



Southern California Desert Habitats *Climate Change Adaptation Synthesis*

Introduction

The following section presents climate change adaptation planning results for desert habitats. The results summarize discussions and activities completed by participants during a two-day adaptation workshop as well as peer-review comments and revisions and relevant examples from the literature or other similar efforts.¹ We first present current management goals identified by participants. The purpose of identifying management goals is to provide a foundation for evaluating whether and how climate change might affect the ability to achieve a given goal, and to develop options for reducing vulnerabilities through revised management activities. For each management goal, participants identified potential climate change vulnerabilities. This activity was followed by the evaluation of current management actions, including whether, in their current form, they can help to reduce identified vulnerabilities and/or how they can be modified to better address climate challenges. Following the evaluation of potential vulnerabilities of current management goals and actions, participants explored potential future management goals and adaptation strategies and identified more specific adaptation actions designed to reduce vulnerabilities or increase resilience of desert habitats. For each adaptation action, participants then evaluated where, when, and how to implement those actions as well as collaboration and capacity needs. Lastly, we present a table summarizing all adaptation actions developed by participants as well as additional actions for consideration from the literature and from other similar efforts. Adaptation actions are grouped according to whether they (1) enhance resistance, (2) promote resilience, (3) facilitate transition, (4) increase knowledge, or (5) engage coordination in terms of responding to climate change.

Defining Terms

Goal: A desired result for a given resource.

Adaptation strategy: General statements of how to reduce vulnerabilities or increase resilience of current management goals.

Adaptation actions: Specific activities that facilitate progress towards achieving an adaptation strategy.

Current Management Goals and Potential Vulnerabilities

Workshop participants identified two key current management goals for desert habitats:

- (1) Manage ex-urban wildlife populations (e.g., crows and ravens, raccoons), and
- (2) Manage or remove invasive plant species.

¹ Workshop participants included: Nicole Bentivegna, CH2M; Jeff Lincer, Lincer & Associates; Chris McDonald, UC Cooperative Extension; Marcia Narog, USFS; Patrick Taber, BIA; and Diane Travis, USFS



As part of the workshop activities, participants identified potential climate and non-climate vulnerabilities to current management goals and actions for desert habitats. Potential vulnerabilities identified included:

- Threats from ex-urban wildlife (e.g. predation, disease), for whom the wildland-urban interface provides resources
- Increased disease vectors due to edge effects
- Changes in the distribution of top predators
- Increased temperatures affecting the sex ratios of some species
- Range shifts for some species toward higher elevations
- Changes in plant phenology
- Increased desertification
- Increased extent of invasive species, as well as the introduction of non-native species into new areas
- Increased water availability for invasive species in the case of increased monsoons
- Enhanced transport of invasive species and the creation of disturbed areas (vulnerable to invasion) by recreation users
- Limited flexibility in funding, which makes it difficult to address boom and bust cycles of invasive species
- Time lag in management of invasive species

In response to these vulnerabilities, participants then evaluated whether or not existing management actions may be effective in reducing vulnerability; identified what, if any, climate and non-climate vulnerabilities the action helps reduce; and evaluated the feasibility of action implementation. Given action effectiveness and feasibility, participants then evaluated whether or not to continue implementation of the action. For those actions recommended for continued implementation, participants then identified both how and where to implement.

Terminology

Action effectiveness: Identify the effectiveness of the action in reducing vulnerability. *High*: action is very likely to reduce vulnerability and may benefit additional goals or habitats; *Moderate*: action has moderate potential to reduce vulnerability, with some limits to effectiveness; or *Low*: action is unlikely to reduce vulnerability.

Action feasibility: Identify feasibility of implementing the action.

High: there are no obvious barriers and it has a high likelihood of being implemented; *Moderate*: it may be possible to implement the action, although there may be challenges or barriers; or *Low*: there are obvious and/or significant barriers to implementation that may be difficult to overcome.

How to implement: Identify how to apply this action given vulnerabilities. For example, consider planting native species that can cope with a range of future conditions or those best adapted to projected future conditions.



Where to implement: Identify the management, ecological, or site conditions where the action could be most appropriately implemented.

For example, is it best to implement in areas with high soil moisture holding capacity, areas projected to lose the most water supply, post-fire areas, highly roaded areas, etc.?

