

Climate Change Adaptation in the Arid Southwest: A Workshop for Land and Resource Management

September 21-22, Tucson, Arizona

Workshop Summary Report



Prepared by
Louise Misztal (Sky Island Alliance)
Jenny Neeley (Sky Island Alliance)

February 23, 2011



Climate Change Adaptation in the Arid Southwest: A Workshop for Land and Resource Management was convened by Sky Island Alliance in partnership with EcoAdapt, the University of Arizona Institute of the Environment and School of Renewable Natural Resources, Climate Assessment for the Southwest, the Bureau of Reclamation, the US Fish and Wildlife Service, the Udall Foundation Institute for Environmental Conflict Resolution, and Sonoran Joint Venture. The workshop was convened in conjunction with the Desert Landscape Conservation Cooperative outreach meeting. This work is funded in part by the Nina Mason Pulliam Charitable Trust and The Kresge Foundation.



Climate Change Adaptation in the Arid Southwest: A Workshop for Land and Resource Management

Table of Contents

Executive Summary	1
Introduction	4
Overview of Climate Change: Present and Projected Effects in the Region, Resources, and Research	6
Welcoming Remarks.....	6
Climate Change Adaptation Survey Findings.....	7
Projected Southwest Climate Changes: An Overview	8
Climate, Fires and Forest Changes in Southern Arizona and the Southwest	8
People, Place and History	9
Forecasting Climate Impacts on Wildlife of the Arid Southwest	9
Science Topics and Needs For the Desert Landscape Conservation Cooperative	10
Southwest Climate Change Initiative: Information for Managing Natural Resources in a Changing Environment	10
Case Studies: Adaptive Natural Resource Management in Response to Climate Change.....	12
Firescape: Landscape Ecosystem Management is a Strategy for Climate Change Adaptation in the Sky Islands	12
Sonoran Desert Conservation Plan	12
Las Cienegas National Conservation Area	13
Panel Discussion	14
Desert Landscape Conservation Cooperative: Overview and Organization..	15
Developing a Response to Climate Change: Workshop Findings	16
Methodology	16
Identifying and Addressing Vulnerabilities	16
Knowledge Gaps and Science Translation: Developing Understanding	17
Management of Invasive Species	18
Human Dimensions	18
Developing Adaptation Actions	18
Developing Adaptation Actions: Research and Monitoring	18
Developing Adaptation Actions: Water	20
Developing Adaptation Actions: Species and Habitat Conservation	22
Mechanisms for Cooperation, Communication, and Access to Information..	25
Summary and Next Steps	27
Key Findings.....	27
Recommendations	28
Next Steps	29
Acknowledgements	30
Appendix A: Workshop Agenda	1
Appendix B: Participant List	1

Executive Summary

Sky Island Alliance convened a climate change adaptation workshop in Tucson, Arizona in September 2010. The workshop was co-convened with EcoAdapt, the University of Arizona Institute of the Environment, the University of Arizona School of Natural Resources and the Environment, Climate Assessment for the Southwest (CLIMAS), the Udall Foundation Institute for Environmental Conflict Resolution, the U.S. Bureau of Reclamation (BOR), the U.S. Fish and Wildlife Service (FWS), and Sonoran Joint Venture. This workshop was the first in a three-part series designed to develop on-the-ground and policy-level adaptation actions to respond to climate change, and to build a regional network of professionals working cooperatively to improve natural resource management under changing conditions. The workshop was co-convened with an outreach meeting for the formation of the Desert Landscape Conservation Cooperative, a Department of Interior initiative being led by FWS and BOR.

More than 70 people from 36 different organizations participated in the workshop. Participants discussed issues related to climate change and natural resource management in the southwest, with a special focus on the Sky Island region of southeastern Arizona, southwestern New Mexico and northern Mexico. Participant discussions produced a wealth of information about climate change impacts that natural resource managers are already facing, anticipated future impacts, information needs, methods for incorporating climate change considerations into decisions, strategies for working together in the region, and opportunities to take action. The following report is a summary of workshop findings, recurring comments and recommendations of the participants, pervasive themes, and initial adaptation strategies.

Key Findings

The following key findings are organized by prominent themes from participant discussions and input at the workshop.

Cooperation and Coordination

Participants repeatedly stated that responding to climate change impacts will require coordination on the management of shared resources, including cooperation and information sharing related to monitoring and data collection.

Non-Stationarity

Management decision structures are based on the concept of stable or stationary states to which a system can be returned when it faces a departure such as a period of drought. Finding ways to incorporate non-stationarity into decision-making presents a large challenge for planning and decision making.

Knowledge Gaps and Building Understanding

According to participants, syntheses, science translation, and trainings that increase their knowledge of climate dynamics and their understanding of how climate change impacts will translate into changes in ecosystems and affects on species will be necessary to make management responses effective.

Invasive Species

Participants identified a variety of challenges associated with managing and controlling invasive species that they expect will be complicated by climate change. Prioritizing the use of limited resources to remove existing invasive species, being on the lookout for new invasive species, and potentially redefining what is native as conditions change will make invasive species management more effective.

Human Dimensions

Participants noted that human demands on natural resources will likely change as human communities try to adapt to climate change leading to competition with ecosystems and species for resources like water.

Research and Monitoring

Participants identified consistent, cooperative, climate-sensitive, monitoring as crucial to understanding climate change impacts as they occur and to building an effective and adaptable management response.

Water

Water is a very prominent issue in wildlife and resource management in this region and is complicated by legal and other issues. According to participants, inventorying the location and state of water resources and identifying restoration activities to keep water flows in streams will help managers respond to decreases in available water in the region, and to cascading effects on species and ecosystems.

Species and Habitat Conservation

Participants expect many changes to occur in the phenological traits of species, the ranges of species, and the make-up of habitat in the region. This may be further complicated by loss of connected habitat, and other non-climate stresses. Participants expect that management targets may be lost no matter what they do, and that difficult questions about prioritization will have to be answered.

Recommendations

Participants recommend enhancing cooperation within the region by creating projects and identifying specific tasks that require collaboration between various entities in the region.

Effective exchange of information, coordination on projects across jurisdictions with shared resources, and collaboration with traditional and non-traditional partners will make climate change planning and management more effective across the region.

Participants recommend bringing organizations, agencies, and landowners from the Mexican portion of the region into the fold through the workshop series and through expanding the Arizona Climate Change Network that is being formed to include northern Mexico.

Participants are very interested in learning about case studies that demonstrate planning processes for climate change adaptation efforts and that demonstrate development of climate-smart monitoring.

Participants recommend bringing speakers from this workshop to agencies, professional meetings, or other similar forums in order to reach more managers directly with this crucial information.

Making scientific information and data available in a format that can inform management decisions will assist managers in incorporating climate change considerations into their work.

Consistent and climate-sensitive monitoring will help managers understand climate change impacts, develop climate change adaptation actions, and assess the efficacy of those actions. Cooperation and even standardization of monitoring targets and techniques can assist managers in sharing information across jurisdictions, and in developing a better picture of the region as a whole.

Development of trend information will help managers identify management intervention points, and develop “trigger points” for management action based on monitoring findings.

In this region monitoring across gradients, such as elevation, and specific monitoring of areas of transition between habitat types known as ecotones, will assist managers in identifying changes as they occur.

Protecting water availability for species and environmental flows will be essential for effective management. Collecting spatial information about resources such as seeps and springs, and identifying appropriate restoration activities and locations will aid managers in maintaining water resources where they currently exist or historically existed. Pursuing strategies to secure water rights and water use will also assist managers in maintaining water resources.

Participants recommend engaging in multi-agency cooperation for water management through activities like multi-agency drought contingency planning and pooling resources to share in core data collection.

Identifying refugia for species and prioritizing protection of those refugia will assist managers in maintaining biodiversity in the region.

Participants recommend paying attention to species that are succeeding in order to better understand the resilience in ecosystems and managing new assemblages for change and resilience as they become established.

Managing human uses of the land to prevent harm and to keep them within the carrying capacity of the resource and staff capacity will assist managers in maintaining resilient ecosystems.

Participants recommend “thinking outside your own parcel of land” through activities such as securing strategic conservation easements around protected areas, and maintaining connectivity both between protected areas and within protected areas.

Adequately allocating resources toward increased responsibilities and activities will assist managers in implementing climate change adaptation activities.

Introduction

Climate change is affecting all ecosystems and will continue to do so for centuries. Research in the southwest United States has documented climate-change related impacts to wildlife and landscapes. Temperatures in Arizona and New Mexico have been rising, particularly since the mid-1970s. Since 1976, the average annual temperature increased by 2.5 degrees F in Arizona and 1.8 degrees F in New Mexico. From 1950 to 2003, winter temperatures in the southwest have warmed even more than summer temperatures. Projections for the southwest show greater temperature increases than the global average, and summer temperatures rising even higher than winter ones. Measurements since 1958 indicate that annual average precipitation has decreased in most of Arizona and has increased in New Mexico. In comparison to time periods before 1950, winter snowpack is melting earlier in the year, rain is replacing some snowstorms, and the April snowpack contains less water. Higher projected future temperatures will likely continue these trends. The number of acres burned and the frequency of fires have increased in the western US. The trends indicate that the number of acres burned in fire events is likely to continue to increase. Annual streamflows in the Colorado River basin have decreased slightly since 1950. Models generally project substantial declines in the average annual runoff in the southwest.¹

Climate change and its cascading effects on ecosystems and species will challenge the work of natural resource managers in the region. The conservation, scientific, and resource management communities recognize that protecting ecosystems and species will require new ways of thinking about land management and natural systems. It will require incorporating strategies that address future climate change and resultant impacts into management plans and actions.

