- Inventory ephemeral drainages in mesquite systems (1)

C. Species traits

- Which species have the genetic diversity that make them better candidates for restoration in the context of climate change?
- What is the vulnerability of species at critical stages (e.g., seedlings) with increased climate variability? (5)
- Need more information about physiological temperature tolerances of key species. (3)
- Identify the species at risk that are especially vulnerable to climate change. (3)

D. Fire

-More information is needed about the natural history of fire in all three riparian/aquatic systems from this effort.

E. Keystone species

- Quantitative selection of keystone species? (5)
- Algae as keystone species for species and seeps?
- Need more thought on which keystone species to select.

F. Synchrony

- How precipitation and temperature influence phenology (identifying problem species) (3)

G. Identifying sensitive species

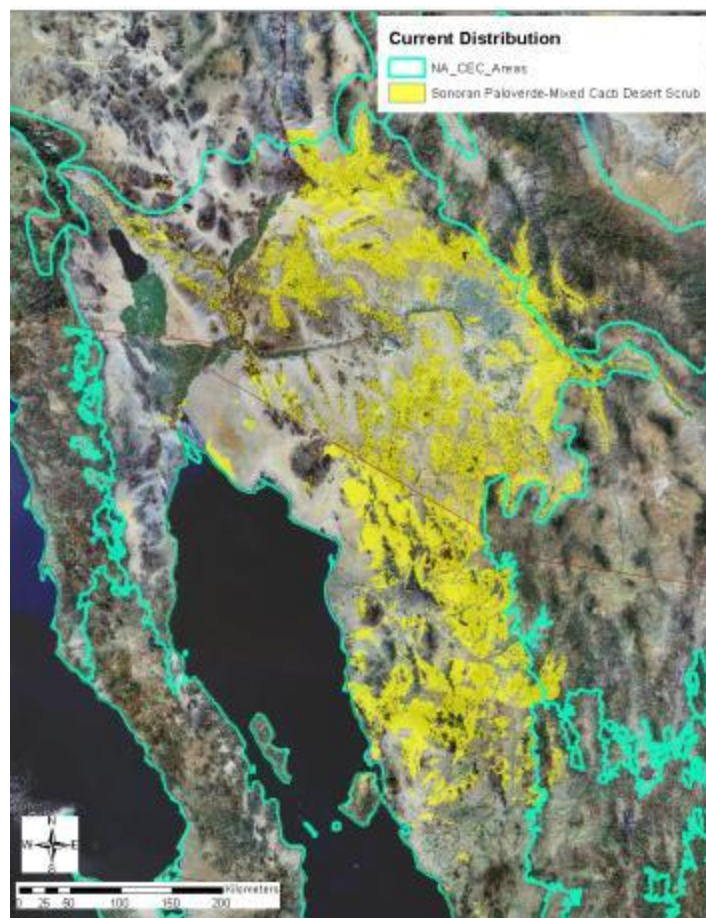
- Establish and maintain long-term monitoring of multi-species and community level variables so we will learn which species are sensitive and what the baseline normal variance is. (2)

Sonoran Palo Verde–Mixed Cacti Desert Scrub

CONCEPT

This ecological system occurs on hillsides, mesas and upper bajadas in southern Arizona and extreme southeastern California. The vegetation is characterized by a diagnostic sparse, emergent tree layer of *Carnegiea gigantea* (3-16 m tall) and/or a sparse to moderately dense scrub canopy co-dominated by xeromorphic deciduous and evergreen tall shrubs *Parkinsonia microphylla* and *Larrea tridentata*, with *Prosopis* spp., *Olneya tesota*, and *Fouquieria splendens* less prominent. Other common shrubs and dwarf-shrubs include *Acacia greggii*, *Ambrosia deltoidea*, *A. dumosa* (in drier sites), *Calliandra eriophylla*, *Jatropha cardiophylla*, *Krameria erecta*, *Lycium* spp., *Menodora scabra*, *Simmondsia chinensis*, and many cacti, including *Ferocactus* spp., *Echinocereus* spp., and *Opuntia* spp. (both cholla and prickly-pear).

The sparse herbaceous layer is composed of perennial grasses and forbs with annuals seasonally present and occasionally abundant. On slopes, plants are often distributed in patches around rock outcrops where suitable habitat is present. Outliers of this succulent-dominated ecological system occur as "Cholla Gardens" in the western Mojave in California. In this area, the system is characterized by *Opuntia bigelovii*, *Fouquieria splendens*, *Senna armata*, and other succulents, but it lacks the *Carnegiea gigantea* and *Parkinsonia microphylla* which are typical farther east. Adjacent and related communities are the Baja California del Norte Gulf Coast Ocotillo-Limberbush-Creosotebush Desert



Scrub (see description at <http://www.natureserve.org/infonatura/>). While there are floristic overlaps, these limberbush and elephant tree communities are not treated here.

Overall Climate Change Vulnerability Score: Moderate

DIRECT EFFECTS

Forecasted Climate Stress Index:

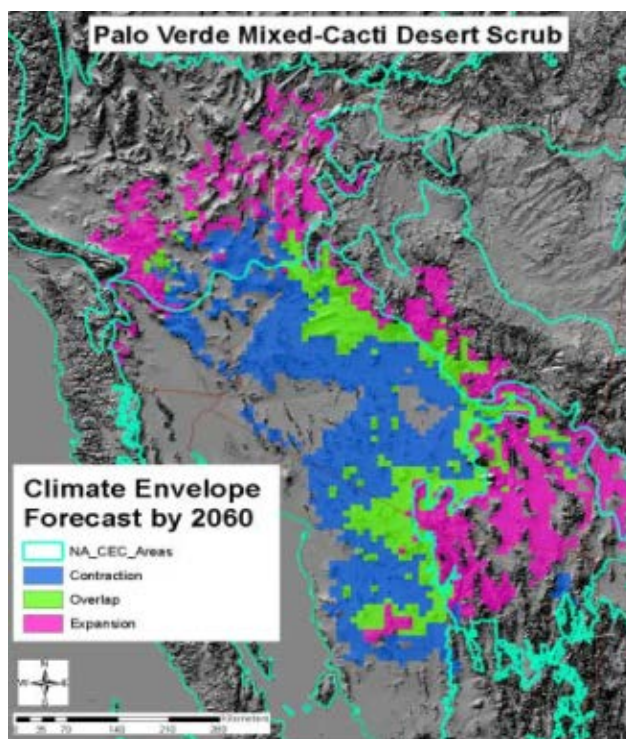
Result **0.45 High Sensitivity**

Climate forecasts from an ensemble of downscaled global climate models are summarized for the period around 2050-2060. These forecasts indicate the relative degree of forecasted climate stress, using forecasted change in temperature and precipitation between current and 2060. The Sonoran Desert may warm by, on average, 2-4 degrees F, whereas the Mojave Desert is predicted to have a 4-9 degree F increase. Precipitation is less predictable. If precipitation increases significantly, this may change the timing or magnitude of peak and low stream flows which may be beneficial to some species and detrimental to others. Given the higher probability of warming, the stress on component species is high for a drought and heat intolerant species. With the higher uncertainty on how precipitation may change, it is difficult to rate the stress this may have on this ecosystem.

Forecasted Climate Envelope Shift Index:

Result **0.20 High Sensitivity**

This spatial model indicates a very substantial contraction in bioclimate where this vegetation most likely co-occurs with creosote-bursage desert scrub, suggesting a potential expansion of creosotebush and related species throughout this portion of the distribution. A considerable area throughout the eastern margins of the Sonoran Desert contains the 'overlap' zone between current and 2060 bioclimate envelope locations, so while the relative percent area of overlap is low, the predicted core zone is contiguous. Local expert review of model output elicited comment that the prediction might be overstated.



Dynamic Process Forecast

Fire Regime Departure Index 2060:

Result **0.62 Medium Sensitivity**

The continued spread of invasive species as fine fuels may continue to introduce a fire regime into this desert scrub. The appearance of additional uncharacteristic successional states resulting from this explains patterns in current and forecasted departure. Local experts comment that the 2060 forecast may be somewhat overstated because increased aridity (higher temp, more/less temperature) may decrease invasive grass cover leading to decline in fuels needed to carry fires

INDIRECT EFFECTS

Landscape Condition 1960:

Result **0.8 High Resilience**

Historic ranching and agriculture took place throughout this vegetation; but until substantial urbanization and irrigated agriculture began, their proportional influence was limited. However, concentrated impacts from livestock may have been more substantial throughout the Plains of Sonora.

Landscape Condition 2010:

Result **0.7 High Resilience**

With expanded urbanization and irrigated agriculture, more substantial proportions of these communities have been affected by landscape fragmentation.

Invasive Species Effects 1960:

Result **0.9 High Resilience**

Building upon spatial model results for current conditions, a review of literature and historical maps supported a relative expert judgment. Past ranching and grazing would have introduced a number of invasive plant species by this time, but their overall distribution and impact would have still been somewhat limited.

Invasive Species Effects 2010:

Result **0.84 High Resilience**

Invasive plant species, such as buffelgrass (*Penstemon ciliare*) and other species, have been expanding their distribution and ecological impact by introducing fire regimes in this community types over recent decades. Current spatial models, albeit limited to US distribution, indicated 16% of the current extent infested with substantial invasive plant species (BLM Sonoran Desert REA 2012).

Dynamic Process Alteration

Fire Regime Departure Index 2010:

Result **0.72 High Resilience**

The introduction of invasive species as fine fuels has introduced a fire regime into this desert scrub. The appearance of additional uncharacteristic successional states resulting from this explains patterns in current and forecasted departure.

ADAPTIVE CAPACITY

Diversity within Plant/Animal Functional Groups:

Result **0.9 High Resilience**

Key ecological function species group is species responses to drought (severity and length), which has high diversity of characteristic dominant species with adaptations to drought (drought deciduous, (33 species).

Keystone Species Vulnerability:

Result **0.7 High Resilience**

Gilded flicker (*Colaptes chrysoides*) (1.0 High): This species exhibits characteristics that both increase and decrease its vulnerability to climate change, but overall it may not be vulnerable to climate change and might actually expand its range in the region. It relies heavily on a small number of species that are critical in providing suitable habitat, and land use changes resulting from human responses to climate change could affect it, but these may be overcome by the bird's good dispersal abilities and other aspects of its ecological versatility.

Littleleaf Paloverde (*Parkinsonia microphylla*) (0.7 High): This species might be highly vulnerable (with moderate confidence) to climate change in the region, mainly due to proposed changes in moisture availability (the species is inherently tied to the summer rains) and the effects of climate change on seed dispersal. As a result, the species range may shift and perhaps leave the assessment area.

Saguaro Cactus (*Carnegiea gigantea*) (0.5 Low): This species might be highly vulnerable (with moderate confidence) to climate change in the region mainly due to forecasted changes in moisture availability, and its dependence on other species that might be affected by climate change for seed dispersal. The species range might shift and/or perhaps leave the assessment area.

Bioclimate Variability:

Result **0.7 High Resilience**

This type occurs in a moderately high number of isobioclimates (13/20) which is expected for a widespread type.

Elevation Range:

Result **0.4 Low Resilience**

Number of 500' (152 m) elevation belts that encompass the type distribution is quite limited; with 5 of 12.

Expert Workshop: Ecosystem Stressor Worksheets

Non-Climate Stressor	Current Scope	Current Severity	2060 Climate Scenario	Description
Burro and cattle grazing	High	High/M	Increased summer temperature and variable change in precipitation	No
Loss of pollinators	Low	Unknown		Yes (mining)
Illegal and military activities 100 miles around border (direct surface effects, fragmentation, noise, and fire ignitions)	Med	High		No

Off highway vehicles	Low	Moderate		No
invasive vegetation (buffel grass) and altered fire regime	Moderate	high		Yes (grazing, OHV, urbanization can increase invasives as well)
Urbanization and development including agriculture	Moderate	High		no
Mining (especially in Sonora MX)	Low	High		no
Wood-collection	Low	High		
Roads, canals	Low	high		
Disease, pathogens, pest outbreaks	Low	Unknown		
Decline in genetic variability	Low	Moderate		Limited to rare species

Novel Climate Stressor	Current Scope	Current Severity	2060 Climate Scenario	Description
Plant species die-off and lower recruitment associated with warming, extreme drought	L	unknown	Increased summer temperature and variable change in precipitation	already observed, rate of die-off exceeding recruitment
Rapid loss of soils, erosion, dust storms	L	unknown		
Effects of changes of phenology	L	unknown		
Increased variability of precipitation, temperature including extreme events and effects on populations and processes	L	unknown		
Increased solar radiation (less atmospheric moisture) leading to declines in herps	L	unknown		
less water availability in tinajas affects mammals depend upon them	L	unknown		
drought = less plant production = increase herbivory xero-riparian systems	L	unknown		

increased temps and possibly reduced rainfall will lead to less water available for mammals and birds				

Potential Climate Change Adaptation Strategies

Non climate-change Stress: Invasive grass/altered fire regime

Management Intervention: NOTE: within the State of Sonora, state agency primarily provides technical assistance in management planning to private landowners, vs. most US participants who are land managers themselves, with their own planning processes.

When buffelgrass / invasive veg: mechanical removal for small infestations, spraying for large infestations. Mechanical thinning at high-probability ignition sites (e.g., roadsides) and around other sensitive resources.

Novel climate-change Stress: Shifts in seasonality of Precipitation

Management Intervention: monitoring to detect severe shortage, and then subsidize locally with water tanks. Need to look at more investment in water storage.

Novel climate-change Stress: Shifts in Phenology

Management Intervention: monitoring to detect shift to gauge relative vulnerabilities for sensitive resources; i.e., need to understand the nature of phenology change before strategies could be considered. E.g., this year blooming season occurred earlier, especially with trees and columnar cacti.

Primary strategy: establish phenology monitoring program targeting key phenologies of likely influence on sensitive resources.

Novel climate-change Stress: Loss of pollinators

Management Intervention: a) Establish monitoring program b) compare blooming seasons with pollinators (Lepidoptera / migratory pollinators [arrival vs. departure]) c) detect change in behavior of pollinators (specialists and generalists) d) detect changes in bat populations, and e) protect roost colonies in caves (those not currently protected). Detect changes in flower/fruit decline?

“No-regrets” actions to take within the next 5 years:

- Fine fuel reduction (exotic annual grass control) and fire suppression in this fire sensitive system.
- Closer management of grazing intensity
- Planning to maintain contiguous natural blocks
- Aggressive prevention and control of invasive plant species
- Aggressive management of wildland fire

Anticipated actions over the coming 5-15 years:

- Develop monitoring program for bats to detect changes in populations and work towards protecting habitats
- Implement a phenology monitoring protocol to document changes in timing of blooming for columnar cacti and effects on pollinators
- Hold workshops that bring together all managers that focus on an important species, and use workshop to share information (e.g., phenology, abundance), develop hypotheses of change (e.g., bat conservation international)
- Evaluate, share, analyze existing weather station information across managed areas, states, countries; and develop strategy to prioritize locations for new stations.
- Increasing fire ignition with drought years, and expanding fire patch size
- Increased densities of invasive plant populations
- In cases where phenology changes are detected, work with partner land management agencies in places that are more appropriate or suitable for bats
-

Potential actions to anticipate over the 15-30 timeframe, with indicators to monitor and inform that future decision:

Research and Monitoring Priorities

- What is the capacity for invasive grasses to expand and therefore shift fire regime?
- Within the Sonoran Desert, what are the indicator and keystone species and what is the impact of their loss?
- How do you characterize adaptive capacity for sparsely vegetated systems (e.g. sand dunes)?
- What are the displacement effects of invasive species in creosote-bursage system?
- Are soil crusts susceptible to climate change and to what degree?
- What is the potential of strategy to inoculate soils for soil crusts?
- Need guidance and best practices on efficient monitoring protocols to track and detect plant community change associated with climate change.
- What is the relationship of precipitation regime (e.g. seasonal precipitation patterns) with plant recruitment?
- What are the contributing factors and pattern to recent plant die-off in Sonoran Desert ecological systems?
- Need a study that identifies pollinators that serve a keystone role in Sonoran Desert ecological systems.

Discussion

The intent of this pilot effort was to explore approaches to documenting relative climate-change vulnerabilities among major natural communities occurring across managed areas of the Mojave and Sonoran deserts. By integrating available information, this effort identified a) variability in current knowledge and data within these two deserts and across national borders, and b) the relative applicability of this information to climate-change adaptation strategy development. A brief discussion follows identifying some key lessons learned from this pilot effort.

CC Vulnerability Assessment for Communities and Habitats

This effort drew inspiration from many similar efforts on the overall structure, measurements used, and available data. By first assembling the data and completing preliminary analysis, local experts were able to review and critique the approach and preliminary results. This process led to a number of refinements in the approach, HCCVI structure, and results for each community type. The overall approach, attempting to apply a systematic framework to climate change vulnerability assessment, followed by its application to identifying adaptation strategies, appears to have been successful. It also appears that by selecting a clear timeframe for assessment; i.e., “CC vulnerability within the next 50 years” brings a meaningful focus for application to decision making. Specific lessons learned regarding the linkages between vulnerability assessment and adaption strategy development are addressed below.

A number of issues with methodology for the HCCVI were identified through this pilot. Some measures of vulnerability are intended as relative measures, comparing results for a wide diversity of community types. For example, measures of bioclimate variability or elevation range for each community type were relative scores based on an overlay of several hundred mapped community types from across the western United States and (for elevation range) adjacent Mexico. This aspect of the approach – utilizing nationally or regionally available spatial data to generate relative scores – presents the opportunity to rapidly develop preliminary scores for many community types. These preliminary results can then feed into refinements by local experts. However, while those two scores (bioclimate variability and elevation range) are easy to replicate for community types across the conterminous United States, a similar measure for bioclimate variability may be more challenging to develop at this time for Mexican communities.

Of most significant challenge methodologically is the application of the climate stress index. In this pilot, prior spatial analysis for the Mojave Desert was easily applied for the types, and likely provides a robust method for gauging relative climate stress by 2060. A weighted averages of monthly climate variables forecasted to have statistically significant departures from the 20th century baseline values goes quite directly towards the intent of this measure. However, we were not able to apply that same method for communities in the Sonoran Desert, and in order to arrive at a robust relative measure, this same type of analysis needs to be replicated with many community types across North America. Alternative methods to gauging climate stress with readily available climate data should be explored to ease the application of this critical measure of vulnerability.

Other challenges identified with this proposed methodology included the treatment of functional species groups and ‘keystone’ species. While both of these concepts for vulnerability measures are desirable and likely provide important contributions, limits to current knowledge become apparent when one attempts to identify species for each category.

The HCCVI was structured to arrive at relative scores for climate change sensitivity vs. ecological resilience; with resilience being an average of scores from indirect effects and adaptive capacity measures. This structure likely provides results that are robust for a wide variety of circumstances. With additional knowledge and data, one could likely move to an additional level of detail within the index and provide some relative weighting of individual measures to influence component averages.

CC Vulnerability Assessment across spatial scale and scales of ecological organization

Climate change vulnerability assessment can and should be done at landscape, community, and species scales of ecological organization. In this pilot, climate-stress measures, along with many indirect effects measures, tended to be similar across all of the major community types in this pilot area. Clearly, the selection of ecoregion-scale units, such as the Mojave vs. Sonoran desert ecoregions, provides a practical and useful spatial structure for this purpose. Based on this pilot, pursuit of climate stress measures, along with measures for landscape condition and dynamic regime alteration may be efficiently pursued across multiple ecoregions.

That said, the upland and riparian/aquatic communities selected for this pilot characterize a very high proportion of each of these ecoregions, and appear to provide a very useful scale of analysis if the aim is to clarify adaptation strategies.

These two scales, ecoregion and community, should most certainly be complimented with assessment of species. There are clearly important facets of biodiversity and wildlife conservation that would not be adequately addressed by focusing only at community and/or ecoregion/landscape scales. However, the focus for species assessments can be on those that a) are already vulnerable in some form, and b) those that are thought to provide some ‘keystone function.’

One additional role for species identified through this pilot was as useful indicators of the climate-change effects likely to occur among the communities of interest. There are quite likely to be a number of species for which, through monitoring of the presence and/or abundance across seasons, should have very high indicator value for coping with climate change over the upcoming decades. By first clarifying the plausible climate scenario for a given ecoregion, and then considering likely effects on communities, these species may be readily identified. This is certainly an area deserving more attention.

Linking CC Vulnerability Assessment to Adaptation Strategies

As stated previously, the overall approach of this effort was to effectively link climate change vulnerability assessment to the identification of adaptation strategies. This was facilitated by a) selection of major natural communities as one scale of analysis, b) organization of vulnerability measures into direct effects, indirect effects, and adaptive capacity, and c) organizing local expert review within each ecoregion, where decisions across jurisdiction pertain to many of the same community types.

Workshop participants most readily identified components of indirect effects scores (e.g., landscape condition, invasive species, dynamic process alteration) as forming the focus of many “no regrets” strategies that could be pursued by managers. In most cases, these factors relate to the stressors that are best known and are currently being addressed within managed areas.

Where indirect effects stressors were less well known, and/or interactions with climate change were less clear, strategies tended to be categorized as “anticipated actions” within the 5-15 year timeframe, where additional information will be required to move forward, but participants could foresee their implementation. Direct effects, such as climate stress and climate envelope shifts, challenged workshop participants to identify novel climate-change stressors, such as effects of heat stress or changes in seasonality of precipitation and their potential effects on biodiversity, such as pollinators. Given the limits to current knowledge in these areas, the strategies identified tended to fall in the “wait and watch” category, where research questions are specified and work will be required over upcoming decades in order to determine appropriate adaptation strategies.

Finally, workshop participants identified a common list of generalized climate change adaptation strategies suitable for application across all community types for this pilot. These included:

- reduce drought stress
- maintain/promote gene flow
- coordinate movement for pollinators & seed dispersers
- protect functions of invertebrates for ecosystem services & processes
- know when NOT to intervene
- manage transition zones and refugia
- stabilize soils after disturbances
- protect current “pristine” ecosystem areas (few disturbances)
- maintain or restore hydrologic functioning – manage ground disturbance depth
- manage/control all impacts of groundwater use – specific to salt desert scrub, dries out causing PM10 dust from playas
- For dunes need to maintain vegetated buffer around dunes
- Inform the public using diverse media and campaigns about impacts/functions of climate
- Outreach to managers

Recommendations to the Desert LCC. At the close of the workshop, participants were engaged in a discussion to identify how the Desert LCC could carry the process forward. There was a sense that although we had made tremendous progress in two days, time was insufficient to prioritize actions for each of the communities examined; let alone develop synergistic strategies applicable across multiple managed areas. The participants recommended coordination of follow-up meetings to further develop the adaptation strategies identified and to place them in the context of strategies being pursued currently. The meeting would be structured somewhat differently, beginning with training and then examining adaptation strategies. Specific suggestions about the meeting were:

Provide Training in Structured Decision Making. Begin with training on rapid prototyping, the method taught in the National Conservation Training Center (NCTC) course on Structured Decision Making, to help participants learn how to decide whether to alter their current management strategies and, if so, how to do so (e.g., see <http://www.structureddecisionmaking.org/>). Then use this approach during the remainder of the meeting to identify the most effective and urgent strategies to implement.

Construct Alternative Scenarios. A concern is that by the time we have enough data to be able act with limited uncertainty; it will be too late for the biodiversity concerned. Therefore, the use of scenario planning together with models and projections would be helpful for exploring management alternatives.

Engage More Experts. Invite experts in particular systems or aspects therein to help better understand ecological interactions and to improve the strategies. For example, the Southern Arizona Buffelgrass Coordination Center (www.buffelgrass.org) may be able to provide expertise on the ecology of buffelgrass in these Sonoran Desert communities.

By supporting a follow-up meeting that considers these points, the Desert LCC could help consolidate the understanding generated during this project and catalyze the next step of land managers enacting strategies that begin to address the threats posed by climate change on the systems they oversee.

Glossary of Terms

Adaptive capacity - The potential or capability of a system to adjust to climate change, including climate variability and extremes, so as to moderate potential damages, to take advantage of opportunities, or to cope with consequences.

Climate change adaptation – Management strategies that minimize the effects of climate change on species, ecosystems, and ecological functions (Cross et al. 2012).

Climate change vulnerability – The degree to which a system is susceptible to - and unable to cope with - adverse effects of climate change; including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC 2007).

Climate change vulnerability assessment – The process of determining which species or systems are likely to be most strongly affected by climate change and why they are likely to be vulnerable (Glick et al. 2011).

Climate envelope – The modeled association between current climates (such as temperature, precipitation and seasonality) and present-day distributions (Thomas et al. 2004).

Climate stress – The perturbation caused to a natural community by departures of climate (temperature, precipitation, seasonality, event intensity) from baseline values.

Direct Effects – the current and forecasted exposure of a natural community to climate change and their likely effects on ecosystem-specific processes.

Ecological resilience – The capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks (Holling 1973, Gunderson 2000, Walker et al. 2004).

Exposure – The degree of climate stress upon a particular unit analysis; it may be represented as either long-term change in climate conditions, or by changes in climate variability, including the magnitude and frequency of extreme events.

Functional group – Groups of organisms that pollinate, graze, disperse seeds, fix nitrogen, decompose organic matter, depredate smaller organisms, or perform other functions in a natural community (Rosenfeld 2002, Folke et al. 2004).

Indirect Effects – The predisposing conditions of a natural community that affect ecological resilience.

Keystone species – Species, which when lost or reduced in abundance, will cause significant cascading effects on the populations of other species occurring in the community.

Landscape condition – An assessment of the state of the physical, chemical, and biological characteristics (including interactions) of a landscape that accounts for the effects of human land uses.

“No-regrets” actions – Management actions that are robust to uncertainty and thus will likely contribute to a desired outcome regardless of other factors.

Sensitivity – The degree to which a system will be affected by, or responsive to climate stimuli.

Stressor – An external agent, event, or condition that causes stress on a species or system.

Common Abbreviation

Bioclim: Bioclimatic variability

BLM: Bureau of Land Management

CART: Classification and Regression Trees

CC: Climate change

CCVI: Climate Change Vulnerability Index (for species)

CEC: Commission for Environmental Cooperation

DOD: Department of Defense

Elev: Elevational range

FWS: Fish and Wildlife Service

GCM: Global Circulation Model

H: High

HCCVI: Habitat Climate Change Vulnerability Index

IPCC: Intergovernmental Panel on Climate Change

IS: Invasive Species index

L: Low

LC: Landscape Condition

LCC: Landscape Conservation Cooperative

M: Medium

MaxEnt: Maximum Entropy (a species habitat modeling algorithm,

see <http://www.cs.princeton.edu/~schapire/maxent/>)

NCTC: National Conservation Training Center

NPS: National Park Service

NRA: National Recreation Area

Precip: Precipitation

PRISM: Parameter-elevation Regressions on Independent Slopes Model (a climate mapping system,

see <http://prism.oregonstate.edu/>)

REA: Rapid Ecoregional Assessment

Stdv: Standard deviation

USGS: United States Geological Survey

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Appendix 1. Field Specialist Survey

A major goal of the project is to develop methods and outcomes useful for natural resource managers. To better understand the needs, concerns, and interests of managers in the Desert LCC, and therefore enhance the chances of creating products useful for them, we initiated the project with a survey of the potential user audience. The survey sought to understand the natural communities managed, the most important stressors to these systems, the communities perceived to be most vulnerable to climate change, the climate change factors causing these stresses, and the greatest needs for scientific information about climate change. Besides providing a general picture of managers' needs and perceptions about climate change, the survey also allowed us to choose ten plant community types to focus our pilot study on vulnerability of desert habitats to climate change.

Survey and method. We used an online survey (www.surveymonkey.com) to canvass land managers during November and December 2011. Members of a project advisory team, representing four U.S. federal agencies, two Mexican government agencies, one U.S. state agency, two nonprofit environmental organizations, and a botanical garden (see Acknowledgements for members), invited appropriate staff (land managers, refuge biologists) from their institutions to participate in the survey. All invited respondents worked in either the Mojave or Sonoran deserts. The survey was intentionally short to encourage a broader response. We estimated that participants would take no longer than 15 minutes to answer the seven questions that made up the survey.