Table 1 below explores current management goals and actions, potential vulnerabilities, and ways to revise current actions to reduce vulnerabilities for desert habitats. The table is structured to provide:

- 1. A current management goal;
- 2. Potential climate and non-climate vulnerabilities that affect the success of achieving the management goal;
- 3. Multiple current management actions;
- 4. An evaluation of action effectiveness, feasibility, and potential vulnerabilities that the may be reduced by action implementation; and
- 5. A description of where and how to implement the action given climate vulnerabilities and whether or not implementation of the action may have indirect effects on other resources, either positive or negative.

Revised Management Actions

The following list describes trends and commonalities amongst the climate-informed current management actions discussed by participants in Table 1.

- Both goals identified by workshop participants focused on addressing non-climate stressors by managing invasive and nuisance species. The adaptation actions primarily relate to invasive species removal and prevention however, education is also included as an action for both management goals, and focuses on local policy makers and the public.
- The majority of these actions are based on *enhancing resistance* in desert habitats by reducing non-climate stressors (e.g., removing ex-urban wildlife, removing invasive plants using herbicide or mechanical methods). However, actions related to public education and policy change are focused on *promoting resilience* of the ecosystem.
- Workshop participants consistently noted that adaptation actions focused on reducing invasive and nuisance species would benefit native species diversity, as well as the aesthetic, recreational, and economic values of the habitat.
- Workshop participants primarily identified the wildland-urban interface and other areas where anthropogenic disturbances affect desert ecosystems (e.g., transportation corridors, recreation areas) as the best locations to implement these adaptation actions. Participants recommended that public education efforts focus on people using desert habitats (e.g., for recreation), as well as schools, environmental education centers, and rest stops.



Table 1. Current management goals, potential vulnerabilities, and current management actions for desert habitats. For each current management action participants evaluated its effectiveness (likely to reduce climate vulnerability) and feasibility (likelihood of implementation), and identified climatic and non-climatic stressors the action could help to ameliorate the effects of. Given action effectiveness and feasibility, participants then evaluated whether or not the action should continue to be implemented. If the action was recommended for continued implementation, participants detailed any changes regarding where and how to implement given climate vulnerabilities. Lastly, participants evaluated whether there were potential conflicts with or benefits to other resources from action implementation.

Current Management Goal: Manage ex-urban wildlife populations (e.g., crows and ravens, raccoons)

Potential vulnerabilities:

- Threats from ex-urban wildlife (e.g. predation, disease), for whom the wildland-urban interface provides resources
- Increased disease vectors due to edge effects
- Changes in the distribution of top predators
- Increased temperatures affecting the sex ratios of some species
- Range shifts for some species toward higher elevations
- Increased desertification

Current Management Action ²	Current	Current Feasibility	Does Action Ameliorate Effects of Any Vulnerabilities?	Continue to Implement Action Given Climate Vulnerabilities?	Where/How to Implement Given Climate Vulnerabilities	Other Resource Considerations
Kill ex-urban wildlife (e.g., poison or shoot	No answer provided by participants	No answer provided by participants	No answer provided by participants	No answer provided by participants	Where: Focus fencing / exclosures in the areas where wildlife is wanted	Other resources action benefits: No answer provided by participants
them) and/or create exclosures					How : Build fencing/exclosures, bait stations, and corridors to connect landscapes; add watering stations in deserts	Other resources with potential conflicts: No answer provided by participants

² Conducting clean-up activities to address pollution and other issues in the wildland-urban interface was also identified as a current management action for this goal, but was not evaluated, so it is not listed in this table.



