National Park Service
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Natural Resource Program Center

Enhanced Monitoring to Better Address Rapid Climate Change in Southwest Desert Parks

A Multi-Network Strategy

Natural Resource Report NPS/IMR/NRR—2011/284

ON THE COVER

Clockwise from left: Organ pipe cactus in bloom, Organ Pipe Cactus National Monument; View from Wilderness Ridge, Guadalupe Mountains National Park; Salt Pool, Death Valley National Park. NPS photos.

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Executive Summary

In fiscal year 2010, the National Park Service (NPS) received funding for a new Climate Change Response Program (CCRP). The goals of the CCRP strategy include enhancing the existing natural resources Inventory and Monitoring Program (I&M) to expand the program's monitoring of climate-sensitive indicators. The results from the enhanced monitoring will be used to evaluate and report the status and trends of park resources for the purpose of facilitating adaptation planning and management. The initial I&M priorities for the CCRP goals build upon existing monitoring and strengthen interagency coordination for parks in four categories of high vulnerability to climate change: high elevation, high latitude, coastal/marine, and arid lands. The Department of Interior (DOI) Landscape Conservation Cooperatives (LCC) provided the organizational framework for collaboration on enhanced monitoring. Working with partners within each LCC, the I&M networks established procedures for enhancing existing monitoring to provide more information on ecological response to climate change.

In April 2010, a workshop, titled "Monitoring Ecological Response to Climate Change in Arid Land Parks in the Desert Landscape Conservation Cooperative," was held to engage managers from southwest desert parks with agency and university scientists and partners. The workshop had three main objectives: (1) Review the current knowledge of the impacts of climate change to arid-land resources, (2) Evaluate existing monitoring efforts in context with high-priority indicators of ecological response to climate change, and (3) Identify opportunities for enhancing existing monitoring, data management, and analysis to support managers in planning, adapting and responding to the ecological impacts of climate change in the desert southwest.

Interest in the workshop was significant, with participation by managers, scientists, university faculty, and others from the National Park Service, U.S. Geological Survey, Bureau of Land Management, U.S. Fish and Wildlife Service (USFWS), Arizona Game and Fish, Pima County, University of Arizona, Sonoran Institute, and others. The results of the workshop were used to establish priorities for enhancing long-term monitoring of climate change impacts to resources in parks of the Chihuahuan, Mojave, and Sonoran desert networks. These priorities are the basis for a long-term strategy and work plan developed by the three I&M desert networks and their partners. Also in 2010, the U.S. Fish and Wildlife Service Refuge System initiated its new Inventory and Monitoring Program. The USFWS has co-located the national staff of their new I&M program with the NPS national staff in Fort Collins, Colorado. The NPS I&M networks of the desert southwest are working closely with the USFWS I&M program to implement NPS monitoring protocols and data management, analysis, and reporting procedures on national wildlife refuges within the Desert LCC. Additionally, we will continue to strengthen our monitoring partnership with other agencies and collaborators within the Desert LCC.

One of the most effective ways to immediately strengthen our collaboration with partners to address the significant challenges of rapid climate change is to share monitoring protocols, data, and information products. As part of the enhanced monitoring component of the NPS Climate Change Response Program, the NPS is developing an integrated data system using DOI and industry standards to allow efficient searching, discovery, and sharing of data and information across multiple data systems. The three I&M networks within the Desert LCC will use the NPS Natural Resource Information Portal (NRInfo, http://nrinfo.nps.gov) to share data and information products with partners and the general public. In addition, the Learning Center of the American Southwest portal (LCAS) and the three I&M network Internet sites will provide our partners within the Desert LCC access to desert park and network products. To increase the ability and efficiency of DOI and bureau managers, scientists, planners, interpreters, and others at all levels of the organization to search for, find, retrieve, share, and disseminate available data and information, and for bureaus to communicate information to their constituencies, tribes, and the general public, we intend to establish an information portal targeted specifically at providing federal, state, university and other partners within the Desert LCC direct access to data and information products resulting from this work.

In fiscal year (FY) 2010, the three desert networks, with the input of federal partners and scientists from academic institutions, began reviewing their existing monitoring plans and partnerships in order to meet the goals of the Climate Change Response Strategy and Secretarial Order 3289. The desert I&M networks developed this document, with input from federal and non-federal partners, to describe their process for identifying critical monitoring needs and enhancing each park's understanding of the effects of climate change. The process included identifying existing monitoring in need of enhancement, as well as new monitoring, to improve understanding of the effects of climate change on parks. The document also describes the strategy for enhanced monitoring of ecological response to climate change in parks of the three desert networks.

Critical to the strategy's successful implementation is an adequate allocation of travel allowance associated with the work. Currently, regional offices are responsible for managing I&M network travel ceilings. The Sonoran Desert and Chihuahuan Desert networks require $8,000 and $8,500, respectively, in travel, and the Mojave Desert Network requires $9,000 allocated for travel. Without these travel allocations, the strategy cannot be implemented in FY2011, and any new funding for climate-change monitoring will need to be returned to the Washington Office.

The strategy to enhance existing monitoring in the three desert networks includes:

- Increasing frequency and spatial extent of monitoring of desert springs in 20 parks.
- Expanding uplands vegetation monitoring along ecotonal and altitudinal gradients in 4 parks.
- Completing and implementing a protocol for consistent reporting of weather and climate data for 24 parks across the three networks.
- Strengthening and expanding current partnerships with the USFWS I&M program and others to efficiently monitor climate-change metrics in a consistent manner.
- Looking for opportunities and funding to further develop and apply key monitoring products (e.g., NPScape, broad-scale phenology monitoring, and the Integrated Resource Management Application) to support collaborative climate-change monitoring across land-management boundaries.
- Contributing data, reports, synthesis documents, and expertise to the broader Desert LCC effort so as to better understand and respond to the consequences of climate change on regional scales.
- Increasing awareness (and access) within the Desert LCC of monitoring protocols, data, reports, and other products useful to our monitoring partners for landscape-scale conservation and management of natural resources.