To understand who actually took the survey, respondents were first given the option of providing their name and contact information and then asked to identify the managed area where they work and the major vegetation communities or habitats that they are tasked with managing. The Survey monkey results also list the IP address of each respondent. Using Internet IP look-up sites, we were able to use this information to identify the institutional servers from which most of the respondents accessed the survey and thus infer the institutional makeup of the respondent pool. The remaining five questions addressed the details of vegetation communities managed and presumed vulnerable to climate change, stressors, and information needs. The questions about stressors and information needs provided options for rating on importance/urgency and allowed respondents to write in additional answers. Respondents simply typed the answers to the other questions.

Results. A total of 66 people filled out the survey. The IP address information indicated their affiliations as follows: U.S. Fish and Wildlife Service (25), Bureau of Land Management (15), National Park Service (9), the State of Arizona (5), Mexican government or NGO (3), State of Nevada (2), U.S. Department of Defense (3), Native American Tribes (1), USDA NRCS (1) and unknown (2). A wide range of protected and managed lands were represented among respondents, with many US Fish and Wildlife Refuges, BLM protected areas (e.g., ACECs, Desert Tortoise critical habitat), National Parks (including Monuments, Conservation Areas, Recreational Areas, and Preserve Units), DoD facilities, tribal lands, and several managed/protected areas and biosphere reserves in Sonora.

The survey showed that respondents manage a wide variety of primary upland vegetation type, wetland or riparian community types, and individual species habitat types. We received a total of 314 answers to this question, most of which were mentioned multiple times under a various names (the survey requested that they list types using whatever nomenclature they commonly used). The most common types were some

sort of riparian, wetland, spring, or wash community (including cottonwood-willow riparian communities), blackbrush scrub, creosotebush communities, desert grasslands, Joshua tree woodlands, sand dunes, mesquite bosques, paloverde associations, pinyon-juniper woodlands, and a variety of desert scrub communities. A few species habitats were also mentioned, including Golden Eagle, desert tortoise, bighorn sheep, and desert pupfish.

Respondents ranked common stressors to the communities for their relative importance (from 1= not important to 5= highest importance). The average scores, listed in decreasing order were:

<u>Stressor</u>	<u>Mean score</u>
Invasive species	4.2
Decreased water availability (other than from pumping)	3.6
Altered fire regime	3.6
Current climate change effects	3.4
Groundwater pumping	3.3
Land use change outside borders	3.2
Recreational activities	3.0
Energy development	3.0
Over grazing	2.2
Mining effects	2.0

Other types of stressors listed by respondents included issues such as:

- Air pollution (nitrogen deposition and other effects on desert tortoise)
- Illegal activity associated with drug/human trafficking and related law enforcement
- Military ground training (e.g., causing soil disturbance/compaction, increased erosion, or dust production)
- Effects of large-scale energy development, especially where wildlife species are translocated and/or concentrated.

Management concerns related to climate change were listed and described by respondents relative to distinct community types. These concerns varied widely, and generally involved interaction with non-climate-change stressors, but included:

- Effects of increasing temperature, such as a ‘drying out’ of sand dunes and effect on groundwater dependent species.
- Higher elevation communities and species already at risk, given limited options for movement upslope.
- Fragmentation (due to water-related stress or other source) of existing migratory corridors for wildlife, such as in riparian zones
- Loss of keystone species or increased stress on narrowly endemic species
- Coastal effects, such as increased storm surge intensity and coastal marine habitat impacts

Respondents were also asked to indicate their relative needs for information regarding climate change. In an established list of categories rated from 1-5 (from 1= not needed to 5= greatly needed) the following average scores were tabulated.

<u>Climate change information need</u>	<u>Mean score</u>
Climate vulnerability of vegetation/community/habitats	4.2
Predictions on how climate change will influence the hydrological cycle	4.0
Climate vulnerability of selected species	3.9
Interaction of climate change relative to other stressors	3.8
Climate-induced phenology change in vegetation	3.6
Modeled climate envelope shifts for vegetation/community/habitats	3.6
Guidelines on monitoring for climate change	3.5
Modeled range shift maps for species	3.4
Downscaled climate predictions	3.1

Additional information needs listed by respondents included:

- Information for plant community management and restoration, in order to maintain ecological health and resiliency
- Understanding of wildlife population changes and movement patterns in light of anticipated climate change effects; including for migratory birds
- Baseline information on current community location and health
- Monitoring of trends in key ecological indicators, for better interpretation of climate change effects
- Understanding edaphic constraints on succession; and how edaphically constrained communities are likely to respond to climate stress
- Management strategies that work with unavoidable change to natural disturbance regimes

The survey also asked about the natural community types that respondents were most concerned about being vulnerable to climate change. Although we intended to use the responses to this question to determine the focal community types for the project, several people answered by stating that they were concerned about all of the communities that they listed under the question about communities that they managed. We therefore used the results of the prior question to develop the list of focal communities. To do so, we first related each type to the NatureServe terrestrial ecological systems classification (see <http://www.natureserve.org/explorer/>). We used this classification because it a) comprehensively describes upland, wetland, and riparian types across the hemisphere, b) describes community types at ‘intermediate’ scales, suitable for management, c) has been used for national and regional mapping and modeling efforts, such as the USGS Gap Analysis, inter-agency LANDFIRE, and BLM Rapid Ecoregional Assessments, and d) links directly to U.S. federal data standards, such as the U.S. Vegetation Classification. This classification forms a common language for rapidly linking interests of survey respondents and facilitates our use of existing investments in mapped and modeled information to advance project goals.

The result of this exercise was to group the 314 communities named into 15 community types that were suggested by at least four respondents (Appendix 1). Through discussions with the project advisory team, we arrived at a final list of ten focal types for the project. The list includes both upland and riparian systems with representation from both the Mojave and Sonoran Deserts:

- North American Warm Desert Riparian Woodland and Shrubland and Stream
- North American Warm Desert Mesquite Bosque

- Mojave-Sonoran Desert Springs and Seeps
- Sonoran Paloverde-Mixed Cacti Desert Scrub
- Sonora-Mojave Mixed Salt Desert Scrub
- Sonora-Mojave Creosotebush-White Bursage Desert Scrub
- Mojave Mid-Elevation Mixed Desert Scrub
- Great Basin Pinyon-Juniper Woodland
- Apacherian-Chihuahuan Semi-Desert Grassland and Steppe
- North American Warm Desert Active and Stabilized Dune

Conclusions. Thanks to a healthy response rate, the survey succeeded in providing a snapshot of Mojave and Sonoran Desert land managers' perceptions about climate change in the larger context of stressors to the biodiversity they help protect. Climate change is but one of numerous stressors that the respondents are confronting, ranking noticeably behind invasive species in importance. Managers are concerned about climate change affecting a wide range of communities via mechanisms that relate to increased water stress, isolation of mountaintops, loss of keystone or endemic species, and storm surge in coastal systems. Their top climate change-related information needs are vulnerability assessments of communities and species as well as predictions of how climate change will influence hydrological cycles. Finally, the survey allowed us to select for vulnerability assessment 10 community types that are relevant to a broad spectrum of land managers.

Appendix 2. Methods Detail (*see separate document*)

Appendix 3. Type Summaries (*see separate document*)

Appendix 4. Workshop Agenda

Mojave-Sonoran Deserts Natural Community Vulnerability Assessment Adaptation Strategy Workshop

1-2 August 2012

Arizona Game and Fish Department Headquarters, 5000 West Carefree Highway, Phoenix, AZ

Workshop Goal

Identify management strategies that can be readily implemented in managed lands of the Sonoran and Mojave deserts to promote adaptation of natural communities and associated species.

Workshop Objectives

- **Communicate the results** of climate change vulnerability assessments of ten focal community types of the Sonoran and Mojave Deserts to biologists and managers of U.S. and Mexican protected areas that contain these communities.
- **Receive feedback** on the methods employed and results obtained in the vulnerability assessments.
- **Document ecological stressors** commonly affecting these communities within managed lands.
- **Discuss and identify specific strategies** that can be employed on the ground in protected/managed areas or areas/programs that have management planning involved to reduce climate change impacts on the characteristic mosaic of natural communities.
- **Create awareness** about climate change in desert ecosystems, potential synergies among non-climate and climate-induced stressors, and the options for managing for change, as well as climate change resources available for managers.

Agenda

Day 1: 1 August 2012

8:00 Coffee, snacks, informal introductions

8:30 Welcome, Introductions, Housekeeping, Lunch plans

Sabra Tonn (Arizona Game & Fish Department) **Genevieve Johnson** (US Bureau of Reclamation) **Bruce Young** (NatureServe)

8:45 Workshop Overview – Goals, Desired Outcomes, Structure, Agenda **Pat Comer** (NatureServe)

9:00 ABCs of Climate Change Vulnerability Assessments and Adaptation Planning, **Bruce Young**

9:30 Climate Change Vulnerability Index for Ecosystems and Habitats, **Pat Comer**

10:30 Break

10:45 (cont'd) Climate Change Vulnerability Index, **Pat Comer**

11:15 Charge for Breakout Groups, **Carol Beardmore**, US-FWS

11:30 Initiate Work in Groups

- 1) *NatureServe ecologists present HCCVI results for subgroup of community types (Pat Comer, Marion Reid [phone], Keith Schulz [phone])*
- 2) *Discuss results for understanding by group; consider interactions among adjacent community types. Consider and describe any alternative climate-change scenarios relative to those used in the draft HCCVI analyses. (capture notes in each community abstract draft)*

12:30 Lunch

1:30 Resume Group Work

- 3) *List the key ecological stressors for each community*
- 4) *Identify and categorize where likely climate stress may intensify non-climate stressors (weak, moderate, strong interaction)*

3:15 Break

3:30 Resume Group Work

- 5) *Rank stressors by scope and severity, [i.e., by % of distribution effected vs. relative intensity of ecological disruption]*

Desired Day 1 outcome: *List of most important stressors for each community that will require action across the ecoregion.*

4:30 Report Back from Groups

5-10 min per group, share highlights & inspirations only, not entire results

4:55 Recap and Preview of Day 2, **Bruce Young**

5:00 Adjourn

Day 2: 2 August 2012

8:00 Orientation to the day's activities, announcements, **Pat Comer**

8:10 Overview of Conservation Adaptation Planning, **Marcos Robles** (*The Nature Conservancy*)

9:20 Charge for Breakout Groups, **Bruce Young**

9:35 Initiate Work in Groups

- 1) *Review matrix developed on Day 1, making adjustments as needed according to any new insights by group members*
- 2) *Briefly characterize management goals for each community from each participants managing agency*

10:30 Break

10:45 Resume Group Work

- 3) *Brainstorm possible points of management intervention and strategies that could ameliorate stress (flip charts)*
- 4) *For each community type, list and prioritize strategies as:*
 - a. *"No-regrets" actions to take within the next 5 years.*
 - b. *"Anticipated Actions" over the coming 5-15 years.*
 - c. *"Wait and Watch" or potential actions to anticipate over the 15-30 year timeframe, with indicators to monitor and inform those future decisions.*

12:00 Lunch

1:00 Resume Group Work

- 6) *Document strategies that would be logical and feasible to initiate or advance within each managed area represented in the breakout group.*

3:00 Break

3:15 Resume Group Work

- 7) *Prioritize research needs that have been documented throughout Day1 and 2.*

8) Discuss desired workshop follow-up.

4:00 Report Back from Groups

10 min per group, share highlights & inspirations only, not entire results

4:30 Recap and Next Steps, **Bruce Young**

5:00 Adjourn

Focal Natural Communities and Breakout Groups

	Breakout Group #
North American Warm Desert Riparian Woodland and Shrubland and Stream	1
North American Warm Desert Mesquite Bosque	1
Mojave-Sonoran Desert Springs and Seeps	1
Apacherian-Chihuahuan Semi-Desert Grassland and Steppe	2
Sonoran Paloverde-Mixed Cacti Desert Scrub	2
Sonora-Mojave Mixed Salt Desert Scrub	2&3
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	2&3
North American Warm Desert Active and Stabilized Dune	2&3
Mojave Mid-Elevation Mixed Desert Scrub	3
Great Basin Pinyon-Juniper Woodland	3

Breakout Groups

Group	Facilitator	HCCVI Presenter	Notetaker
1 – Riparian/Springs	<i>Carol Beardmore</i>	<i>Marion Reid (phone)</i>	<i>Bruce Young</i>
2 – Sonoran Desert uplands	<i>Pat Comer</i>	<i>Pat Comer</i>	<i>Marcos Robles</i>
3 – Mojave Desert uplands	<i>Jim Weigand</i>	<i>Keith Schulz (phone)</i>	<i>Laurie Simons</i>

Appendix 5. List of Workshop Participants

Attendee	Institution
Invitees	
Tom Anderson	Sonny Bono Salton Sea National Wildlife Refuge, Fish & Wildlife Service
John Arnett	DOD, Luke Air Force Base & Barry Goldwater Range
Cristi Baldino	Ash Meadows National Wildlife Refuge, Fish & Wildlife Service
Kathleen Blair	Bill Williams National Wildlife Refuge, Fish & Wildlife Service
David Braun (phone)	Sound Science
Sandee Dingman	Lake Mead National Recreation Area, NPS
Chris Gregory	Carlsbad Ecological Services Office, Fish & Wildlife Service
Kerry Griffiths-Kyle	Texas Tech University
Jennifer Holmes	Northern Arizona University
Izar Izaguirre Pompa	Pinacate Biosphere Reserve, Comisión Nacional de Áreas Protegidas
Genevieve Johnson	Bureau of Reclamation, Phoenix
Janel Johnson	Nevada Natural Heritage Program
Mark Kaib	Fish & Wildlife Service Region 2
Sonja Kokos	Bureau of Reclamation, Las Vegas
Marty Lawrence	The Nature Conservancy
Yadid Antonio León Moreno	Comisión de Ecología y Desarrollo Sustentable del Estado de Sonora
Alberto Macías	Centro de Estudios del Estado de Sonora, Hermosillo
Bernadine McCollum	The Nature Conservancy
Hector Munro	Pinacate Biosphere Reserve, Comisión Nacional de Áreas Protegidas
Alice Newton	Lake Mead National Recreation Area
Horacio Ortega Morales	Pinacate Biosphere Reserve, Comisión Nacional de Áreas Protegidas
Kris Randall	Arizona Field Office, Fish & Wildlife Service
Marion Reid (phone)	NatureServe
Keith Schulz (phone)	NatureServe
Sid Slone	Cabeza Prieta National Wildlife Refuge, Fish & Wildlife Service
Lindsay Smythe	Desert National Wildlife Refuge, Fish & Wildlife Service
Lisa Soo	BLM-Arizona
Bob Unnasch	Sound Science
Kim Veverka	Cabeza Prieta National Wildlife Refuge, Fish & Wildlife Service
Jim Weigand	BLM-California State Office
Brian Wooldridge	Arizona Field Office, Fish & Wildlife Service
Advisory Team Members	
Carol Beardmore	Fish & Wildlife Service Phoenix
Patrick Comer	NatureServe
Peter Holm	Organ Pipe Cactus National Monument, NPS
Elroy Masters	BLM, Arizona
Marcos Robles	The Nature Conservancy
Laurie Simons	Desert National Wildlife Refuge Complex, Fish & Wildlife Service
Sabra Tonn	Arizona Game and Fish Department
Bruce Young	NatureServe



CALIFORNIA'S FOURTH
CLIMATE CHANGE
ASSESSMENT

Inland Deserts Region Report



Coordinating Agencies:

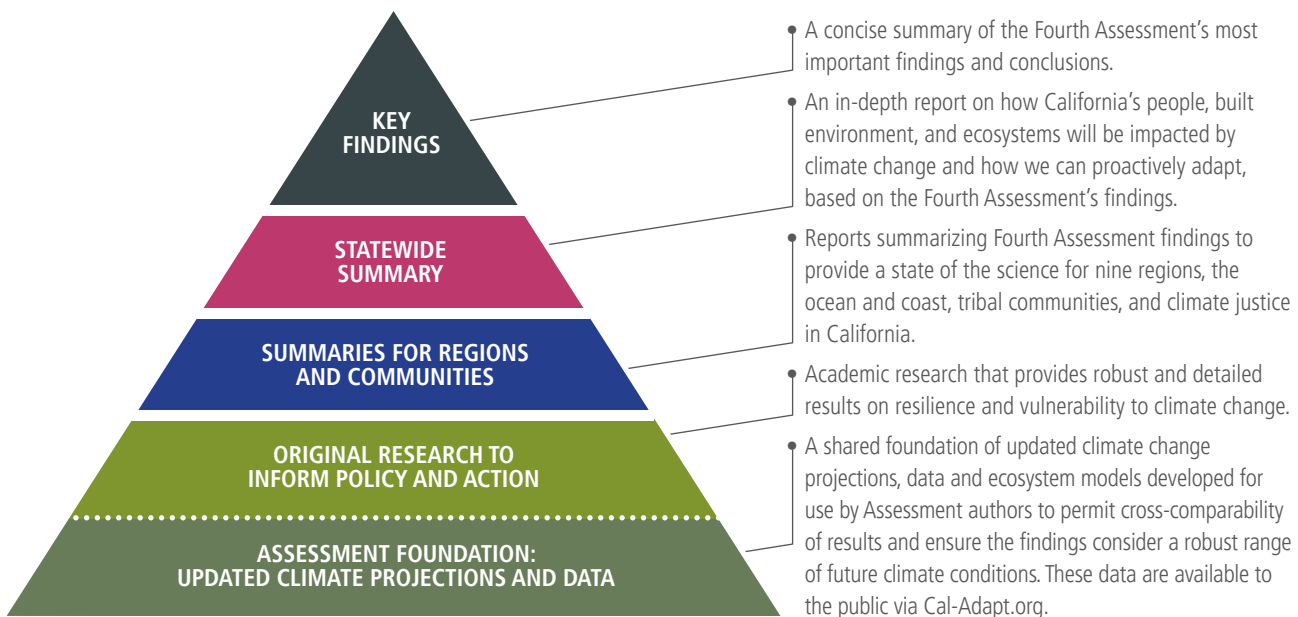




Introduction to California's Fourth Climate Change Assessment

California is a global leader in using, investing in, and advancing research to set proactive climate change policy, and its Climate Change Assessments provide the scientific foundation for understanding climate-related vulnerability at the local scale and informing resilience actions. The Climate Change Assessments directly inform State policies, plans, programs, and guidance to promote effective and integrated action to safeguard California from climate change.

California's Fourth Climate Change Assessment (Fourth Assessment) advances actionable science that serves the growing needs of state and local-level decision-makers from a variety of sectors. This cutting-edge research initiative is comprised of a wide-ranging body of technical reports, including rigorous, comprehensive climate change scenarios at a scale suitable for illuminating regional vulnerabilities and localized adaptation strategies in California; datasets and tools that improve integration of observed and projected knowledge about climate change into decision-making; and recommendations and information to directly inform vulnerability assessments and adaptation strategies for California's energy sector, water resources and management, oceans and coasts, forests, wildfires, agriculture, biodiversity and habitat, and public health. In addition, these technical reports have been distilled into summary reports and a brochure, allowing the public and decision-makers to easily access relevant findings from the Fourth Assessment.



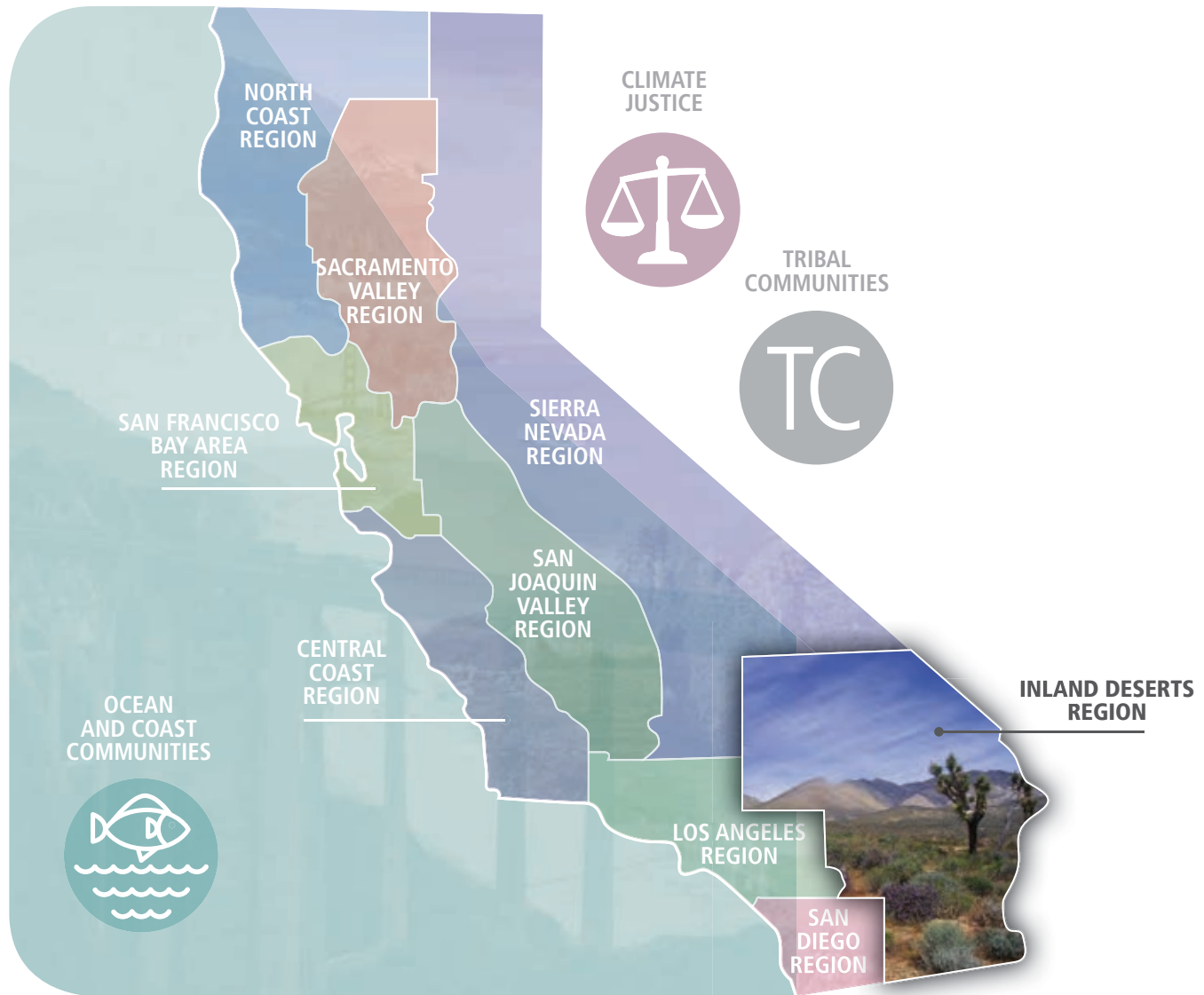
All research contributing to the Fourth Assessment was peer-reviewed to ensure scientific rigor as well as, where applicable, appropriate representation of the practitioners and stakeholders to whom each report applies.

For the full suite of Fourth Assessment research products, please visit: www.ClimateAssessment.ca.gov



CALIFORNIA'S FOURTH CLIMATE CHANGE ASSESSMENT

Inland Deserts Region



The Inland Deserts Region Summary Report is part of a series of 12 assessments to support climate action by providing an overview of climate-related risks and adaptation strategies tailored to specific regions and themes. Produced as part of California's Fourth Climate Change Assessment as part of a pro bono initiative by leading climate experts, these summary reports translate the state of climate science into useful information for decision-makers and practitioners to catalyze action that will benefit regions, the ocean and coast, frontline communities, and tribal and indigenous communities.

The Inland Deserts Region Summary Report presents an overview of climate science, specific strategies to adapt to climate impacts, and key research gaps needed to spur additional progress on safeguarding the Inland Desert Region from climate change.



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Executive Summary

The Inland Deserts region is the hottest and driest region of California, with a desert climate that varies primarily due to elevation. The region's climate is becoming more extreme, with daily average high temperatures projected to increase by up to 8-14°F by the end of century. Rainfall rates are currently low (approximately 5 inches per year) and highly variable from year to year. This variability is projected to increase over the coming decades, with extreme drought and extreme wet events both becoming more common. In turn, increasing frequencies of these extreme events will increase the risk of flash flooding and wildfire, given the close relationship between precipitation variability and growth of invasive grasses that serve as the major fuel for wildfire in the region.



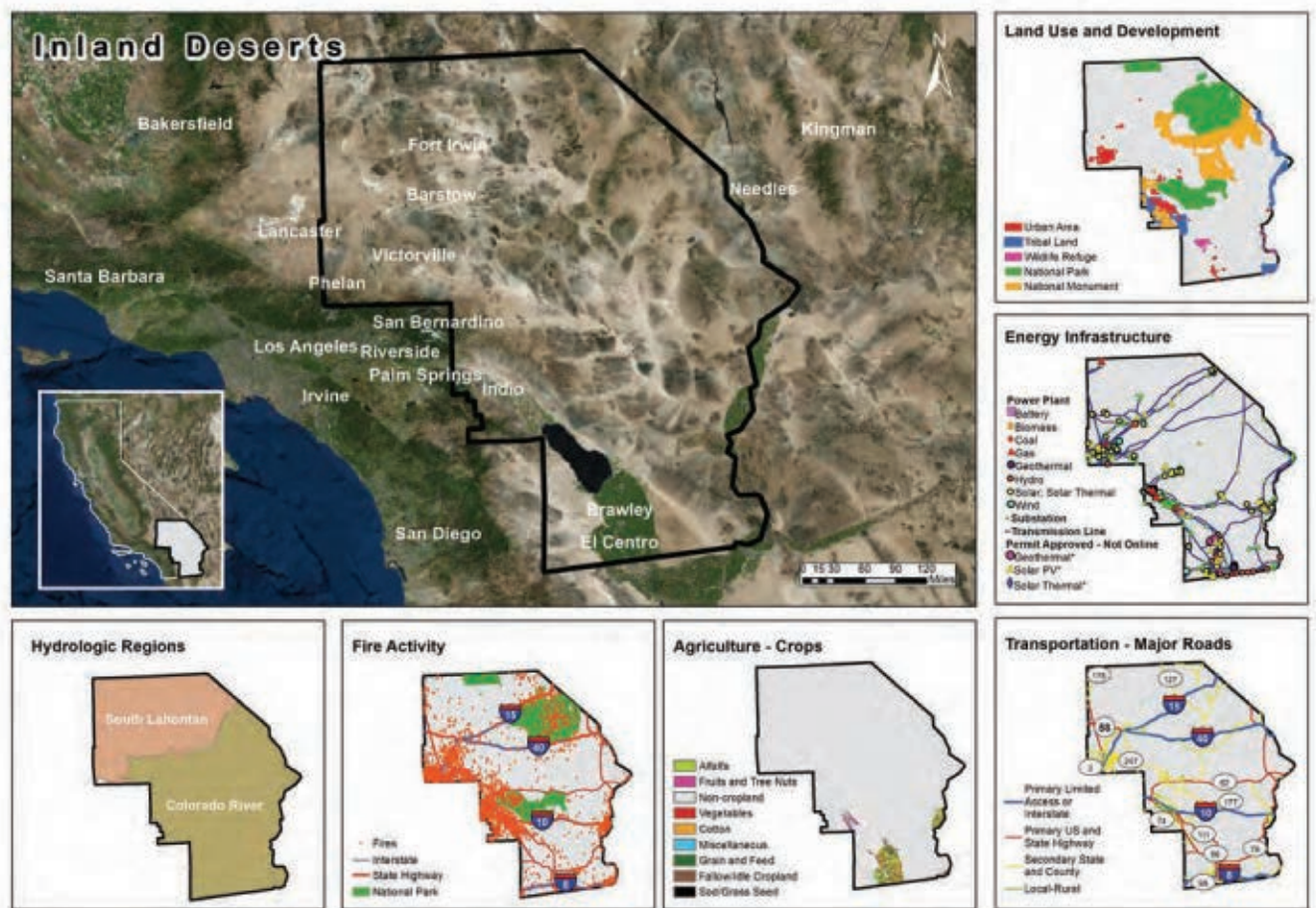


CALIFORNIA'S FOURTH CLIMATE CHANGE ASSESSMENT



Physically, the region encompasses the Mojave and Sonoran deserts in the southeast corner of the state (Figure 1A). The domain includes all of Imperial County and the desert portions of Riverside and San Bernardino Counties. The region has about 1 million inhabitants, with 85% of those residing in urbanized areas including the Victor Valley in San Bernardino County (Victorville, Apple Valley, Hesperia), the Coachella Valley in Riverside County (Indio, Palm Springs, Palm Desert), and the El Centro Metropolitan Area in Imperial County (El Centro, Brawley, Calexico) [American Communities Survey estimated 2017 population]. In addition, the tribal lands of 12 different groups are contained in the region (Figure 1B). Future development will likely take place within and amongst these urbanized areas.