Design educational programs to address the issues of pollution and invasive species	No answer provided by participants	No answer provided by participants	No answer provided by participants	No answer provided by participants	Where: No answer provided by participants How: Focus education programs on encouraging the positive actions people are already taking, and providing them with additional no-regrets actions they could put into place. Engage people through citizen science. Encourage flexibility in policy-making (e.g., policies could state that grazing allotments increase or decrease	Other resources action benefits: No answer provided by participants Other resources with potential conflicts: No answer provided by participants	
Current Managemen	t Goal: Manage	or remove inva	asive plant species		depending on precipitation).		
Potential vulnerabilities:							
 Changes in plant 	Changes in plant phenology						
 Increased extent 	 Increased extent of invasive species, as well as the introduction of non-native species into new areas 						
Increased water	availability for in	vasive species i	in the case of increa	ased monsoons			
Enhanced transp	ort of invasive sp	pecies and the o	creation of disturbe	d areas (vulnerable	to invasion) by recreation users		
 Limited flexibility in funding, which makes it difficult to address boom and bust cycles of invasive species 							
Time lag in management of invasive species							
				Continue to			
			Does Action	Implement			
Current			Ameliorate	Action Given			
Management	Current	Current	Effects of Any	Climate	Where/How to Implement		
Action ³	Effectiveness	Feasibility	Vulnerabilities?	Vulnerabilities?	Given Climate Vulnerabilities	Other Resource Considerations	

³ Fire prevention was also identified as a current management action for this goal, but was not evaluated, so it is not listed in this table.



Spray herbicides	No answer provided by participants	No answer provided by participants	No answer provided by participants	No answer provided by participants	 Where: Along transportation corridors, campgrounds, and other places that require maintenance How: Create GMO weed pollen and spray to reduce spread of invasives; identify and plan for the species that may come in after spraying 	Other resources action benefits: Native grass and wildlife diversity, aesthetics (due to decreased fire), cultural, heritage, recreation (non-consumptive), and economic value Other resources with potential conflicts: Other plants and wildlife species
Manual and/or physical removal of invasives	No answer provided by participants	No answer provided by participants	No answer provided by participants	No answer provided by participants	Where: Palm oases, transportation corridors, recreation/human activity sites, near likely ignition sources How: Same as current practice	Other resources action benefits: Native grass and wildlife diversity, aesthetics (due to decreased fire), cultural, heritage, recreation (non-consumptive), and economic value Other resources with potential conflicts: Other plants and wildlife species
Education (e.g., importance of boot checks)	No answer provided by participants	No answer provided by participants	No answer provided by participants	No answer provided by participants	Where: Nature education centers, 4 th grade classrooms (and schools in general), roadsides and rest stops, museums, campgrounds, dumps How: Utilize electronic media, apps, crowd-sourcing, social media	Other resources action benefits: Native grass and wildlife diversity, aesthetics (due to decreased fire), cultural, heritage, recreation (non-consumptive), and economic value Other resources with potential conflicts: Other plants and wildlife species



Future Management Goals and Adaptation Actions

Workshop participants identified the following possible future management goals and adaptation actions for desert habitats:

Management Goal/Adaptation Strategy: Determine whether plantings will be successful under different future climate conditions.

Adaptation action: Develop baseline conditions necessary for plant reproduction.

- Management Goal/Adaptation Strategy: Reduce anthropogenic stressors (e.g., fire ignitions). <u>Adaptation action</u>: Close access to roads, campgrounds, etc. during high fire hazard years or when site needs to recover.
- Management Goal/Adaptation Strategy: Establish monitoring programs to detect changes.

<u>Adaptation action</u>: Monitor the movement of desert sand and the relationship of sand movement to floral and faunal movement.

Management Goal/Adaptation Strategy: Identify and protect desert refugia.

<u>Adaptation action</u>: Protect desert refugia through varied strategies such as land acquisition, land use planning, and land transfers.

Management Goal/Adaptation Strategy: Improve our understanding of synergistic relationships in the desert.

<u>Adaptation action</u>: Investigate the possibility of using restoration techniques that establish resilient native plants more quickly.

Adaptation action: Identify the synergistic relationships between species.

After identifying possible future management goals and actions for desert habitats, participants were asked to evaluate action effectiveness and feasibility; identify the timeframe for action implementation; describe where and how to implement the action; and identify collaboration and capacity needs. Timeframe, collaboration and capacity needs are defined below.

- Implementation timeframe: Identify when the action could feasibly be implemented.
 - *Near*: <5 years; *Mid*: 5-15 years; or *Long*: >15 years.
- **Collaboration:** Identify any other agencies, organizations, or people both internal and external needed to collaborate with in order to implement this tactic.
- **Capacity needed**: Identify capacity needed for implementation such as data, staff time and resources, funding, or policy changes, among others.