In September of 2010, Sky Island Alliance convened the two-day workshop, *Climate Change Adaptation in the Arid Southwest: A Workshop for Land and Resource Management*, in Tucson, Arizona. Sky Island Alliance partnered with EcoAdapt, the University of Arizona Institute of the Environment, the University of Arizona School of Natural Resources and the Environment, Climate Assessment for the Southwest (CLIMAS), the Udall Foundation Institute for Environmental Conflict Resolution, the U.S. Bureau of Reclamation (BOR), the U.S. Fish and Wildlife Service (FWS), and Sonoran Joint Venture. In an effort to work cooperatively with similar initiatives in the region and to effectively reach our target audience, the workshop was convened in conjunction with a Desert Landscape Conservation Cooperative outreach meeting led by FWS and BOR.

This workshop was the first in a three-part series designed to develop on-the-ground and policy-level adaptation actions to respond to climate change impacts, and to build a regional network of professionals working cooperatively to improve natural resource management under changing conditions. This first workshop focused on developing a shared understanding of key vulnerabilities to climate change in the arid southwest, with an emphasis on the Sky Island region of southeastern Arizona, southwestern New Mexico, and neighboring northern Mexico.

Climate change adaptation for natural systems can be defined as a dynamic management strategy that involves identifying, preparing for, and responding to expected climate change in order to promote ecological resilience, maintain ecological function, and provide the necessary elements to support biodiversity and sustainable ecosystem services. For the purposes of this workshop, when

¹ Climate Assessment for the Southwest (CLIMAS). 2010. Accessed February 20, 2011. <http://www.climas.arizona.edu/sw-climate/climate-change>

talking about species adaptation to climate change, we mean active efforts that will be implemented by humans.

The workshop made significant progress toward meeting its objectives:

- Review and share knowledge about climate change and its applications to land and resource management decision making
- Identify vulnerabilities, initial adaptation strategies, and potential opportunities to work together across the region and the state
- Develop and engage participants in mechanisms for ongoing sharing, communication, and access to information related to climate change
- Provide a foundation for subsequent meetings to further develop adaptation strategies to address the implications of climate change for land and resource management
- Explore and articulate the Desert Landscape Conservation Cooperative priorities, structure, steering committee development, and science and research needs

The workshop drew 71 participants from 36 different organizations, including state and federal agencies, local governments, conservation organizations, research institutions, and private landowners. There were staff and planners present from ten different public land management units. Workshop participants represented a wide of range of perspectives and expertise, including water management, endangered species management, wildlife and game species management, invasive species management, regional land-use planning, conservation ranching, conservation planning and advocacy, land management, research and more.

Reports, power point presentations, and other information regarding *Climate Change Adaptation in the Arid Southwest* are available at www.skyislandalliance.org/adaptationworkshop2010.htm

The Desert Landscape Conservation Cooperative

In 2010 the Department of Interior developed a plan for a coordinated, science-based response to climate change impacts on our land, water and wildlife resources. Landscape Conservation Cooperatives (LCCs) are being created in specific geographic areas to facilitate the delivery of applied science to inform resource management decisions that address climate change and other regional scale stressors. LCCs will help inform resource managers as the partners develop adaptation strategies for natural resources. The Desert LCC encompasses portions of five states in the US, three different deserts (Mojave, Sonoran and Chihuahuan), grasslands and valley bottoms, isolated mountain ranges known as the “Sky Islands,” and several large river systems, including the Colorado River Basin, one of the most critical sources of water in the west. The LCC outreach meeting that was co-convened with *Climate Change Adaptation in the Arid Southwest* made significant progress toward the goals of:

- Developing a shared conservation vision for the Desert LCC
- Determining threats to priority resources, habitats, species and science needs
- Identifying existing resource and science partnerships relevant to the LCC

Overview of Climate Change: Present and Projected Effects in the Region, Resources, and Research

As a launching point for conversation, attendees were provided background information on the goals of convening this workshop and how this project integrates with formation of the Desert Landscape Conservation Cooperative, were presented information about climate change dynamics and impacts in the southwest, and the needs and knowledge gaps of natural resource managers. The panel presentations provided an overview of what is already known about climate change and impacts, what can already be seen happening around the region, and climate change projections and potential impacts.

Summaries of the major points of each presentation are provided below. The related power point presentations for these talks are available at:

<http://www.skyislandalliance.org/adaptationworkshop2010.htm>

Welcoming Remarks

Melanie Emerson, Executive Director, Sky Island Alliance

Sky Island Alliance (SIA) heard a strong message from land managers grappling with climate change about the urgent need to address gaps in science, communicate more effectively, and collaborate cross jurisdictionally in order to address the impacts of climate change. This workshop is one of the organization's initiatives that aims to help land managers respond to a changing climate.

It is necessary to look at the region as a holistic landscape, and to look beyond administrative and political boundaries. This will require sharing resources and the workload. The goal of this workshop is to identify shared goals, vulnerabilities on the ground, and strategies to address them. SIA has worked to structure the workshop to identify actions for both the short and long term, and to foster dialogue.

This is the first in a three-part series of workshops, with the next workshop designed to build on what is learned here and to focus specifically on ecosystems of the Sky Island region. Today's workshop will be aimed at capturing science needs and identifying actions that can be taken immediately.

Overview of the Desert Landscape Conservation Cooperative

Leslie Myers, Bureau of Reclamation

Leslie Myers began her presentation with an introduction to Landscape Conservation Cooperatives (LCCs), which are part of a Department of Interior (DOI) initiative led by the U.S. Bureau of Reclamation and the U.S. Fish and Wildlife Service. The initiative also includes Climate Change Centers (CSCs), led by US Geological Survey. There are eight regional CSCs, and their focus is fundamental science. The LCCs, in contrast, are focused on applied science, and are in place to access and share applied science. Most LCCs are led by the Fish and Wildlife Service, but those located in river basins are co-led by the Bureau of Reclamation.

The Desert LCC has numerous potential partners, and the goal for the LCC portion of this workshop is to learn more about the existing science and research needs, existing partnerships and projects in the region, and suggestions on the most effective way to structure the Desert LCC. At the CAMNet Rendezvous, a climate change-focused conference earlier this year, Jonathan Overpeck outlined the degree to which the southwest is threatened by climate change. Addressing this threat will require new ways of thinking and planning at a much larger scale. Individual reserves, parks, and parcels are not at the scale necessary to address the changing climate, leaving many managers grappling with how to address these concerns on the ground. The Desert LCC hopes to assist in addressing these concerns in the southwest region.

Climate Change Adaptation Survey Findings

Louise Misztal, Conservation Policy Program Coordinator, Sky Island Alliance

In April 2010, a survey was sent to professionals working on land and resource management issues in the southwest. Survey respondents were associated with federal, state, and local agencies, non-governmental organizations, academic institutions, and private landowners. The goals of the survey were to identify key knowledge gaps and other resource needs related to planning for and implementing climate change adaptation strategies and to identify some of the most pressing threats to land management related to climate change. The survey received 180 responses with 43 percent of responses coming from government agencies, the largest response group.

Below are some of the highlights from survey results:

- According to respondents, the most pressing threats to wildlife and natural systems are:
 - Water scarcity and drought, which had the highest response
 - Human pressures, such as land development
 - Invasive or non-native species
 - More severe and frequent fires
 - Changes in weather patterns including timing, intensity, and temperature
 - Habitat changes or loss
- 75 percent of respondents indicated they get information about climate change from journal articles; in person meetings and conferences emerged as the second highest percentage response rate
- The greatest challenge facing land managers was identified as a lack of resources, which received the highest response rate. Uncertainty about what will happen and what to do was the second highest response, and the most common response among all groups of respondents.
- In identifying the greatest current needs for land managers, the three most common responses were stable funding, a framework for dealing with uncertainty, and “translation” of science.
- Potential activities identified by respondents included monitoring of native and non-native vegetation and wildlife species.

The survey yielded a wealth of information that directly informed the content and structure of this workshop. The responses to the survey will be further analyzed, and Sky Island Alliance will translate the information into action. Once complete, a survey summary report will be available on the workshop website.

Projected Southwest Climate Changes: An Overview

Gregg Garfin, Director for Science Translation and Outreach, Institute of the Environment, and Assistant Professor, School of Natural Resources and the Environment, University of Arizona

The southwest receives moisture through two mechanisms: the winter-frontal system and the summer-monsoonal system. Gregg Garfin provided an overview of projected changes to the climate in the southwest region, stating that a snapshot of trends since 1985 shows increased aridity and increased temperature, with a rapid rate of temperature increase in past few decades.

Greg acknowledged the uncertainties related to using models, including future GHG emissions, related laws, policies, and institutions, and economics. Although there are many uncertainties to consider, models can provide some insights. For example, Models predict it to be 2 to 4 degrees F warmer in the future, with drier winters and springs. For the central Arizona rivers, the cool season will bring a decrease in stream flow and overall decrease in runoff; a decrease in baseflow; an overall decrease in precipitation; and an increase in evapotranspiration. The warm season will bring an increase in streamflow runoff and precipitation.