FIGURE 1



Satellite composite image of the Inland Deserts (A). Subplots B-G show geography and infrastructure in the region, including Land Use (B), Energy (C), Transportation (D), Agriculture (E), Fire Activity (F), and Watersheds (G).



Despite its sparse population, the region is important for protected lands, tourism, and agriculture. The region has the largest acreage of federally protected lands in the state (US BLM NLCS National Monuments and Conservation Areas)—7,448 square miles of National Parks and Monuments, including ecologically unique and sensitive ecosystems in Joshua Tree National Park and the Mojave Trails National Monument. It contains important wildlife refuges, including the Salton Sea. Biodiversity hotspots are found at high elevation, in oases, and sand dunes that provide a climatic refuge against extreme heat and aridity that characterizes sandy lowland areas (bajadas). These hotspots are threatened by climate change as well as other land-use pressures, and identifying and protecting appropriate climate refugia is likely to be the best strategy for conservation.

Tourism in the region derives from proximity to these protected lands and is a direct result of the region's climate. The Coachella Valley is a major tourist destination that developed in the 1950s as a warm-weather winter retreat for residents of cold, snowy climates. Tourism is the number one contributor to the Coachella Valley's economy. The close relationship between tourism and climate may make the region's economy uniquely vulnerable to the effects of climate change.

Crops cover 4% of land area in the region, primarily in the Imperial Valley (Figure 1E). While crop coverage may seem low in the region as a whole, it belies the importance of agriculture to the fully agrarian Imperial Valley, the Palo Verde Valley along the Colorado River, and the southeastern portion of the Coachella Valley adjacent to the Salton Sea. Agriculture is the primary economic driver of the Imperial and Palo Verde Valleys, and is second only to tourism in the Coachella Valley. Because its warm climate enables winter harvests, the Imperial Valley is a major source of winter fruits and vegetables for the U.S. and abroad. Other important crops include forage and fodder such as alfalfa and hay. Already at the high temperature limit for agriculture globally, climate change will bring additional heat stress to field crops, livestock, and the health of farm workers. Agriculture in the valleys is nearly completely irrigation dependent, and demand will likely increase with rising evapotranspiration rates under a warmer climate. Currently, the Imperial Valley has the highest per capita water consumption in the state due to its water-intensive agriculture, relatively low population, and senior water rights to the Colorado River. Potential climate-driven reductions to Colorado River flow and competing water needs in other regions pose another threat to agriculture.

Like much of California, many of the effects of climate change will be mediated through climate-driven stress to water supply and quality. Land use patterns in the region are highly dependent on water availability, and competing needs for water amongst urban development, agriculture, and natural ecosystems. High variability amongst climate model predictions of future rainfall rates make projections of future water availability highly uncertain; however, climate warming will dry soils and increase the risk of severe drought.

Much of the region is challenged by high poverty and unemployment rates and low educational attainment levels, making the residents more vulnerable to the effects of climate change. Imperial County has a poverty rate of 23%, making it the 5th highest poverty county in the state (CA Budget Project/US Census). Riverside and San Bernardino Counties also have poverty rates above the state average (15.6 and 17.6% respectively, vs. 14.7% statewide). The extreme heat projected for the region is likely to threaten this vulnerable population directly through heat-related illness, and indirectly through strain on infrastructure and via changing levels of air pollution and disease. Increasing climate extremes—extreme high temperatures, likelihood of flash flooding, and wildfire risk—will stress transportation and energy infrastructure currently in place, and will increase energy demand for cooling. Population



growth and urbanization in the region, expected to be higher here than for the state as a whole, is likely to exacerbate strains on infrastructure, land use, and water supply, and may increase wildland-urban interface areas that could potentially lead to more wildfire activity without careful planning that takes these issues into account.

In addition to climate-sensitive tourism and agriculture, other industries important to the region are based on the relatively inexpensive land costs compared to nearby coastal areas. These include real estate development and construction, renewable energy development, logistics and warehousing, and correctional facilities. Climate change mitigation policies implemented over the past decade have had a net positive economic impact on the region, mainly through construction of new renewable energy sources (Jones et al., 2017). These new renewable energy sources are a key part of attaining statewide greenhouse gas reduction goals while providing future energy supply. While beneficial for the economy and for greenhouse gas mitigation, development of renewable energy poses a threat to sensitive ecosystems that are contracting in size due to higher temperatures and more severe drought, and to competing land uses, including agriculture and recreation.

A major geographic feature of the region is the Salton Sea, the state's largest lake, which is maintained by inflows from agricultural runoff. Future environmental quality of the region is highly dependent on the fate of the Salton Sea, which is currently threatened by diminishing levels of inflows from agricultural runoff. As the Sea shrinks, the increasingly exposed playa (dry lakebed) is likely to become a major source of dust, polluting the air of the region and potentially of areas beyond. The region already suffers from high rates of childhood asthma and cardiovascular disease thought to be linked to dust emissions from the Sea (Imperial County Public Health, 2016), making increased playa dust emissions of particular concern in terms of human health and environmental justice. Climate change will exacerbate water supply and quality issues that hamper efforts to restore the Sea, and will place additional stress on environmental quality, habitat, and public health challenges related to the shrinking Sea.

A general summary of climate risks facing the California's Inland Deserts region include:

- Extremely high maximum temperatures are expected to occur in the Inland Deserts.
- The fate of the Salton Sea is a critical determinant of future environmental quality.
- Renewable energy development will have big impacts on the economy and infrastructure.
- Continuing current land use/development patterns (i.e., housing development in the region to compensate for lack of development on the coast) will require increased energy for cooling to compensate for a rise in extremely high temperatures.
- Higher temperatures will exacerbate water stress in an already very water-limited region.
- Changing water availability is a key determinant of the future for ecological and agricultural systems.
- Population in the Inland Deserts is highly vulnerable to the effects of climate change.
- Tourism is a major economic driver that is likely to be threatened by a changing climate.

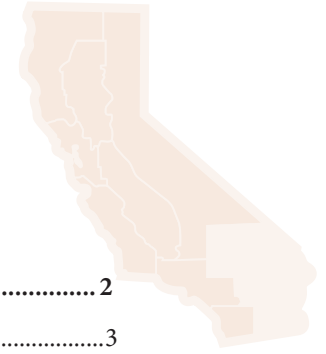


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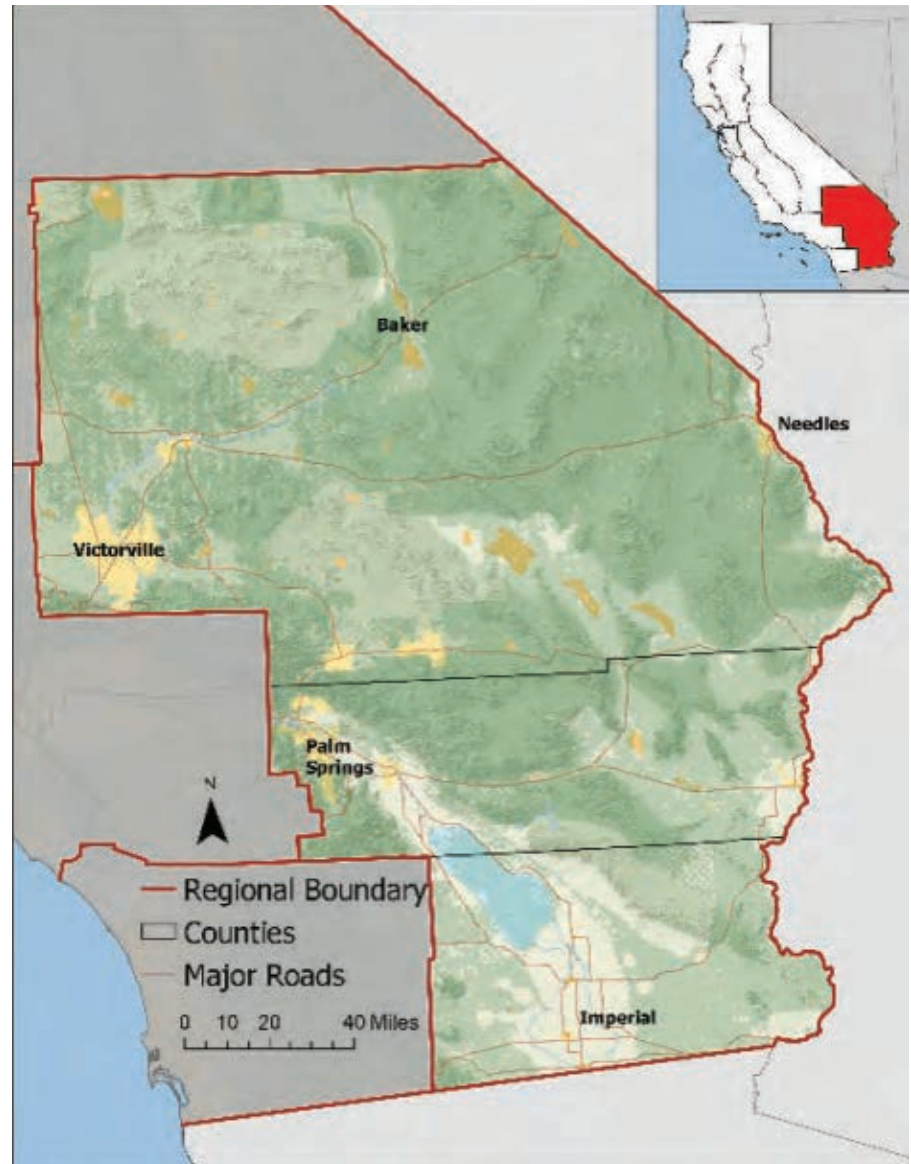
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Introduction

The Inland Deserts of California are comprised of the Mojave and Sonoran deserts in the southeast corner of California (Figure 2). The region includes all of Imperial County and the desert portions of Riverside and San Bernardino Counties. In this report, we summarize the major climate change risks for natural, managed, and human systems in the region, drawing on peer-reviewed literature, government reports, and other reports that contribute to California's Fourth Climate Change Assessment. In addition to synthesizing the state of knowledge, we identify adaptation options that can help lessen the impact of climate change in the region. The report is organized into 3 sections (Figure 3). Section 1 (Inland Deserts Physical Climate) describes the projected climate of the region to the end of the 21st century, along with direct impacts of climate on wildfires and hydrology of the Inland Deserts. Section 2 (Natural and Managed Resource Systems) addresses climate change effects on natural and managed resource systems, including biodiversity and agriculture. Section 3 (Human Systems) explores climate change effects on human systems, including land use decisions, risks to infrastructure, and the vulnerability of Inland Desert communities. Finally, section 4 (Research Needs) identifies knowledge gaps where future research can contribute an improved understanding of climate change impacts and adaptation strategies for Inland Deserts.

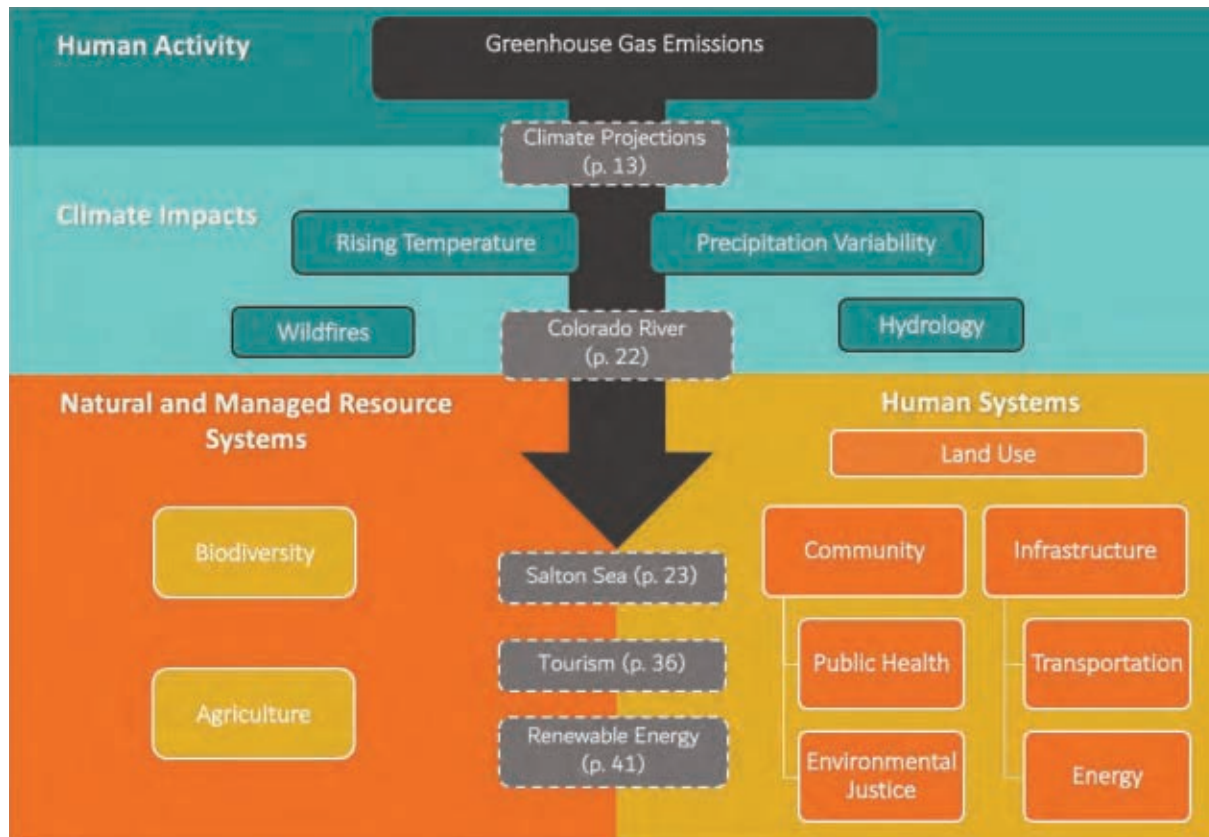
FIGURE 2



Inland Deserts. Source: Jim Thorne.



FIGURE 3



Greenhouse gases emitted by human activities have a direct effect on climate, including temperature and precipitation amounts and seasonality. In turn, these climatic drivers affect wildfires and hydrology, and indirectly impact natural and managed resource systems, and human systems including land use, community, and infrastructure.

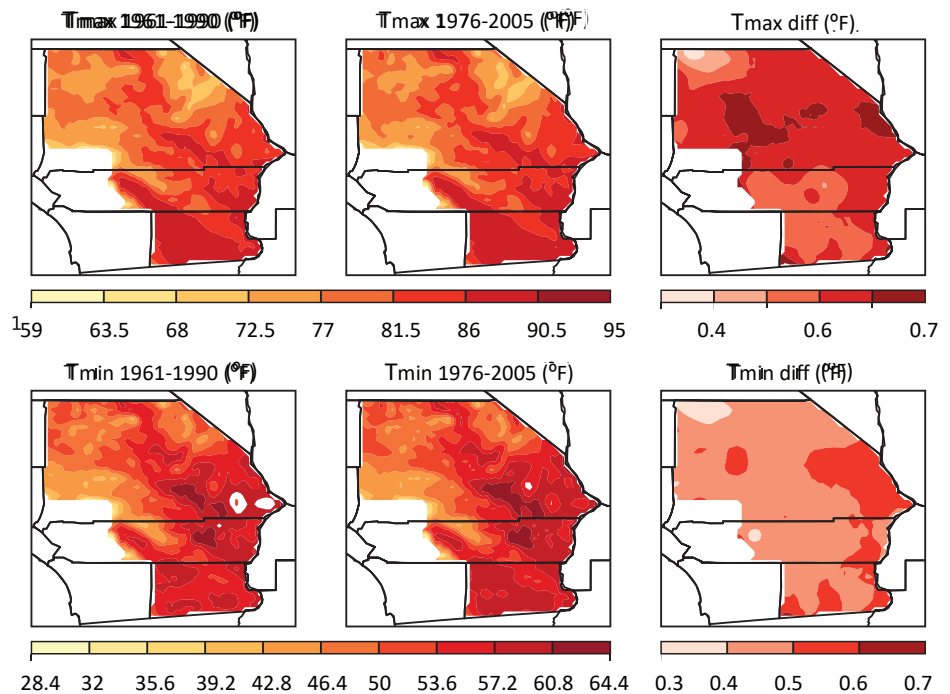


Inland Deserts Physical Climate

In this section, we describe the direct impacts of climate change on temperature and precipitation projections in the Inland Deserts over the 21st century. These climate changes have important consequences for wildfire by changing the type, amount, and connectivity of vegetation that fuel fire intensity and spread. Climate change will also affect hydrology and water supplies in the region, which strongly depend on future precipitation amounts and variability. Of particular importance is how climate change will affect the flow of the Colorado River, which is the major water supply for most of the region.

The Inland Deserts of California have an extremely warm and dry climate that is becoming even more extreme with climate change. Average high temperatures average 81°F across the region, with very hot, dry summers (average July highs 99°F-109°F) and warm, dry winters (average December lows 30-44°F). Rainfall averages just 5 inches per year, but annual totals are highly variable. Spatially, the climate varies primarily with elevation (Figure 4). The Mojave Desert is the relatively cooler high desert (Köppen Climate Class BWk: cold desert), while the Sonoran is the hotter low desert (Köppen Climate Class BWh: hot desert). Climate change has already increased temperatures in the region. Over the second half of the 20th century, daily maximum temperatures warmed by 0.4-0.7 °F, comparing 1976-2005 with 1961-1990 (Figure 4). It is extremely likely that increased levels of greenhouse gases in atmosphere due to human activities are responsible for warming over this period (IPCC, 2014).

FIGURE 4



Distribution and changes to daily temperature extremes in the Inland Deserts in the second half of the 20th century. Top panels: Average daily maximum temperature (°F), and bottom panels: average daily minimum temperature for 1961-1990 (left), 1976-2005 (middle) and difference between these periods (right). Source: Neil Berg, UCLA.



Scientific Basis for Climate Change Projections

Greenhouse gases, such as carbon dioxide and methane, trap heat in Earth's atmosphere. Levels of these greenhouse gases have increased since the Industrial Revolution, and in particular since the 1950s, due to human activities such as fossil fuel burning. 21st century climate will depend on future emissions of greenhouse gases, which in turn depends on human decisions over the next several decades (IPCC, 2014).

Predictions of future climate requires that future levels of greenhouse gases are estimated in a systematic way. Projections of future greenhouse gas emissions are called Representative Concentration Pathways (RCPs), and are based on future scenarios of global population, economics, energy and land use, technology, and policy (van Vuuren et al., 2011).

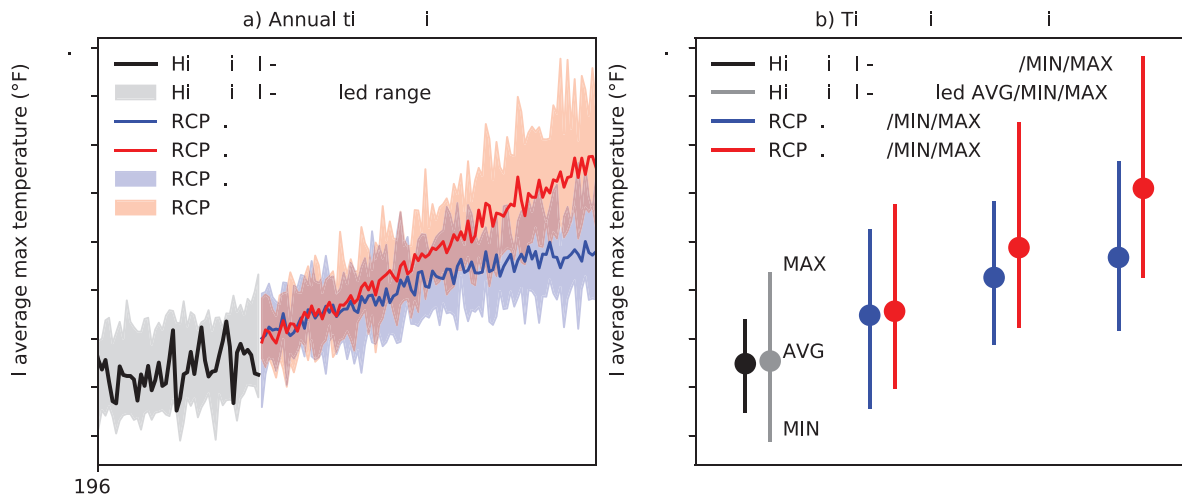
Climate projections given in this report are based on two RCPs: RCP 4.5, a moderate emissions pathway requiring greenhouse gas mitigation, and RCP 8.5, a "business-as-usual" scenario that extends current emission trends forward in time. These RCP emissions were used in 10 global climate models that best simulate aspects of California's climate to project climate conditions out to 2100 (Pierce et al., 2018). Projections of temperature and precipitation were downscaled to ~6 km (Pierce et al., 2014), and are presented here for the Inland Deserts. These data and accompanying visualizations are freely available at www.cal-adapt.org.



21st Century Climate Projections

California's Inland Deserts are known for extreme heat, which will only become more extreme in the future. Daily maximum temperatures are projected to increase by +5-6°F for 2006-2039, by +6-10°F for 2040-2069, and +8-14°F for 2070-2100 on average for the region, with ranges depending on future greenhouse gas emissions (Figure 5). Historically, the hottest day of the year ranges from the high 90s (°F) at upper elevations to >115°F in eastern low desert regions. By the end of the 21st century, these hot extremes are projected to rise by at least +6°F, and up to +9°F on average, depending on future greenhouse gas emissions (RCP 4.5 and RCP 8.5, respectively; Figure 6). The region also has a high frequency of extremely hot days, defined as temperatures >95°F, averaging 90 per year in the Mojave, and 135 per year in Palm Springs during the 1981-2000 period (Sun et al., 2015). Climate change is expected to increase the frequency of >95°F days, with projection of up to 141 days in the Mojave, and 179 days—half the year—in Palm Springs by the end of the 21st Century under RCP 8.5 (Sun et al., 2015).

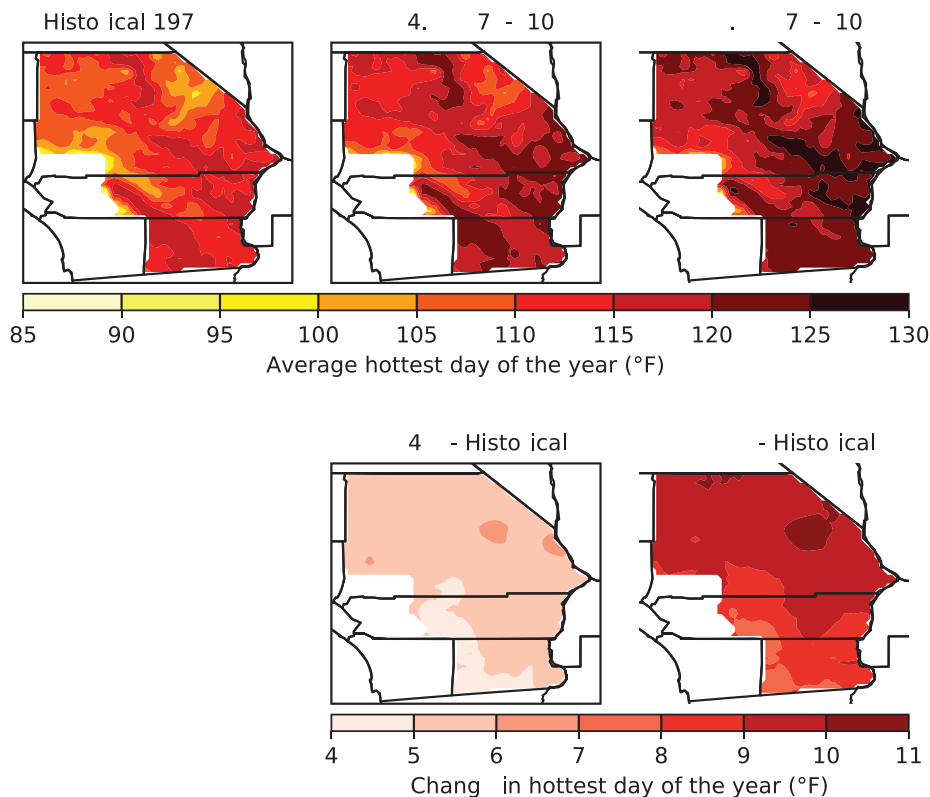
FIGURE 5



Historical (black) and projected annual average maximum temperature in the Inland Deserts for two emission scenarios (RCP 4.5: blue, RCP 8.5: red). Panel a: Annual Time Series: Solid lines show model averages, and shaded areas show modeled ranges. Panel b: Three decade summaries: Circle markers show model averages, and error bars show modeled ranges. Source: Neil Berg, UCLA.



FIGURE 6

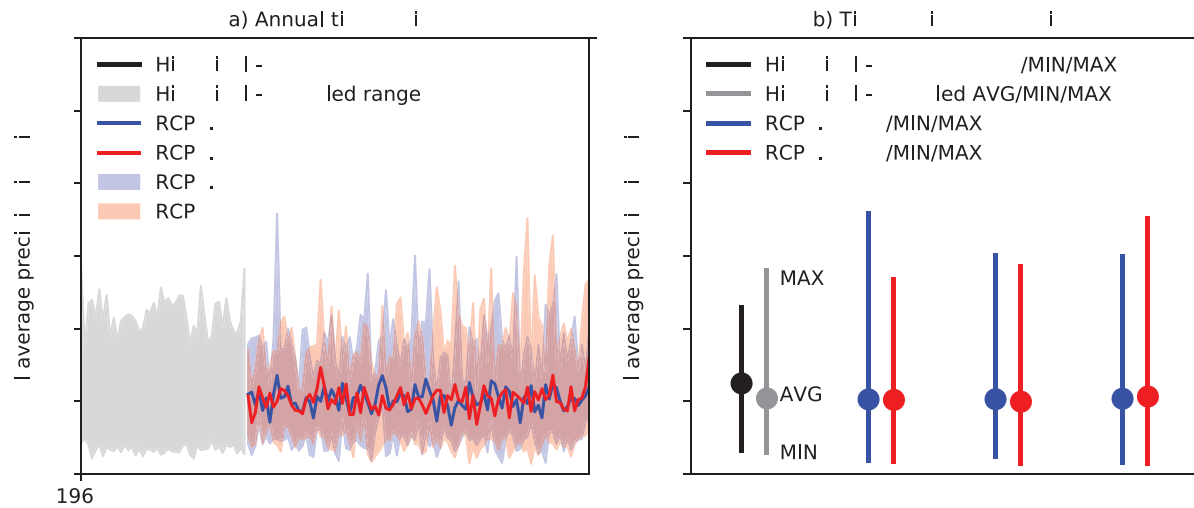


Average hottest day of the year (°F) across the Inland Deserts for historical observations (1976-2005) and modeled end of century (2070-2100) for RCP 4.5 and RCP 8.5 scenarios (top panels), and change in the temperature of the hottest day of the year at the end of century for RCP 4.5 and RCP 8.5 (bottom panels).
Source: Neil Berg, UCLA

In addition to these hot extremes, low temperature extremes warmed over the 20th century by 0.3-0.6°F (1976-2005 period compared to 1961-1990; Figure 4). 21st century projections also show warming of daily minimum temperatures, albeit less than for daily high temperatures, ranging from +0-1°F for 2006-2039, +3-4°F for 2040-2069, and +4-7°F for 2070-2100 (Figure 5). This change is particularly relevant for high elevation areas that currently experience minimum temperatures below freezing ($\leq 32^{\circ}\text{F}$). During 1981-2000, NOAA records indicate that Victorville (2,726' elevation) experienced 44 days a year of freezing temperature, but this number is projected to decline to 9 days per year midcentury, and to 2 days by the end of century (Sun et al., 2015).