Table 2 below explores the future management goals/adaptation strategies, actions, and implementation recommendations developed by workshop participants for desert habitats. The table is structured to provide:

1. A future management goal/adaptation strategy;



- 2. Adaptation actions for each goal/strategy;
- 3. An evaluation of action effectiveness, feasibility, and implementation timeframe; and
- 4. A description of where and how to implement and collaboration and capacity needed to move forward with implementation.

This workshop activity was intended to generate a range of recommended adaptation actions that could be implemented both now and in the future. The resulting actions are not comprehensive, and users of this report are encouraged to explore additional adaptation actions that may help reduce vulnerabilities, increase resilience, or capitalize on opportunities presented by climate change for desert habitats.

Future Management Actions

The following list describes trends and commonalities amongst the future management actions discussed by participants in Table 2.

- The majority of future management actions identified by participants focused on gaining a deeper understanding of relationships and processes that are occurring in desert habitats. Examples of these include identifying baseline conditions for plant reproduction, understanding synergistic relationships between species, and learning about the movement of desert sand and how that relates to the movement of flora and fauna. Other actions also address:
 - Development of management techniques that are appropriate under changing climate conditions,
 - Restricting access in areas vulnerable to disturbance, and
 - Land use planning and protection.
- These management actions are primarily focused on *increasing knowledge* (e.g., research and exploration of desert processes) and *promoting resilience* (e.g. exploring restoration techniques that would allow resilient species to become more quickly established). However, one action attempts to *facilitate transition* by identifying and protecting desert refugia through land acquisition, land use planning, and land transfers.
- Many of these actions, especially those based on research and exploration, would require collaboration among federal, state, and local agencies, universities, and other members of the scientific community. Several participants also mentioned the need for funding and administrative support, and noted that it is important to avoid duplicating efforts.
- Participants recommended several locations where these actions could be focused, including:
 - \circ Areas where sensitive species occur,
 - Areas where native plant species are thriving,
 - Areas that are highly disturbed (or are at high risk of disturbance),
 - Areas that are expected to be strongly impacted by climate change, and
 - Potential locations of refugia, including springs and seeps, dunes, and desert foothills.



Table 2. Potential future management goals, adaptation actions, and action implementation details including where and how to implement and collaborationand capacity needs for desert habitats. Action effectiveness (likelihood of reducing vulnerability), feasibility (likelihood of implementation), and timeframe(near: <5 years; mid: 5-15 years; long: >15 years) were also evaluated for each adaptation action.

Management Goal: D	Management Goal: Determine whether plantings will be successful under different future climate conditions				
Adaptation action Develop baseline conditions necessary for plant reproduction	Effectiveness Low	Feasibility Moderate	Timeframe Near	Implementation (where/how) Where: Areas with particularly sensitive or resilient species; areas in need of restoration How: Identify species that are vulnerable and those that are stable or thriving; coordinate field crews to take measurements/surveys in the field; develop citizen science programs to gather additional data	Collaboration & Capacity External collaboration: Scientists who can offer technical expertise Internal collaboration: Other departments (to avoid duplicating efforts), administrative and budgetary staff Capacity needed: Funding
Management Goal: R	Management Goal: Reduce anthropogenic stressors (e.g., fire ignitions)				
Adaptation Action	Effectiveness	Feasibility	Timeframe	Implementation (where/how)	Collaboration & Capacity
Close access to roads,	High	High	Near	Where: Sensitive plant communities, areas with high fire risk	External collaboration : No answer provided by participants
campgrounds, etc. during high fire hazard years or when site needs to recover				How : Regulate human activities in areas that are at risk of wildfire (e.g., if high fire risk year, do not allow campfires and close more roads to traffic); direct visitors to more resilient sites. Provide education through apps and citizen science. Communicate with the public through signage, visitor centers, and brochures.	Internal collaboration: No answer provided by participants Capacity needed: Use existing staff
Management Goal: E	stablish monitor	ing programs	s to detect cha	anges	
Adaptation action	Effectiveness	Feasibility	Timeframe	Implementation (where/how)	Collaboration & Capacity