Climate, Fires and Forest Changes in Southern Arizona and the Southwest

Tom Swetnam, Director & Professor of Dendrochronology, Tree-Ring Lab, University of Arizona

Tree ring information shows that high severity crown fires are not unnatural in some southwest ecosystems, however, as Tom Swetnam explained in his presentation, the patch size of modern events is extraordinary. In ponderosa pine and mixed conifer forests, this is associated with loss of surface fires, change in forest structure, drought, and consequent change in fire behaviors. Trends show increased areas burned, particularly in lower elevations. This trend is projected to continue over the next 30 years. While there is significant uncertainty, including factors such as invasive species and population increases, the trends are clear.

Tom noted that there are several options for land managers in response to these trends, including adaptation, triage, and adaptive management. Adaptation responses can include creating resistance to change, promoting resilience to change, and enabling forests to respond to change. A triage response would include prioritizing ecosystems and landscapes where treatments to increase resistance and resilience are likely to be either 1) most effective; 2) unnecessary, or lower priority and therefore deferrable; or 3) too late or impractical. Finally, the adaptive management response should include learning from experience and iteratively incorporating lessons into future plans. Treatments and management actions should be carried out in a scientific and experimental framework.

Examples of these types of approaches include the Firescape group, a collaboration of scientists, managers, and citizen community groups working to address urgent problems in the Huachuca, Santa Catalina, and Rincon Mountains, and in the Tucson Basin, related to drought and climate change, catastrophic fires, insect outbreaks, invasive species, and changing patterns of land use. Similarly, the Collaborative Forest Landscape Restoration Program aims to encourage the collaborative, science-based ecosystem restoration of priority forest landscapes.

People, Place and History

Julia Fonseca, Environmental Planning Manager, Pima County Office of Conservation Science and Environmental Policy

In her presentation, Julia Fonseca explained how the particularities of place, time and people can magnify or reduce the predicted effects of climate change. She suggested that this region can consider these factors in a more nuanced way in order to lend greater understanding to predictions, and to bring more focus to the potential responses.

History matters:

In Julia's words, "There will be hell to pay for past groundwater pumping," a point brought home by describing potential impacts of the proposed Rosemont mine, where there may not seem to be an immediately high impact, but over time it will have enormous impact. It may possibly take hundreds of years for the effects to be transmitted, and the effects of climate change will be added on top. Delayed effects of this type are seldom studied and need to be taken into account when attempting to address climate change impacts.

People matter:

How people react is one of the most important factors to consider. In this region, there is a very poor inventory of surface water resources, and people tend toward the most seemingly reliable source. In contrast, in the Colorado Plateau area they have inventoried resources and how people affect it. We need that kind of study here.

Place matters:

For example, topographic diversity is an important factor, and there is a great amount of variation in this region. Soils and substrates should also be considered, as they provide important persistence of biota. Diversity of rock types should also be considered, including how soil types, vegetation and climate interact and affect water supply.

Forecasting Climate Impacts on Wildlife of the Arid Southwest

Christina Vojta, Deputy Director, USGS Southwest Biological Science Center, and Assistant National Wildlife Ecologist, US Forest Service

A project by the U.S. Geological Survey, Southwest Biological Science Center and Northern Arizona University, this project consists of four modules:

- Module 1: Use down-scaled global climate change models to predict changes in plant species distribution
- Module 2: Formulate an Advisory Team to select species, refine methods, and determine means of information transfer;
- Module 3: Forecast the effect of climate change on distributions of selected species
- Module 4: Provide web-based dissemination of information

Christina Vojta explained that the scope of the project includes forecasting changes in ranges of species at a coarse scale and over broad regions, such as the western and southwestern U.S.

Available climate data sets being used in the project include climate grids from PRISM Climate Group and the Intergovernmental Panel on Climate Change's General Circulation Models.

The project has been underway for nine months. Preliminary results are showing that for the Joshua tree there are areas of current distribution where the population is not likely to be sustainable in the future. For the pinyon pine, preliminary results indicate changes in spatial distribution over time. Focal species in the project include birds, reptiles and amphibians, with assessments of presence/absence models and predicted shifts in suitable climate.

As the project progresses, it will link vegetation models to wildlife models, and will consider modeling specific mammals. When complete, model results will be shared on the project web site.

Science Topics and Needs For the Desert Landscape Conservation Cooperative

Christina Vojta, Desert LCC Science Coordinator, USFWS

For the Desert Landscape Conservation Cooperative (LCC), Christina Vojta outlined the reasons to identify science needs, including ensuring relevancy to management in support of landscape conservation goals, developing a common understanding of shared science needs, and finding opportunities to leverage funding. The scope of a science needs assessment includes impacts and interactions of climate change, processes and impacts across large landscapes and ecosystems, and human environment threats and interactions. The process will involve collating science needs identified in stakeholder documents, obtaining additional science needs from outreach meeting participants, prioritizing science needs, and addressing those needs through research.

Southwest Climate Change Initiative: Information for Managing Natural Resources in a Changing Environment

Marcos Robles, Conservation Science Specialist, The Nature Conservancy

The Nature Conservancy initiated the Southwest Climate Change Initiative (SWCCI) in 2008 to provide guidance to conservation practitioners and land managers in climate change adaptation planning and implementation on more local scales in Utah, Colorado, New Mexico and Arizona. This project specifically includes a combination of regional assessments and site-specific adaptation planning.

As Marcos Robles explained, habitats, watersheds, and species in the southwest are already experiencing temperature change. Between 1951 and 2006, 90 percent of habitats warmed and 40 percent of habitats had observed species and ecological effects. Watersheds in the southwest are also already experiencing temperature changes – 70 percent have warmed and 50 percent have recorded changes in their hydrology. The Upper Colorado River Watershed has experienced a 1.6 degree F warming from 1951 to 2006, and the Lower Colorado River has experienced a 1.9 degree F warming over that same period.

Some observed direct effects from warming in the region include yellow-bellied marmots emerging earlier from hibernation, robins migrating sooner, and Mexican jays breeding earlier. Warming in the region is driving ecological changes and contributes to changes in hydrology,

including a 15 to 30 percent decline in snowpack, peak stream flows occurring one to four weeks earlier, and a higher incidence of rain compared to snow. Warming has been shown to amplify drought. A high mortality of pinyon pine in the region is attributed to drought combined with increased temperatures.

The SWCCI is assisting land managers through adaptation processes across four case study sites. Through two-day workshops with resource managers and scientists, practical adaptation actions are being identified.

Case Studies: Adaptive Natural Resource Management in Response to Climate Change

Firescape: Landscape Ecosystem Management is a Strategy for Climate Change Adaptation in the Sky Islands

Don Falk, Associate Professor, School of Natural Resources and the Environment, University of Arizona

Don Falk began his presentation by explaining that the primary assumption of the FireScape project is that landscape-scale management is the best way to manage fire regimes in this region. The need for landscape-scale approaches to fire management is driven by several factors, including fuel conditions from a history of fire exclusion that creates the potential for extreme events; the interactions of fires, insects and climate variations; the expanding wildland-urban interface in fire-prone settings; and invasive species, which create new pathways of fire spread.

Don identified the drivers of change in the Sky Island bioregion, which include steep ecological gradients; naturally fragmented landscapes that constrain species movements; proximity to major metropolitan areas; ecological communities “on the edge,” and sensitive to climatic variation; and critical disturbance processes, like fire and insects.

Currently we have a good understanding of historic fire chronology. The challenge is to sort out historic variability to see what’s “normal.” Historic low severity fires often covered large areas – a category of fire rarely seen today – and so the challenge is in restoring the natural fire regime.

The principles of the FireScape project include planning and implementing at large scale; working across jurisdictional boundaries; applying science throughout the process; adjusting the model for each landscape; and achieving more efficient and effective implementation through large-scale, multi-year approvals, including NEPA compliance strategies and multi-year permits, among other things.

The focus of FireScape science includes looking at fire behavior modeling, fuels and vegetation, carbon pools and flux, fuel moisture stress, treatment optimizing, and fire return interval departure, with the goal of developing and testing treatment alternatives. This will lead to tangible on-the-ground actions. Partnerships are already in place for sharing models and data. FireScape has a large working group with many partners, and is a good example of a science-based collaborative project.

Sonoran Desert Conservation Plan

Brian Powell, Program Manager, Pima County Office of Conservation Science and Environmental Policy

Brian Powell provided an overview of the Sonoran Desert Conservation Plan (SDCP), which is a long-term vision for protecting the heritage and natural resources of Pima County. It incorporates key conservation biology concepts, such as identifying key corridors and following watershed level conservation principles, among others. It also includes an active citizens’ process.

The SDCP came out of the idea that Tucson is a massively expanding “blob” of development, and there is a growing need for conservation planning in the region. The County has sought to address this need in a number of different ways, including through acquisitions of land for conservation, focusing on those lands close to existing reserve systems and including low elevation grasslands, wetlands, and other key habitats. The county has also applied principles of conservation planning through its rezoning process, with required open space set-asides, and protection of species corridors, among other things.

A big goal of the SDCP is the preservation of cultural resources, including preserving the ranching way of life, and taking advantage of the historic continuity of ranchers through acquisition of ranches and keeping those ranchers ranching. At the same time, the county can plan for critical landscape connections through these acquisitions, as well as change current cattle ranching for greater sustainability, and eventually implement a long-term monitoring program. Overall, the SDCP has incorporated conservation into the way the county does business.

While the SDCP has been a great success so far, challenges remain. These include incorporating climate change into planning, and focusing on impacts and actions that will still be around in 50 years, as well as planning for resilience and incorporating climate change into an adaptive management framework. The county needs to develop additional partnerships with other entities to help in planning and addressing these challenges.