FIGURE 7



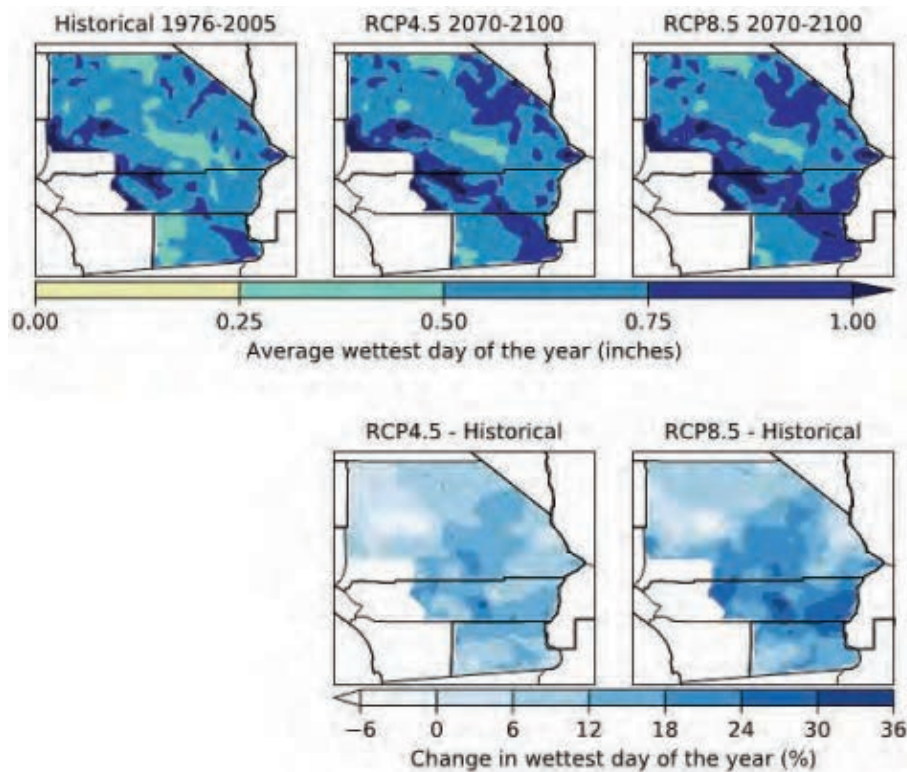
Historical (black) and projected annual average precipitation in the Inland Deserts for two different emission scenarios (RCP 4.5: blue, RCP 8.5: red). Panel a: Annual Time Series: Solid lines show model averages, and shaded areas show modeled ranges. Panel b: 3 decade summaries: Circle markers show model averages, and error bars show modeled ranges. Source: Neil Berg, UCLA.

Historically, precipitation in the region is highly variable, averaging around 5 inches per year, with rainfall some years as low as 1½ inches and as high as 10¾ inches over the 1950-2005 period (Figure 7). There is also large spatial variation in precipitation rates across the region driven by elevation and location, with averages ranging from 3 inches per year to roughly 8 inches per year (Figure 8). Projecting climate impacts on precipitation is highly uncertain in California, in particular for annual rainfall totals in the Inland Deserts (Allen and Luptowitz, 2017). For the suite of downscaled climate models used in this assessment, there is little projected change in average rainfall each year to the end of the 21st century (<10%), even under different emission scenarios (Figure 7). However, projections reveal an increase in inter-annual precipitation variability, with reductions in minimum annual precipitation of up to 50% and increases in maximum annual precipitation of 40-65% by the end of the 21st century (Figure 7).



Precipitation in the Inland Deserts occurs during two seasons. In the winter, large scale global circulations occasionally bring extratropical cyclones from the northern and eastern Pacific region. These storms are responsible for most of the annual rainfall across the desert region, with February typically being the wettest month. Winter precipitation increases with elevation and decreases going from north to south, and west to east. In the summer, global circulations reverse, allowing the North American Monsoon to periodically drift westward into this portion of the state (Hereford et al., 2006). Historically, summer monsoon precipitation falls primarily in July, August, and September (Tubbs, 1972). The monsoonal rains account for about 30% of precipitation over the eastern deserts, decreasing to around 15% in the western Mojave.

FIGURE 8



Average wettest day of the year (inches) across the Inland Deserts for historical observations (1976-2005) and modeled end of century (2070-2100) for RCP 4.5 and RCP 8.5 scenarios (top panels), and percent change in wettest day of the year at the end of century for RCP 4.5 and RCP 8.5 (bottom panels). Source: Neil Berg, UCLA.



These seasonal patterns of precipitation may also change with the climate. As winter and summer precipitation have different climatic drivers, current research suggests these phenomena will be affected differently by climate change. Winter precipitation (falling mainly in December, January, and February) is projected to increase over the region due to warming of the tropical Pacific according to roughly half of the current generation of climate models (Allen and Luptowitz, 2017). In contrast, summer monsoonal precipitation is thought to decrease by up to 40% (Pascale et al., 2017). While it is difficult to predict precipitation changes in the region, higher temperatures mean the atmosphere will be capable of carrying more water vapor, thus increasing evaporative demand on already scarce water supplies and decreasing soil moisture. High interannual and interdecadal variability along with the difficulty of simulating future sea surface temperatures pose challenges to precipitation simulations in current climate models (Pascale et al., 2017). Better prediction of precipitation trends and seasonality is an important area where future research is needed.

Over most of the region, the wettest day of the year is projected to increase by as much as 30% in some areas by 2100 (Figure 8). The combination of more intense rainfall events and drier soils in an already very dry region will increase the probability of flash floods. Dry soils are poor absorbers of rainfall, causing high runoff rates. Moreover, infrequent rainfall increases the possibility of debris flow of accumulated material such as dead vegetation and rocks during flash flood events (Reid et al., 1994). Because of the dry climate, infrastructure is generally not designed to handle large flows of water that may be generated in a flash flood event—for example, many roads cross dry creek beds without bridges—making intense rainfall events a large risk here than in wetter areas.



Projected Fire Activity through 2100

The combination of low annual precipitation amounts and high precipitation variability from year to year often results in discontinuous fuel beds (i.e. the horizontal and vertical spacing of fuels over a given area) across this portion of California. The Mojave Desert flora within these fuel beds is mainly comprised of annual grasses and shrubs such as manzanita, California buckwheat, and desert holly, while higher elevations are favorable habitats for juniper pine, sagebrush and some white fir. The Joshua tree is iconic and is a common flora across much of the Mojave, particularly over the southern Mojave (Figure 9). Various species of cacti are home to this portion of California but are more prevalent over the southeast portions of the Inland Deserts. Within the desert ecosystem, fuels have the most significant contribution to the overall fire regime (Brooks et al., 2004).

FIGURE 9



Joshua tree against a smoke plume from the 2015 Lake fire burning near Yucca Valley. The same region burned in 2006 during the Sawtooth Complex Fire. Source: Kurt Miller, Riverside Press-Enterprise/SCNG,
<https://www.pe.com/2015/06/25/pioneertown-desert-community-still-shaken-by-sawtooth-blaze-now-frets-over-lake-fire/>



CALIFORNIA'S FOURTH CLIMATE CHANGE ASSESSMENT

Consequently, fire activity is highly variable from year to year depending on the amount of loading, continuity, and vertical arrangement of the fuels that are present. A brief analysis was performed on historical fire data across the region that consisted of 9,784 records which spanned the years 1992 to 2015 (Short, 2017). Displaying the dataset graphically reveals that most of the fire activity is clustered around the national forests, in and near the more populated areas, and along major transportation corridors such as interstates and railroads (Figure 1F), illustrating that most of the fire activity in the region is human related. Specifically, 22% of the fires were caused by equipment use, 30% were attributed to miscellaneous causes, and 37% were related to various other causes, with only 10% started by lightning (Table 1). However, lightning played a disproportionately large role in the ignition of extremely large fires; it was cited as the cause for 40% of the fires that were 500 acres or more. While many incidents are covered at the initial attack stage, these larger fires require additional resources from outside the area, thus making them more costly to suppress.

Perhaps the most significant meteorological effect of climate change would be the potential for a weaker North American Monsoon signal over the Desert Southwest (Pascale et al., 2017). Some climate models project lower precipitation amounts during the summer months in the coming decades. Since lightning is responsible for igniting nearly half the large fires that are listed in our database, a diminished monsoon influence would suggest potentially fewer starts due to lightning.

TABLE 1. CAUSES OF FIRE IGNITIONS FOR 1992-2015.

Data from Short, 2017.

CAUSE	NUMBER	%
Miscellaneous	2,998	31%
Equipment Use	2,109	22%
Lightning	978	10%
Missing/Undefined	806	8%
Arson	743	8%
Children	562	6%
Smoking	516	5%
Debris Burning	477	5%
Campfire	419	4%
Railroad	64	1%
Fireworks	52	1%
Powerline	48	0%
Structure	12	0%



CALIFORNIA'S FOURTH CLIMATE CHANGE ASSESSMENT

Projected warmer and periodically drier conditions during the next 80 years may increase the risk for more severe drought (Pierce et al., 2015). Although an increase in average temperatures will probably have little impact on fire activity, changes to the frequency, amount, and spatial distribution of annual precipitation could have dramatic effects on future amounts and types of desert vegetation. It has been suggested that the changing climate has fostered the advancing invasion of non-native grasses which has led to increased fire activity in recent years (Brooks and Matchett, 2006, Figure 10). However, the 1992-2015 record of fires in the region shows no distinct trend in large fires (>500 acres), which could imply that non-native grasses have limited influence on fire activity in this region. Despite a drier climate outlook for the remainder of this century, variability of precipitation from year to year will govern the length and severity of fire season through fuel loads.

One major factor to consider when addressing the propagation of wildfire is wind. The Inland Deserts have a number of well-known high wind prone areas such as the San Geronio (Banning) Pass, which serves as the gateway to the Coachella Valley, and the Cajon Pass leading to the Victor Valley. Prevailing wind directions over these areas are generally from the west, except in the Colorado River Valley where the majority of wind comes from the south. Winds across these areas are strongest during the evening and overnight hours mainly from April through September (Fisk, 2008). The stronger winds that frequently occur in these areas play a vital role in the spread of wildfires, particularly in areas where vegetation is sparse. It is important to note in our discussion of wind that we are not referencing “Santa Ana Winds”, which mainly affect the coastal and mountain areas of Southern California to the west of this region (Rolinski et al., 2016).

Speculation on how wind speed may be influenced by climate change is difficult to ascertain. Since the majority of these desert winds, particularly during the summer, are thermally driven, it is plausible that there would be an upward trend in velocity. The projection of higher temperatures would imply a stronger temperature gradient between the coast and the interior of California, which would subsequently enhance onshore flow during the afternoon and evening hours, especially over the western sections of the Inland Deserts. However, the current generation of climate models only projects subtle (5-10%) changes in wind speeds (Kulkarni & Huang, 2014). Future research is required to ascertain the effect of climate change on winds in the region.

As 60% of the cause of large fires are related to human activity, climate-driven changes in human population of the region, human behavior, and transportation infrastructure and activity are likely to have a large effect on future fire activity. How these various factors evolve in the coming years will dictate the kind of fire activity that occurs across this portion of the state. As an adaptation strategy, residents and visitors to the region need to be informed of the risk of human ignitions of wildfires despite the perception that deserts are not susceptible to fires. Further research that better elucidates the relationship between climate change and risk of ignition from human activity is needed.

FIGURE 10



The 2006 Sawtooth Fire as it moves through the desert landscape. Source: photo taken near Mocking Bird Ln, Morongo Valley by Taya Lynn Gray of the Desert Sun newspaper.



The Colorado River: Key Water Resource for Development of Inland Deserts

The Colorado River is the lifeblood of agriculture and urban development in the Inland Deserts, supplying the vast majority of water resources to the Imperial, Coachella, and Palo Verde Valleys. Colorado River flows supply around 3.5 million acre-feet of water to the region, with drainage and runoff waters from agriculture feeding into and maintaining the Salton Sea. The Colorado River is also an important water resource for approximately 40 million people in six U.S. states in addition to California, and in Mexico. In most years, the entire flow of the river is consumed for human uses. Allocations of river water are governed by seniority of water rights, with California as a senior rights holder, and major agreements, including the 1922 Colorado River compact, the 1944 US-Mexico treaty, and amendments to both. However, these allocations were made based on high streamflow volumes during a historically wet period in the early 20th century, so river water has been over-allocated much of the time since. This shortfall has worsened with reduced streamflow during the 2000-2012 drought, the driest period in recorded history (U.S. Bureau of Reclamation, 2012), and will likely worsen with further 21st century climate change (Vano et al., 2012). Increasing evapotranspiration is projected to reduce Colorado River flows by 20-30% at mid-century, and 35-55% at end-century (Udall and Overpeck, 2017). As a result, less water will be available for human use across the entire Colorado River Basin. Furthermore, the amount of precipitation falling as snow in the region is projected to decline substantially, which impacts timing of streamflow, with implications for downstream users (Wi et al., 2012).

In addition to climate change pressures, increasing municipal use demands have already put additional pressure on irrigation districts to reduce agricultural water use. The 2003 Quantification Settlement Agreement identified a pathway for California to reduce its reliance on Colorado River water to its legal allocation, 4.4 million acre-feet, via water conservation and land fallowing schemes. These schemes transfer water from agricultural uses in the Inland Deserts to growing municipal populations in coastal Southern California served by the Metropolitan Water District and the San Diego County Water Authority. However, this “conserved” agricultural water reduces drainage inflows to the Salton Sea and, consequently, will cause significant ecosystem damages and health impacts to local communities due to a shrinking, increasingly saline Salton Sea. The potential political pressure for additional water use reduction in the Inland Deserts will likely depend on the magnitude of increased future demands elsewhere in the Colorado River basin and in coastal Southern California as well as the magnitude of future reductions in Colorado River flow.



The Salton Sea

The Salton Sea, located below sea level in Riverside and Imperial counties, is California's largest lake by surface area (> 340 square miles). It is ecologically important as a rest stop for millions of migratory birds along the Pacific Flyway, and a year-round habitat for several endangered and sensitive species, including the desert pupfish, Yuma clapper rail, and burrowing owl (Audubon California, 2016; U.S. Fish and Wildlife Services, 2011). Formed in its most recent state in the early 1900s due to a dam break along the Colorado River, this terminal lake was maintained by inflows consisting mostly of runoff emanating from irrigated farmland around the Sea. Since its formation, the Sea's water quality has been in a slow decline due to the accumulation of salts and pollutants. This decline accelerated in 2018 with cessation of water transfers to the Sea resulting from competing demands on water from the Colorado River. Agricultural runoff is also declining due to large transfers of Colorado River water from the Imperial Valley to urban users in coastal Southern California under the 2003 Quantification Settlement Agreement.

Reductions in agricultural runoff to the Salton Sea pose a hazard for public health and the region's economy, in addition to destroying the Sea's ecological benefits. As inflows are reduced, the shrinking Sea leaves exposed lakebed (playa) that is a source of airborne dust causing severe air quality impacts on the region (Frie et al., 2017). Increasing dust and potential toxic airborne emissions may lead to major environmental justice issues for the vulnerable population living nearby through increased asthma and respiratory illness. High levels of dust also threaten the region's economic drivers, tourism and development.

Over the next dozen years, inflow volumes will decrease by 40%, leaving 100 square miles of exposed playa, and increasing salinity by threefold (Cohen, 2014). Higher salinity levels threaten fish and birds that currently depend on the Salton Sea habitat. The estimated public damages of a continual decline of the Sea have been estimated at between \$11 and \$70 billion over the next 30 years (Cohen, 2014). These estimates cover impacts including increased respiratory illness associated with higher airborne particulates levels emitted from exposed playa, decreased property values, decreased recreation, and the loss of wildlife habitat. Climate change poses an additional threat not included in these assessments, including increasing evapotranspiration rates, and possible changes in agricultural water management inputs and Colorado River allocations to the region. Climate change will exacerbate stresses to the limited water supply feeding the Sea and may accelerate the pace of decline. Currently, there are no comprehensive restoration projects in place (Salton Sea Restoration Renewable Energy Initiative, 2015).



Hydrologic Assessment: Current Status and Future Challenges for Adaptation to Climate Change

The Inland Deserts encompasses two main hydrologic regions of the state. These include the Colorado River hydrologic region and the southern portion of south Lahontan hydrologic region, with 92% and 39% of their areas located in this region respectively (Figure 1G). The Colorado River hydrologic region is the largest water user in California based on 1996-2005 data, at a rate of 379 gallons per capita per day. Surface water provides 91% of its water supply. Groundwater is the primary water supply in the south Lahontan hydrologic region, providing 66% of the region's water supply (California Department of Water Resources, 2013a).

The Colorado River Region has a subtropical desert climate. The northern part of this region includes Mojave Desert and San Bernardino and San Jacinto mountains with peaks higher than 10,000 ft above the sea level, as well as the Sonoran Desert. The Sonoran Desert is comprised of the Salton Sea, California's largest lake as measured in surface area, and significant irrigated land within the Imperial, Palo Verde, and Coachella Valleys (California Department of Water Resources, 2013b). Agriculture is the main land use in the Imperial Valley, and Colorado River water delivered through the All-American Canal is the main water source for this region. The Coachella Valley contains most of the urban areas within this region, and its main water source is Colorado River water transported by Coachella canals as well as groundwater. There are 64 groundwater basins in this region. According to the California State Groundwater Elevation Monitoring Program (CASGEM) basin prioritization, only the Indio and San Geronio Pass sub-basins of Coachella Groundwater Basin are classified as high priority basins, meaning that government and water agencies should reduce groundwater depletion in these sub-basins and determine sustainable pumping rates. Land subsidence has occurred in some areas as a result of high intensity pumping. Currently, water levels in the Salton Sea are primarily maintained by agricultural tailwater and runoff, with some contributions from urban wastewater flows. Salton Sea water levels are in decline due to water rights transfers away from the region (see Salton Sea sidebar) as well as below average precipitation in recent years and decreases in return flows from both local irrigated agriculture and surface flows from Mexico. As the Sea is a terminal lake, rising salinity levels are a significant concern.

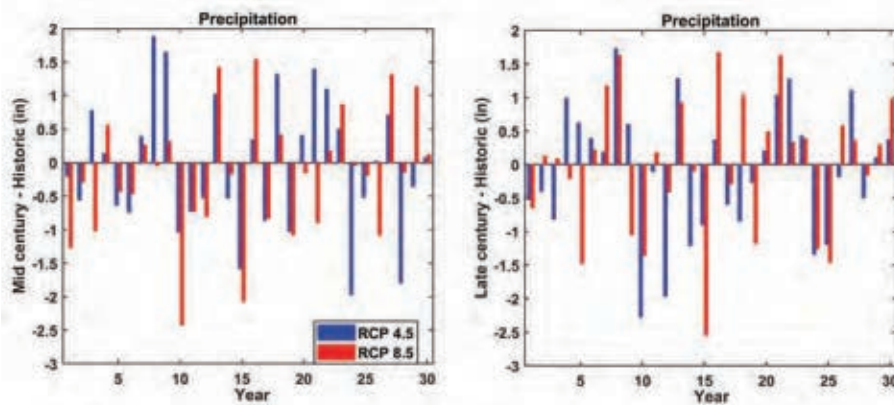
The South Lahontan hydrologic region (Figure 1G) has an arid climate with mean annual precipitation of 8.2 inches (1981-2010). Surface water resources include ephemeral and intermittent streams and waterways that mostly flow during summer thunderstorms. The winter season is typically cool and dry. Groundwater resources for the South Lahontan hydrologic region are mainly supplied by the alluvial aquifers composed of sand and gravel or finer sediments. In areas near the mountains and foothills, fractured rock aquifers exist which typically have less capacity than the alluvial aquifers. The Los Angeles Aqueduct is the major water facility in this region (California Department of Water Resources, 2013c). The Mojave River watershed is one of the major watersheds of South Lahontan hydrologic region that is fully contained in the Inland Deserts domain. This watershed is amongst the most populated areas of the South Lahontan hydrologic region, with 66% of its water supplied by groundwater. This dependence on groundwater is expected to increase in the future as surface water supplies become limited due to recent and projected severe droughts. According to the CASGEM basin prioritization, the western portion of the Mojave River watershed is classified as a high priority basin. Lowering of groundwater levels in recent years has impacted important wetland and riparian communities in this region; efforts are underway to restore these important habitats (California Department of Water Resources, 2013c).



CALIFORNIA'S FOURTH CLIMATE CHANGE ASSESSMENT

Future changes in water availability are assessed by comparing projected precipitation, surface runoff, and potential recharge with historic values. Historical annual precipitation from 1951-1980 is about 5 inches per year, with projections indicating a decline to 3.9 inches per year by the end of 21st century. While there are no significant differences between the projected 30-year mean annual precipitation and the historic period from the 10 global climate models (GCMs) considered to be most representative of the California climate (ACCESS1-0, CCSM4, CESM1-BGC, CMCC-CMS, CNRM-CM5, CanESM2, GFDL-CM3, HadGEM2-CC, HadGEM2-ES, MIROC5), there is a considerable year-to-year variability among the GCMs and RCP scenarios. Differences in the direction of precipitation changes relative to the historic period are strongly dependent on future emissions scenarios (RCPs; Figure 11). Projected mean annual precipitation from these 10 GCMs mostly representative of the California climate indicate that 50% of the years in the mid-century period (2035-2064) will be drier than historic conditions (1951-1980) based on the RCP4.5 simulations. However, RCP 8.5 simulations illustrate a drier mid-century and a wetter late century period relative to historic conditions. These variabilities among the GCMs ensemble averages complicate water resources planning.

FIGURE 11

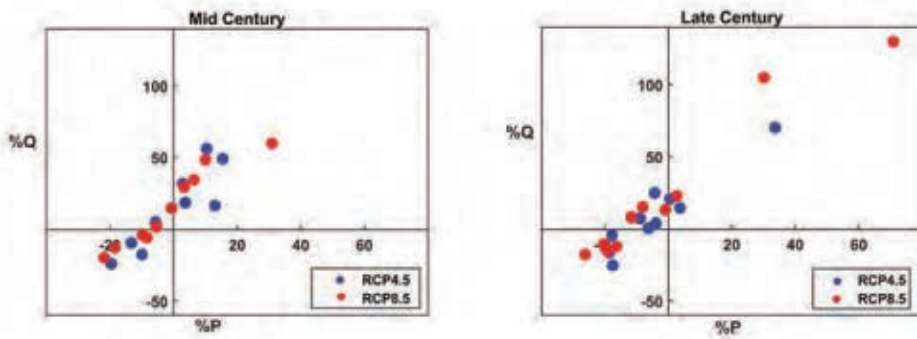


Relative annual differences between the ensemble annual mean precipitation from 10 GCMs and historic precipitation. The historic period corresponds to 1951-1980, the mid-century period to 2035-2064 and the late century period to 2070-2090.



Variability in precipitation projections further translate to relative changes in surface runoff simulated by the Variable Infiltration Capacity (VIC) model, which has been widely used for climate change impact assessments. Previous investigations have shown that subsurface runoff simulations from VIC can be used as proxy for groundwater recharge (Niraula et al., 2017a). In the Inland Deserts, changes in 30-year mean annual surface runoff is linearly related to changes in precipitation amount relative to the historic period (Figure 12). While there is no clear consistency in the magnitude and direction of surface runoff among multiple GCMs at mid-century, almost all simulations converge to a drier than average surface runoff by end-century.

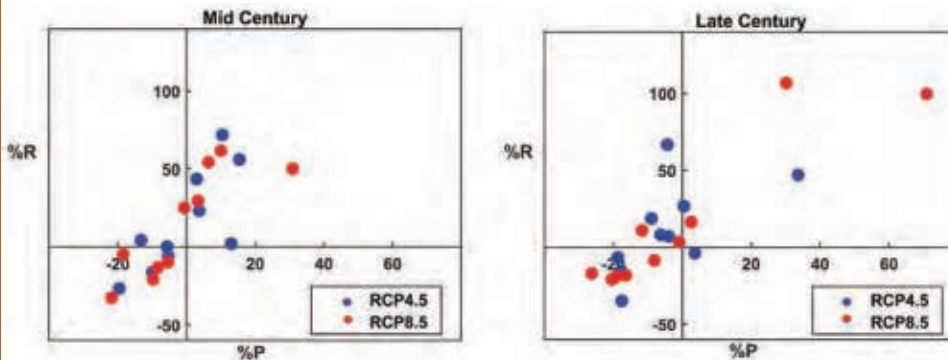
FIGURE 12



Percent changes in 30-year mean annual surface runoff (%Q) and precipitation (%P) from 10 GCMs relative to the historic condition. The historic period corresponds to 1951-1980; mid-century period to 2035-2064; and the late century period to 2070-2090.



FIGURE 13



Percent changes in 30-year mean annual recharge (%R) and precipitation (%P) from 10 GCMs relative to the historic condition. The historic period corresponds to 1951-1980, the mid-century period to 2035-2064 and the late century period to 2070-2090.

Subsurface runoff simulated by the VIC model was used as a proxy for potential recharge similar to the methods used by Niraula et al. (2017b). While changes in the 30-year mean annual recharge are mostly consistent with the projected changes in precipitation relative to the historic period, in some cases during the mid-century, increases in recharge were projected despite decreases in precipitation relative to the historic mean. There is more scatter in the relationship between 30-year mean recharge and precipitation compared to the relationship of surface runoff and precipitation (Figure 13). Future changes in the magnitude and direction of changes in runoff and recharge depend mostly on the precipitation rate, which is highly variable amongst GCMs (Figures 12, 13). Another source of uncertainty is related to the incomplete representation of land surfaces in the VIC model. It should be noted that these simulations only illustrate changes in surface runoff and potential recharge as a function of changes in precipitation and temperature. The role of human activities and how they change in response to future changes in the climate are not considered.

Various strategies have been implemented and are being considered as adaptation options for robust water resource management. The focus for water managers—both within the Inland Deserts and the state—will be to address future increases in water scarcity, which is defined as the degree to which demand exceeds supply. With respect to supply management, the region is heavily reliant on imported water from the State Water Project and the Colorado River, but also on groundwater recharged from local sources and precipitation.

Since new freshwater supplies are unlikely to be appropriated on a permanent basis, the region must, and is, considering augmenting these current supplies through a number of avenues. To this end, the region is pursuing strategies such as recycling of treated municipal wastewater, capture and recycling stormwater, recharge and conjunctive use of ground water, desalinization of brackish groundwater, and the reuse of agricultural runoff.



In addition to these measures, water agencies within the region are increasing their cooperation to manage water more efficiently. As an example, a number of water agencies within the Inland Deserts have partnered in a joint project to manage their aquifers as a connected system in which dry year yields can be shared, and coordinated efforts have arisen to improve habitat for the Santa Ana Sucker fish species and to remove the invasive reed *Arundo donax* (SACCUP, 2017). Alternatively, the main wholesale water provider continues to develop long-term water sharing agreements with irrigation districts to ensure that water moves to its highest valued uses and to cover basic human needs during extreme droughts and periods of shortage (MWD, 2017).

On the demand side, the region has invested significantly in water conservation efforts. More effective water pricing structures, rebate programs for water conservation technologies, and education programs are part of the strategy to improve water use in the region. These strategies are particularly important given expected increases in the region's population. There is reason to believe significant gains in addressing water scarcity can be achieved by looking at the declining trend in per capita water use since the 1990s in the region. One area with significant possibilities for water savings is in urban outdoor conservation. More than 50% of the water used by households is for outdoor watering, with much of the indoor use already benefiting from decades of conservation efforts. In response, agencies are spending significant resources—time, money, personnel—to identify and encourage efforts by homeowners and business to reduce their outdoor water use.

Finally, the region is investing significantly in effective and efficient storage. While surface water storage will be limited in the region given lack of land for such purposes, groundwater storage and improved management will likely provide significant opportunities to the region to decouple water supply availability to yearly surface water deliveries. Future climate change impact assessment research in this region should implement integrated groundwater-land surface models to simulate dynamic feedback processes between land cover condition, groundwater flow, and surface runoff in response to changes in climate and changes in human water use.