Acronyms

AAR	annual administrative report
CCRP	Climate Change Response Program
CHDN	Chihuahuan Desert Network
CSC	Climate Science Center
DOI	Department of the Interior
FY	fiscal year
I&M	inventory and monitoring
IMR	Intermountain Region
LCAS	Learning Center of the American Southwest
LCC	Landscape Conservation Cooperative
MODIS	Moderate Resolution Imaging Spectroradiometer
MOJN	Mojave Desert Network
NCPN	Northern Colorado Plateau Network
NHP	national historical park
NHS	national historic site
NM	national monument
NMem	national memorial
NP	national park
NPres	national preserve
NPS	National Park Service
NRA	national recreation area
PWR	Pacific West Region
SODN	Sonoran Desert Network
spp.	species
USFWS	U.S. Fish and Wildlife Service
WSR	wild & scenic river

1 Introduction

In response to the growing knowledge and awareness of the effects of climate change on federal lands, the National Park Service (NPS) developed a national strategy to implement the new Climate Change Response Program (CCRP). The CCRP strategy (http://www.nature.nps.gov/climatechange/about.cfm) provides guidance and direction to the NPS for addressing the effects of climate change on park lands. The goals and objectives are described under four main components: science, adaptation, mitigation, and communication. The NPS vision, as described in the national Climate Change Response Strategy, is to adapt to climate change and effectively preserve and restore park resources and opportunities for visitor enjoyment. This vision will be achieved through collaboration among NPS employees, partners, and the public to promote climate-change science and apply best management practices and sustainable behaviors toward reducing climate change and its impacts.

The specific science goals of the national strategy include: (1) developing and applying climate science, (2) collaborating with and among scientific agencies and institutions to advance climate science at the local to national level, and (3) identifying and conducting scientific studies and resource monitoring activities necessary to support NPS mitigation, adaptation, and communication. In keeping with the main objective of the National Park Service's Inventory and Monitoring Program (NPS I&M), the NPS Climate Change Response Strategy states that only the best available scientific data and knowledge will be used to inform decisionmaking about climate change.

Secretarial Order No. 3289, of September 14, 2009, established a climate-change strategy to integrate the work of each Department of Interior (DOI) bureau to mitigate and adapt to the effects of climate change in the pursuit of their respective missions. Given the broad impacts of climate change, management responses are expected to be coordinated at the landscape level. The DOI has adopted a framework of 22 ecosystem-based Landscape Conservation Cooperatives (LCCs) to coordinate the Department's efforts to respond to climate change and other stressors. LCCs are management–science partnerships that link science and conservation delivery and inform integrated resource-management actions within and across landscapes. At the core of each LCC will be a scientific and technical staff with an applied resource-management focus, similar to the staff of the I&M networks, who produce data, reports, synthesis documents, and models to inform management and planning.

The National Park Service expects to participate with each of the DOI-proposed LCCs to address climate-change impacts to park resources with an integrated strategy that includes science, adaptation, mitigation, and communication activities. The initial I&M priorities for the CCRP goals build upon existing monitoring and strengthen interagency coordination for parks in four categories of high vulnerability to climate change: high elevation, high latitude, coastal/marine, and arid lands. One of the network groups that received funding from the CCRP includes three networks in the desert southwest: the Sonoran Desert Network (SODN) and Chihuahuan Desert Network (CHDN) within the NPS Intermountain Region, and the Mojave Desert Network (MOJN) in the Pacific West Region.

In fiscal year (FY) 2010, the three desert networks, with the input of federal partners and scientists from academic institutions, began reviewing their existing monitoring plans and partnerships in order to meet the goals of the Climate Change Response Strategy and Secretarial Order 3289. This document describes the strategy developed by the networks to monitor climate-change impacts and their effects on NPS arid lands in the desert southwest, as well as the vital-sign prioritization and selection process and the final vital signs chosen for new and enhanced monitoring. It includes options for monitoring based on anticipated project budgets (for all three networks combined) ranging from $325,000 to $350,000 annually.

1.1 Objectives and Scope

The objectives of this strategy document are to:

1. Describe the predicted impacts of climate change on aquatic and terrestrial ecosystems in graphic form, using conceptual models;
2. Show, in graphic form, how current and potential monitoring indicators link to these conceptual models and contribute to understanding some of the predicted impacts of climate change;
3. Describe the criteria used for prioritizing potential indicators or vital signs;

4. Define the three networks' priorities for additional monitoring of climate-change impacts on arid-land resources, including which indicators the networks propose to measure, and which additional indicators should be kept in mind for future consideration; and

5. Identify how the networks will collaboratively work within the DOI Landscape Conservation Cooperative (LCC) and Climate Science Center (CSC) frameworks and partner with U.S. Fish and Wildlife Service (USFWS) and other federal agencies, states, and academic institutions to make efficient and effective use of staff and funds and to standardize data collection, analysis, and reporting procedures.

The scope of this monitoring strategy includes 24 National Park Service units in the desert southwest. The arid-land park units from each of the three I&M networks include:

- Chihuahuan Desert Network: Seven park units in west Texas and southeastern New Mexico: Amistad National Recreation Area, Big Bend National Park, Carlsbad Caverns National Park, Fort Davis National Park, Guadalupe Mountains National Park, Rio Grande Wild and Scenic River, and White Sands National Monument.

- Sonoran Desert Network: Eleven parks in southern Arizona and New Mexico: Casa Grande Ruins National Monument, Chiricahua National Monument, Coronado National Memorial, Fort Bowie National Historic Site, Gila Cliff Dwellings National Monument, Montezuma Castle National Monument , Organ Pipe Cactus National Monument, Saguaro National Park, Tonto National Monument, Tumacácori National Historic Site, and Tuzigoot National Monument.

- Mojave Desert Network: Six parks in Arizona, California, and Nevada: Death Valley National Park, Grand Canyon-Parashant National Monument, Joshua Tree National Park, Lake Mead National Recreation Area, Manzanar National Historic Site, and Mojave National Preserve.*

This workplan describes the multi-network strategy for enhancing monitoring activities within parks of the Desert LCC. Beginning in 2011, the three I&M networks (SODN, CHDN, and MOJN) anticipate receiving approximately $350,000 annually to support enhanced monitoring of the ecological response to climate change across the 24 NPS units. The three networks will work collaboratively with the National Wildlife Refuge System I&M program and other partners to implement and manage the enhanced monitoring for climate change within the Desert LCC.