Las Cienegas National Conservation Area

Karen Simms, Ecosystem Planner, Bureau of Land Management

The resources found at Las Cienegas National Conservation Area (NCA) are incredibly important for the region. Cienega creek is a small stream, but it supports the entire resource. For example, the area provides 20 percent of the water recharge for Tucson, and it is one of the most intact wetland and aquatic systems near Tucson. Significant quality resources are found here, including five of the rarest plant communities in the southwest, such as sacaton grasslands, cienega wetlands, and mesquite bosque, among others. It is home to 26 special species, and is managed with a multi-species emphasis. One of the challenges here is that legislation directs protection of often conflicting resources within the Las Cienegas NCA. There is a multiple-use mandate, and climate change is worsening the stress of multiple uses.

The current resource management plan emphasizes adaptive strategies and adaptive management, and includes resource objectives that can also be adaptive. Restoration objectives include grassland restoration, and aquatic and riparian restoration. There is a foundation of baseline inventories, which provides an opportunity to mine historic data for future monitoring efforts. The monitoring program is targeted to resource objectives. There is a long-term foundation of stakeholder involvement that includes multiple stakeholders with diverse interests.

The adaptive management strategy incorporates climate change issues mainly by improving resource conditions and building resilience, such as through floodplain protection; adaptation planning with water as a focus; and ongoing investigation and understanding through experiments and testing, for example in grassland restoration efforts, where experiments are

proposed to restore the grassland areas and obtain test data. Addressing climate change presents other challenges, including those related to understanding the mechanics of climate change, public attitudes towards the science, uncertainty, understanding the filters for understanding, and ultimately taking responsibility for solving the problem.

Panel Discussion

How much should we embrace change, and how much should we try to hold back?

Answer (Brian Powell): We need to get data and an assessment to help make decisions on where to focus efforts. Once the data is in, managers will be able to make better decisions. We need to make the distinction between giving up and letting go: how much change can we tolerate? How much is adaptive and how much is a sign that something's wrong?

Answer (Karen Simms): With Las Cienegas, we conduct experiments with fire and mesquite eradication – conversions, and attempt to determine what trade-off's are necessary and whether we can embrace change or not.

Pima County used indicators to decide what land use should be acquired – is this a good process?

Answer (Brian Powell): This process informed their decision making; diversity informed their regulatory side.

Have past studies been done to get a better understanding of exotic species, and different ways of managing exotic species on public lands?

Answer (Don Falk): Data suggests high fire frequency where it was not the native ecosystem – with a novel presence of a pyrophilic species, managers can take a prescribed approach.

Answer (Karen Simms): We have exotic grass even within Las Cienegas. We need better strategies to deal with such competitive species. BLM is trying to protect non-fire-adapted species. Fire is a preserver and also destroyer – fire destroys in areas not natively adapted to it – and certainly invasive species change the equation for the Sonoran desert.

Desert Landscape Conservation Cooperative: Overview and Organization

The Bureau of Reclamation (BOR) and the U.S. Fish and Wildlife Service (FWS) are working to formulate the Desert Landscape Conservation Cooperatives (LCCs). LCCs are a Department of Interior effort to address landscape scale changes such as habitat loss, climate change, invasive species, and wildlife disease through linking science with land and resource management. Through Secretarial Order 3289 the DOI established Climate Science Centers (CSCs) and LCCs. CSCs are designed to be science partnerships. There will be 8 science centers based out of Universities established across the country. LCCs are designed to be management science partnerships created to address climate change that will include both private and public stakeholders. 15 LCCs are being established nationwide to provide a seamless network extending from Canada to Mexico

Expected benefits of the Desert LCC include development and access to applied science, leveraging of funding, development of information and technical expertise for applied science projects, collaboration and communicating on matters of common interest. Applied science will be developed through an RFP funding process. Example products include science-based decision support tools, and species and habitat assessments. The Desert LCC will not be a conservation funding agency, will not replace existing organizations or partnerships, and will not be regulatory in nature

The Desert LCC will be implemented through a steering committee of partners, an LCC coordinator through BOR, a Science Coordinator through FWS, a planning and technical staff, GIS capability, and communications. The outreach meeting that occurred at this workshop was designed to explore the structure and function of the Desert LCC steering committee. The steering committee is expected to include senior leaders from partner groups who can commit organization resources. The committee will provide leadership and guidance and establish LCC work priorities.

Through outreach meetings the Desert LCC seeks to identify science needs and resource priorities, identify existing organizations and cooperative groups to engage in the LCC, define the organizational structure of the LCC, and identify steering committee participants and describe roles and responsibilities.

The first Steering Committee meeting for the Desert LCC is expected to occur in April of 2011. A summary report of the findings from the LCC breakout group discussions will be available at <http://www.usbr.gov/WaterSMART/lcc.html>

Developing a Response to Climate Change: Workshop Findings

The breakout group sessions generated a wealth of information. Participants' discussions document a diversity of perspectives on what climate change in the southwest may mean for the resources they are managing. Their responses offer a solid overview of shared management and conservation goals, overlapping work, vulnerabilities, and actions that may be undertaken in the region.

Methodology

Participants were split into pre-assigned breakout groups with 20 to 25 people per group in order to create a mix of expertise and organizational representation in each room. All three groups had the same objectives and discussed the same series of questions. The discussion was structured to determine shared management and conservation goals and vulnerabilities of those goals due to climate change, and to identify actions that could be undertaken to ameliorate the vulnerabilities.

Participants were asked to:

- Explain their programmatic and organizational goals
- Identify shared goals as a group
- Develop a list of how these shared goals are vulnerable to climate change
- Choose two priority common goals and identify actions to ameliorate vulnerabilities by answering the following questions: What could we be doing right now? What should we be doing right now?

Because of the diversity of participants and large size of breakout groups, each of the three groups was asked to prioritize two areas of overlapping goals to discuss more in-depth. Prioritized goals and their vulnerabilities to climate change were the basis for a focused brainstorming session to identify initial adaptation strategies.

Identifying Vulnerabilities to Climate Change

Participants' current work and organizational goals spanned a range of themes, including applied management goals such as protecting habitat for endangered species, research goals such as using remote sensing to observe changes in ecosystems and conducting species vulnerability assessments, and educational or advocacy goals such as translating climate change science into conservation policies and youth education.

According to participants, climate change will pose many, often complex challenges in addition to the myriad non-climatic stressors already affecting their work. Vulnerabilities identified by participants were due both to climate change effects and non-climatic stressors. Changing conditions on the ground is an ongoing challenge because of existing workloads, lack of capacity, conflicting management goals, cumbersome political and regulatory limitations, and lack of funding.

Participants repeatedly noted that they face problems of scale, because spatial scales normally used for planning purposes in parks and other management units do not sufficiently matching the scale of the problem created by climate change. Additionally, the temporal scale of funding does not match the temporal scale of the problem.

Non-stationarity was an important recurring theme. Many management decisions are currently based on the premise of stability or stationarity in systems. When faced with a departure from

stationarity such as time periods of drought, managers look to manage for the interim until things return to their previous stable state. As one participant pointed out, there are no longer any assurances that things are going to stabilize.

Vulnerabilities identified by participants that will affect all management and conservation goals include:

- Lack of effective exchange of information and duplication of efforts
- Multiple-use mandates and competing interests
- Staffing and workload limitations
- Increasing human demand for resources such as timber, water, and grass for grazing
- Lack of coordination on research and monitoring
- Lack of consistency in data collection
- Uncertainty about what to monitor, and the necessary frequency and timing of monitoring
- The potential for climate change to lead to irreversible damage to habitats and ecosystems

Through participant discussions, specific thematic areas of vulnerability emerged, including knowledge gaps and science translation, management of invasive species, and human dimensions. The following sections take a more in depth look at participant discussions related to these themes of vulnerability.

Knowledge Gaps and Science Translation: Developing Understanding

According to participants, there is a strong need to better understand climate change impacts. Although there may be information available about projected changes in temperature or precipitation, resource managers and other decision makers need to understand what those changes mean for the ecosystems and species they are managing. This theme was reflected in goal statements such as building readiness to use climate information, making conservation science available to groups working on the ground, making science more applicable to those who are using the tools, and building decision support tools for managers. One participant asked, "Are species going to be affected by direct or indirect effects from climate change, and which species?" Based on participants' discussions, developing a better understanding of climate change implications may be a need that must be addressed before other articulated needs, such as developing better science and monitoring. Echoing this idea, one participant asked the question, "*Where* does it matter if your science is better?" - a question that can be answered through a better understanding of climate change impacts.

Developing a better understanding of which species, habitats or other management targets can actually be protected or helped through management activities versus which have no hope of being protected will help managers prioritize the use of limited resources. Participants posed questions that will be key to developing responses to climate change that are based on understanding. Example questions are: "What difference does management make in what dies, what survives, and what is resilient to change?" and "What can we do with existing and/or new information to help manage these systems better?"

Discussions about monitoring were consistently linked to discussions about research and data, and how all of these components interact with management decisions. Participants repeatedly

commented on the need for science translation, referring to making scientific information and data available in a format that can inform management decisions. According to participants, many people do not know what information is available, how or where to find it, and how to determine if it is the right information to meet their needs. Participants indicated that limited time and limited capacity to find and apply scientific information related to climate change are barriers to utilizing climate-related scientific information in decision-making. This was also reflected in repeated requests for decision support tools.