Natural and Managed Resource Systems

In this section, we describe the effects of projected climate change on agriculture and ecosystems. Agriculture is the primary economic driver in the Imperial and Palo Verde Valleys, and is second only to tourism in the Coachella Valley. The region is a major source of winter fruits and vegetables. The region also has a large acreage of federally protected lands (U.S. Bureau of Land Management National Conservation Lands), including nearly 7500 square miles of National Parks and Monuments. This includes ecologically unique and sensitive ecosystems in Joshua Tree National Park and the Mojave Trails National Monument that are also tourist draws for the region. High biodiversity in the region is a product of localized refuges from climatic extremes that will likely contract as the climate warms. Both agriculture and natural systems are uniquely adapted to the already extreme climate of the Inland Deserts and serve as a model for how other regions of the state might respond to a warmer, drier climate.

Agriculture

The agricultural valleys of the Inland Deserts are some of the hottest agricultural regions in the world, with maximum summer temperatures that can reach 122°F. These extreme temperatures are projected to increase by up to +8°F by the end of the century under RCP 8.5. The number of extreme heat days per year, with maximum temperature greater than 112°F, are predicted to increase from ~10 to more than 80. The major crops in the region are forage crops (alfalfa, Sudan grass, and Bermuda grass) and winter vegetable crops. Alfalfa, a crop with a C3 photosynthetic pathway, already shows heat stress and reduced yields during the warmest periods (Ottman and Mostafa, 2014). Less is known about the effect of extreme heat on other forage crops like Sudan and Bermuda grass, which use the C4 photosynthetic pathway. C4 crops also have a significant advantage in higher physiological water use efficiency. Recent studies of C4 energy crops show little evidence of reduced photosynthesis at the highest observed temperatures, thus biomass production could be maintained even as water stress increases (Oikawa et al., 2015). However, excessive temperatures can cause seed abortion of crops such as sorghum during the grain filling period (Nguyen et al., 2013). High temperatures can also substantially increase the risk of scalding in flood irrigated crops (Hutmacher et al., 2001).

Besides summer heat, the relatively minimal risk of winter frost in the region's agricultural valleys could diminish even further under climate change. Most of these valleys are currently in the US Department of Agriculture's plant hardiness zone of 10a or warmer (planthardiness.ars.usda.gov) which implies an extreme minimum temperature of 30°F or warmer. If the threat of frost were removed, crops that are highly intolerant of frost could become new candidate crops for cultivation in the Inland Deserts in winter.

Along with crops, another major face of agriculture is cattle production, both on grazing lands and in feedlots in the Palo Verde and Imperial Valleys. The feedlot cattle are often steers from dairy operations in California's Central Valley. Shade and sprinkling water to provide evaporative cooling are often used to successfully mitigate heat stress, but studies have shown contradictory impacts of sprinkling on animal weight gain and feed efficiency (Morrison et al., 1973; Correa-Calderón et al., 2010). Different cattle breeds have varying susceptibility to heat and ability to acclimatize, but commonly used dairy breeds (such as Holsteins) are recognized to be more heat-sensitive (Blackshaw & Blackshaw, 1994). Along with increases in temperature, potential increases in humidity may be important for cattle production as humidity increases mammal heat stress and reduces the effectiveness of evaporative cooling measures such as sprinkling. Besides animal health, potential impacts on farm workers need to be considered for summer



workers. One mitigating factor in the Inland Deserts, unlike other parts of California, is that the main demand for farm labor occurs during the cooler winter vegetable season. Temperature changes may also exacerbate insect, weed, and other pest problems for humans, animals, and crops due to the potential for increased insect, pathogen, and weed growth under higher temperatures (Rosenzweig et al., 2001).

Agriculture is also vulnerable to increased stress to water supplies and extreme high temperatures under projected 21st century climate change. Agriculture in the region is nearly completely dependent on irrigation, primarily by water from the Colorado River. The Colorado is said to be the most litigated river on Earth, and much has been written about contested water rights for this overallocated resource that will only become more scarce and precious in the future. Inland Desert valleys are already one of the hottest agricultural regions in the world, and essentially serve as a model for what many other agricultural regions will face in the future with respect to heat tolerance and high salinity soils. Much research about temperature effects on agriculture has taken place here, but projected warming will take this region far past what it has experienced in the past.

Water for irrigation is critical to agriculture in the Inland Deserts, which have too little precipitation to support crops apart from marginal grazing lands. Precipitation in major agricultural valleys of the region is under 4 inches per year; climate change models under the RCP 8.5 scenario show wide relative variance in precipitation (0.5-8 inches/year), but all scenarios show that the major valleys retain their hyper-aridity (CalAdapt). The hydrologic scenarios show an increase in reference evapotranspiration, representing meteorological evaporative demand, of 2-4% by 2100 (CalAdapt). These increases in evapotranspiration will increase crop water demand, but this will depend on the type of crop grown. For some crops, such as alfalfa and winter vegetables, rising atmospheric carbon dioxide levels that cause climate change may also improve plant water use efficiency (Gago et al., 2014), but this is not relevant for the sorghum varieties that comprise most of the forage crops in the region since they have a C4 photosynthetic pathway.

The vast majority of irrigation water in the Inland Deserts comes from the over-allocated Colorado River, which is likely to see major streamflow reductions in the 21st century (see Colorado River sidebar). While irrigation districts that supply water to the region have some of the most senior water rights on the Colorado River (e.g., the Imperial Irrigation District, the Palo Verde Irrigation District, and the Coachella Valley Irrigation District), reduced streamflow may put additional pressure on these water suppliers to reduce their water use to alleviate shortfalls elsewhere in the Colorado River basin, especially if less than 7.5 million acre-feet are available for the US portion of the Colorado River Basin (MacDonnell et al., 1995). Efforts to reduce water use have already occurred, primarily with the Quantification Settlement Agreement that reduced Imperial Irrigation District use, regulated Coachella Irrigation District use, and implemented fallowing within the Palo Verde Irrigation District (Anderson, 2004; Hanak, 2003).

Along with the major agricultural valleys, there are smaller, isolated agricultural areas in the Inland Deserts, primarily in the alluvial regions of the Mojave Desert, that are irrigated primarily with groundwater. While small in area, they are isolated from other agricultural regions and can support cultivation of high-value, organic food crops (Jansen & Vellema, 2004). The water supplies for these isolated areas may be limited if climate change reduces the intensity and frequency of aquifer recharge during wet years. Besides reduced quantity, agricultural water quality may decrease under climate change as well. Water salinity is strongly and inversely correlated with stream flow in the Colorado River (Spahr, 2000). Irrigation districts in the region are in the downstream reaches of the Colorado, and thus experience higher salinity. As salinity of irrigation water rises, additional water will need to be leached through the soil profile to avoid deleterious yield losses (Grismer, 1990), which will reduce the water use efficiency of



agricultural systems in the region. Reuse of urban waste water that has higher salinity may also have an effect if that water is applied to agriculture (Glenn et al., 2009).

In addition to direct effects of climate on water supply, there are several non-climate issues that intersect with agricultural water use. These factors that may independently respond to climate change, indirectly affecting agriculture through changed water supply. First, urbanization of the agricultural valleys of the Inland Deserts competes with agriculture for both land and water. The populations in the Palo Verde, Coachella, and Imperial Valleys have increased by more than 20% per decade recently (US Census), and now exceed 600,000 people. The water needs of new urban development depends greatly on landscaping choices, and water used for indoor use can be reused for other purposes following secondary and tertiary treatment. Second, there is a potential for additional water transfers away from the region. Despite senior water rights of irrigation districts in the Inland Deserts for Colorado River water, serious shortages in the lower Colorado River Basin could cause some curtailment of current water allocations to the region during droughts or possibly the need to transfer water to urban water districts outside of the region. Finally, restoration of the Salton Sea could affect water availability for agriculture, depending on the desired physical and ecological condition of the Sea, which depends directly on the quantity and quality of water flowing in (Glenn et al., 1999; Kjelland & Swannack, 2018). If the Salton Sea continues to shrink, potential agricultural impacts include crop damage from dust storms from the exposed playa (Abuduwaili et al., 2015) and health impacts on cattle in feedlots close to the sea.

There are a number of adaptation options that can maintain agricultural productivity in the Inland Deserts in the face of reduced water supply and extreme heat expected with 21st century climate change. Drip irrigation, despite higher initial capital costs, can increase yields in forage crops compared to furrow or flood irrigation with the same evapotranspiration rates (Hutmacher et al., 1992). For vegetable and crops with sparser canopies, drip irrigation can reduce water losses by minimizing soil evaporation (Ayars et al., 2015). Deficit irrigation of alfalfa during summer can conserve water during periods of peak evaporative demand (Hanson et al., 2007), but may affect yields if not carefully implemented. While reduced yields are undesirable for farmers, alfalfa yields during extremely hot periods are already reduced by heat stress, and yields can recover quickly if the crop is well developed and the applied stress is not too severe. Conversion of forage crops from alfalfa to C4 pathway crops can result in increased water use efficiency and biomass production with similar evapotranspiration rates (Anderson, 2010).

Alternately, changing the planting date of crops might reduce water use by minimizing full canopy cover during periods of peak evaporative demand. For vegetable crops, the impact of changing crop season on agricultural markets needs to be considered. Crops that arrive earlier or later in the season may command lower prices due to competition from other regions. Switching to salt-tolerant crops that can be irrigated with drainage water or urban waste water is possible if water use regulations are appropriately modified and technical safeguards are in place to protect crop, soil, and human health (Rahman et al., 2016; Rhoades et al., 1988a; Rhoades et al., 1988b). However, market acceptance and crop quality of salt-tolerant crops is a substantial unknown. Changing crop timing is also likely to be of limited benefit for perennial crops including citrus, dates, and grapes.

While more efficient water use and water reuse are adaptation options, careful management of salinity of applied water is crucial for protecting soils and aquifer health in the Coachella and Palo Verde Valleys, as groundwater can be used in both of these regions (Harter, 2015). Moreover, improvements in irrigation and on-farm water use efficiency, both due to management changes and increased evaporative demand from climate change, will accelerate



the Salton Sea's decline, unless other mitigation water is provided, due to the increased salinity of drainage water entering the sea.

Further research is needed to project the impacts of higher temperatures on agriculture in the Inland Deserts. As the region already has some of the warmest climate agricultural systems in the world, there are no good analogues for potential changes under future climate scenarios. Research is needed on how current crops will fare under future climate, as resilience of crops and animal production systems to future temperatures is a key unknown. The tradeoffs between increasing evaporative demand and improved plant water use efficiency on controlling plant water consumption needs to be evaluated holistically. It is currently an open question as to whether breeding programs can help develop more heat-tolerant cultivars and whether there are cost-effective cooling strategies to help reduce stress and production losses in feedlot cattle. Along with heat-tolerance, new information on the impact of crop management practices and cultivars on water use is needed. Specifically, further research needs to examine how crop yields change with reduced amount and quality of irrigation water, how this varies over a season, and how much water can be saved by changing the timing of crop cycles.

More research is needed to better understand the risks of a changing water supply to the Inland Deserts in the 21st century. Projections of water supply require improved understanding of how external demands for Colorado River water will change, particularly with respect to pressure on Inland Desert irrigation districts to transfer water to coastal Southern California. Climate effects on water supply and quality must also be considered for better understanding of the requirements of restoration of the Salton Sea given that the amount and quality of agricultural drainage water will be altered by a changing climate and changing agricultural practices. Finally, work is needed on modeling and understanding different types of agricultural systems in the region that can maintain agricultural productivity (in terms of crop yield, quality, agricultural employment and revenues, etc.) while using less water.

Biodiversity and Ecosystems

Contrary to popular perception of deserts as a desolate wasteland, the deserts of southeastern California are in fact a biodiversity “hotspot” (Kraft et al., 2014). The California deserts comprise 28% of the state and include 37% of California's plant species (Figure 14). The rich biodiversity of these deserts is a product of both geography and topography; here, both the cooler Mojave Desert and the hotter low-elevation subset of the Sonoran Desert, the Colorado Desert, transition across a boundary extending from just north of Palm Springs and northeast to Needles. Additionally, the Baja California Peninsula bioregion extends into California along the Peninsular Mountain Range, through Anza Borrego State Park to its

FIGURE 14



Desert wildflowers.



northern terminus near Palm Springs. Each of these bioregions brings with it a characteristic flora and fauna. The Mojave Desert includes at least 1,409 plant species, 20 of which are endemic to that bioregion and 51 found nowhere else in California (Raven and Axelrod, 1977; Baldwin et al., 2002). The Colorado Desert includes at least 709 plant species; seven are endemic to this bioregion, with 100 species found nowhere else in California (Raven and Axelrod, 1977; Baldwin et al., 2002). These numbers are conservative—new varieties and species are being identified each year. Patterns of high biodiversity go beyond plants. A region that includes the northern part of the Peninsular Mountain range, the southwestern edge of the Mojave Desert, and the northwestern edge of the Colorado Desert, includes 33 species of native lizards, more than any similar sized area in all of North America [33 species] (Barrows et al., 2013).

The highway corridors of Interstate Highways 8, 10, 15 and 40 across the California deserts are often zones of low biodiversity, whereas the desert region's biodiversity is concentrated in the isolated mountain ranges ("sky islands") where somewhat cooler and relatively wetter climates occur (Kraft, 2014), at isolated springs, oases, and rare river courses (such as the Mojave and Amargosa Rivers), and on sand dunes. The two factors explaining these biodiversity hotspots are isolation and the occurrence of conditions that can buffer species from the harsh heat and aridity otherwise characterizing these deserts. Even sand dunes often hold more moisture than the surrounding coarser bajada sands. Unlike coarser sands or finer silts, aeolian sands absorb and hold onto rainfall for long periods at levels readily accessible to plant roots and burrowing mammals, lizards, snakes, and arthropods (Seely, 1991; Lei, 2004; Rosenthal et al., 2005). If species evolve adaptations to deal with the scouring, wind-blown sand that creates and maintains dunes, their populations can and do thrive there. Burrowing just a few tens of centimeters below the dune surface, creatures can enter a cooler zone of near-100% humidity and therefore survive through the summer droughts. Every dune system in the deserts of southeastern California includes plants, arthropods, and/or lizards that occur nowhere else in the world.

A warming and likely drier climate, with more intense and prolonged droughts, would clearly stress populations anywhere. For those species already near their presumed physiological limits living in deserts, there is reason for concern for common iconic desert species as well as for narrow endemic ones. Joshua Trees, *Yucca brevifolia*, are one such iconic, widespread Mojave Desert species (Figure 15). Using models to predict the future distribution of species under expected warmer conditions, Cole et al. (2011) concluded Joshua Trees in California and Arizona could likely be largely extinct by the end of this century due to the effects of modern climate change. Using comparable methods, but at a much finer scale and focusing on Joshua Tree National Park, models constructed by Barrows and Murphy-Mariscal (2012) similarly identified increasing levels of unsuitable habitat where

FIGURE 15



Joshua trees (*Yucca brevifolia*) are an iconic Mojave Desert species.



these trees currently occur. However, rather than extinction, the models also identified small areas of climate refugia (10% of their current distribution), where this species could continue to sustain populations in the Park. That more optimistic prediction has received support from on-the-ground measurements of patterns of seedling recruitment; recruitment is highest and most consistent in those same areas shown to be climate refugia in the models. In contrast, Joshua Tree seedling recruitment has been poor to non-existent for several decades in areas beyond these climate refugia. Outside of Joshua Tree National Park, high recruitment and expanding populations of Joshua trees at higher elevations and latitudes indicate distributional shifts consistent with a sensitivity to increasingly warmer and drier conditions.

Agassiz's desert tortoise, *Gopherus agassizii*, is yet another iconic and widespread species of the California Deserts (Figure 16). This region has many competing human land uses that can, at local scales, compromise and potentially cause local extinction of these federally threatened tortoises (Lovich and Bainbridge, 1999; Averill-Murray et al., 2012). However, risks associated with climate change extend beyond local scales, encompassing the entire range of this species. Modeling the response of this species to anticipated modern climate changes levels, Barrows (2011) identified a precipitous decline in suitable habitat if temperatures continue to increase and precipitation declines. Just 7% of the tortoise's current habitat would still be suitable within Joshua Tree National Park. That 7% represents potential climate refugia where the tortoises may still be able to sustain small populations. Using a similar modeling approach to predict tortoise impacts from climate change for the US Marine Corps Air and Ground Combat Center (MCAGCC) in Twentynine Palms, a region north of Joshua Tree National Park, a more optimistic 40% of suitable habitat would remain in climate refugia (Barrows et al., 2016). Validating these predictions with real on-the-ground data is more challenging for tortoises than for Joshua Trees, as young tortoises are notoriously difficult to find and therefore survey. Nevertheless, Lovich et al. (2014) reported a dramatic decline in tortoises within the National Park, a landscape protected from land uses that could otherwise cause tortoise declines. The tortoise decline occurred over the past two decades, a period associated with persistent drought and warming consistent that presage future climate conditions.

Joshua Trees and desert tortoises are presented here as examples because of their iconic nature and because of the detailed research done on these species. People will take notice if either are lost to extinction. However, for the vast

FIGURE 16



Agassiz's desert tortoise (*Gopherus agassizii*).



number of desert species, we lack such information. Almost certainly some will be more resilient to the effects of climate change, while other will be more sensitive (e.g., Wu et al., 2018). Identifying and protecting climate refugia may be the best opportunity to stem widespread climate-related extinctions in southeastern California's desert region. The climate buffering noted for sites that are desert biodiversity hotspots is an indication that they too are acting as climate refugia. High species richness and genetic diversity (Harrison and Noss, 2017) and endemism (Sandel et al., 2011) are characteristics of climate refugia, as are sustainable populations with on-going successful recruitment. However, modern climate change is just one of several threats they face; as such it is critical that within these potential refugia other anthropogenic stressors are eliminated or managed (i.e. Abella and Berry, 2016; Berry et al., 2014).

Pumping water from desert aquifers that may be supplying critical water to desert springs, oases, and rivers is an on-going concern. Without that water, the refugial capacity of these sites could dry up as well. Invasive plants represent another threat. To the extent that those weeds out compete and displace native plants, important food for vegetarian tortoises may be lost. Invasive plants also fuel wildfires in desert areas where the native desert plants, such as Joshua Trees, have little or no evolutionary history for adapting to fire, and so lack a capacity to survive intense fires. Invasive weeds and the fires they fuel are particularly problematic within the airflow corridors extending from the Los Angeles basin out onto the desert landscape. Those corridors carry nitrogen-laden smog, which then falls onto the desert soils, acting like a fertilizer that provides a competitive edge to non-native invasive grasses, to the detriment of the native flora (Rao et al., 2014). As anthropogenic stressors layer upon California's rich desert biodiversity, extinction risk is heightened. However, the benefits of identifying and protecting climate refugia can go beyond the reduction of climate effects; they represent relatively finite targets for focused management of weeds, fires, and water resources, thereby increasing the resiliency of the plants and animals therein.



Tourism in the Coachella Valley

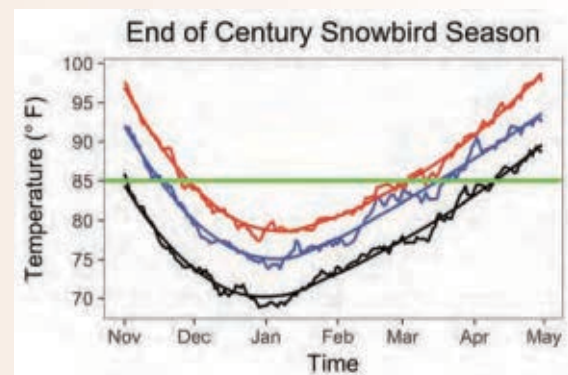
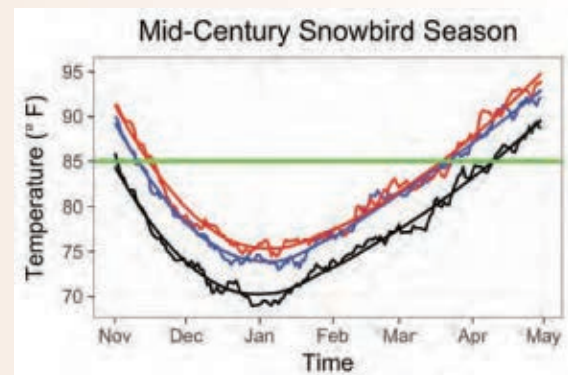
The Coachella Valley hosts thousands of out-of-state visitors every year. Tourism is the number one contributor to the local economy, generating 50,000 jobs and more than \$6.4 billion annually. Climate change poses a threat to the tourism in the Coachella Valley as mild winter temperatures are expected to warm, and as the length of the mild temperature period contracts. The seasonal influx of visitors lasts typically during the time when the daily maximum temperature ranges 70-85°, roughly from November to May, with the season's peak in March. This period of visitors is often called the "Snowbird Season" because of the large number of visitors who come to escape cold and snowy winter climates in their hometowns.

The Snowbird Season is an obvious economic driver, as employment and business revenue peak during this time. Jobs in tourism-related occupations such as accommodation, food services, waste management, arts, recreation, and entertainment decline significantly during the months outside of the Snowbird Season. These data show that tourism is the main driver for seasonal economic patterns in the Coachella Valley (CVEP, 2016).

This highly seasonal tourism may make the region economically vulnerable to climate change. With hotter winters to come, so-called "snowbirds" may be less inclined to visit the region due to both push and pull factors. That is, the Coachella Valley may be too hot for their liking or their hometowns may not be cold enough to make them want to leave. If temperature is a factor that tourists consider when they decide whether or not to visit the Coachella Valley, this could be a big blow to the local economy.

Climate projections from 4 models downscaled to the region suggests that the Snowbird Season, measured as number of days with high temperatures in the range of 70-85°, will be reduced from its historical length of ~5.5 months to around 4.5 months at mid-century, and to 3.5-4 months by the end of this century. By the end of the century, this represents a reduction of 25-33% in days with favorable temperatures for outdoor activities that are popular tourist attractions in the Coachella Valley, such as golf, tennis, and the Palm Springs Tramway.

Other main attractions in the Valley such as the Coachella Valley Music and Arts Festival, Stagecoach, The Palm Springs International Film Festival, and BNP Paribas Open attract many visitors annually. These major events will be affected by extreme heat, particularly since much of them take place outdoors. The venues will have to either shift their dates or provide more cooling infrastructure to accommodate their guests.



Historical and model projections of daily maximum temperature in Indio during Snowbird Season (Nov.-May) at mid- and end-century (historical: black, RCP 4.5: blue, RCP 8.5: red)



Human Systems

This section addresses the effects of climate change on human systems, encompassing land use, infrastructure, and human communities. The Inland Deserts have around 1 million inhabitants, with 85% living in urbanized areas including the Victor Valley in San Bernardino County (Victorville, Apple Valley, Hesperia), the Coachella Valley in Riverside County (Indio, Palm Springs, Palm Desert), and the El Centro Metropolitan Area in Imperial County (El Centro, Brawley, Calexico) [American Communities Survey estimated 2017 population]. Tribal lands of 12 different groups are contained in the region (Figure 1B). More information how already-occurring and projected climate change impacts disproportionately affect California's Tribal and Indigenous Communities may be found in the Fourth Assessment "Tribal and Indigenous Communities Summary Report"). In addition to agriculture, the major economic drivers are tourism; transportation, logistics, and warehousing; and real estate development, which includes housing and renewable energy. Land use is divided between natural and managed lands and those designated for the energy and transportation infrastructure that drive these industries. Use of land for renewable energy development is expected to grow in importance to meet California's climate change goals. Projected extremes in temperature and precipitation pose a threat to energy and transportation infrastructure, but these can be mitigated with careful planning. On the other hand, people and communities may be more vulnerable to climate change. Residents of the Inland Deserts are particularly vulnerable because of high poverty and unemployment rates, along with low educational attainment levels compared to state averages. The deterioration of the Salton Sea will additionally burden the population with worsening public health. Indeed, the fate of the Salton Sea will have a major negative impact on the region and will become a critical environmental justice issue for the State of California as a whole if it continues on its current trajectory of decline. A plan for the restoration of the Salton Sea is critically needed and will lessen the impact of many other climate-driven hardships that the region faces.

Land Use and Community Development

Land use decisions determine the impact of development on the environment, while in turn the environment shapes the type and form of development possible. Climate change affects land use both through changing patterns of development with the intent to minimize greenhouse gas emissions that cause climate change, and by directly altering the environment that shaped existing development patterns. Climate change affects not only public and private land use decisions, but is mediated by changing water availability and usage, and energy choices (Dale et al., 2011). In the Inland Deserts, water availability plays a fundamental role in determining the environment, society, and development. Climate change is likely to alter water availability in the region, with wide-ranging impacts on individuals and communities, industries and institutions, and entire ecosystems. Energy choices in the context of climate change, namely the drive toward emissions-reducing renewable energy sources, have become another fundamental driver of land use in the Inland Deserts.



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Climate change is transforming land use priorities in the Inland Deserts under the California Renewables Portfolio Standard (RPS), which requires that 50% of electricity come from renewable sources by 2030 (Penn, 2017). The San Geronio Pass Wind Farm is California's third largest source of wind energy (Figure 17), with more than 2,000 turbines producing nearly 700 MW of power in 2015 (California Wind Energy Association, 2017). The Inland Deserts lead the state in solar power production and installation that includes investment in solar panel manufacturing and installation (Steinberg, 2014; Sullivan, 2017). In 2014, the Ivanpah Solar Electric Generating System in the Mojave Desert was the largest in the world, although that honor passed to India two years later (Al Jazeera, 2016). Renewable energy facilities as well as the land, roads, and transmission corridors necessary to transmit and distribute electricity constrain land use options and have important tradeoffs with natural environments.

Yet the drive towards more renewable energy, as a response to California's climate change mitigation policy, can conflict with other land use goals, such as wildlife protection. Research addressing natural ecosystem impacts has suggested that future developments can and should be sited in more developed areas (Hernandez et al., 2015; Turney and Fthenakis, 2011). The Desert Renewable Energy Conservation Plan (<https://www.drecp.org/>), developed by a collaboration of state and federal agencies with the involvement of local stakeholders has the goal of conserving desert ecosystems in California while facilitating siting and permitting of renewable energy projects (see sidebar on Impact of Renewable Energy Development).

In addition to wildlife protection, development of land for renewable energy also competes with other uses of land such as for recreation and agriculture (Moore-O'Leary et al., 2017). Decisions to invest resources on energy production may reduce the money and space available to preserve open space, manage parks, and to invest in conventional and urban farm projects. In the Inland Deserts, only marginal or abandoned farm land in the Imperial Valley has been slated for utility-scale solar power development to date (Imperial County Planning & Development Services Department Cluster: Solar Power Project Draft Environmental Impact Report). Yet, as renewables become a larger fraction of California's energy portfolio, there is likely to be greater conflict on what might be considered less marginal land.

Increased adoption of renewable energy will help the region reduce its carbon footprint, albeit at some cost to future land use decisions and environmental services. In contrast, other land uses such as urbanization and agriculture are the most significant sources of climate change due to human activity, and account for the bulk of the region's greenhouse gas emissions (Kalnay and Cai, 2003, 2004; U.S. Environmental Protection Agency, 2015). Urban areas

FIGURE 17



Wind turbines near the San Geronio Pass



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account for as much as 80 percent of carbon emissions since 2008 (World Bank, 2018). In California, the majority of these emissions come from passenger vehicles. Since the mid-1980s, urbanization has surpassed land use for farming, grazing, and water resources in Inland Southern California (Chen et al., 2010). This urbanization trend is expected to continue, with state population projections showing future development around existing urban centers (Fourth California Climate Assessment Statewide Report, 2018).

Future land use planning of these expanding and developing urban centers will play a major role influencing the region's ability to reduce greenhouse gas emissions. These considerations are already included in California law, such as with the 2008's Sustainable Communities and Climate Protection Act (SB 375, 2008), which requires cities and counties to implement sustainable land use plans that reduce regional emissions from passenger vehicles in order to access statewide transportation funds. Specifically, each of California's Metropolitan Planning Organizations must develop and implement a Sustainable Communities Strategy as part of its Regional Transportation Plan. In the Inland Deserts, this role is played by the Southern California Association of Governments (SCAG). The region's current Regional Transportation Plan/Sustainable Communities Strategy, developed in cooperation with local governments, county transportation commissions, tribal governments, non-profit organizations, and businesses and local stakeholders throughout the six counties of Southern California, seeks to "[balance] future mobility and housing needs with economic, environmental and public health goals" (SCAG, 2016, Chapter 5). These land use strategies emphasize higher density, mixed-use, and transit-oriented development to encourage public and active transportation, which simultaneously reduce greenhouse emissions and increase physical activity and opportunities for social interactions (Maibach et al., 2008; Rissel, 2009). Improving access to efficient public transportation and other alternatives to automobile travel— both of which are targeted in the general as well as climate action plans of Inland Desert cities and the structure of subregional governments— is critical to reducing greenhouse gas emissions throughout the Inland Deserts, and are also a means to improve public health (Ahern, 2011; Aylett, 2015; Carter et al., 2015; Flint, 2018).