1.2 Core Team and Working Group

This monitoring strategy was developed by a core team and a broader working group. Core team members included:

1. Bruce Bingham (Intermountain Region I&M Program Manager)
2. Kirsten Gallo (Chihuahuan Desert Network Program Manager)
3. Andy Hubbard (Sonoran Desert Network Program Manager)
4. Penny Latham (Pacific West Region I&M Program Manager)
5. Nita Tallent-Halsell (Mojave Desert Network Program Manager)

The broader working group included the core team members plus:

1. Fred Armstrong (Guadalupe Mountains National Park)
2. Gorden Bell (Guadalupe Mountains National Park)
3. Jeff Bennett (Big Bend National Park)
4. Scott Bischke (Mountain Works)
5. David Busch (Biological Resources Division, USGS)
6. Shawn Carter (Inventory & Monitoring Division)
7. Nina Chambers (Sonoran Institute)
8. Steve Fancy (Inventory & Monitoring Division)
9. Evan Gwilliam (Sonoran Desert Network)
10. Debra Hughson (Mojave National Preserve)
11. Cheryl McIntyre (Sonoran Institute)
12. Tom Philippi (Inventory & Monitoring Division)
13. Dusty Perkins (Northern Colorado Plateau Network)

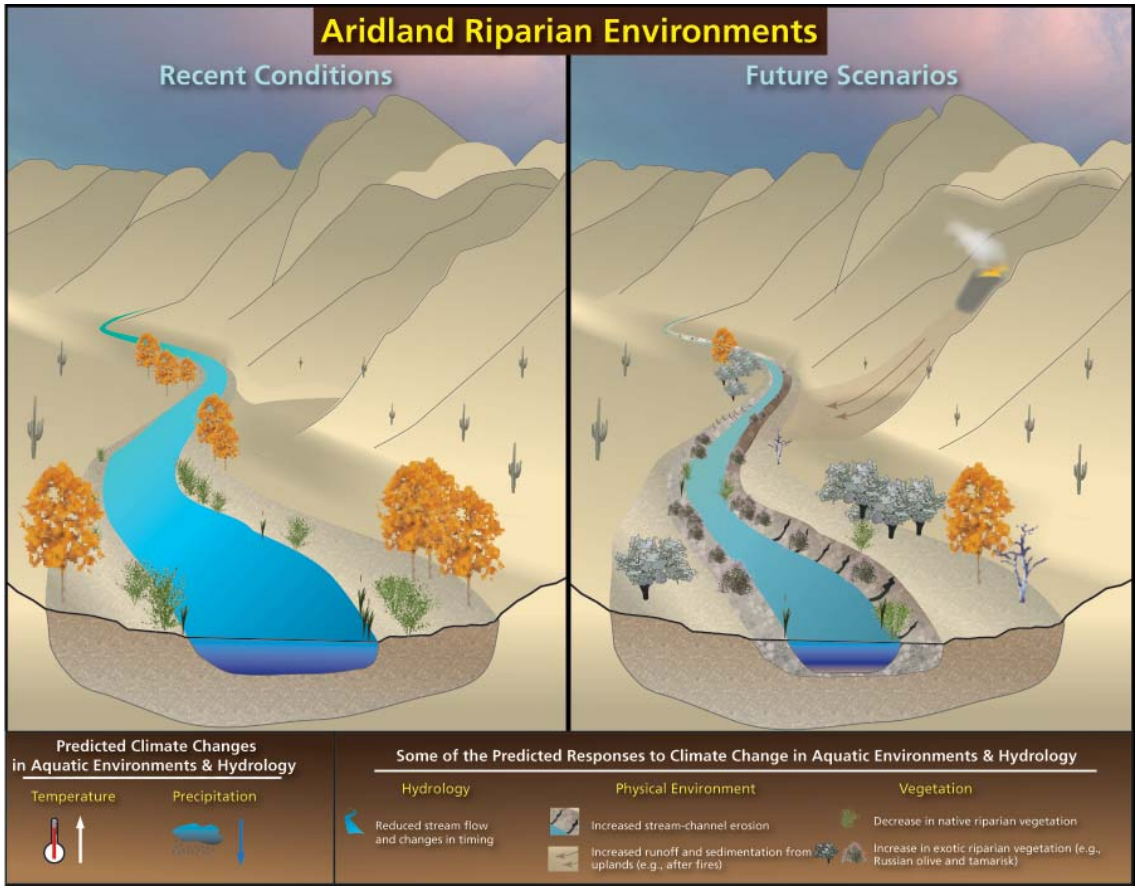
*Great Basin NP, also part of MOJN, is included in the Great Basin LCC, instead of the Desert LCC.

14. Mark Strum (Organ Pipe Cactus National Monument)
15. Sarah Studd (Sonoran Desert Network)
16. Lisa Thomas (Southern Colorado Plateau Network)
17. Michael Vamstad (Joshua Tree National Park)
18. Phil Wilson (Big Bend National Park).

1.3 Approach

Development of this strategy included several steps. First, the core team began to develop conceptual models to describe the predicted effects of climate change on terrestrial and aquatic ecosystems in graphic form. As an example, Figure 1 is the conceptual model developed for arid-land riparian ecosystems. Current conditions are shown on the left panel and predicted future conditions on the right. It is assumed that climate change will result in increased temperatures and an overall decrease in precipitation in the desert southwest. Timing of precipitation could also change, and the frequency and intensity of storms is expected to change or increase. Under these conditions, it is predicted that there will be reduced flows (less water quantity) and changes in the timing of flows. A change in extent of native riparian vegetation is also predicted, as is an increase in invasion of exotics, such as Tamarisk spp. and Russian olive. These changes, with increased likelihood of fire, may result in increased channel erosion and increased runoff and sedimentation from uplands. Conceptual models for arid-land biomes, uplands, and tinajas are presented in Appendix A.

Second, the core team reviewed each network's list of vital signs and looked for opportunities to enhance existing monitoring and for gaps in existing monitoring that, if filled, would provide valuable information to park managers and others about the ecological impacts of climate change. The result of this step was a table linking management issues with vital signs and the recommendation for enhancing or expanding monitoring. Tables were developed for flowing-water ecosystems, standing-water ecosystems, and terrestrial ecosystems.