Management of Invasive Species

The management of invasive species was a recurring topic of discussion. Participants believe that some invasive species in the region such as buffelgrass, red brome, and bullfrogs will increasingly build a competitive advantage over native species as the climate changes. Habitat changes, changes in disturbance regimes, and even assisted migration may facilitate the spread of invasive species. Participants suggested that new species may become invasive as the climate and habitats change, and methods used to eradicate invasive species can cause harm to habitat and other species. Invasive species management is always limited by availability of money and other resources, but prioritization of locations to eradicate invasive species can assist managers in addressing this issue.

Human Dimensions

Participants repeatedly noted that human behavior will affect the impacts of climate change. Some of the noted effects include: human adaptation responses to climate change that put pressure on public lands resources; shifts in land use; human activities exacerbating climate change impacts such as increased groundwater withdrawal during drought; lack of appropriate policies to deal with vulnerabilities; and an inability to respond quickly with policy changes.

Participants expressed concern that public perceptions about climate change, including whether or not it is happening, to what extent it is happening, and to what extent it is due to human causes, are affecting their ability to manage resources effectively in the face of climate change. Some participants indicated that a lack of cultural acceptance of the perils of climate change may create public resistance to potential adaptation strategies.

Developing Adaptation Actions

Each of the three breakout groups chose two vulnerabilities to focus on for an in-depth discussion to develop adaptation actions. Although breakout groups had the potential to choose a total of six different vulnerability themes, there was an overlap in topic choice and the three chosen themes were, research and monitoring, water, and species and habitat conservation. Based on participant discussions throughout the two days, addressing these three themes of vulnerability is high priority for the participants of this workshop.

Developing Adaptation Actions: Research and Monitoring

Monitoring emerged as one of the most prominent recurring themes in participant discussions. Two of three breakout groups choose to focus on research and monitoring for development of initial adaptation actions. Responses in all three breakout groups highlighted the importance of monitoring for informing management decisions. Although monitoring has always been an important part of resource management, participants indicated that monitoring is now even more crucial because of climate change and projected impacts. Monitoring was identified as a tool for developing a better understanding of how species and ecosystems interact, for understanding how climate change is

affecting species and ecosystems, for developing baseline information, and for assessing the effectiveness of climate change questions. Climate change and resultant impacts may affect the utility of information gathered through monitoring for purposes of decision making. For example, markers chosen for monitoring may not be climate sensitive or may be too climate sensitive, or the location of monitoring sites, the selection of what to monitor, and the scale of monitoring may need to be changed. According to participants, there is a need for the use of common methodologies and for coordination among agencies and organizations for monitoring to be effective.

Participants repeatedly expressed a need for consistent and long-term monitoring. Not only is monitoring into the future important, but so is utilizing past monitoring information. Revisiting existing data resources through the perspective of climate change may offer new insights. Participants repeatedly suggested that what is being monitored, and how it is being monitored could and should be standardized across jurisdictions.

Participants indicated that monitoring will be most effective if it is structured to test a hypothesis related to climate change. This can also guide research and monitoring site selection. For example, if species A responds to climate the way we expect it to, then it will disappear from location B first. Thus, monitoring should be directed to location B. Related to this idea was the suggestion that predictive models could be used to help managers know what to look for as climate change impacts manifest. According to participants, it will be important to be aware of potential incoming change. One identified research need was modeling what may be entering the region from Mexico in order to see what kinds of flora and fauna may be replacing the flora and fauna that can no longer persist here.

One participant noted that we may have to redefine what “native” is, relative to the ecosystems in which the species are found, and that “biodiversity” is likely going to have a different composition in the future. A key management consideration will be whether we try to keep the vegetation communities intact and in place where they are, or whether we try to adapt to the movement of vegetation communities.

Research and Monitoring Adaptation Actions

- Develop additional trend information to help identify management intervention points
- Develop trigger points for action based on monitoring findings
- Incorporate climate-sensitive metrics into monitoring, such as tree rings, pack rat middens, and other metrics that provide historical information
- Identify indicator species to monitor, rather than trying to monitor everything
- Identify sensitive places such as water resources or ecotones for indicator site monitoring
- Monitor the ecotones between biomes with presence/absence counts to get a quick view of plants and animals
- Include confounding and interactive factors such as human behavior in research design
- Ensure that monitoring addresses gradients such as spatial and altitudinal, for example, monitoring species distribution across elevations
- Identify where common data sets are appropriate and where different data sets can be combined
- Develop agreements across agencies and partners that delineate the primary attributes to measure

In addition to these actions, participants identified opportunities related to a lack of coordination around monitoring and data. The National Phenology Network and workshops such as this one that bring together scientists and managers, are both sources for improved coordination. The current lack of coordination on monitoring and data collection presents opportunities for policy level coordination through standardizing baseline data collection methodologies on public lands across agencies, building agreement between organizations regarding what they are going to monitor, and establishing common indicators for monitoring across organizations. A suggestion related to this is to create regional models for monitoring through multi-agency monitoring teams.

Case Study: Pima County Working Ranches

Pima County owns and manages large land tracts that include a combination of grazing leases on federal and state lands. These lands are managed as working ranches with a long-term goal of maintaining the landscape consistent with its ecological potential for both species conservation purposes and for grazing, and where applicable, for restoring quality of habitat. Based on climate change projections, Pima County is looking at a future reduction of water on these landscapes, the potential drying of natural springs, and other similar effects. The county is trying to determine if they can improve water sources through their management practices.

Potential actions the County can take that were discussed by participants include:

- Repurposing livestock water developments to create habitat for species by maintaining pumping
- Abandoning existing water developments and letting them revert to a natural state
- Taking water from a development and moving it to a natural stream.

There are many outstanding questions and uncertainties related to these possible actions. For example, would abandoning developments and allowing them to revert to natural states engender a “tragedy of the commons” and lead to abandonment of water rights?

Because of projected climate change, there is an expectation that some natural waters such as spring and seeps may disappear. In the case of repurposing livestock waters for wildlife, will the County be maintaining historic function? If water is going away, is it wrong to use the developments to try to mimic the natural systems?

In the case of taking water from a development and moving it into a natural stream, the County is uncertain whether this approach will be effective for maintaining wildlife diversity. Some studies indicate that vegetation may migrate downstream, and the county has not yet studied this potential approach for effectiveness. A participant suggested this approach may have negative impacts, including supporting large predators in an area where they wouldn't naturally be able to live year-round without the aid of artificial water.

Developing Adaptation Actions: Water

Participants identified a number of climate change related threats to hydrological systems and water supply in the southwest. These include: changes in the timing of precipitation; more variability in water availability; less available water overall; diminished water quality; increased human extraction of water leading to decreased availability of water for the environment; interrupted hydraulic connectivity, such as groundwater-to-surface connections between wetlands and cienegas;

reduced water table; and changes in hydrologic regimes, moisture regimes, water recharge, and timing and amounts of peak flows.

Two of the three breakout groups chose to focus on water and water scarcity for development of initial adaptation actions. Water management in Arizona and the greater southwest involves complicated laws and regulations that are not often linked to the reality of how hydrological systems function. Both of the breakout groups spent time discussing legal and regulatory barriers to effectively addressing water vulnerabilities. Many of the suggested actions related to the legal and regulatory aspects of water management are likely beyond the scope of activities the participants at this workshop are in a position to take. However, these actions may be essential to successfully respond to climate change in the region for both human and natural communities. They include a need to: expedite the legal processes for securing water rights; address private property groundwater rights; address the real costs of water with decreased supply leading to increased cost; require reporting of water use in Arizona; change Arizona water law to limit withdrawal in key places; improve water quality laws to include climate change considerations; and tie development regulations directly to water supply. It was suggested that Adaptive Management Areas might be a model for making management of watersheds more flexible and responsive to changing conditions, instead of trying to change Arizona water law.

One breakout group identified the development of end-user incentives for water conservation as one of two high priority actions. The group noted that human population growth and development in the region will continue, and there is a need to find ways to accommodate more people with the same amount of available water. The group suggested tax incentives and popularizing water conservation with the public as two ways to encourage end-user conservation. Examples of end-user conservation measures include water harvesting, xeroscaping, installing filter systems and metal roofs, and the idea of “getting off the water grid.”

Participants identified a variety of ways to address water uncertainties, including developing collective water budgets, determining what instream flows are needed, and projecting future rainfall patterns and changes in timing and intensity of rainfall events. Participants felt this type of information will help managers make more informed decisions.

From participant discussions about water, there emerged a variety of actions that are under the control of resource managers, researchers, and planners and, with the proper resources, can be undertaken immediately.

Water Related Adaptation Actions

- Conduct field-based inventory of springs, their conditions, and their biodiversity
- Engage in multi-agency contingency planning for drought conditions
- Determine where agencies can work together to pool resources and share core data collection
- Identify restoration actions to keep water in streams
- Work with local governments, such as counties, to engage in water planning
- Develop information on environmental flows (the amount of water needed in a watercourse to maintain healthy ecosystems) to determine what in-stream flows are needed
- Look to volunteers as a potential resource for addressing scarcity of money and time
- Revisit water quality standards in the face of climate change
- Close the gap between land-use planning and water use at the county level

- Educate the public about the importance of ecosystem services of water for species
- Pursue strategies to secure water rights and water use

Participants noted that water is a multi-agency, multi-ownership managed resource with each entity looking at its own stretch of river in a different way. There is lack of cooperation among states, municipalities, and other agencies, and regional divisions complicate matters. However, this situation presents an opportunity for agencies to work together in resource planning efforts. One of the breakout groups highlighted the strategy of agencies working together to pool resources and maintain core data collection as one of two highest priority actions for addressing water vulnerabilities. Participants presented a vision of establishing a regional multi-organization coalition of water groups linked with research organizations such as the U.S. Geological Survey (USGS) that would work together on water budgets, and work out sustainable allocations. It was noted that there are currently many individual projects but no larger regional focus. The Upper San Pedro Partnership was given as an example of a cooperative group that has experienced some success, thanks to adequate funding to produce substantive science after the Base Realignment and Closure process put pressure on Fort Huachuca and the surrounding community to address endangered species and water management issues.