The land use element of a general plan guides the physical development of city or sub-region, including greenhouse gas emissions associated with residential, retail, and industrial development. The land use elements designed to manage growth and development in the Inland Deserts emphasize transition to renewable energy, especially solar, urban infill where possible, improved access to effective public transit, reliance on drought-tolerant landscaping, and increased resilience to climate-related emergencies, including extended droughts and wildfires (Imperial County Planning and Development Services, 2015; Riverside County Planning Department, 2017). These plans do not identify the specific actions that counties, sub-regional governance organizations, or cities will take to adapt to climate change; those are made in Climate Action Plans.

Climate Action Plans specify the activities that a state, county, sub-regional organization, or city will undertake to reduce greenhouse gas emissions and otherwise adapt to a changing climate. In addition to the SCAG Regional Transportation Plan/Sustainable Communities Strategy, which anticipates significant declines in greenhouse gas emissions (SCAG, 2016), climate action plans developed by Riverside and San Bernardino counties and many of the region's cities detail strategies for reducing greenhouse gas emissions associated with energy production and use, waste water treatment and solid waste disposal, manufacturing, transportation, and agriculture (Riverside County, 2015; San Bernardino County, 2014; WRCOG, 2014). Overall, these documents support Smart Growth, a development approach that favors higher densities, mixed use buildings, and public transit to reduce sprawl, improve



environmental quality, and encourage community engagement. The success of these plans, which are consistent with California's SB 375 (Benfield, 2012) that directs governments to coordinate their investments in transportation, land use, and housing to minimize emissions and environmental impacts, are evident in the region's investment in solar energy, public and active transportation, and infill development rather than further expansion of housing into the Wildland-Urban Interface. Solar energy investment is expected to benefit the region's economy by supporting the region's energy independence, especially in the case of emergency, and generating jobs with middle class earnings potential (Jones et al., 2017).

A significant concern the region is confronting is development within the Wildland-Urban Interface, the zone where human development meets or intermixes with wildland fuel (Stein et al., 2018). Today, more than one-third of new development occurs in the Wildland-Urban Interface, with California leading the nation (U.S. Department of Agriculture-Forest Service, 2015). To address this issue, the region's smart growth strategies emphasize urban/suburban infill, a development strategy that limits opportunities for people to live in the Wildland-Urban Interface, thereby reducing the potential damages and risk surrounding wildfires. Regarding those who already live in areas vulnerable to wildfires, community participation, which the region has "in abundance," as noted in Guzman (2018), is central to best practices for managing the Wildland-Urban Interface and reducing the damages associated with wildfire (Lachapelle and McCool, 2012). "Best practices" in addressing wildlife in these vulnerable areas include incorporating defensible space around properties and emergency preparation, actions that are essential to mitigating property damage and loss of life that can be caused by wildfires. The success of these efforts to address wildfire risk, and more generally to promote sustainable development and to adapt to climate change depend on many factors, including community participation and awareness (perhaps facilitated through online and ad hoc dissemination strategies and education forums regarding best practices), quality data available that elected officials, policymakers, and community members can use to better inform their decisions, and the flexibility and capacity to develop and implement evidence-based strategies to increase climate resilience (Fisichelli et al., 2016; Hallegate, 2009; Hunt et al., 2011; Shulte and Miller, 2010). This challenge may be complicated by political as well public resistance to climate change adaptation strategies.

Of course, the ability of the community, agencies, and governments to make informed decisions, and implement scientifically sound climate action plans, depends critically on the quality of the data and science available, with recognition that there may be significant heterogeneity across cities or regions in how to best address climate change due to natural, social, economic, or demographic differences. Recent meta-analyses of local climate action plans and related subnational planning for climate change adaptation (see Moser and Ekstrom, 2010; Tang et al., 2010) suggest that there is considerable variation among climate action plans.

To best aid communities and decision makers in their efforts to continually update their climate action plans based on sound science, efforts and commitments are needed to develop consistent data sources and methods of analysis. Such efforts will facilitate both the comparison and assessment of climate change adaptation strategies, and perhaps increase regional coordination and cooperation. There has to be increased consideration (and science) into the effects of climate-induced heat waves, droughts and floods, and wildfires on natural ecosystems. The Inland Deserts region is vast, covering expansive deserts, uninhabited mountain ranges, rural settlements in the east, and both large and small agricultural areas. Most of the focus to date in the region has been on the impacts to plants and wildlife that might be impacted by renewable energy production and wildfire threats. While a focus on plants and wildlife should not wane,



Impact of Renewable Energy Development

The Inland Deserts are set to play a major role in California's energy future through development of new utility-scale renewable energy capacity that will supply California's energy needs while minimizing greenhouse gas emissions. The Inland Deserts have a strong competitive advantage for production of renewable energy because of abundant solar and wind resources, geothermal resources at the Salton Sea, proximity to demand centers and transmission infrastructure, and relatively inexpensive land available in large parcels (Jones et al., 2017; EES Consulting, 2013). Twenty-nine renewable energy projects (out of a statewide total of 150) have been granted permits in the region (CEC REAT Projections). Most of these projects are utility-scale solar energy systems, particularly those using solar photovoltaic panels mounted on steel and aluminum structures. In addition to reducing greenhouse gas emissions, solar energy improves air quality when it replaces fossil fuel burning. Carefully sited solar farms can reclaim degraded land, such as is taking place on abandoned farmland in the Imperial Valley (Imperial County Planning & Development Services Department Cluster: Solar Power Project Draft Environmental Impact Report: <http://ftp.co.imperial.ca.us/icpds/eir/cluster-lsolar>). Energy storage technologies can also support clean energy goals by reducing greenhouse gas emissions by delivering stored renewable energy, reducing demand for peak electrical generation from natural gas peaking plants, improving the reliability of the electrical transmission and distribution grid, and increasing the efficiency of existing infrastructure to meet energy system demands. In the Inland Deserts, operational energy storage systems are electrochemical (e.g., batteries) (California Energy Commission – Tracking Progress Report, http://www.energy.ca.gov/renewables/tracking_progress/documents/energy_storage.pdf). Imperial County, for example, is home to a 30-megawatt, 20-megawatt-hour lithium-ion battery energy storage system that helps the grid accommodate power from two large solar energy projects, SunPeak 2 and Midway III.

However, development of renewable energy, even on desert lands, involves trade-offs between ecological, political, and socioeconomic values (Moore-O'Leary et al., 2017). Specifically, avian mortality (birds and bats), death of insects, disruption to wildlife and habitat—such as that of the desert tortoise—are concerns due to large amount of land needed, dry cooling systems, effects due to other construction, operation and maintenance, proximity of power plants to protected areas including rare and endangered species habitat. In an effort consider these competing issues, the Desert Renewable Energy Conservation Plan (DRECP) was developed to ensure the conservation of desert ecosystems in light of renewable energy projects in California. This landscape-scale planning effort is a collaboration between the U.S. Bureau of Land Management, California Energy Commission, U.S. Fish and Wildlife Service, and California Department of Fish and Wildlife, with input from local stakeholders, that covers 22.5 million acres of California. A primary objective of the DRECP is to conserve sensitive desert resources by meeting climate adaptation requirements for desert wildlife and identifying sensitive ecosystems and species. For example, the DRECP streamlines the renewable energy permitting process by identifying lands closed to renewable energy, such as those designated as California Desert National Conservation Lands, Areas of Critical Environmental Concern, National Scenic and Historic Trail management corridors, and wildlife allocations. Specifically, in the Inland Deserts, the counties of Imperial, Riverside, and San Bernardino—along with the counties of Los Angeles and Inyo—were granted a Renewable Energy Conservation Planning Grant (RECPG) from the Energy Commission to effectively plan and promote renewable energy projects that align well with federal, state, and local renewable energy and conservation goals.



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more research is needed on ways to mitigation and adapt to the health effects of climate change. Finally, there has to be increased development and dissemination of disaster-preparedness plans. Climate change adaptation planning emphasizes making transitions to renewable energy, public transit, etc. affordable at the expense of preparing the region for the real threat of drought, increased fresh food costs, wildfire, and deadly heat waves (Pierce et al., 2008; United States EPA, 2016). Failure to address these threats may be tied up in policymakers' reluctance to embrace climate science in a relatively conservative region. Yet disaster preparedness need not require accepting climate science; for example, measures can involve preparing for drought and wildfire as we do for earthquakes by improving infrastructure, limiting where people can live, preparation kits, and drills specific to the Inland Deserts region (Boulter et al., 2013; Lloyd et al., 2017).



Energy

Energy supply and demand in the Inland Deserts will be sensitive to rising temperatures projected with 21st century climate change, in addition to concurrent changes in population, technology, and policy. Climate change will affect energy supply because higher temperatures reduce production capability by decreasing capacity and efficiency of electricity production, transmission and distribution systems. At the same time, higher temperatures will increase electricity demand for air conditioning, which will become particularly necessary for human well-being in the Inland Deserts, a region of already extremely high temperatures. These effects are important considerations for energy development planning in the region.

Energy generation in the Inland Deserts is currently being transformed by a transition from fossil fuel to renewable energy sources required under the California Renewables Portfolio Standard (RPS). The RPS requires that 50% of retail electricity sales come from renewable sources by 2030 and is a major component of California's climate change mitigation strategy. Construction of new renewable energy generation infrastructure in the Inland Deserts— mainly solar photovoltaic (PV) and solar thermal systems— has already begun to replace natural gas power plants as the primary electricity source. Many new utility-scale renewable energy projects have come online since 2010, and more are proposed for the region, which will turn the region from a net electricity importer to an exporter, with a substantial positive effect on the region's economy (Jones et al., 2017). While likely to be effective at reducing greenhouse gas emissions from electricity generation, utility-scale renewable energy in the region could have cross-cutting, potentially negative, effects on some

TABLE 2.

PRIMARY ENERGY SOURCE (TOTAL ELECTRICITY CONSUMPTION*)	SOUTHERN CALIFORNIA EDISON (85,448 GWH)	IMPERIAL IRRIGATION DISTRICT (3,385 GWH)	OTHER ELECTRIC UTILITIES (424 GWH)
Coal	0%	14%	21%
Hydro	6%	4%	6%
Natural gas	19%	35%	1%
Nuclear	6%	3%	5%
Renewable	28%	28%	17%
<i>Biomass & biowaste</i>	1%	10%	0%
<i>Geothermal</i>	7%	3%	8%
<i>Eligible hydroelectric</i>	0%	8%	0%
<i>Solar</i>	10%	7%	1%
<i>Wind</i>	10%	0%	7%
Other	0%	0%	1%
Unspecified**	41%	16%	50%

Primary energy sources by utility provider in the Inland Deserts in 2016. Please note that the values for total electricity consumption and primary energy sources represent the entire region served by each individual electrical utility. The "Other Electric Utilities" refers to the City of Needles, City of Banning, Victorville Municipal Utility Services, Anza Electric Co-op, and Bear Valley Electric Service. (Source: California Energy Commission, Utility Annual Power Content Labels for 2016 (<http://www.energy.ca.gov/pcl/labels/>))

* Total electricity consumption data is for the year 2016 (Source: California Energy Commission, Electricity Consumption by Entity (<http://www.ecdms.energy.ca.gov/electbyutil.aspx>))

** "Unspecified" sources of power refers to transactions of electricity that are not traceable to specific generation sources.



aspects of ecology and human systems in the Inland Deserts without careful planning to minimize and mitigate these effects (see sidebar “Impact of Renewable Energy Development”).

Finally, the Inland Deserts region is likely to experience large increases in energy demand as the climate warms due to extreme high temperatures. Compared to the state as a whole, the region has higher than average transportation fuel use, and lower than average per capita income, meaning that it is more vulnerable to possible increases in the cost of energy (electricity and transportation fuel). Nevertheless, energy-related climate change mitigation policies have had a net positive impact on the economies of Riverside and San Bernardino Counties between 2010-2016, and the positive impact is expected to continue (Jones et al., 2017).

The major sources of electricity in the Inland Deserts are provided by Southern California Edison (SCE) and Imperial Irrigation District (IID) (Table 2). Meanwhile, five other electrical utilities serve the remainder of the region, including the City of Needles, City of Banning, Victorville Municipal Utility Services, Anza Electric Co-op, and Bear Valley Electric Service. The current electricity generation mix in the region is composed of both in-state and out-of-state electricity generated from fossil fuels and renewable sources of energy (Figure 1C). Most of the electricity in region is generated from fossil fuel combustion (coal and natural gas) and from unspecified sources of energy, which are transactions of electricity that are untraceable to specific sources. However, the largest providers of electricity (SCE and IID) in the region use close to 30% renewable energy (biomass/biowaste, geothermal, small hydroelectricity generation, solar, wind).

Southern California currently imports electricity from out of state via major transmission lines, most of which pass through the Inland Deserts region (Sathaye et al., 2012). A large fraction of this energy comes from coal, which California is eliminating from its energy supply mix as part of efforts to decrease greenhouse gas emissions (Mahone et al., 2018). Nevertheless, out of state imports of electricity and transmission through the region will likely still be necessary in the future with increasing utilization of renewable energy sources. Supplies of wind and other renewables from out of state are abundant at times when local solar power is insufficient and will be needed to overcome the mismatch in the timing of peak energy demand versus energy supplied from local renewable sources (CEC, 2017).

Currently, a total of 166 operating power plants exist in the Inland Deserts region and use a variety of energy sources to generate 8.6 gigawatts of power (<https://cecgis-caenergy.opendata.arcgis.com/datasets/california-power-plant>). Some of the power stations burn natural gas, while others use renewable energy sources, including solar, wind, biomass, hydropower, and geothermal energy (Figure 1C). In this region, there are six natural gas power plants (2709 MW). Approximately 95% of the power plants in this region are fueled by renewable sources, including 94 solar/solar thermal (4034 MW), 33 wind (943 MW), 1 biomass (54 MW), 10 hydropower (124 MW), and 20 geothermal power plants (718 MW). This shift toward renewables, driven by the RPS, has led to replacement of older fossil fuel power plants by new renewable sources (Jones et al., 2017). Of the 150 permitted renewable energy projects statewide, 29 of them are located in the Inland Deserts (<https://cecgis-caenergy.opendata.arcgis.com/datasets/california-renewable-energy-action-team-reat-projects>). These 29 plants, 90% fueled by solar energy and 10% by geothermal sources, are estimated to produce up to 2.4 gigawatts of energy.

Increasing temperatures will reduce the efficiency of energy generation by natural gas fired power plants and solar



photovoltaic systems. For a combined cycle natural gas fired power plants in the Inland Deserts, power output is reduced by 0.14-0.25% per °F above 96°F for wet and dry cooling systems, respectively (Maulbetsch and DiFilippo, 2006). For photovoltaic systems, voltage output is reduced linearly with temperature. Reductions have been reported as 0.21-0.25% per °F warming; however, the relationship between power loss and increased temperature will vary among systems depending on the material and other system properties (Fouad et al., 2017). In contrast, concentrated solar thermal systems, such as the Ivanpah Solar Power Facility (392 MW) located in the northeast corner of the Inland Deserts region, increase efficiency with rising ambient temperatures. Projecting the combined effects of warming and changes in radiation due to air pollution using CMIP5 models up to mid-century, Wild et al. (2017) found no net change in power output from concentrated solar in southern California.

In addition to electricity generation, the region has infrastructure for distribution and storage of electricity that will also be vulnerable to climate change. A little over 4,900 miles of transmission lines exist in the region (<https://cecgis-caenergy.opendata.arcgis.com/datasets/california-electric-transmission-line>). These transmission lines currently serve an important role transmitting imported electricity from out of state into the population centers of southern California. This will likely continue with further development of renewable energy in the Inland Deserts and out-of-state. Transmission lines are vulnerable to warming because high temperatures can damage lines, leading to capacity losses around 0.8% per °F of warming when conductor temperature rises above the design limit of 176°F (equivalent to an air temperature of 100°F) (Sathaye et al., 2012).

Electric substations then convert high voltage electricity to lower voltage that is suitable for homes and industrial purposes. There are 262 operational electric substations in the region, and three proposed substations (<https://cecgis-caenergy.opendata.arcgis.com/datasets/california-electric-substation>). Voltage transformers are a critical component vulnerable to climate change, since heat causes energy loss and increases the rate of transformer failure (Gao et al., 2017). Transformer capacity is sensitive to ambient temperature conditions at the time of peak load (Sathaye et al., 2012) and decreases roughly 0.4% for every 1°F increase of ambient temperature above 86°F (Li et al., 2005). Using climate model projections, Sathaye et al. (2012) project a 1.5-5% reduction in regional peak load capability by mid-century, and a 2-3% reduction by end of century.

As a whole, California's current residential electricity consumption is 2,333 kWh per capita. Meanwhile, the energy demand by residents of Inland Desert counties of Imperial, Riverside, and San Bernardino is 2,679 kWh per capita (<http://ecdms.energy.ca.gov/elecbycounty.aspx>). Both per capita and total electricity demand in the region are expected to increase with climate change and population growth. Population in Imperial, Riverside, and San Bernardino counties is projected to increase close to 70% by the year 2100 along with increased land use development (California Department of Finance, 2016). Per capita energy use will go up as increased penetration of residential air conditioning will play a vital role in ensuring the adaptation of the growing population in this region to a warming climate (Sailor & Pavlova, 2003; Auffhammer & Aroonruengsawat, 2011). By the end of the century, the non-coastal portions of Southern California are projected to experience the largest increases in household electricity demand in the state (Auffhammer, 2018). Parts of the Inland Deserts will require increases of up to 2.5 and 3.4% in electricity demand by mid-century, and 10.6 and 29% under RCP 4.5 and 8.5, respectively (Auffhammer, 2018).

Future research and adaptation planning is needed to address energy challenges due to 21st century climate change in four areas. First, as electricity generation transitions to renewable sources, a more nuanced analysis of the costs and benefits of different types of renewable energy sources under a warming climate is needed. Specifically, more



attention is needed to comparing trade-offs between distributed generation, such as rooftop solar and local storage, with utility-scale solar energy with traditional transmission and distribution pathways. Some of the negative effects of utility-scale renewable energy may be partially mitigated by the additional generation of distributed renewable energy. Second, better predictions of the impacts of climate change on energy supply and reliability are needed for this region in particular, with a focus on the electricity consumption of disadvantaged communities, and on vulnerability and resilience of current and proposed power system equipment to ensure a reliable supply given temperature projections. Furthermore, increased utilization of renewable energy will also require new research on coordinating the operations of distributed generation and solar and wind energy resources to deliver a steady energy supply, including microgrids and energy storage systems. Third, with the increasing adoption of smart sensor technology such as advanced metering infrastructure, big data analytics are critically needed to improve energy efficiency, reduce emissions, and enhance the security of the smart power grids under a changing climate. Last but not the least, there is an urgent need to study electric vehicle sharing and coordinated charging strategies to improve air quality and reduce transportation costs by leveraging the electric grid infrastructure.

FIGURE 18



Bridge washout along I-10 near Desert Center, July 2015.



Transportation

California has a large multi-modal transportation system, consisting of thousands of miles of roadways and railways, several seaports, airports and transit systems, as well as extensive biking and walking networks. This large transportation network is critical to millions of travelers and for the efficient movement of goods. The Inland Deserts region includes most of Caltrans District 8, the largest of 12 statewide Caltrans districts that covers approximately 28,650 square miles of land, and the Imperial County part of Caltrans District 11. Within District 8, there are four major interstates and 32 state routes totaling 7,200 lane miles.

In the last several years, the impacts of climate change on transportation has been a topic of high interest. In 2015, the Transportation Research Board (part of the National Academies, see www.trb.org) formed a Transportation Systems Resilience Section consisting of committees on infrastructure protection, business continuity and disaster logistics, and emergency evacuation research. There have been several specific workshops on these topics and a research roadmap is currently being developed. The impacts of climate change on transportation consist of three main areas: 1) impacts on transportation infrastructure; 2) impacts on travel behavior; and 3) impacts on goods movement and supply chain business continuity.

It is clear that transportation infrastructure such as roadways (highways, arterial roads, residential streets, etc.), bridge supports, railways, seaports, and airports are all potentially at increased risk due to severe storms, flash floods, higher temperatures, and increased wildfire risk (Radke et al., 2018). As an example, in July 2015 a bridge over a desert wash collapsed during a major flash flood near Desert Center (Figure 18). As a result, bridges like this are being rebuilt with deeper foundations, with the expectation that flash floods will increase in frequency due to climate change. Wildfires can also directly affect the transportation infrastructure, literally melting pavement and buckling concrete. Debris flows or mudslides can also wash out or damage transportation infrastructure.

Temperature extremes are also increasing within the Inland Deserts (see “Regional Climate Projections,” Figures 4, 5). In general, these higher temperature extremes do not necessarily have a strong effect on transportation, except when temperatures are so high, that airplanes may be restricted on being able to take off and land. This is dependent on a number of factors, including airport altitude, runway length, type of aircraft and payload. As an example, many flights were cancelled at several southwest US airports during June 2017 when temperatures exceeded 119 °F (https://www.washingtonpost.com/news/capital-weather-gang/wp/2017/06/20/its-so-hot-in-phoenix-that-airplanes-cant-fly/?noredirect=on&utm_term=.63bea31f7125).

In addition to the direct effects on transportation infrastructure, extreme weather events can cause major disruptions in normal everyday travel. When parts of the transportation infrastructure fail, then typical travel routes for both passenger travel and goods movement may be affected. In recent years, the California Department of Transportation has set up Traffic Management Centers (TMCs) around the state to provide roadway information to the public; as an example, Caltrans District 8's TMC can be accessed at <http://www.dot.ca.gov/dist8/tmc/>. In addition to providing real-time information on lane- and road-closures, it also offers rerouting information, future conditions on the roadways, and other information. This allows travelers to choose different routes to avoid travel delays, congestion, and other related problems. In the extreme cases of a major disaster where evacuations are required, the TMC and related websites can also provide evacuation routes and related information. There are a variety of examples of the effectiveness of these TMCs over the last several years. A good example for the Inland Deserts region was the re-routing of traffic along the I-10 freeway during the bridge washout incident in July 2015 (Figure 18).



Beyond re-routing and evacuations that may be related to climate change and extreme weather events, it is unclear whether actual travel behavior changes due to higher temperature extremes. Most current vehicles have robust climate controls; therefore, there is little evidence that people change their travel behavior (e.g., deciding to make a trip, trip departure times, trip route) due to extreme heat. However, when the extreme heat is combined with traveling on roads with significant road grade, more vehicle breakdowns along the roadside have been recorded, potentially affecting traffic operations.

Transportation is often thought of as simply trips made by typical passenger vehicles. However, perhaps just as important is the goods movement system. Southern California is home to two major seaports (Port of Long Beach and Port of Los Angeles) that process approximately 43% of all the goods entering the United States. In addition to the ports, there is a sophisticated system of goods movement that include railyards, transfer stations, trucking fleets, rail systems, and distribution warehouses. All of these are vulnerable to transportation disruptions due to climate change and extreme weather events. Missed shipments can drastically affect material supply, the manufacturing process, and the distribution of the finished goods. Any disruption can have a deep effect on the economic vitality of the region and on the livelihood of many businesses (Radke et al., 2018). As a result, many companies are engaged now in resiliency planning and preparation to mitigate these potential effects due to transportation disruptions.

Inland Southern California plays an important role in the goods movement and supply chain business continuity. This region is home to a large and expanding number of warehouses and distribution centers, a critical link for goods movement and manufacturing. In addition to addressing re-routing issues described in the previous section made by trucks, companies are now eliminating “weak-links” in their transportation system, seeking out multiple modes of good movement and delivery.

There are a variety of actions that can and should take place in order to adapt to climate change and mitigate its impacts. In terms of transportation infrastructure, more resilient structures should be built, including bridges, ramps, and drainage systems. In many cases, actions are already being taken to fortify structures susceptible to flooding. For example, bridges such as the one along the I-10, described above, are being rebuilt with deeper and stronger footings. Use of materials with a higher heat tolerance should be considered during the next repaving cycles to increase resilience to extreme heat events. Barriers and diversions can be built along roads to protect critical locations from potential mudslides.

California has already set up effective traffic management centers to deal with strategy development and for disseminating information to travelers during infrastructure failures or disruptions. These traffic management centers should continue to embrace new techniques in “intelligent traffic management”, including:

- Innovative monitoring solutions that use traffic and roadway sensing to improve situational awareness among travelers.
- Advanced traffic routing methods (e.g., distributed routing algorithms) that can be utilized during extreme weather events, which may result in isolated road closures all the way up to full blown evacuations.
- Innovative traffic control techniques that can potentially change traffic signal timing and ramp metering.

For goods movement and supply chain management, businesses should continue to identify risks and impacts associated with supply chain disruptions. Based on this assessment, action plans can be developed to minimize



these disruptions through redundant pathways. For Inland Southern California, the majority of the distribution warehouses were developed and located in an ad-hoc manner based on land prices and availability. It would be valuable for regional planners to now examine the warehousing and distribution system as a whole and identify weaknesses. Based on this analysis, specific roadway and management techniques could be developed to increase the resiliency of current goods movement system in the Inland Deserts.

There are a number of specific research needs and knowledge gaps, specifically on the relationship between climate change and transportation as a whole. Specific research questions include: 1) improving our understanding of the linkages between climate change events and traffic operations, where numerous “what-if” case studies can be carried out to determine how we can improve traffic operations to increase resiliency; 2) improving our understanding of the linkages between climate change events and travel behavior; to date, there are no solid studies showing how people change their travel habits based not just on disruptive weather events, but on extended extreme heat; this also pertains to goods movement; and 3) improving how transportation agencies (e.g. Caltrans District 8) interact with city traffic managers and private-sector entities during extreme weather events.

Public Health: Vulnerability and Adaptation Options

Within the Inland Deserts region, climate change is poised to increase multiple public health vulnerabilities by exacerbating environmental risks to health and well-being while also compromising the capacity to address risks. Direct effects of increasing temperatures within the region, already characterized by extreme heat, could include increased risk of rapid and lethal health consequences as well as chronic degradation in well-being (Kostas and Hajat, 2008). Indirectly, climate change is expected to interact with other global change drivers and exacerbate health vulnerabilities associated with air pollution and disease (Patz et al., 2005). Climate changes in the Inland Deserts may degrade or add strain to health-related infrastructure, including electricity, water delivery, and transportation. Spatial and demographic variability in climate-related health risks also have high potential for increasing environmental justice issues, with greater predicted warming impacts in low income and minority communities (Tayyebi and Jenerette, 2016). Differences in the availability of air conditioning and other mitigation measures can further exacerbate these differences in heat vulnerability among communities (Harlan et al., 2006; Jenerette et al., 2016). In preparing and adapting to future climate warming, a suite of uncertainties may lead to alternate public health futures. The fate of the Salton Sea in particular, which may be affected by climate change, could have a large effect on public health in the region.