NPS/R. BENNETTS

Figure 1. Conceptual model depicting recent conditions and possible effects of climate change on aquatic and riparian environments.

The third step was to conduct a workshop to engage managers and scientists from the NPS, other agencies, and universities to help establish priorities for monitoring ecological response to climate change within desert parks. On April 6–7, 2010, the NPS I&M program and the Sonoran Institute co-hosted a workshop titled "Monitoring Ecological Response to Climate Change in Arid Land Parks" in Tucson, Arizona, that included more than 70 participants. The workshop emphasized opportunities for enhancing ongoing monitoring and data management, and for improving information sharing and collaboration within the NPS and with partners. The conceptual models and analysis of opportunities for enhancing existing monitoring and filling climate-related "gaps" were presented. Feedback from the entire group was solicited. Groups examined the tables developed in step 2 and classified each issue according to its responsiveness to climate change, how common the recommendation was for all parks in the LCC, cost-effectiveness, and relevance to management (Appendix B). The group was also invited to share additional ideas and opportunities for collaboration. A final workshop report is available at the Learning Center of the American Southwest portal, http://www.southwestlearning.org/getinvolved/outreach/workshops/climate/aridlands.

Directly following the workshop, the full work group met to reflect on input provided during the workshop and begin drafting a strategy and workplan for the I&M networks in the Desert LCC. The work of the planning group built on the results (i.e., prioritized vital signs for climate-change response) from the two-day workshop. The work group determined that the two highest-priority indicators were springs ecosystems and terrestrial vegetation—specifically, sampling across altitudinal or ecotonal gradients (areas likely to be first affected by changes in climate).

Finally, based on input from the workshop and the work group, the core team developed a budget for $350,000 of anticipated additional funding and determined management responsibilities for each network for tracking funds and developing annual workplans and administrative reports. The budget defines the expenses needed to establish and enhance monitoring activities and gather existing data for the proposed high-priority indicators. The entire budget is allocated toward salary, travel, and equipment expenses for field-data collection. All data management and reporting is currently being absorbed by existing network infrastructure. An additional $40,000 could be used to implement an existing monitoring protocol to detect changes in phenology and snowpack across all federal lands in the LCC. Other additional funding would go to support data management, reporting, and science communication. Any reduction in funding would result in less field data collected.

1.4 Priorities for Enhancing Existing Natural Resource Monitoring

Water and water-dependent ecosystems are scarce resources in the arid and semi-arid southwest and are generally regarded as biodiversity hotspots. It is anticipated that climate change will alter ground and surface water quantity, as well as seasonal patterns of availability, including flooding and drought. I&M networks in the southwest are currently monitoring channel geomorphology and riparian vegetation communities along selected streams, springs, and tinajas. However, sampling intensity is low and of limited spatial distribution, restricting our ability to make parkwide or broader inferences. We propose to increase the number of springs sampled and the frequency with which springs are revisited. We expect that the increase in sampling intensity will improve our understanding of climate-change effects in riparian systems and expand our capacity to make inferences.

Our current upland-vegetation monitoring efforts on arid lands are largely focused on selected predominant communities within each park and will detect trends in vegetation structure and community composition. Using our existing sampling methods, we will expand our vegetation monitoring to include changes in ecotonal and azonal vegetation—areas more likely to exhibit early climate-change effects.

1.5 Partnering

As intended, the LCC framework provides numerous opportunities for NPS I&M networks and other NPS programs to collaborate with other federal and state agencies, as well as with external public and private entities. At this time, the primary partners for the desert climate-change monitoring collaboration include the NPS I&M program networks, the USFWS I&M program, individual USFWS refuges, the Southwest Climate Science Center (University of AZ, Tucson), the Bureau of Reclamation (co-lead for "standing up" the Desert LCC), the Bureau of Land Management, and the U.S. Geological Survey. There is

significant opportunity to increase collaboration with the Department of Defense, as their land base is extensive in the desert southwest.

Specific partnering opportunities that are planned or currently underway include:

- The three desert NPS I&M networks will engage with the USFWS to develop and implement monitoring protocols consistently across the USFWS refuges and NPS units.
- The networks will engage with LCC partners by participating on the LCC science committee, charged with determining LCC-related science needs and priorities.
- The three I&M networks will collaborate on implementing a springs-monitoring protocol consistently across the networks and work toward having shared crew training and data-management functions.

2 FY 2011 Administration, Budget, and Workplan

The work group formed at the April 2010 workshop prioritized two groups of vital signs: springs ecosystems and uplands vegetation. Both groups offer excellent opportunities for enhancement as indicators of ecological impacts of climate change in southwest deserts.

The Sonoran Desert and Chihuahuan Desert networks require $8,000 and $8,500, respectively, in travel, and the Mojave Desert Network requires $9,000 allocated for travel. Without these travel allocations, this strategy cannot be implemented in FY2011, and any new funding for climate-change monitoring will need to be returned to the Washington Office. The long-term strategy for monitoring these indicators includes:

- Springs—The three desert I&M networks will work together to implement a protocol for monitoring desert springs (Table 1).

  Funding will go toward hiring field crews for each network—one for CHDN, one for SODN, and two crews for MOJN—to conduct field sampling. Although the three networks will all run their own crews, training and contract administration will be shared, where practical. Additional funds will be allocated for equipment purchases/ maintenance and sample analysis.

  CHDN will have the lead on reporting for CHDN and SODN. MOJN will lead ts own reporting.

- Vegetation Sampling along Ecotonal Gradients—Ecotonal monitoring will be conducted in four parks within CHDN and SODN, using the SODN monitoring protocol for integrated uplands (Table 1). As MOJN develops and implements an integrated uplands protocol, they will evaluate whether sampling vegetation along ecotonal gradients in MOJN parks would be useful for detecting changes in productivity over space and time.

  Funding will go toward hiring a single field crew shared by CHDN and SODN.

  SODN will have the lead on reporting for CHDN and SODN.

If additional funding is available, the work group's next priority was to implement the phenology protocol adapted from the Northern Colorado Plateau Network (NCPN) and apply it across the Desert LCC. The protocol is based on use of MODIS data, which would be coordinated with the Great Northern LCC networks as well as the USFWS I&M program. Funds in FY 2010 were used to adapt the NCPN protocol for use in the Desert LCC. Implementing the protocol would include hiring a shared ecologist or physical scientist to analyze phenology and snowpack data and to harvest and analyze existing climate data as per the approved protocol shared by the Greater Yellowstone and Rocky Mountain networks.