Case Study: Leslie Canyon NWR

Leslie Canyon National Wildlife Refuge is managed by the US Fish and Wildlife Service (FWS). Located at the southern end of the Chiricahua Mountains, the 2,765-acre refuge was established to protect habitat for the endangered Yaqui chub (*Gila purpurea*) and Yaqui topminnow (*Poeciliopsis sonoriensis*). The refuge also protects a rare velvet ash-cottonwood-black willow gallery forest. The water of Leslie Creek supports these species and many others found on the refuge.

Since its creation in 1988, the refuge has faced changes in the amount of available water in Leslie Creek to support fish habitat. Portions of the Leslie Creek watershed upstream from the refuge are not managed by FWS so the refuge does not have direct control of management activities in those areas. Because of the small size of the refuge and its location, direct refuge management may not be enough to ensure survival of the species living there. In order to provide critical watershed protection for Leslie Creek the refuge has worked with neighboring ranch owners to bring approximately 24,000 acres of land under conservation easement to protect the watershed from development of residential land uses.

In addition to affording some measure of protection for the watershed, these conservation easements may provide other benefits to species found on the refuge as climate change impacts occur.

Developing Adaptation Actions: Species and Habitat Conservation

The most commonly identified vulnerabilities that emerged from all three breakout groups relate to the goal of conserving species and habitats. Species' interactions with resources they depend on are complex and have both temporal and spatial components. Participants indicated that species may become decoupled from resources they depend on for survival due to phenological changes. For example, flowers may no longer bloom in sync with the pollinators that feed on them. Climate change impacts may change species' competitive ability if invasive species are better able to grow

and reproduce under new climatic conditions. For example, a prolonged drought may give a drought-tolerant invasive species enough of a toehold in a habitat that, when drought conditions subside, native species are no longer able to outcompete the invasive.

Habitat may be lost or damaged due to vegetation die-off under new climatic conditions, changes in major disturbance regimes, or changes in land-use, such as a parcel of land that was being actively ranched converted to housing developments. For example, there may be a greater duration of time between good regeneration years such that species composition begins to favor invasive species. Or, vegetation may die off at such a rate that there is no time for recruitment. Even shifts in composition and structure of habitat without outright loss of habitat may negatively affect species.

The persistence of individual species may be threatened by increased vulnerability to disease, degradation of the quality or quantity of food resources, changes in competitive interactions with other species, hybridization or other genetic changes, and geographical shifts in the habitat on which they depend.

Related to threats to species and habitats, participants discussed the importance of connectivity and corridors. Identifying and maintaining important corridors for species movement across the landscape and between protected areas was a common goal for many participants. Participants expressed a need for researchers and managers to work together to identify key corridors for species and to build better connectivity. Participants noted that climate change and subsequent habitat changes may occur at a faster rate than species can actually move to take advantage of existing corridors. They also noted that corridors may become fragmented due to changes in the vegetation communities within them so that they no longer facilitate species movement. The topic of assisted migration or enhanced dispersal came up in these discussions as an area where more research is needed, and as a potential action for protecting species. Participants noted that protection of future appropriate habitat will be important for species conservation and regulations may need to be adapted to deal with shifting habitats. In addition to the concept of connectivity for species, participants brought up the concept of hydrological connectivity and noted that connections between groundwater and surface water for wetlands, cienegas, seeps, and springs may be changed by changes in the water table and other hydrological changes, thus disconnecting these habitat types from their water sources.

There was recognition among participants that the impacts from climate change may cause the loss of some important resources, forcing them to prioritize. One participant posed an important question for thinking about prioritization and management: "What difference does management make in what dies, what survives, and what is resilient to change?" Breakout group discussions revealed that conserving species and the habitats they depend on is a strongly shared goal of the resource management community in the southwest.

Embracing change or preparing for the loss of certain species and habitats was a recurring theme throughout breakout group discussions. There is a strong recognition on the part of managers that tough questions will need to be answered in the course of their work, such as when to stop managing for a certain species or habitat. Participants recognized a need to better understand species genetics and how the characteristics of a species may lend itself to adaptive potential. Single-species conservation may be ineffective, and managers need to protect for or against species interaction with disease, competitors, and pollinators, to give a few examples.

Preparing for multiple outcomes through scenario planning was discussed as a way to identify management strategies that could be useful under different future conditions.

Species and Habitat Conservation Adaptation Actions

- Pay attention to species that are succeeding in order to better understand the resilience in the system
- Identify important refugia for species, and manage to maintain those refugia
- Move away from single species conservation toward protecting community structure and connectivity
- Secure strategic conservation easements around protected areas to maintain connectivity -- "think outside your particular parcel of land"
- Identify population targets for the conservation of individual species
- Manage human uses of the land to prevent harm and within the constraints of resource carrying capacity and agency staff capacity
- Pay attention to factors that contribute to the primary productivity of a species, and incorporate these considerations into management
- Manage new assemblages for change and resilience once they are established and recognized
- Protect water availability for species
- Build connectivity with an eye toward interactions – understand community structure and connectivity

Mechanisms for Cooperation, Communication, and Access to Information

In a facilitated plenary session workshop participants were asked a series of questions devoted to understanding their information, communication and training needs. Based on participant responses it is clear that there are a variety of ways to engage the resource management community in ongoing learning, dialogue, and even in active projects to foster collaboration in the region. Below is a summary of responses to each question. Participants were asked how we as a resource management community could create sustained interaction outside of the workshop, what specific training topics would help build institutional capacity, and who should attend future workshops similar to this one.

Participant suggestions for keeping the community of people at the workshop engaged include:

- Take the show on the road by getting some of the speakers from this workshop to talk to more groups, including the public, managers, and federal agency staffs, among others
- Identify specific tasks on which workshop participants can collaborate
- Have technical groups that people can participate in prior to the workshops
- Create a very structured webinar series
- Extend the climate change network to the Mexican Sky Islands
- Communicate about projects as they are being planned, and find a way to notify people, which is especially important for research projects that are applying for funding
- Distribute a regular newsletter to inform people about new opportunities
- Build a website with links to information on climate change issues for Mexico
- Create a portal within Climate Adaptation Knowledge Exchange (CAKE) to post case studies so that people beyond the region can learn about these examples

Participants indicated that case studies on both successful and unsuccessful adaptation projects would help build institutional capacity for climate change adaptation and, if shared through a platform such as CAKE, could foster sustained interaction. Participants also indicated that examples of climate smart monitoring in real projects would be useful. Participant responses to training topics reiterated the already mentioned need to learn what data is available, where it can be found, and its potential usefulness and limitations. Other suggestions for training topics to build institutional capacity include:

- Climate dynamics to develop a solid understanding of the climate system
- Short courses on statistical applications often used in applied climatology
- Translation of climate change information into what it may mean for ecosystems
- Decision support tools
- Strategies for communicating climate change information to stakeholders or other audiences
- Synthesis of the major climate model groups, how they work, what they are good at or not good at, and what they are used for

- Tools for responding to skeptics, both internal and external

Participants stated that the focus on regional climate change created by this workshop is good because there is already a lot of effort at the national level. Suggestions for identifying who should attend future workshops, and how to ensure the proper people participate, include:

- Identify opportunities for bringing the presentations from this workshop to agencies, and consider that timing and location could be synchronized with professional societies' meetings
- Capture ongoing smaller landscape efforts so the full range of regional activities can be known to participants and collaborators
- Develop a set of best practices that agencies and organizations can apply to themselves
- Ensure effective dissemination of key papers, such as Robin Craig's U.S. Forest Service paper identifying a framework for climate change adaptation

Summary and Next Steps

Through the course of the two-day workshop it became clear that the participants were very much interested in finding ways to work cooperatively as a regional community to effectively manage land, wildlife, water and other natural resources of the region. There was significant interest and participation in the full group discussion about how to better communicate, cooperate and share information.

Workshop participants provided insightful comments and recommendations during the facilitated discussions. All of these were previously discussed in the section entitled, “Developing a Response to Climate Change.” The following section provides a summary of key findings from the workshop and recommendations to help resource managers in the region formulate strategies to address climate change and build a natural resource management community working in cooperation.

Key Findings

Limited time and limited capacity to find and apply scientific information related to climate change continues to be a barrier to utilizing climate-related scientific information in decision-making.

Management decision structures are based on the concept of stable or stationary states to which a system can be returned when it faces a departure such as a period of drought. Finding ways to incorporate non-stationarity into decision-making presents a large challenge.

Participants lack understanding of how to interpret projected changes in climate into possible impacts to species and ecosystems. They would like to better understand which species, habitats, and other management targets could be protected or helped through their work.

Participants anticipate that the management and control of invasive species will become more complicated and difficult due to climate change increasing the competitive advantage of new invasive species arriving on the scene.