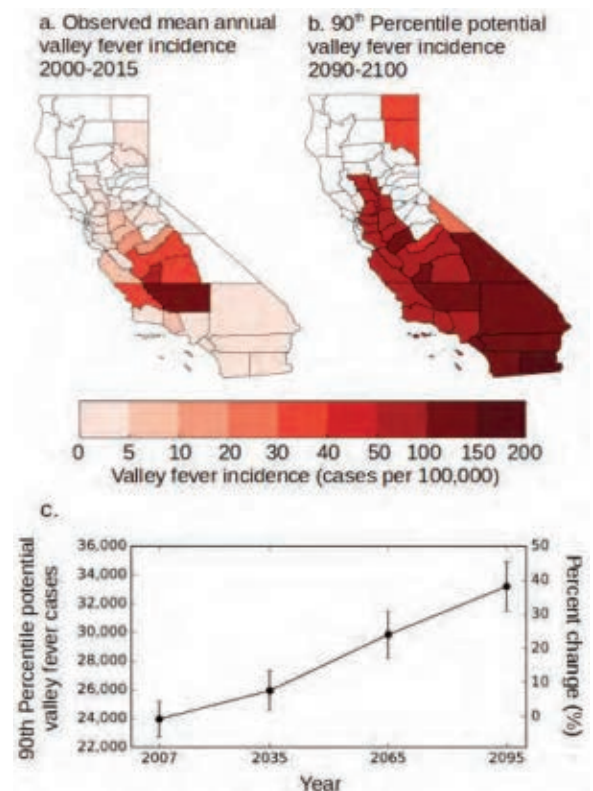
Heat-related health impacts are associated with increases in both chronic and peak exposure to high temperatures (Basu, 2009; Ostro et al., 2011; Sherbakov et al., 2018). High temperatures can have extensive health impacts ranging from degraded quality of life to mortality (Kovats and Hajat, 2008). These negative health effects can result both from increased average temperatures and increased intensity and duration of acute heat waves. The projected increases in daytime high temperatures for the Inland Deserts are associated with increasing risk from a diverse set of respiratory and pulmonary health consequences, as well as the aggravation of other health conditions (Patz, 2007; McMichael et al., 2007). The specific mechanisms linking high temperatures to the resulting health impacts are an active area of research, and translating outdoor meteorological conditions to physiological warming and health vulnerabilities is an ongoing research challenge (Hondula et al., 2014; Harlan et al., 2014).



In measuring environmental temperature and impacts to health, two metrics are commonly evaluated: air temperature and surface temperature. Air temperature is a widely used metric of environmental temperature representing conditions in shaded locations, and has been repeatedly found to influence human health through many heat-related illnesses (Kalkstein, 1991; Hondula and Barnett, 2014; Harlan et al., 2014). The influence of air temperature on heat-related illness is frequently related to elevated nighttime temperatures, as projected increases in minimum temperatures reduces a person's ability to recover during sleep from high daytime temperatures. A second temperature metric, surface temperature (frequently defined as land surface temperature) is measured as the emission of long-wave infrared radiation from a surface primarily viewed from thermal cameras or satellite platforms (Voogt and Oke, 2003). Surface temperatures have also been shown to directly correlate with heat-related health incidents (Laaidi et al., 2012; Vanos, 2015; Jenerette et al., 2016), and are more closely related to negative health outcomes than air temperature (Jenerette et al., 2016). These two metrics provide alternate windows into temperature-related health threat: air temperature is measured continuously but only from a limited number of locations, while surface temperature measure by satellite provide extensive spatial coverage but only limited timing of available temperature. Resolving the uncertainties in the drivers of spatial and temporal variation for both air temperature and land surface temperature will contribute to a more robust understanding of the drivers of climate change related heat impacts.

In addition to direct effects of warming on public health vulnerability, climate change in the Inland Deserts is also likely to exacerbate air quality-driven health impacts (Jacob and Winter, 2009). Increasing temperatures and more drought conditions may increase concentrations of ozone and particulates (West et al., 2016; West et al., 2017). Specifically, formation of ground-level ozone generally increases with temperature (Cardelino and Chamedies, 1990), so warming is expected to increase harmful surface ozone levels. Emissions of the ozone precursor NO_x from agricultural soils may also increase with higher temperatures, further enhancing ozone production (Oikawa et al., 2015). Climate change may also increase exposure to particulates resulting both from increased dust and fire. More severe and frequent drought and high temperature conditions could increase dust production from the extensive desert regions (Engelstaedter et al., 2006) as has been implicated for the Owens Lake region in southern California (Borlina and Renno, 2017). Increasing fire frequency can create recurring air quality degradation events leading to respiratory health effects and growing evidence of increased risks of all-cause mortality (Reid et al., 2016). Increased air emissions from an expanded playa of the Salton Sea may also add to these air quality problems.

FIGURE 19



Observed and projected increase in Valley Fever incidence by county for (a) 2000-2015, and (b) 2090-2100 under RCP 8.5.

Source: Gorris, Zender et al., in prep



Simultaneous with increasing health risks associated with climate changes, the capacity to cope with risks may also be compromised. Public health infrastructure associated with both electricity and water distribution may be compromised by climate change effects on those systems. With increasing temperatures, electricity demands for cooling increase, which can increase the risk of blackouts (Gao et al., 2018). In turn, electricity failure during heat waves may lead to widespread heat-related health impacts. Water distribution may also be impacted by climate change. Warming can increase water demand and decrease water availability, stressing water distribution systems. Climate change may also increase risks from infectious disease in the Inland Deserts. Mosquito borne diseases are expected to increase in prevalence with climate change (Gould and Higgs, 2009). Coccidioidomycosis, the fungal pathogen responsible for Valley Fever, may also increase in response to climate change due to warming and more variable precipitation patterns (Gorris et al., 2018, Figure 19).

Across most of these health risks, the consequences of climate change-induced health vulnerability are poised to magnify environmental justice concerns (Harlan et al., 2006). The Inland Deserts already have large disparities in wealth and heat risk (Tayyebi and Jenerette et al., 2016). Urbanized regions include some highly affluent neighborhoods featuring extensive outdoor irrigation supporting lush vegetation and cooler microclimates. Other urbanized neighborhoods contain extensive poverty, with limited irrigation and vegetation. Within the agricultural regions that are home to very disadvantaged communities, exposure to health risks may be higher, given that most farm workers perform strenuous labor outside in high temperature conditions and may be exposed to higher levels of atmospheric pollutants from agricultural activities. The increased health risks from climate change may exacerbate these differences.

Several strategies may help the Inland Deserts adapt to climate change by mitigating these health vulnerabilities. The increased use of urban vegetation may provide a buffer against higher maximum temperatures through vegetation-derived cooling (Jenerette et al., 2016); however, this strategy generally requires sustained water inputs, which may also be at risk given increasing water shortage predicted for the region. Better planning for increased peak electricity use and water demand can increase resilience of critical public infrastructure to climate change. Resource conservation efforts may also limit potential increases in infrastructure demand. Strengthening social networks may also provide added coping capacity to reduce climate change related health impacts. Climate effects on air quality can be minimized by reducing ozone precursors, both from on-road and agricultural sources, and reducing wind-blown particulates in general throughout the region and specifically in response to the shrinking Salton Sea. In alleviating climate change impacts to health vulnerability in the Inland Deserts, multiple strategies will be needed to address the breadth potential health impacts.

Further research could reduce the uncertainty in the effectiveness of these public health adaptations. A crucial uncertainty is the fate of the Salton Sea – both in terms of the water quality and from increasingly exposed playa sediments. Degraded water quality in the remaining sea may lead to increased emissions of the toxic gas hydrogen sulfide (H₂S) due to mass fish mortality, leading to noxious odors throughout the region. Toxic pollutants in the Salton Sea sediments may have a large potential for emissions during high wind events. Outside of the Salton Sea, abandonment of agricultural lands may lead to dust emissions from soils contaminated with pesticides and other residues. These legacies of contamination need further study to characterize the distribution of contaminants and assess the potential health impacts. Changing vegetation cover in natural and managed lands due to changing water availability may also pose a stress that is not well understood. In the end, translating environmental health



risks associated with climate change to specific health vulnerabilities has large uncertainties. With increased coping capacity and public infrastructure, some of the health risks can be mitigated. However, the implications of coping-based strategies will need foresight to avoid enhancing environmental injustice.

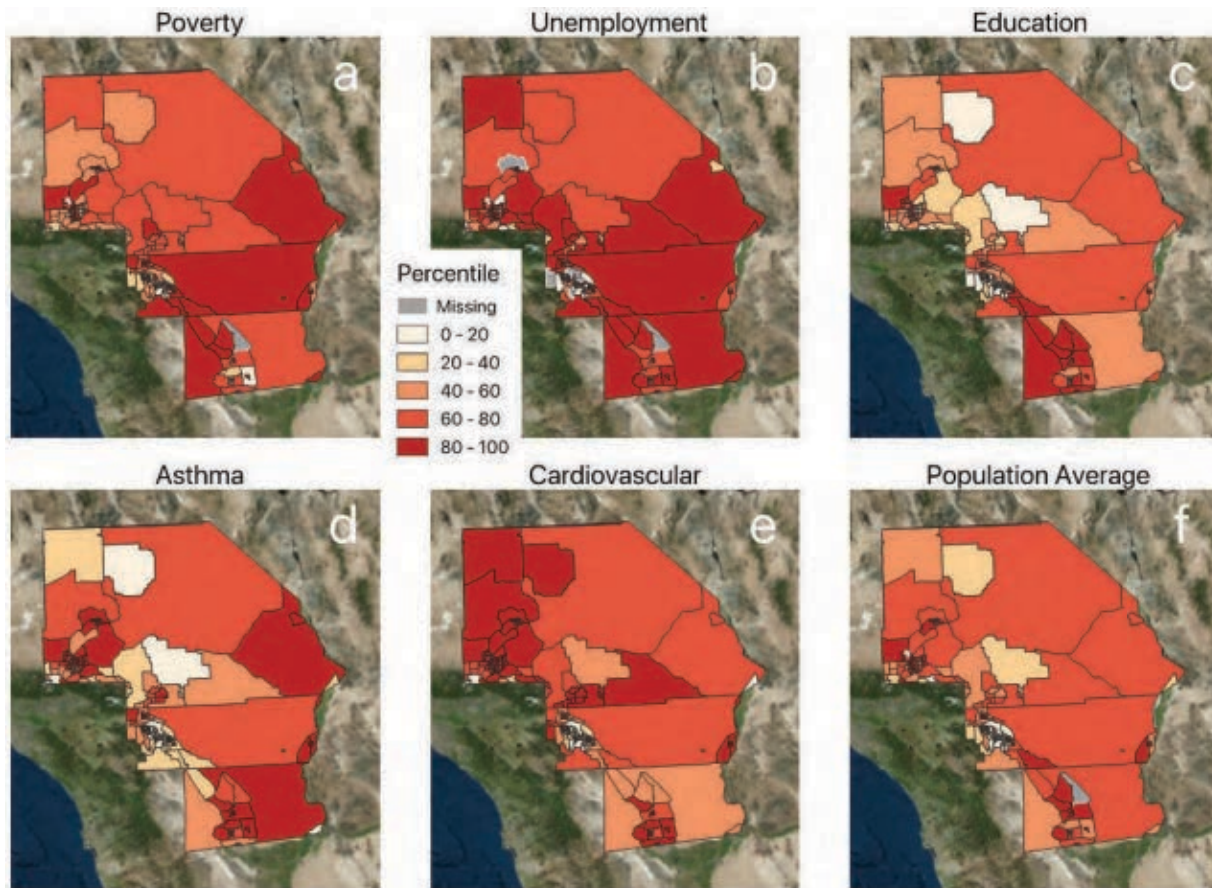
Environmental Justice

The impacts of environmental changes such as those expected with climate change in the Inland Deserts are not uniformly distributed across communities and population demographics. Health impacts associated with air pollution, for example, are typically most severe for specific at-risk populations, such as young children, senior citizens, and those already suffering from respiratory or cardiovascular disease. Many other factors can further influence the ability of any given group of people to successfully adapt to the local effects of environmental changes, including socio-economic status, mobility, employment opportunities, and language barriers. Collectively, analyzing and mitigating the disproportionate effects of climate change depending on these types of factors is an important environmental justice concern, and one that has been an increasingly highlighted policy priority within the state of California. For more information on Statewide environmental justice issues, please refer to the companion Fourth Assessment Climate Justice report (Climate Justice Summary Report 2018).

The Inland Deserts of California shows signs of disproportionate vulnerability to climate change through multiple demographic and environmental metrics currently in use. CalEnviroScreen, a data product of California's Office of Environmental Health Hazard Assessment (OEHHA), reveals a disproportionate number of census blocks in the Inland Desert region that rank in the upper quintiles for population vulnerability metrics such as poverty, unemployment, education, and existing incidence rates of asthma and cardiovascular disease (Figure 20). Combined, these metrics highlight some of the ways in which Inland Deserts residents in particular may struggle to respond to increasing challenges related to climate change relative to populations with greater resources and resilience. The Environmental Justice Screening Method, another tool used for the identification of at-risk communities on a regional scale, supports and extends the results of the CalEnviroScreen metrics, underscoring the importance of addressing resilience disparities within regional communities when planning for future environmental problems (Sadd et al., 2011). To estimate climate change vulnerability, the Environmental Justice Screening Method examines 7 indicators related to heat stress, including economic, social, and environmental factors (Figure 21). The resulting Climate Change Vulnerability metric reveals unique spatial patterns of climate-related risks: while metrics measuring current vulnerability to environmental health risks are concentrated almost entirely within the greater Los Angeles area of southern California, the climate-focused vulnerability metrics highlight the vulnerability of Inland Desert residents relative to those of more urban areas. In particular, Inland Deserts have some census tracts with a high proportion of the population with no vehicle, and who are elderly and living alone. There is also a low proportion of tree canopy that can provide a cooler microclimate in residential areas. Extending and responding to these and other risks associated with future climate change will require a careful examination of individual community resiliencies and vulnerabilities, enabling policies that can mitigate the disproportionate negative effects of climate change on at-risk groups.



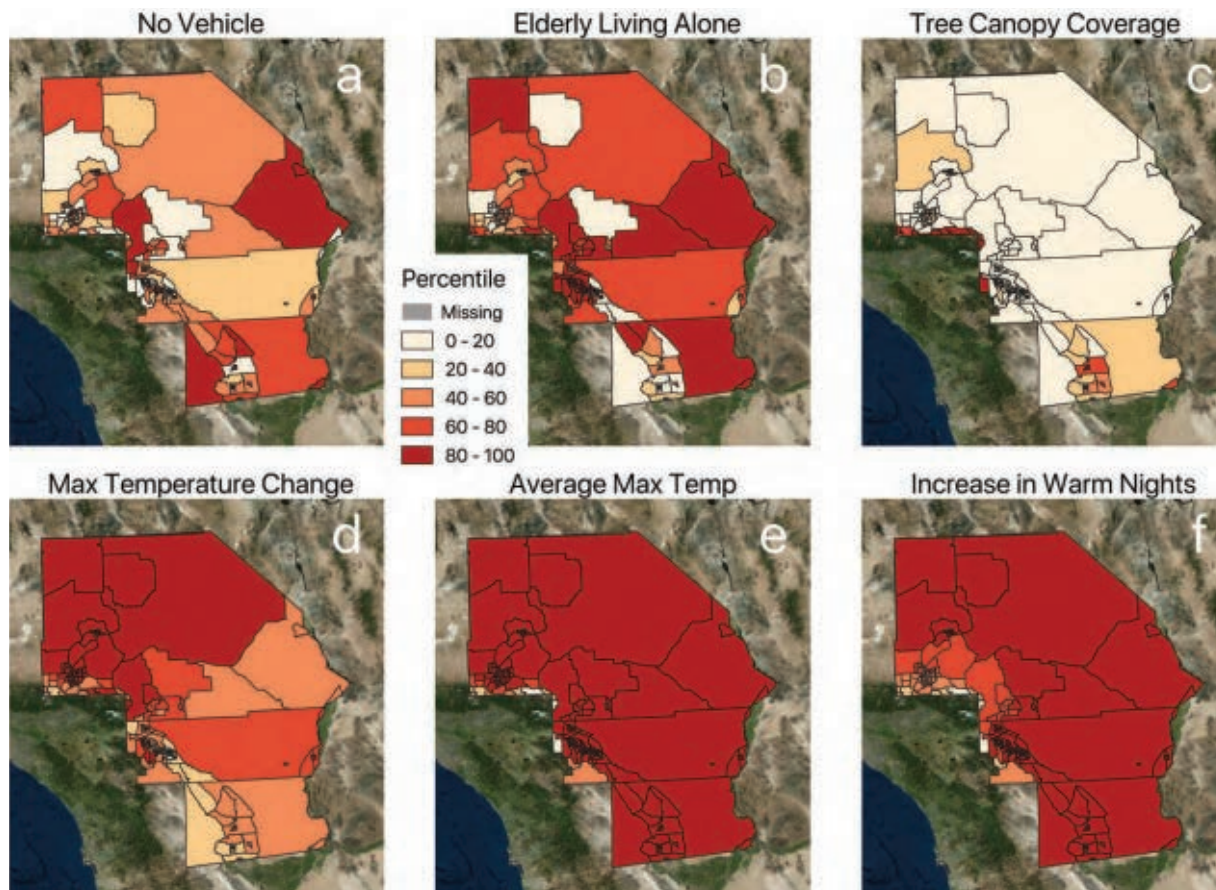
FIGURE 20



Population vulnerability estimated by census-block quintile for poverty (a), unemployment (b), low educational attainment (c), asthma rates (d), cardiovascular disease rates (e), and population average risk (f). Source: CalEnviroScreen.



FIGURE 21



Climate change vulnerability estimated by census-block quintile for percent of households with no vehicle (a), population of elderly living alone (b), tree canopy coverage (c), changing in maximum monthly average temperature change from 2000s to 2050s (d), average maximum monthly temperature in 2050s (e), and increase in warm nights for 2000s to 2050s (f). Source: Environmental Justice Screening Method.



Research Needs

Because of the central role of water resources to the endurance of human and natural biological systems in the Inland Deserts, it is clear the uncertainty in the amount and seasonality of future precipitation complicates predictions about the future of the region. More robust climate model simulations of intra- and interannual precipitation would provide broad support for improved projections in other areas, since precipitation governs runoff and groundwater recharge rates, and development of fuel beds that control risk of severe wildfire. Another critical need for better understanding of future water resources is integration of surface and groundwater modeling, allowing simulations of the relationship between future climate, land cover, groundwater recharge, and surface runoff in response to climate change and human decisions.

Apart from physical drivers of water availability, there are also important questions about potential changes to water rights under climate change. For example, how would extreme reductions in Colorado River flows affect current water allocations? Similarly, the future of the Salton Sea is pivotal to the well-being of humans and ecosystems, but in the face of inaction, critical research questions remain. What kind of governance solution would it take to halt the shrinking of the Sea? What volume of fresh water is needed to maximize outcomes, and from where might this water come? How much will climate change exacerbate Salton Sea shrinkage rates? How severe are the public health risks from the Salton Sea within and beyond the region given different restoration scenarios?

The strength of the future economy of the Inland Deserts will likely depend on the development of robust renewable energy supplies that reduce greenhouse gases and air pollution. In order to realize this future while minimizing negative impact to other systems, research into the tradeoffs between distributed generation and utility-scale renewables that considers climate change effects on system infrastructure is needed. Development of smart sensor technology, microgrids, and efficient forms of energy storage will also be critical. Ideally, this will involve pilot demonstrations of these new technologies.

Continued strength of the tourism sector depends on a better understanding of the strength of the link between tourist decisions about where and when to travel to the Inland Deserts, and local climate conditions at their destination. Research on the link between travel behavior and temperature will also be useful for improved adaptation and resilience of the transportation sector.

More research is needed to identify community specific adaptation and mitigation strategies that are most appropriate for this region. Further research on the mechanisms of heat stress and its interactions with other health vulnerabilities may reveal new strategies to ameliorate the effects of extremely high temperatures on public health. How do spatial and temporal variability of air or land surface temperature affect the impact of heat on health, and can such information be used to mitigate this threat? Ways in which climate adaptation and mitigation strategies can be used in tandem to ameliorate current environmental justice issues and stresses should be explored, such as optimizing local climate in disadvantaged neighborhoods with combinations of solar panels and vegetation. Also, more research is needed to understand the future of urban development in the region given the expectation of extremely high temperatures in the region paired with climate impacts to other regions from which migrations to the Inland Deserts can be expected, such as loss of habitable land in coastal areas due to sea level rise.

Inland Desert valleys are already one of the hottest agricultural regions in the world, and essentially serve as a model for what many other agricultural regions will face in the future with respect to heat tolerance and high salinity soils. Much research about temperature effects on agriculture has taken place here, but projected warming will take



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this region far past what it has experienced previously. More research about crop and animal response to higher temperatures, and ways to increase resilience is greatly needed. This may include research about the effectiveness of different cultivars, water application, crop planting cycles, and new models that better represent vegetation response to heat and elevated carbon dioxide levels.

While the climate refugia approach has been well studied for charismatic desert species such as the Joshua tree and the desert tortoise, such information is lacking for most desert species. Research to identify and protect refugia for a broader suite of endemic desert species could reveal the best adaptation options for these ecosystems as a whole.



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Off-Road Vehicle Recreation Management Policy for Public Lands in the United States: A Case History

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ABSTRACT / Three annual motorcycle races on the Johnson Valley-Parker course in California's Mojave Desert have resulted in conspicuous modifications of soil and vegetation in a Wilderness Study Area (WSA) and in other lands of high resource values. The extent of damage caused by the races, which have involved fewer

than 400 participants, exceeded the expectations of the managing agency by 360%–640% and the allowable limits imposed by the agency by 40%–76%. After three races, no resource monitoring results have been obtained by which compliance with the regulations for interim management of the Wilderness Study Area may be judged. Designation of the remaining parts of the course on lands of high resource value was based on criteria subsequently determined by a federal court to be in violation of regulations derived from two Executive Orders.

For the past three years, the US Bureau of Land Management (BLM) has issued permits for a 380-km cross-country "hare and hound" motorcycle race in the California desert, the Johnson Valley-Parker race (Figure 1). Such races begin with mass starts of hundreds of motorcycles aligned side-by-side. The winner is the first to cross the finish line. The Johnson Valley-Parker race replaced the old Barstow-Las Vegas race that was finally cancelled by BLM after eight annual events. The last of these 1974 was described by the Sierra Club's Off-Road Vehicle (ORV) Monitor as "a race to end all deserts" (see BLM 1975 for an assessment of the effects of that race). Illegal running of the Barstow-Las Vegas course in protest to BLM's denial of annual permit applications has been a serious management problem since 1977. Substitution of the Johnson Valley-Parker course was designed in part to eliminate this problem.

BLM considers the Johnson Valley-Parker races to be well controlled and run on an environmentally acceptable route. However, substantial objections were raised as to the environmental acceptability of the route and the degree of control exercised by BLM by a number of organizations and individuals (BLM 1980b and 1982a). Moreover, these races were to provide baseline-monitoring information to help guide management policy. To date, after three annual events, no useful baseline-monitoring data have been provided by BLM, and illegal running of the Barstow-Las Vegas route continues. BLM has nevertheless continually stated that no significant impact has occurred (BLM 1981a and b, 1982a and b; Hillier 1982) and has used the experience to justify a proposal to reopen the Barstow-Las Vegas race with even more permissive conditions than apply on paper to the Johnson Valley-Parker event (BLM 1982b).

Management Background

The California desert encompasses 25 million acres, of which half form the California Desert Conservation Area (CDCA). The CDCA was established by the Federal Land Policy and Management Act (FLPMA) of 1976 because Congress recognized that "the California desert environment is a total ecosystem that is extremely fragile, easily scarred, and slowly healed." Congress called for "the immediate and future protection" of this area through long-range planning.

By the time FLPMA was enacted, off-road vehicles were predominant among the threats to the integrity of natural and cultural resources of the desert (Geological Society of America 1977, Wilshire 1977, Webb and Wilshire 1978) and were a focus of controversy throughout the development of management plans for the CDCA (Sheridan 1979). The plan's attempted compromise called for establishing Open Areas (unrestricted vehicle use), permissive use of I and M class lands (I designates intensive use, M designates moderate use) that cannot be practically managed, and establishing vehicle routes in L class lands (L designates limited use) under criteria that were recently determined to be in violation of BLM regulations by a federal district court. Use of vehicles in C class lands (C designates lands inventoried as having wilderness characteristics) was restricted to existing routes, except under very special circumstances in which the agency must guarantee that wilderness qualities will not be impaired and can be reclaimed (BLM 1979a).

The route chosen for the Johnson Valley-Parker race begins in the Johnson Valley Open Area and traverses both L and C class lands (Figure 1). Of the 380 km, 106 km are cross-country where no previous route of travel existed. Of the 106 km of cross-country routing, 22 km are in Wilderness Study Area (WSA) 304A, and the remainder is in L class lands. The final part of the route is on an existing ORV race course—the Parker 400 course—which was so prominent a

KEY WORDS: Off-road vehicles; Management policy; Public lands

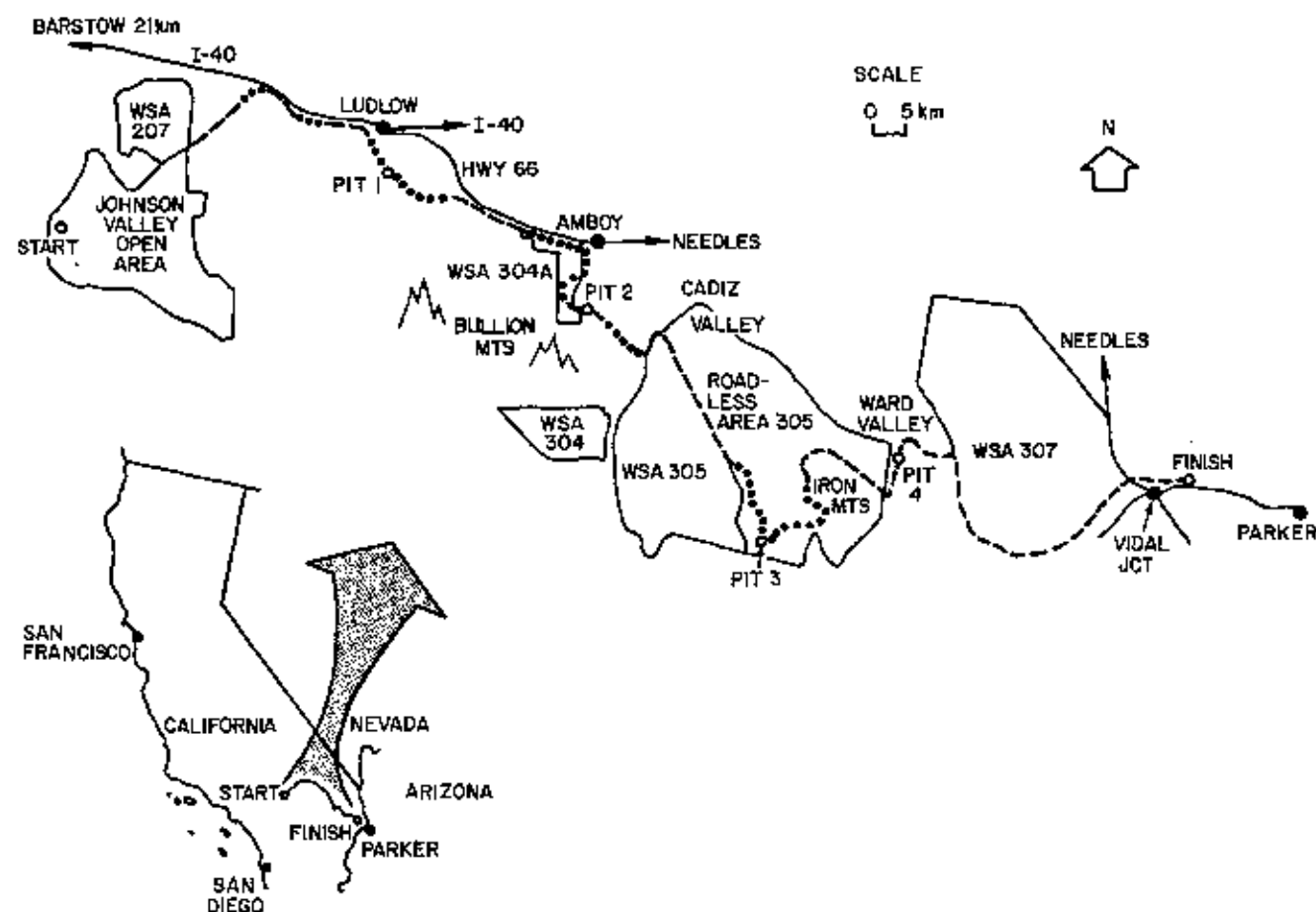


Figure 1. Johnson Valley-Parker race course.

feature on the landscape after eight annual events (Figure 2) that it was selected as a boundary of Wilderness Study Area 307 (BLM 1979b). Selection of this route, which has progressed in fits and starts since 1976, has involved (a) rejection by BLM of the CDCA Advisory Committee's recommendation (September 1977) that the Cadiz-Danby area, through which the route passes, not be used for competitive ORV events, (b) special manipulation of BLM's official definition of existing ways and trails (Interim Critical Management Plan) to allow use of cross-country segments said by ORV-user groups to have been used in earlier races, and (c) special appeal to the Environmental Protection Agency to truncate the public review period of the Environmental Impact Statement in order to meet the event promoter's schedule for the first race.