2.1 Multi-network Collaboration

The enhanced monitoring described in this document will be jointly managed by the program managers from CHDN, SODN, and MOJN. The three network program managers will meet as needed to discuss work planning, budget, and implementation of monitoring activities. Decisions will be made by consensus. Each year, the networks will collaborate on a single, shared workplan that will be submitted to the Intermountain Region (IMR) and Pacific West Region (PWR) I&M program managers for approval. Where opportunities arise, the three desert networks will interact with staff from the Desert

Table 1. Southwest desert parks where climate change-related monitoring will be conducted.

Park	Sampling type		
	Springs	Uplands-Ecotonal	Climate
Chihuahuan Desert Network			
Amistad NRA	X		X
Big Bend NP	X	X	X
Carlsbad Caverns NP	X		X
Fort Davis NHS			X
Guadalupe Mountains NP	X	X	X
Rio Grande WSR			X
White Sands NM	X		X
Sonoran Desert Network			
Casa Grande Ruins NM			X
Chiricahua NM	X	X	X
Coronado NMem	X		X
Fort Bowie NHS	X		X
Gila Cliff Dwellings NM	X		X
Montezuma Castle NM	X		X
Organ Pipe Cactus NM	X		X
Saguaro NP	X	X	X
Tonto NM	X		X
Tumacácori NHP			X
Tuzigoot NM	X		X
Mojave Desert Network			
Death Valley NP	X	TBD	X
Grand Canyon-Parashant NM	X	TBD	X
Joshua Tree NP	X	TBD	X
Lake Mead NRA	X	TBD	X
Manzanar NHS	X	TBD	X
Mojave NPres	X	TBD	X

TBD=to be determined.

LCC, the USFWS I&M program and refuges, the Southwest Climate Science Center, other federal or state agencies, and academic partners to collaborate on monitoring, data analysis, and reporting.

2.1.1 Budget (FY 2011 and subsequent years)

New funding will be allocated across the three networks equitably, and each network will have specific budget-management responsibilities (Tables 2 and 3):

- The MOJN program manager will manage funds (including salary and travel) for crews working in MOJN.
- CHDN will manage funds for springs crews in CHDN and SODN.
- SODN will manage funds for vegetation crews conducting ecotonal sampling in CHDN and SODN.
- CHDN will manage funds allocated for equipment and sample analysis for springs work.

Funding allocations for field crews include travel costs.

An annual administrative report (AAR) that describes the monitoring accomplishments and the use of CCRP monitoring funds will be generated at the end of each fiscal year. These AARs will be separate from those developed by individual networks for accomplishments using vital-signs funds. The CHDN, MOJN, and SODN program managers will each contribute to the AAR and rotate as lead for the report. The CHDN program manager will have the lead on developing the FY 2010 report. MOJN will take the lead in FY 2011, and the SODN will lead development of the FY 2012 report. These annual reports for monitoring accomplishments using CCRP funds will require the approval of the IMR and PWR I&M program managers and the I&M division chief. AAR development will follow the timeline used for individual network annual administrative reports for vital signs monitoring funds.

Table 2. Funding distribution summary for budget-management responsibilities.

Network	Account code	Amount
SODN	2123	$ 87,000
MOJN	2128	$126,000
CHDN	2124	$137,000

2.1.2 Protocols

The three networks will use the same Standard Operating Procedures (SOPs) for monitoring springs. CHDN and SODN will use also the same protocol and the same field crew for uplands ecotonal sampling. Where SOPs are shared and field sampling is involved, field crews from the networks will be trained together to ensure that data-collection methods are implemented consistently across the networks. Where practical, the three networks will also gain efficiencies through shared purchasing and contract administration for water-chemistry and macroinvertebrate sample analysis.

2.1.3 Staffing

Field crews will be composed of a GS-6 or 7 field crew leader, hired either on a term or permanent subject-to-furlough basis, and interns hired through the Student Conservation Association or similar organization. The number of interns will vary depending on the protocol. No additional staff will be hired under the proposed $350K budget (Table 3).

If additional funds are available, a shared GS-11 ecologist or physical scientist would be hired to implement the MODIS phenology protocol in the Desert LCC. Duty station and other details, such as supervision and budget management responsibilities, will be determined when funding becomes available.

Table 3. New funding allocation.

Manager	Description	Amount
CHDN	Springs crew for CHDN and SODN for 6 months	$122,000
MOJN	Springs crews (2) for MOJN for 6 months	$126,000
CHDN	Equipment, sample analysis for CHDN, MOJN, SODN	$15,000
SODN	Ecotonal crew for CHDN and SODN for 6 months	$87,000
TOTAL		**$350,000**

2.1.4 Data management and reporting

All data management will be conducted using existing network infrastructure. Existing data-management processes across the three networks will be examined to look for efficiencies in sharing data-management resources. For springs, which represent new data sets for each of the networks, multi-network collaborative databases and data-management strategies will be explored and implemented where efficiencies and other benefits exist. CHDN and SODN will manage all data collected together. MOJN will physically manage their data separately from the other two networks using databases and data-management procedures employed by CHDN and SODN, where possible.

The three networks have agreed to adopt common formats for reporting on ecological response to climate change. Reporting on springs and ecotonal sampling will be conducted using existing network staff. Products for springs and ecotonal uplands will include annual field reports to parks describing the sampling effort and work conducted in the park. A status and trend report will be completed every five years.

The three I&M networks within the Desert LCC will use the NPS Natural Resource Information Portal (NRInfo, http://nrinfo.nps.gov) to share data and information products with partners and the general public. In addition, the Learning Center of the American Southwest portal (LCAS) and the three I&M network Internet sites will provide our partners within the Desert LCC access to desert park and network products. To increase the ability and efficiency of DOI and bureau managers, scientists, planners, interpreters, and others at all levels of the organization to search for, find, retrieve, share, and disseminate available data and information, and for bureaus to communicate information to their constituencies, tribes, and the general public, we intend to establish an information portal targeted specifically at providing federal, state, university and other partners within the Desert LCC direct access to data and information products resulting from this work.