Human behavior and responses to climate change will complicate resource managers’ ability to respond to climate change impacts. Participants expect humans to alter their behavior in ways that may put additional pressure on natural resources, especially water, and public perceptions about climate change create resistance to change and a lack of support for adaptation efforts.

Monitoring and targeted research are increasingly crucial to developing understanding of, and responses to climate change. Lack of consistency, long-term data gathering, common methodologies, and climate sensitive markers all make current monitoring systems vulnerable.

Water is a very prominent issue in wildlife and resource management in this region. Participants expect that many factors related to climate change and human behavior will decrease available water in the region and have cascading effects on species and ecosystems. There are many outstanding questions about precipitation projections, hydrological dynamics, and how policy

and human behavior will change, or not. Management of water resources and natural resources that depend on water is very complicated and difficult in this region.

Participants expect many changes to occur in the phenological traits of species, the ranges of species, and the make-up of habitat in the region. This may be further complicated by loss of connected habitat and other non-climate stresses. Participants expect that management targets may be lost no matter what they do and that difficult questions about prioritization will have to be answered.

Recommendations

Participants recommend enhancing cooperation within the region by creating projects and identifying specific tasks that require collaboration between various entities in the region.

Effective exchange of information, coordination on projects across jurisdictions with shared resources, and collaboration with traditional and non-traditional partners will make climate change planning and management more effective across the region.

Participants recommend bringing organizations, agencies and landowners from the Mexican portion of the region into the fold through the workshop series and through expanding the Arizona Climate Change Network that is being formed to include northern Mexico.

Participants are very interested in learning about case studies that demonstrate planning processes for climate change adaptation efforts and that demonstrate development of climate-smart monitoring.

Participants recommend bringing speakers from this workshop to agencies, professional meetings, or other similar forums in order to reach more managers directly with this crucial information.

Making scientific information and data available in a format that can inform decisions will assist managers in incorporating climate change considerations into their work.

Consistent and climate-sensitive monitoring will help managers understand climate change impacts, develop climate change adaptation actions, and assess the efficacy of those actions.

Cooperation and even standardization of monitoring targets and techniques can assist managers in sharing information across jurisdictions, and in developing a better picture of the region as a whole.

Development of trend information will help managers identify management intervention points and to develop “trigger points” for management action based on monitoring findings.

In this region, monitoring across gradients such as elevation and specific monitoring of areas of transition between habitat types known as ecotones will assist managers in identifying changes as they occur.

Protecting water availability for species and environmental flows will be essential for effective management. Collecting spatial information about resources such as seeps and springs, and identifying appropriate restoration activities and locations will aid managers in maintaining water resources where they currently exist or historically existed.

Pursuing strategies to secure water rights and water use will also assist managers in maintaining water resources.

Participants recommend engaging in multi-agency cooperation for water management through activities like multi-agency drought contingency planning and pooling resources to share in core data collection will.

Identifying refugia for species and prioritizing protection of those refugia will assist managers in maintaining biodiversity in the region.

Participants recommend paying attention to species that are succeeding in order to better understand the resilience in ecosystems and managing new assemblages for change and resilience once they are established and recognized.

Managing human uses of the land to prevent harm and to keep them within the carrying capacity of the resource and staff capacity will assist managers in maintaining resilience of ecosystems.

Participants recommend “thinking outside your own parcel of land” through activities such as securing strategic conservation easements around protected areas, and maintaining connectivity both between protected areas and within protected areas.

Adequately allocating resources toward increased responsibilities and activities will assist managers in implementing climate change adaptation activities.

Next Steps

All of the information collected through this workshop is being used to inform the second workshop in the three part series, to be convened April 13-14, 2011. The next workshop in the series will focus on the unique species and ecosystems of the Sky Island region, and vulnerabilities and adaptation strategies specific to projected climate changes in the region. The workshop will be designed to produce specific adaptation strategies based on the emerging themes of importance determined through this workshop.

Sky Island Alliance has initiated formation of an Arizona Climate Change Network as a tool to foster sharing of information and findings and collaboration in the region. We will continue to develop and expand this Network to engage participants in ongoing sharing of information and findings, and to improve access to information related to climate change. You can register for the Network at <http://www.skyislandalliance.org/aznetwork.htm>

Acknowledgements

Organizing and Convening the Workshop

The following people and organizations contributed to organizing the workshop series and to convening this first workshop:

Lara Hansen, EcoAdapt

Zack Guido, CLIMAS

Leslie Meyers, US Bureau of Reclamation and the Desert Landscape Conservation Cooperative

Gregg Garfin, University of Arizona Institute for the Environment and School of Natural Resources and Environment

Courtney Conway, University of Arizona School of Natural Resources and Environment

Mima Falk, US Fish and Wildlife Service

Larry Jones, Kimberly Caringer, Gail Brooks, and Maggie Mccaffrey, US Institute for Environmental Conflict Resolution.

Robert Mesta, Sonoran Joint Venture

Speakers and Panelists

We would like to extend our sincere gratitude to all of the speakers and panelists who contributed their time and expertise to make this workshop possible.

Volunteers and Sky Island Alliance Staff

The event ran smoothly and effectively due to the excellent work of many of Sky Island Alliance's staff members including Sergio Avila, Melanie Emerson, Trevor Hare, Acasia Berry and Jenny Neeley.

Sponsors

The Climate Change Adaptation in the Arid Southwest workshop series is made possible in part through generous support from the Nina Mason Pulliam Charitable Trust and The Kresge Foundation.

Appendix A: Workshop Agenda

Monday, September 20

Morning: Climate Change Effects and Land and Resource Management Issues What We Know, Science and Programs

- 7:30 – 8:30** **Registration in Hotel Lobby and Continental Breakfast in Gold Room**
- 8:30 – 8:40** **Welcome and Orientation by Conveners in Gold Room**
Melanie Emerson, Executive Director, Sky Island Alliance
- 8:40 – 8:50** **Introduction to Desert Landscape Conservation Cooperative**
Leslie Meyers, US Bureau of Reclamation
- 8:50 – 9:00** **Setting the Stage for the Workshop**
Melanie Emerson, Executive Director, Sky Island Alliance
- 9:00 – 10:00** **Climate Change: Present and Projected Effects in the Region, Resources
and Research** *Moderator, Lara Hansen, Executive Director and Chief Scientist,
EcoAdapt*
- Climate Change Adaptation Survey Findings *Louise Misztal, Conservation Policy Program
Coordinator, Sky Island Alliance*
 - Projected Southwest Climate Changes: An Overview *Gregg Garfin, Director for Science
Translation and Outreach, Institute of the Environment, and Assistant Professor, School of
Natural Resources and the Environment, University of Arizona*
 - Fire *Tom Swetnam, Director & Professor of Dendrochronology, Tree-Ring Lab, University of
Arizona*
 - People, Place and History, *Julia Fonseca, Environmental Planning Manager, Pima County
Office of Conservation Science and Environmental Policy*
 - Forecasting Climate Impacts on Wildlife of the Arid Southwest, *Christina Vojta, Deputy
Director, USGS Southwest Biological Science Center, and Assistant National Wildlife
Ecologist, US Forest Service*
- 10:00 – 10:15** **Break**
- 10:15 – 11:00** **Climate Change: Present and Projected Effects in the Region, Resources
and Research (continued)**
- Science Topics and Needs, *Christina Vojta, Desert LCC Science Coordinator, USFWS*
 - Southwest Climate Change Initiative: Information for Managing Natural Resources in a
Changing Environment, *Marcos Robles, Conservation Science Specialist, The Nature
Conservancy*
 - Panel discussion and questions
- 11:00 – 11:45** **From Awareness to Action: Incorporating Climate Change into Your
Conservation and Resource Management Work**
Lara Hansen, Executive Director and Chief Scientist, EcoAdapt
- 11:45 – 12:00** **Goals and Logistics for Remainder of Workshop**

12:00 – 1:00 Lunch in Silver Room

Monday, September 20

Afternoon: Developing a Response to Climate Change Part I

1:00 – 3:30 Conservation and Resource Management Goals for the Region and Key Vulnerabilities, Breakout Groups Assemble in Conference Rooms

- ⇒ **Breakout A**, El Con Room (2nd floor hotel lobby), *Facilitated by Larry Fisher, Udall Foundation US Institute for Environmental Conflict Resolution*
- ⇒ **Breakout B**, Buckley Room (1st floor, hotel lobby), *Facilitated by Gregg Garfin, Institute of the Environment, University of Arizona*
- ⇒ **Breakout C**, St. Augustine Room (2nd floor, hotel lobby), *Facilitated by Lara Hansen, EcoAdapt*

Objectives for Breakout Groups

- Participants introduce themselves to each other, and explain their background and programmatic conservation and resource management goals
- Consider understanding of climate changes and impacts in the region to develop a list of key vulnerabilities
- Identify common goals and objectives the group is working toward

3:30 – 4:00 Break (Beverages Provided on 1st Floor Lobby Outside Buckley Room)

4:00 – 5:00 Shared Goals, Mandates and Vulnerabilities to Climate Change
(Reassemble in Gold Room)

- Review of themes and commonalities from breakout groups
- Are these the right themes and commonalities, what is missing
- Homework Question: What can you do about vulnerabilities to climate change in your programmatic work starting now?