The choice of the Johnson Valley-Parker race course, and use of the experience to support designation of other cross-country motorcycle routes and open areas (BLM 1982b) has

important management implications for all BLM lands in wilderness review as well as other lands of high resource values (L class). It is important, therefore, to examine the effects of these races and the extent to which the managing agency has complied with regulations.

Setting

This report focuses on two parts of the race course: WSA 304A and L class lands at the south end of Cadiz Valley (Figure 1). WSA 304A encompasses Amboy Crater and its associated lava flow, which is one of several young basaltic cinder cones near US Highway 66 between Amboy and Barstow (Figure 1). Amboy Crater is the only undamaged representative of young volcanic landforms in this area that is accessible to the public. The characteristics of Amboy Crater that led to its designation as WSA 304A were described by

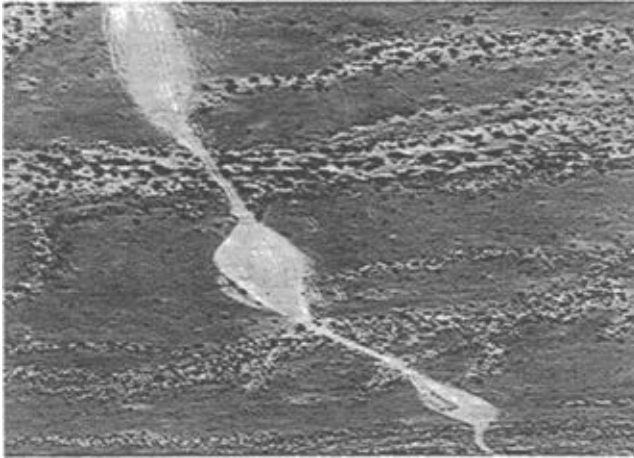


Figure 2. Aerial view of part of the Parker 400 race course used by four-wheel vehicles and motorcycles. The wider parts of the course are on surfaces with desert pavement; the scarcity of vegetation on those surfaces makes passing easy. The course narrows where it crosses active drainage channels that are rougher and contain abundant vegetation. After only eight annual events, this course was so marked a manmade feature that it was chosen as the boundary of Wilderness Study Area 307.

BLM (1979b) as follows:

Outstanding opportunities for solitude and for primitive and unconfined types of recreation are provided within the area. The cinder cone and lava flow provide excellent opportunities for education and study.

Although the plant community—creosote and burro-weed—is common in the Mojave Desert, the volcanic landform provides an unusual physical setting for the wildlife community that occupies it; no special study of the wildlife has been made.

Despite these natural characteristics, BLM decided not to recommend WSA 304A as wilderness, stating that it is traversed by World War II tank tracks, previous motorcycle race courses, and random ORV tracks. Although the area receives no protection from vehicle incursions and there are random ORV tracks, there is little impact from military maneuvers and no evidence of earlier motorcycle races. This contrasts with clear evidence of extensive military maneuvers and older motorcycle tracks elsewhere in the desert on similar terrain. In fact, the evidence for preexisting tracks was absent along the proposed race course so that some BLM personnel refused to drive on it during the resource evaluation phase of the route selection. Their reports contained the following descriptions of what was to become the route across the Amboy Crater WSA: "... the proposed route is essentially devoid of



Figure 3. Sidewinder photographed in Pit 3 area the day before the 1981 race. Area is extremely rich in small mammals, reptiles, and other wildlife.

existing roads or any semblance thereof." "The proposed segments of the course between the start and pit area #2 cross significant areas which show no evidence of existing vehicle routes and trails." "The course ... does not follow existing roads and trails. . ."

L class lands in the southern Cadiz Valley are broad valley surfaces mantled by alluvium derived from granitic source rocks. Occasional inselbergs of granite protrude from the alluvium far from the Iron Mountains on the east and an unnamed range on the west, which bound Cadiz Valley. The vegetative community is dominated by creosote, and the area has remarkably abundant wildlife (Figure 3). The surface between shrubs is stabilized by lichen and algal mats, which are extremely fragile (Wilshire 1983).

The 1980, 1981, and 1982 Races

During the 1980 race, 329 motorcycles crossed the Amboy Crater WSA, which is about 185 km into the race. In 1981, 289 crossed the WSA, and in 1982 the number dropped to 229. Probably substantially smaller numbers lasted until Pit 3 at the south end of Cadiz Valley, which is about 255 km into the race. First arrivals in WSA 304A were at 9:45 AM in 1980, 9:52 AM in 1981, and 9:51 AM in 1982. The last racer came through at 1:15 PM in 1980, 1:55 PM in 1981, and 2:00 PM in 1982. Thus in each succeeding year, the duration of the race has been longer and the total number of participants reaching the Amboy Crater WSA smaller. This is important because the more crowded the racers, the more they tend to spread out, thereby expanding the area of influence of the race. The largest

Table 1. Number of vehicles passing station 20 per minute.

Time	Number per minute		
	1980	1981	1982
10:25	1.6	2.5	1.1
11:07	4.1	3.3	2.3
11:20	2.8	2.3	1.8
11:24	0.5	1.5	1.0
11:31	1.1	1.0	1.1
12:15	0.8	0.5	0.8
1:00	0.2	0.1	0.4
1:15	0.3	0.0	0.4
Total duration (min)	210	243	249

number of racers to pass a given point per minute was 4.1 (Table 1) in the 1980 race when the frequency was too high at the peak of the race to keep detailed records. In contrast, the frequency in the 1982 race was so low that minute-by-minute records were kept throughout the race. My impression from observing the participants is that this is the result of substantially higher proportions of young amateurs in the 1981 and 1982 races than in the 1980 race.

According to BLM (1981a and b), both the 1980 and 1981 races (assessment of the 1982 race has not yet been released) were run "... as specified by BLM design and stipulation," as a consequence of which there were "... no significant impacts." These judgments were based upon qualitative assessment of visual impact. Although BLM planned that these events would yield baseline-monitoring data, and that determination of impairment of the WSA would be based on impact "... such as soil compaction, disturbance to or destruction to [sic] archaeological sites or adverse changes in habitat," to date no data on soils, vegetation, or wildlife impact have been provided.

Size of Area Affected

The approach used by BLM (1975) in defining the area or zone of influence was used here. The zone of influence is the area within which the majority (about 95%) of tracks occur. Thus isolated tracks removed from the main route are excluded. Of course not all the land within the zone of influence is directly impacted. The zone of influence, not measured, of noise impact on wildlife (Brattstrom and Bondello 1983) would be much larger than that directly scarred by motorcycles, as would the zone affected by dust fallout and sedimentation resulting from erosion of the tracks.

Using information provided by BLM (Table 2), it is apparent that neither the 1980 or 1981 races were controlled to meet BLM's stipulations. In the Draft Environmental Impact Statement (EIS), BLM (1980a) authorized a corridor through

WSA 304A 5 m wide and predicted an "... actual area of disturbance less than 10 feet" wide. The same width of actual impact was predicted for other cross-country segments in L class lands in authorized corridors 7 m wide. In the final EIS (BLM 1980b), the authorized corridors in both the WSA and L class lands were enlarged to 15 m and the anticipated zone of impact was enlarged to 5 m. In 1981, BLM (1981a) increased the authorized corridor in the eastern part of WSA 304A to 21 m, an explicit recognition of failure to control that segment of the races. The width of the zone of influence measured by BLM (Table 2) shows that the zone of influence of the 1980 and 1981 races was as much as 320% larger than predicted.

This author's measurements, made at 20 stations in the western part of the WSA, contrast significantly with those of BLM (Table 3). Average widths of the zone of influence were 22.5 m in 1980, 23 m in 1981, and 14 m in 1982. The cumulative average width as of 1982 is about 23 m. These figures exceed BLM's predicted impact by 360%. They exceed the total authorized corridor width by 40%. Measurement of the route at 5 stations before the 1982 race in the eastern part of WSA 304A on straight segments of the route indicated an average width of 37 m, which exceeds the predicted width by 640% and the total authorized corridor (21 m) by 76%.

At the south end of Cadiz Valley, measurements of the aggregate width of the 1980-1981 routes were made at 12 stations before the 1982 race (Table 4). These stations were located north of the entry to Pit 3 and exclude the 1980 route, which was not designated according to BLM stipulations. The average width of the 1980-1981 route exceeds the predicted width by 394% and the total authorized corridor width by 65%. Although there were substantially fewer participants in the 1982 race than previously, and the total zone of influence of the 1982 race was slightly smaller (23.8 m compared to 24.7 m for the previous races), the size of the zone of influence of all races increased by an average 6 m.

Additional information was gathered at refueling Pits 2 and 3 (Figure 1). The EIS (BLM 1980b) stipulates that pit areas shall be limited to 1.6 ha and shall be appropriately marked. No markings that outline the designated 1.6 ha were seen at Pits 2 or 3 for any of the races. BLM (1981a) called Pit 2 the best-operated pit in 1980. The author measured heavy impact (direct soil impact covering more than 50% of the surface) at Pit 2 over an area of 2.4 ha and lesser impact (direct soil impact covering 10%-50% of the surface) over an additional 1.6 ha after the 1980 race. BLM (1982a) reported that Pit 3 was "... a model for a smooth, trouble-free pitting operation." The author measured heavy impacts in a zone more than three times the authorized width and lighter impact in a zone six times the authorized width in 1981. In 1982, substantial impact occurred in an area of about 3.2 ha as a result of

Table 2. Course width in WSA 304A as determined and authorized by BLM.

	Average width of affected zone	Maximum width	Authorized width	% Change	
				Measured	Authorized
1980 draft EIS	3 m (predicted)	5 m (predicted)	5m		
1980 final EIS	3 m (predicted)	5 m (predicted)	15 m		+200
1981 EA ^a	9 m (west)	36 m	15 m	+ 80	
	15 m (east)	21 m	15 m	+200	
1982 EA ^b	15 m (west)	Not given	15 m	+200	
	21 m (east)		21 m	+320	+ 40

^aBLM (1981a) ^bBLM (1982a)

Table 3. Course width (m) in western part of WSA 304A as observed by author.

Station	1980	1981	1982	Station	1980	1981	1982	Average width (m)		
								1980	1981	1982
1		15	12	11	18	31	7			
2	8	9	14	12	19	11	8	22.5	23	14
3	32	3	14	13	16	21	3			
4	17	11	17	14	16	15	6			
5	7	24	16	15	27	40	18	% Change from EIS, predicted		
6	21	35	27	16	18	37	9	1980	1981	1982
7	23	26	18	17	40	23	27			
8	26	43	21	18	17	9	8			
9	35	38	9	19	37	27	30	+350	+360	+180
10	30	26	7	20	21	15	3			

Table 4. Course width (m) north of pit 3.

Station	1980 + 1981	1982
1	11	13
2	12	22
3	14	26
4	3	11
5	14	34
6	34	22
7	27	13
8	24	21
9	29	22
10	41	41
11	41	45
12	46	27

refueling operations, parking, camping, and free play. Lesser impact was incurred over a much larger unmeasured area. The aggregate size of the area of conspicuous influence of Pit 3 is now approximately 6.5 ha.

In addition to impact on the designated route and within the designated pit areas, substantial damage is done annually by the small percent of participants who grossly violate the marked course and by free play in the pit areas, which is ostensibly prohibited. BLM (1982b) states that free play in the pit areas has been controlled. While this may be true during the

time BLM monitors have been present, the condition of the land around the pit areas after all participants have left shows that BLM's assessment is incorrect. Especially where the land is as sensitive as it is near Pit 3, free play even by a few motorcycles is very damaging to soil stability and to wildlife (Figure 4). The magnitude of the problem can be appreciated with the understanding that a motorcycle directly impacts 1 ha of land for each 80 km or less of travel (Geological Society of America 1977).

Categories of Damage

The types of damage inflicted on the cross-country parts of the course include direct slaughter of wildlife (Figure 5), soil compaction, destruction of a 2- to 5-cm-thick vesicular (A) soil horizon, destruction of desert pavement surfaces, and excavation (mechanical erosion) of A and B soil horizons to depths of 20 cm (Figure 6B). Exposure of soils contributed to accelerated natural erosion, which occurred during high winds two days after the 1980 race, during heavy rains on September 30 through October 1, 1981, November 28, 1981, and in much of March 1982. Burrows of small animals in and adjacent to the marked course were generally crushed, lichen ground cover, algal mats, and remnants of summer annuals were eradicated. In a 0.8-km length of the course, eight damaged creosote and 11



Figure 4. Isolated motorcycle track north of Pit 3 made by pit attendants at play. Note soil disturbance caused by single pass of the motorcycle and crushed burrows in near middleground.

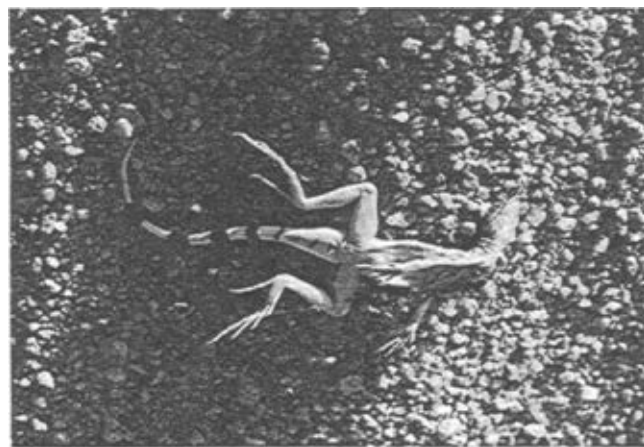
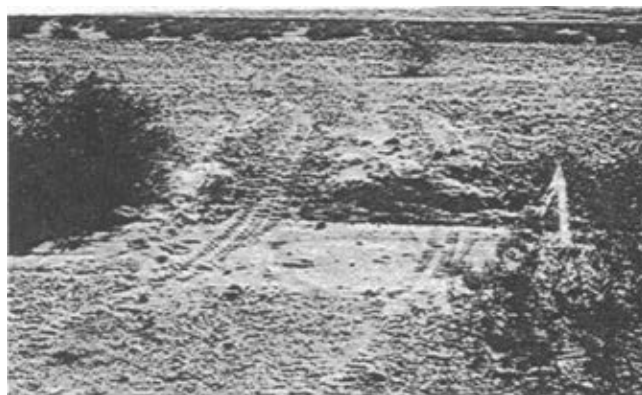


Figure 5. Zebra-tailed lizard crushed by motorcycles in Pit 3 area.

damaged burro-weed were counted along the main route in 1980, which amounts to 2500 shrubs for the 106 km of cross-country routing. Observations without counts in 1981–1982 suggest that this is a conservative estimate, and repeat photographs before and after each event show substantial increments of damage to vegetation from race to race. After



A



B

Figure 6. (A) Photograph of race course in the western part of Wilderness Study Area 304A before the first race in 1980. Amboy Crater is the low hill on skyline toward right side of the photograph. (B). Same scene as 6A photographed after the 1982 race. The soil beneath the desert pavement is soft and has been mechanically eroded by the motorcycles to a depth of 20 cm. A 4- to 5-cm-thick vesicular A horizon that lay immediately below the rock pavement has been destroyed.

three events, complete destruction of perennial vegetation has become noticeable in pit areas.

Visual Impact of the Route

BLM (1981a) reported that

The four mile section of the course crossing the bajada in the western portion of the WSA was already disturbed by vehicle tracks (including tank tracks) and was noticeable (7 months after the 1980 race) only when one was very close to it.



A



B



C

Figure 7. (A) Photograph of race course in the western part of Wilderness Study Area 304A after the first 22 motorcycles in the 1980 race had passed. (B) Same scene as 7A after 297 motorcycles in the 1980 race had passed. (C) Same scene as 7A the day before the 1982 race.

Photographs (Figure 7C) show that while the course was still readily evident more than 11 months after each event, it is the terrain and vegetation that screen it from distant view, not natural erasure of the tracks. It is more conspicuous now because the intensity of impact within the zone of influence has increased (Figure 8). Moreover, the statement that this segment was already disturbed is contradicted by the EIS (BLM 1981b, p. III-38), by the testimony of BLM resource personnel quoted before, and by simple observation (Figures 5A and 6A). The fact is that the 1980 race produced a conspicuous track across previously undisturbed land and that subsequent races have added to the damage (Figure 9).

Prospect for Recovery

BLM (1980b, p. IV-26) states

If disturbance generated by a race exceed[sic] expectations, future events would be denied or rerouted around the WSA, allowing natural rehabilitation to occur before the area's wilderness status is decided by Congress.

A number of studies show that the natural recovery expected by BLM will not occur in the near future, certainly not in the time frame of the wilderness review process. Studies of soil compaction in desert townsites abandoned for as long as 70 years show that the soil does not recover for about a century (Webb and Wilshire 1980, Webb and others 1983); if erosion takes place, the recovery time is much longer. Recovery of the perennial plant community requires much more time, measured in millenia (Vasek and others 1975, Webb and Wilshire 1980, Lathrop and Rowlands 1983). In the immediate area of the WSA, scattered tracks made by single passes of a tank in the 1964 Desert Strike maneuvers remain vivid today, 18 years later (Figure 10), and along other parts of the course, similar relics of World War II maneuvers remain etched on the land, illustrating the slowness of recovery. Certain visual effects, however, are quickly eradicated, such as disturbances across lava with loose lag gravel and unvegetated eolian sands that have accumulated in pockets on the rough lava surface. For the

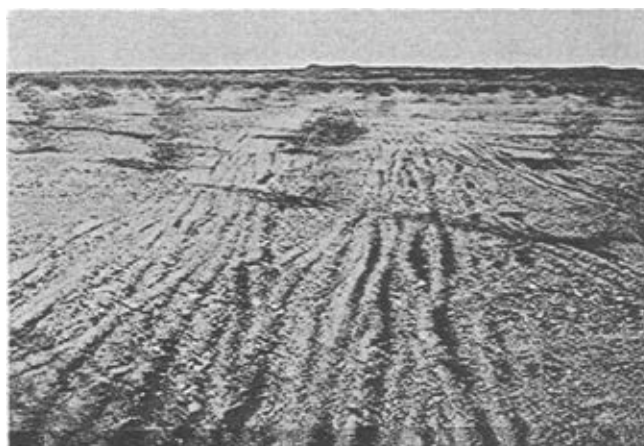


Figure 8. A typical view of the race course in the western part of WSA 304A, after the 1982 race. The width of the zone of influence in view is 9 m, $\frac{3}{4}$ the width of Highway 66.



Figure 9. View south toward Pit 3 after the 1982 race.

most part, however, the language used by Congress to describe this land—"extremely fragile, easily scarred, and slowly healed"—is accurate. BLM's expectation of rapid natural recovery lacks foundation.

Compliance with Regulations Governing Use of C and L Class Lands

Congress directed (FLPMA 1976) that all WSAs be managed to prevent impairment of their wilderness qualities until such time as Congress decides whether or not to include them in the wilderness system. BLM's regulations, which implement



Figure 10. Track made by a single pass of a tank in the 1964 Desert Strike maneuvers, eastern part of WSA 304A. Photograph taken in October 1982.

Congress' direction, set forth specific criteria for nonimpairing uses (Interim Management Policy and Guidelines for Lands Under Wilderness Review-IMP). To satisfy the nonimpairment criteria for cross-country travel BLM must (a) demonstrate that damaged land is capable of being reclaimed to a state that is substantially unnoticeable in the WSA as a whole, (b) identify cumulative impacts and act to restrict them, and (c) maintain the wilderness qualities of the area. The difficulties in meeting these criteria for motorcycle races was recognized (BLM 1979a):

Based on past practice, it is expected that ORV events involving cross-country travel (off existing ways and trails) as part of the route would rarely satisfy the nonimpairment criteria [emphasis added].

BLM has not demonstrated that reclamation of land damaged by motorcycles is either possible or feasible. The difficulty in reclaiming severely disturbed arid land is well known and thoroughly documented (Wiener and others 1980, National Academy of Sciences 1974, Wali 1975). Many of the problems of reclaiming mined arid land, especially those of restoring topsoil and revegetation with native species as specifically required by the IMP (BLM 1979a), are just as severe in lands damaged by motorcycles (Kay and Graves 1983, Brum and others 1983, Heede, 1983). Well-developed soils are probably relics of climates that no longer exist in the desert, and therefore are no more reclaimable than destroyed archaeological resources. Thus the races have been authorized without the information required by the IMP.

The IMP further enjoins BLM to monitor potential cumulative impacts which "while individually nonimpairing," may be continuing use or indirect effects, come to impair the area's wilderness suitability. Such a monitoring program has not been established, even after three annual races, and some resources (wildlife for example) are not scheduled to be monitored at all (BLM 1981a), yet BLM stated in its Desert Plan (1980c) that "monitoring and surveillance of vehicular use in WSAs will be a priority in Plan implementation."

BLM (1980b, p. IV-25-26) stated its position on consistency of the proposed races with maintenance of wilderness qualities in the final EIS as follows: "... the impacts of annual races would be substantially unnoticeable ..." because (1) the total amount of land in the WSA that would be affected (in a corridor that was assumed to reach a maximum width of 5 m) is only 0.13% of the WSA; (2) the course across natural terrain is not visible from highway 66 nor from the most frequently visited spots in the WSA; (3) much greater areas of the WSA are already affected by ORVs than would be affected by the races; (4) the course follows previous race routes, no signs of which are evident now, indicating rapid natural erasure of the impacts; and (5) the vegetation is so sparse, that visual changes caused by the races would be insignificant.

With respect to items 1 and 2, neither FLPMA nor the IMP indicate that impairing uses of some portion of a WSA is permissible because that portion is small or is not visible from specific parts of a WSA. In fact, the assessment of the IMP, previously quoted, that cross-country routing "would only rarely satisfy the nonimpairment criteria" implies the opposite. Furthermore, the size of the area affected by three races has grown over that predicted by as much as 320% by BLM's accounting, and by as much as 640% by the author's measurements. BLM's criterion has not been reassessed in view of these unanticipated increases.

While it is true that the western part of the course is not visible from highway 66, the reverse is true also; highway 66 is not noticeable from that part of the race course, and, except for bridge structures, is not noticeable from very much closer either. This is due to the terrain and the size and density of the vegetation and is one of the conditions that provides the opportunity for solitude cited in the wilderness classification of the area. What the race course really does is further segment the land that affords opportunity for solitude by establishing a new manmade feature that becomes noticeable with proximity, as does highway 66.

Item 3 is a prediction that was clearly not borne out. There are no vehicular corridors through WSA 304A that approach the magnitude of impact or the size of the present race course after only three events. Moreover, further widening and inten-

sification of the impact within this corridor may confidently be predicted on the basis of the past experience that ostensibly guided the decision to allow this use.

Item 4 has no support from the observations of the resource evaluation team quoted before, nor from the persistence of isolated tank tracks.

Item 5 probably would not be true even if the impact had been contained within a 5-m corridor. It does not appear to be true of the actual course that is now 3-5 times that width.

The effects of three races show clearly that compliance with provisions of the IMP has not been achieved. The impact on the land in Amboy Crater WSA has not been shown to be reclaimable. The impacts are accumulating at a very rapid rate, but no monitoring of critical resources has been accomplished whereby cumulative effects could be assessed. The only provision of the IMP that allows potentially destructive ORV events to cross natural terrain in WSAs requires that BLM determine "... that the event *can and will be* carefully controlled to ensure that it fully satisfies the nonimpairment criteria" (emphasis added). The races have not been controlled in the WSA. There have been no BLM monitors present during any of the events, and riders have departed from the prescribed course by as much as 150 m. The average width of the affected zone has increased greatly over that which was prescribed. After only eight annual events, the Parker 400 race course (Figure 2) was so significant a manmade feature that it was chosen as the boundary of WSA 307. Thus it is evident that this use impairs wilderness quality.

For the same reasons that this race impairs wilderness qualities, it is inconsistent with the criteria for designation of cross-country vehicular routes in L class lands. Recently, a federal court ruled that BLM's criteria (BLM 1980c) for designation of such routes violated provisions of Executive Orders (nos. 11644 and 11989) and BLM regulations derived from those orders. These orders require that adverse effects of vehicular use be minimized (*California Native Plant Society vs Watt*, 543 F. Supp. 789, C.D. Cal. 1982). Before the 1982 race, BLM asked the court to determine that its designation of the Johnson Valley-Parker route in L class land was legal. The court responded that it did not have jurisdiction over the matter, but if it did, "... federal defendant's motion would be denied." The court further stated that "it is apparent that sufficient consideration has never been given to the impact of a motorcycle race on the class L area included in the race course under the designation criteria of 43 C.F.R. 8342.1. Under these circumstances, authorization of the October 9 race appears not to have been in compliance with the judgment herein" (*California Native Plant Society vs Watt*, No. CV 81-489 AWT, Memorandum Order on Motion for Clarifica-

tion, September 29, 1982). Ten days later the third annual Johnson Valley-Parker race was run.

Conclusion

BLM's attempt to eliminate illegal use of the Barstow-Las Vegas race course by providing a major legal event for the motorcyclists has not worked. Uncontrolled illegal use of the Barstow-Las Vegas route and unmonitored, uncontrolled trail rides said to be legal uses of that route go on as before. To provide the legal event, BLM has had to make serious compromises:

- BLM's own definition of existing ways was manipulated to accommodate the Johnson Valley-Parker route.
- the first race on the route was declared to be of such overriding national importance that the full public review period for the EIS required by the National Environmental Policy Act was truncated to meet the racer's schedule.
- the races have been authorized without the information on reclamation potential that is demanded by the nonimpairment criteria of the IMP.
- decisions to authorize the races have not been based on any monitoring data, acquisition of which was the *prima facie* reason for establishing the course.
- new criteria for impairing uses were ascribed to the IMP that have no basis in law.

The principal lesson of the Johnson Valley-Parker races is that the best job, under foreseeable funding/manpower levels, that BLM can be expected to do in controlling, monitoring, and assessing impacts of cross-country motorcycle races falls far short of Congress' vision in establishing the California Desert Conservation Area. The damages to C and L class lands by these races will likely worsen in the future, but a greater danger lies in the extension of this kind of management practice to other vulnerable public lands.

Acknowledgments

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NOP Ocotillo Wells State Vehicular Recreation Area General Plan Update- Request for extension of time,

Lisa Belenky <lbelenky@biologicaldiversity.org>
To: "info@planocotillowells.org" <info@planocotillowells.org>
Cc: Zeynep Graves <zgraves@biologicaldiversity.org>

Tue, Mar 24, 2026 at 9:18 AM

Erik Taylor, General Plan Project Manager.

The Center for Biological Diversity (Center) requests an extension of time of 10 days to submit comments on the Notice of Preparation (NOP). The Center has no record of receiving a copy of the NOP and I only learned of it yesterday.

As you are no doubt aware, the Center has engaged with State Parks many times in the past regarding management of the OWSVRA area and is concerned about protection of many species in the OWSVRA. In 2025 we submitted comments on the Draft Ocotillo Wells SVRA Soil Conservation Plan. Among other work, the Center has advocated for protections of flat-tailed horned lizards that occur in the OWSVRA and has advocated for protections for the environmental and cultural resources of the Desert Cahuilla Acquisition area for decades.

Please ensure that the Center is on the notice list for all future updates and notices associated with the OWSVRA General Plan Update and its environmental review.

Please include both of the following on the notice list:

Lisa Belenky lbelenky@biologicaldiversity.org

Zeynep Graves zgraves@biologicaldiversity.org

Thank you for considering this request for an extension of time.

Sincerely,

Lisa Belenky

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Center Comments OW SVRA SCP 3 24 2025.pdf
274K



Matt Kirkland <info@planocotillowells.org>

New form submission on Webflow for Ocotillo Wells SVRA General Plan Update

Webflow forms <no-reply-forms@webflow.com>

Tue, Mar 3, 2026 at 11:30 PM

Reply-To: no-reply@webflow.com

To: info@planocotillowells.org

You just received a new form submission on your website Ocotillo Wells SVRA General Plan Update.

Name: Charlie Willard

Email Address: diverx69@yahoo.com

Organization:

Comment: How about allowing permitted events in Truckhaven north of S-22.

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