2.2 FY 2011 Workplan

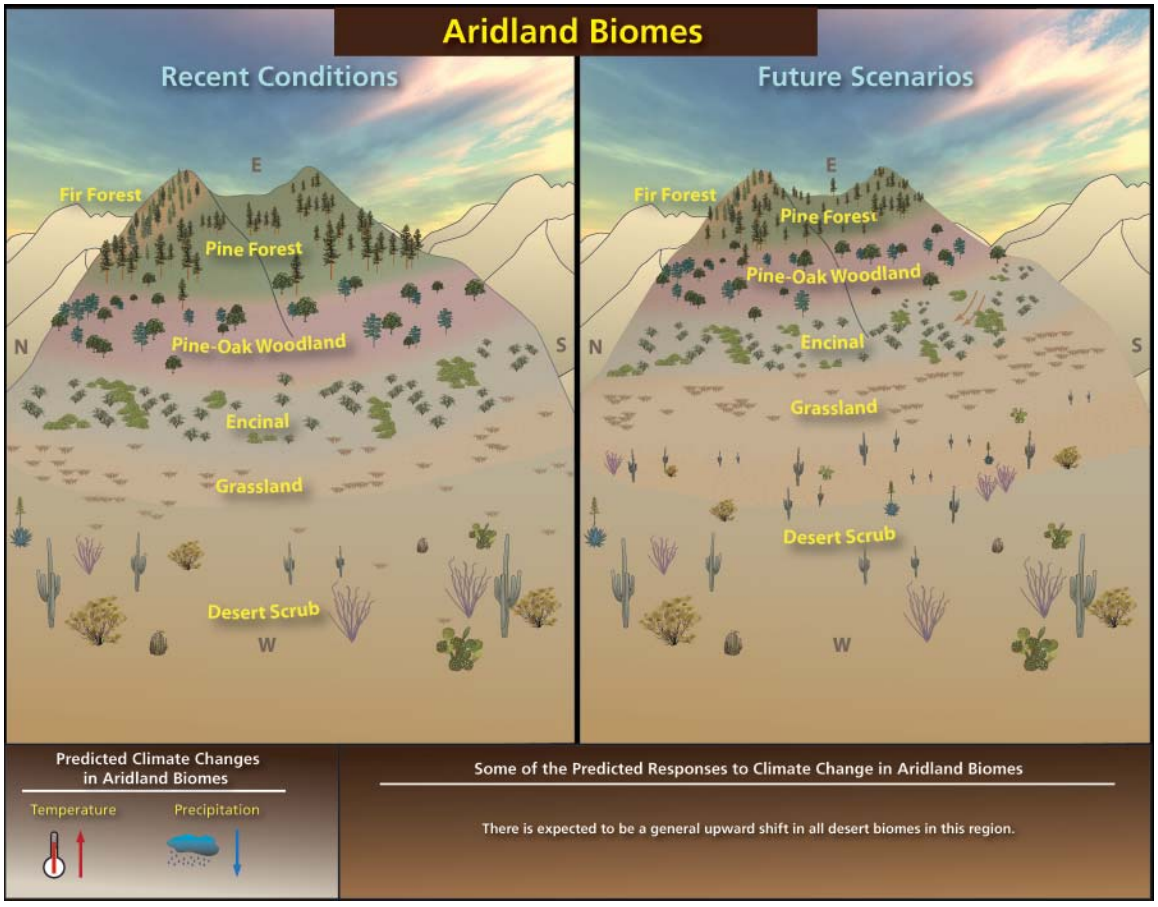
Planned implementation activities and schedule for FY2011 appear in Table 4.

Table 4. Activities and schedule for enhanced climate-change monitoring in FY 2011.

Activity	Date
Administration	
If additional funding is available, hire and orient new ecologist (Term GS-11) to support development of phenology and climate protocol (duty station to be determined)	3/1/2011
Hire and orient new science writer-editor (GS-9) to be shared by CHDN and MOJN (duty station to be determined)	3/1/2011
Springs Monitoring	
Develop draft protocol narrative and SOPs for joint CHDN and SODN springs protocols and MOJN small springs and riparian vegetation monitoring protocols	3/1/2011
Purchase equipment and supplies	3/1/2011
Field-test methods and develop data-management components as protocols are developed	7/1/2011
Hire and train CHDN and SODN springs field crews	9/1/2011
Hire, orient, and train MOJN springs field crews	4/15/2011
Implement field effort, including collecting water samples and characterizing riparian and emergent vegetation in MOJN	4/15/2011
Implement springs protocol in CHDN/SODN	9/15/2011
Vegetation Sampling for Ecotonal Gradients	
Hire and train one CHDN/SODN ecotonal field crew	8/15/2010
Implement field effort in CHDN/SODN	9/1/2010
Conduct quarterly inter-network coordination meetings	quarterly
Develop FY11 AAR: Draft, edit, submit to I&M program manager for review	11/1/2011
Track inter-network expenses (i.e., contracts, agreements, purchases, personnel, equipment, supplies) and close budget	9/30/2011

Appendix A. Desert LCC Conceptual Models

From the April 2010 Workshop, "Monitoring Ecological Response to Climate Change in Arid Land Parks in the Desert Landscape Conservation Cooperative."



NPS/R. BENNETTS

Figure A.1. Conceptual model depicting recent conditions and possible effects of climate change on aridland biomes. Image courtesy of Rob Bennetts.