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Monitor the	Moderate	High	Near	Where: Locations where wind- or water-	External collaboration : Local, regional, county,
movement of desert		_		generated sand movement occurs;	state, federal, scientific, and planning entities
sand and the				prioritize areas where climate change	(goal is for entities to be mutually supportive,
relationship of sand				impacts are anticipated to be greatest.	coordinated, and avoid duplication); involve
movement to floral				How: Incorporate ownership and	Habitat Conservation Plan and Natural
and faunal				management (public, private, etc.) in the	Community Conservation Planning processes
movement				consideration of desert systems. Develop	Internal collaboration: Administrative and
				stakeholder-based plans that are detailed	logistical support (personnel and purchasing):
				and objective, and which include a	consolidate similar activities where possible to
				schedule for responsibilities: practice	avoid duplicating efforts and resource use
				adaptive management. Depending on	Canacity needed: Consistent long term
				scale, could involve citizen science if	funding and political support
				QA/QC is addressed.	
Management Goal: Io	entify and prot	ect desert ref	ugia		
Adaptation Action	Effectiveness	Fossibility	Timoframo	Implementation (where /how)	Collaboration & Canacity
Drotoct decert	Mederate	Peasibility	Near	Where Desert featbills dura accounter	External collaboration Universities Dursey of
rofugia through		Wouerate	Near	desort accos (soops (springs	Land Management, National Park Service, U.S.
variad stratogias	півн			desert bases/seeps/springs	Land Management, National Park Service, 0.5.
varieu strategies				How: Model changes in climate and	Porest Service, Dept. of Defense, NGOS, local
such as land				drivers of change in plant communities;	agencies, technical experts
acquisition, failu use				map and monitor vulnerable communities,	Internal collaboration: No answer provided by
transfors				as well as known or potential refugia,	participants
transfers				recharge zones, and land ownership/	Capacity needed: Data, funding, staffing,
				management. Identify existing policies	possibly policy changes
				that could support this project (Prop 1	
				funding).	



Management Goal: Improve our understanding of synergistic relationships in the desert					
Adaptation action	Effectiveness	Feasibility	Timeframe	Implementation (where/how)	Collaboration & Capacity
Investigate the possibility of using restoration techniques that establish resilient native plants more quickly	Moderate	Moderate	Mid	Where: Disturbed sites How: Research and implement field trials utilizing techniques such as mycorrhizal inoculation, establishing water reservoirs, and planting native vegetation; include habitat conservation plans	 External collaboration: Universities, researchers groups Internal collaboration: Existing native plant nurseries Capacity needed: Staff, funding, information sharing



Additional Adaptation Actions for Consideration

Table 3 summarizes all of the adaptation actions generated by workshop participants for desert habitats and includes additional actions for consideration; additional actions comprise those from the literature as well as those identified by land and resource managers during other workshops. These strategies and actions are grouped according to one of five categories:

- 1. **Enhance Resistance**. Implementation of these strategies can help to prevent the effects of climate change from reaching or affecting a resource. One common type of resistance actions are those designed to reduce non-climate stressors.
- 2. **Promote Resilience**. These strategies can help a resource weather the impacts of climate change by avoiding the effects of or recovering from changes.
- 3. Facilitate Transition (or Response). Transition or response strategies intentionally accommodate change and enable resources to adaptively respond to changing and new conditions.
- 4. **Increase Knowledge**. These strategies are aimed at gathering more information about climate changes, impacts, and/or the effectiveness of management actions in addressing the challenges of climate change.
- 5. **Engage Coordination**. Coordination strategies may help align budgets and priorities for program of work across lands or establish or expand collaborative monitoring efforts or projects, among others.



Table 3. Summary of adaptation goals and actions for desert habitats, grouped by category (enhance resistance, promote resilience, facilitate transition, increase knowledge, and engage coordination). Adaptation goals and actions include those generated by workshop participants for desert habitats, as well as additional actions identified from the literature and by land and resource managers during other workshops.

DESERT HABITATS						
Category	Adaptation Goal	Adaptation Action				
Enhance resistance	Manage ex-urban wildlife populations (e.g., raccoons)	 Lethally remove ex-urban wildlife Create exclosures in areas where wildlife is not desired 				
	Design educational programs to limit non-climate stressors	 Create educational programs focused on encouraging positive actions that are already occurring, and providing information about additional no-regrets actions that could address pollution and invasive species Communicate with the public about access to roads and recreation areas through signage, visitor centers, and brochures 				
	Manage invasive species, including non-native grasses	 Remove invasive species, focusing on palm oases, transportation corridors, and recreation sites Remove non-native grasses around potential ignition sites Create sterile weed pollen (GMO) and spray to reduce spread of invasives Identify the species that may colonize sprayed areas and develop a plan Treat Sahara mustard infestations near areas of high resource value (e.g., near threatened and endangered species)⁴ 				
	Reduce possibility of severe wildfire	 Close access to roads and campgrounds during high fire hazard years or when site needs to recover; direct visitors to more resilient sites Reduce response time to fires in years following heavy Nov/Dec rain⁴ Remove non-native grasses around potential ignition sites 				
	Prevent soil erosion and loss of biological crust	 Limit off-highway vehicle (OHV) use and livestock grazing in sensitive areas⁴ Evaluate the feasibility of inoculating soils for biological soil crust regeneration⁴ Use soil stabilization treatments (e.g., local mulch, native seeds)⁴ 				

⁴ Comer, P. J., Young, B., Schulz, K., Kittel, G., Unnasch, B., Braun, D., ... Hak, J. (2012). *Climate change vulnerability and adaptation strategies for natural communities: piloting methods in the Mojave and Sonoran deserts*. Arlington, VA: Report to the U.S. Fish and Wildlife Service. NatureServe.



Promote resilience	Educate the public about the importance of desert ecosystems	 Develop citizen science projects to gather data and raise awareness of desert ecology 		
	Increase water residence times	 Consider engineering modifications that increase residence time of water in a particular area (check dams, long and low berms)⁴ 		
	Protect and enhance seeps and springs, as well as the source aquifer(s) that supply them ³	 Strategically remove some springs from publically available maps⁴ Protect a buffer zone for natural vegetation around spring sites to minimize effects of storm runoff⁴ Protect aquifer recharge areas and their surface catchments to provide long-term insurance for continued recharge⁴ 		
Facilitate transition	Identify and protect desert refugia	 Prioritize land acquisition to target areas with potential refugia, such as seeps and springs, foothills, and dunes Protect desert refugia through varied strategies such as land acquisition, land use planning, and land transfers 		
	Determine whether plantings will be successful under future climate conditions	 Establish baseline conditions necessary for desert plant reproduction Conduct surveys to identify vulnerable species, as well as those that are thriving or may thrive under future conditions 		
	Increase habitat connectivity to allow species migration in response to shifting climatic envelopes	 Create wildlife corridors to facilitate the movement of reptiles and amphibians across roads and other anthropogenic barriers 		
Increase knowledge	Establish monitoring programs to detect changes in desert habitats over time	 Establish a program to monitor changes in the timing of plant blooms (e.g. saguaro cactus) and pollinator arrival⁴ Monitor the movement of desert sand and the relationship of sand movement to floral and faunal movement Map and monitor vulnerable communities, incorporating information about known/potential refugia, recharge zones, and land ownership/management Monitor desert biodiversity, including invertebrates and soil microbial communities Develop monitoring program for bats to detect changes in populations and work towards protecting habitats⁴ Map water sources and aquifers to understand spatial and temporal connections between surface flows and groundwater⁴ 		



Increase knowledge (con't)	Conduct research to better understand complex dynamics in desert habitats	 Identify the synergistic relationships between species to improve our understanding of these relationships in the desert Identify pollinators that serve a keystone role in desert ecological systems⁴
	Investigate restoration techniques that establish resilient native plants quickly	 Conduct research and field trials into the use of techniques such as mycorrhizal inoculation, establishing water reservoirs, and planting native vegetation
Engage coordination	Collaborate with decision-makers to create policies that support healthy desert ecosystems	 Encourage flexible policies that take into account changing climate conditions (e.g., grazing allotments could increase or decrease depending on precipitation) Promote policies that would value the ecosystem services provided by the habitat⁵ Identify current policies that could offer funding or logistical support for desert research and restoration projects
	Work with other professionals to monitor changes in desert ecosystems	 Collaborate with ecologists, botanists, etc. to develop indicators of ecosystem health to assist adaptive management⁴ Bring together all managers that focus on an important species and hold a workshop to share information (e.g., phenology, abundance) and develop hypotheses of change⁴

⁵ Kershner, J. M. (Ed.). (2014). A climate change vulnerability assessment for focal resources of the Sierra Nevada. Version 1.0. Bainbridge Island, WA: EcoAdapt