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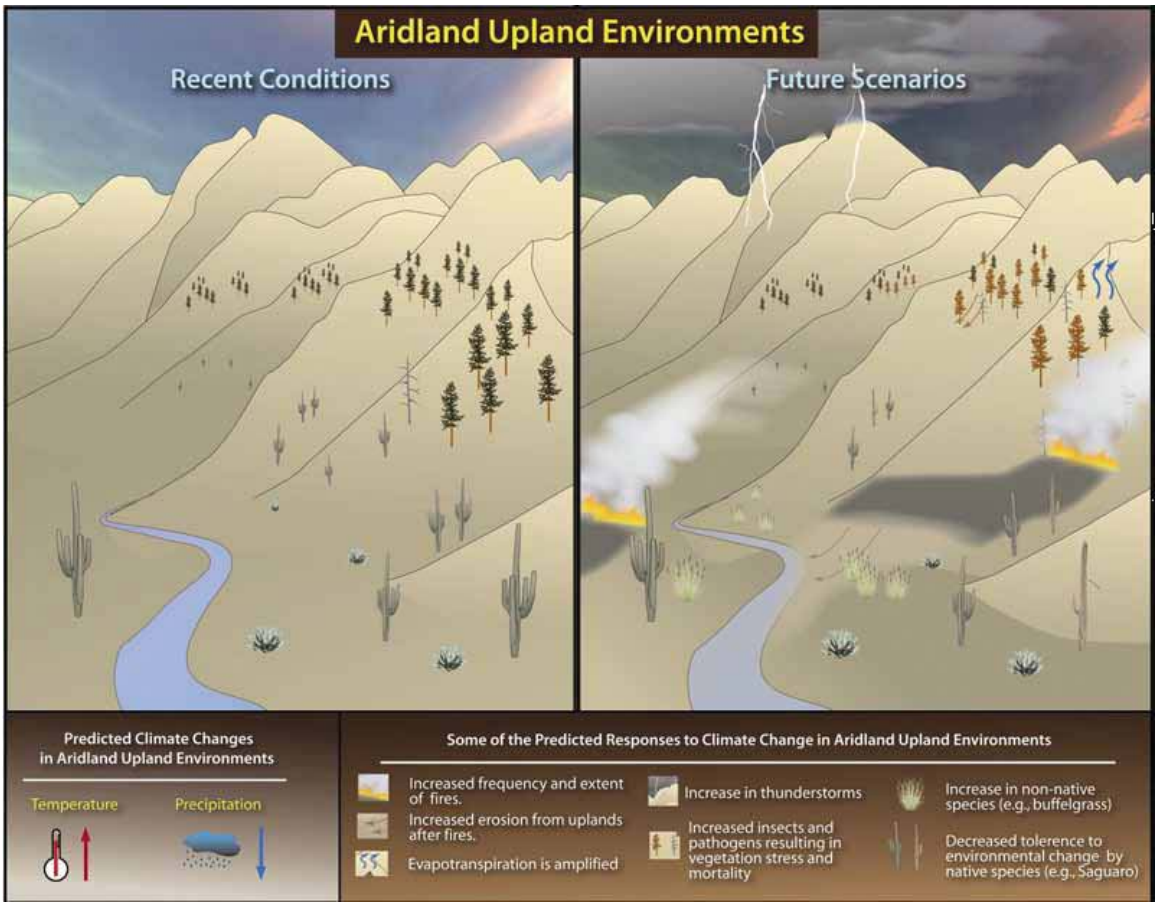

Figure A.2. Conceptual model depicting recent conditions and possible effects of climate change on upland environments.

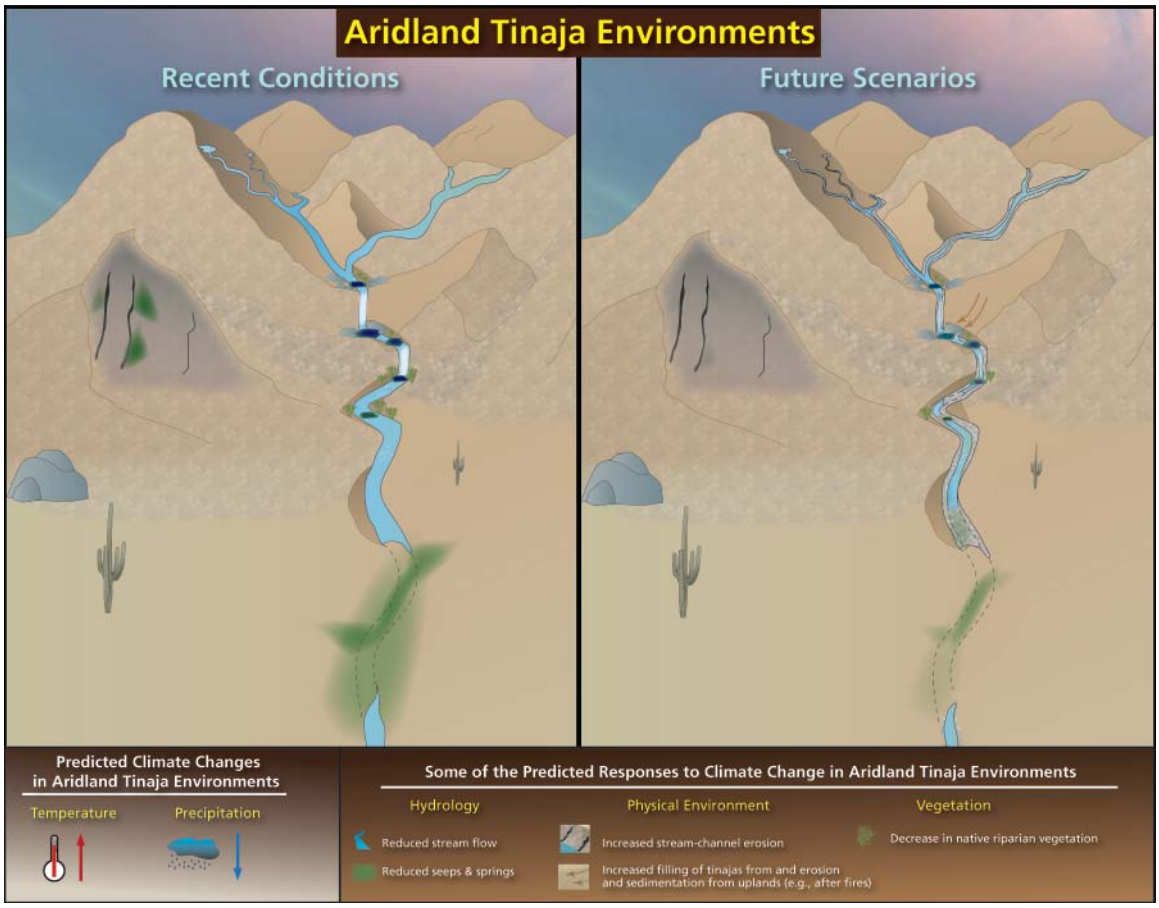

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Figure A.3. Conceptual model depicting recent conditions and possible effects of climate change on tinaja environments.

Appendix B. Combined List of Ranked Management Issues, Vital Signs, and Recommendations

Management Issue	Protocol/ Vital signs	Recommendation	Responsiveness to climate change (1–5)	Common to parks or within LCC (1–5)	Cost-effectiveness (1–5)	Relevance to management (1–5)	Sum of scores
Changes in species composition due to salinity levels	Streams, Springs	Monitor changes in riparian soil salinity	4	5	1	5	15
	Streams	Monitor aquifer water quality (salinity)	3	5	2	3	13
Changes in the watershed, including land use and impervious surfaces, affect runoff characteristics	Land Cover/Land Use	Monitor land use and impervious surfaces in watershed	5	5	1	4	15
Changing climate will affect iconic/ charismatic species composition such that there will be "winners" (resistant or invasive) and "losers" (highly sensitive, intolerant) with consequences for ecosystems	NEW	Add vertebrates (i.e., “popular” species). Collect additional condition and demography measures on susceptible and resistant indicator species; resume measurements from legacy research studies.	3	5	3	5	16
Changing climate will affect plant species composition such that there will be "winners" (resistant or invasive) and "losers" (highly-sensitive, intolerant) with consequences for ecosystems	Terrestrial Vegetation and Soils	Collect additional condition and demography measures on susceptible and resistant indicator species; resume measurements from legacy research studies	3	5	5	5	18
Changing climate will affect vertebrate species composition such that there will be "winners" and "losers" with consequences for ecosystems	NEW	Collect additional condition and demography measures on susceptible and resistant indicator species; resume measurements from legacy research studies	5	5	3	5	18
Changing climate will shift the distributions of terrestrial species	Terrestrial Vegetation and Soils	Add additional monitoring plots along gradients	3	5	5	3	16
Climate	Weather and Climate (from Terrestrial)	Collaborate with NOAA and others. Fill in the gaps to have enough data for the network/ LCC.	5	5	5	5	20

Appendix B. Combined list of ranked management issues, recommendations, and vital signs.

Management Issue	Protocol/ Vital signs	Recommendation	Responsiveness to climate change (1–5)	Common to parks or within LCC (1–5)	Cost-effectiveness (1–5)	Relevance to management (1–5)	Sum of scores
Climatic change will affect phenology and snowpack over time	Land Cover/Land Use	Use remote sensing (MODIS, LandSat, no development) to determine spring green-up, snow extent, and productivity using existing adjacent network protocols	5	5	4	3	17
Concentration of metals in water & soils	Water Quality		1–2[a]	2	2–3[b]	3–5[c]	10
Disappearance of springs (individual springs going dry)	Water Quantity		3 or 5[d]	5	5	5	19
Groundwater levels	Groundwater Quantity	Focus on those most likely to change	1–2	5	1–2	3–5	12
Increased erosion from uplands and deserts	Terrestrial Vegetation and Soils	Add additional measures of actual and potential soil erosion; resume measurements from legacy research studies.	2	5	3	5	15
Increased exotic plant invasions in uplands and deserts	Exotic Plants - Early Detection (Streams)	Investigate remote sensing applications. Improve data management and data sharing across agencies.	5	5	3	5	18
	Exotic Plants - Early Detection (Terrestrial)	Increase the spatial extent and temporal frequency of existing sampling; resume measurements from legacy research studies.	2	5	3	5	15
	Disturbance Database (from Streams)	Collaborative effort with other agencies. Expand spatial and thematic scope of SODN Disturbance Database; accelerate population of database.	5	5	5	5	20
Increased fire occurrence, extent, intensity in uplands and deserts	Disturbance Database (from Terrestrial)	Expand spatial and thematic scope of SODN Disturbance Database; accelerate population of database	4	5	5	5	19
	Terrestrial Vegetation and Soils	Collect additional information on fuel loading, continuity, and other fire-ecology parameters; improve programmatic integration with fire (READ/BAER/ FEMO) per CHDN and SOPN; resume measurements from legacy research studies.	4	5	4	5	18

Appendix B. Combined list of ranked management issues, recommendations, and vital signs.

Management Issue	Protocol/ Vital signs	Recommendation	Responsiveness to climate change (1–5)	Common to parks or within LCC (1–5)	Cost-effectiveness (1–5)	Relevance to management (1–5)	Sum of scores
Increased sedimentation	Streams	Monitor sediment transport and dynamics. Understand flux, sources, etc.	5	5	3	5	18
Invasion of exotic species	Plant and Non-plant Species		2	4	4	3–5[e]	14
Loss of habitat due to reduced streamflow	Streams	Monitor backwaters (extent), sedimentation, invasive species, water quality	5	2	2	5	14
Retrospective studies of climate change effects	NEW	Identify extent of long-term datasets from prior research or monitoring in LCC parks, using tight criteria.	5	5	4	5	19
Rare and endemic species	Vegetation, Invertebrates, Fish, Water Quality, Birds		3–5[f]	4	4[g]	5	17
Reduced streamflow (SODN& CHDN)	Riparian/Alluvial Groundwater	Monitor depth to groundwater in riparian area. Monitor riparian aquifer characteristics.	5	5	4	5	19
Spatial/temporal distribution of springs	Water Quantity, Groundwater		3 or 5[h]	5	1–2	5	15.5
Water recharge zone characterization (baseline inventory)	Groundwater, Land Cover/ Land Use, Vegetation, Disturbance, Aquifer Characterization		1–2	5	1 or 3[i]	3	11.5
Water recharge zone condition (monitor long term)	Groundwater, Land Cover/ Land Use, Vegetation, Disturbance		1–2	5	4	4	14.5

From the April 2010 workshop, "Monitoring Ecological Response to Climate Change in Arid Land Parks in the Desert Landscape Conservation Cooperative."

[a]depends on why levels are changing
[b]could be higher, depending on lab costs
[c]depends on how accessible/important the contaminated source is
[d]3 if related to development; 5 if related to increased temperatures
[e]depending on the species
[f](depends on how vulnerable the species is)
[g]depends on if data exists
[h]3 if related to development; 5 if related to increased temperatures
[i]1 if no data exists; 3 if USGS data exists

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