5:00 – 7:00 Evening Poster Reception and Networking in Copper Room

7:15 pm Dinner (Meet up in lobby to depart for dinner at local restaurants)

Tuesday, September 21

Morning: Developing a Response to Climate Change Part 2

7:30 – 8:15 Registration in Hotel Lobby and Continental Breakfast in Gold Room

8:15 – 8:30 Welcome and Overview of Day 2 in Gold Room

8:30 – 10:00 Developing Land and Resource Management Strategies in Relation to Climate Change, Breakout Groups Assemble in Conference Rooms

- ⇒ **Breakout A**, El Con Room (2nd floor hotel lobby), *Facilitated by Larry Fisher, Udall Foundation US Institute for Environmental Conflict Resolution*

- ⇒ **Breakout B**, Buckley Room (1st floor, hotel lobby), *Facilitated by Gregg Garfin, Institute of the Environment, University of Arizona*
- ⇒ **Breakout C**, St. Augustine Room (2nd floor, hotel lobby), *Facilitated by Lara Hansen, EcoAdapt*

Objective for Breakout Groups

- Start identifying opportunities where action can be taken to ameliorate vulnerabilities. What could we be doing right now? What should we be doing right now?

10:00 – 10:15 **Break** (Beverages Provided in Gold Room)

10:15 – 11:45 **Available Science and Programs to Assist in Adaptive Natural Resource Management Efforts in Gold Room**

- Report back from breakout groups
- Current landscape scale partnerships and conservation initiatives in the region
- Case studies and discussion of local landscape scale collaborative work

Presentations

- Firescape, *Don Falk, Associate Professor, School of Natural Resources and the Environment, University of Arizona*
- Sonoran Desert Conservation Plan, *Brian Powell, Program Manager, Pima County Office of Conservation Science and Environmental Policy*
- Las Cienegas National Conservation Area, *Karen Simms, Ecosystem Planner, Bureau of Land Management*

11:45 – 12:15 **Mechanisms for Sharing, Communication, and Access to Information Related to Climate Change in Gold Room**

- Opportunities for ongoing interactions until the next workshop and beyond
- Network building

12:15 – 1:15 **Lunch** (Provided in Silver Room)

Tuesday, September 21

Afternoon: Overview and Development of the Desert Landscape Conservation Cooperative

1:15 – 2:15 **Overview of Desert Landscape Conservation Cooperative in Gold Room**

- **What is a Landscape Conservation Cooperative and What is it Not**, *Leslie Meyers, US Bureau of Reclamation*
- **What is Going on With Other LCCs – How have they been structured** *Leslie Meyers, US Bureau of Reclamation*

2:15 – 2:30 **Move to Silver Room, Gather Refreshments, Seat Yourself at a Table**

2:30 – 3:30 **Gather Input on Major Goals, Potential Structure and Membership for Desert LCC in Silver Room, moderated by Jody Erikson, Keystone Center**

1. **Existing Partnerships – What landscape scale partnerships are in the area? How could the LCC add value and support the existing partnership?**
2. **Governance Structure – What should the governance structure be to meet those goals**
 - General overall structure

- Representation – what are the criteria for selecting steering committee members?
- What is the appropriate balance of representation to make it successful?
- Possible names of key organizations
- How would you like to be involved individually? (fill out form)

3. **Wrap up and Next Steps**

3:45– 4:30

Conclusions and Next Steps, Where do we go from here? Silver Room

*Melanie Emerson, Executive Director & Louise Misztal, Conservation Policy
Program Coordinator, Sky Island Alliance*

Appendix B: Participant List

Josh Avey
Habitat Chief
Arizona Game and Fish Department
javey@azgfd.gov
(623) 236-7619

Carol Beardmore
Science Coordinator
Sonoran Joint Venture
carol_beardmore@fws.gov
602-2420524

Sergio Avila
Northern Mexico Conservation Program
Manager
Sky Island Alliance
sergio@skyislandalliance.org
520-624-7080

Brian Bellew
Field Manager
Bureau of Land Management
Brian_Bellew@blm.gov
520-258-7201

Dana Backer
Restoration Ecologist
Saguaro National Park
Dana_Backer@nps.gov
520-733-5179

Dave Bertlesen
Secretary of Board of Directors
Cienega Watershed Partnership
520-419-1308

Kerry Baldwin
Natural Resources Division Manager
Pima County Natural Resources, Parks and
Recreation
kerry.baldwin@pima.gov
520-877-6161

William Block
Program Manager
USFS Rocky Mountain Research Station
wblock@fs.fed.us
928.556.2161

Sherry Barrett
Assistant Field Supervisor
U.S. Fish and Wildlife Service
Sherry_barrett@fws.gov
(520) 670-6150 x 223

Gitanjali Bodner
Conservation Ecologist
The Nature Conservancy
gbodner@tnc.org
520-545-0178

Paul Barrett
Regional Science Advisor and Climate
Change Coordinator
U.S. Fish and Wildlife Service
Paul_barrett@fws.gov
505-248-6281

Kenneth Boykin
College Associate Professor
New Mexico State University, Department
of Fish, Wildlife, and Conservation Ecology
kboykin@nmsu.edu
575/646-6303

Erin Boyle
Assistant Forest Planner
USFS Coronado National Forest
eboyle@fs.fed.us
520-388-8357

Sharon Coe
Postdoctoral Ecologist
USFS Rocky Mountain Research Station
scoe@fs.fed.us
505-724-3684

Mark Briggs
Program Officer
World Wildlife Fund
mkbriggs@msn.com
520-548-4045

Roger Cogan
Conservation Coordinator
National Audubon/Appleton-Whittell
Research Ranch
snakeman5@rocketmail.com
520- 455-5522

Lindy Brigham
Executive Director
Southern Arizona Buffelgrass Coordination
Center
lbrigham@email.arizona.edu
(520) 626-8307

Dan Cohan
Wildlife Biologist/ GIS
USFWS Buenos Aires National Wildlife
Refuge
dan_cohan@fws.gov
520-823-4251 x107

Gail Brooks
Program Associate
U.S. Institute for Environmental Conflict
Resolution
brooks@ecr.gov
520-901-8532

Jeff Conn
Natural Resource Specialist
Bureau of Land Management - Safford Field
Office
Jeffery_Conn@blm.gov
928-348-4470

Kim Caringer
Senior Program Associate
U.S. Institute for Environmental Conflict
Resolution
caringer@ecr.gov
520-901-8534

Courtney Conway
Associate Professor
University of Arizona
cconway@ag.arizona.edu
520-626-8535

Joneen Cockman
Lead Natural Resource Specialist
Bureau of Land Management
Joneen_Cockman@blm.gov
(928) 348-4464

Sam Cushman
Research Ecologist
USFS Rocky Mountain Research Station
scushman@fs.fed.us
406-241-6537

Robert Davis
Director of Planning, Watershed and Air
USDA Forest Service - Southwestern
Region
bdavis03@fs.fed.us
505-842-3210

Jennie Duberstein
Education and Outreach Coordinator
Sonoran Joint Venture
Jennie.Duberstein@fws.gov
520-882-0837

Angela Elam
Deputy District Ranger Catalina Ranger
District
USFS Coronado National Forest
aelam@fs.fed.us
520-749-7707

Melanie Emerson
Executive Director
Sky Island Alliance
emerson@skyislandalliance.org
520-624-7080

Carolyn Enquist
Science Coordinator
USA National Phenology Network -The
Wildlife Society
cenquist@email.arizona.org
520-904-7098

Jody Erikson
Senior Mediator
The Keystone Center
jerikson@keystone.org
303-468-8862

Mima Falk
Region 2 Senior Listing Biologist
U.S. Fish and Wildlife Service
mima_falk@fws.gov
520-670-6150 x225

Don Falk
Associate Professor
University of Arizona, School of Natural
Resources and the Environment
dafalk@email.arizona.edu
520-626-7201

Deborah Finch
Supervisory Research Wildlife Biologist
USFS Rocky Mountain Research Station
dfinch@fs.fed.us
(505) 724-3671

Larry Fisher
Senior Program Manager
U.S. Institute for Environmental Conflict
Resolution
fisher@ecr.gov
520-901-8544

Julia Fonseca
Environmental Planning Manager
Pima County Office of Conservation
Science and Environmental Policy
Julia.Fonseca@pima.gov
520-740-6460

Glenn Frederick
Wildlife Biologist
USFS Coronado National Forest
gfrederick@fs.fed.us
520-803-2827

Gregg Garfin
Director of Science Translation and
Outreach
University of Arizona Institute of the
Environmental, School of Natural Resources
and the Environment
gmgarfin@email.arizona.edu
520-626-4372

Sage Goodwin
Conservation Rancher

Dave Grandmaison
Research Biologist
Arizona Game and Fish Department
dgrandmaison@azgfd.gov
520-609-2164

Zack Guido
Associate Staff Scientist
CLIMAS
zguido@email.arizona.edu
520-622-8149

Sadie Hadley
Conservation Rancher

Phil Hanceford
Associate Attorney
The Wilderness Society
phil_hanceford@twc.org
303-650-5818 x122

Lara Hansen
Executive Director and Chief Scientist
EcoAdapt
lara@ecoadapt.org
206-201-3834

Trevor Hare
Landscape Restoration Program Manager
Sky Island Alliance
trevor@skyislandalliance.org
520-624-7080

Mark Hart
Public Information Officer
Arizona Game and Fish Department
mhart@azgfd.gov
520-388-4445

Holly Hartmann
Director, Arid Lands Information Center
University of Arizona
hollyoregon@juno.com
(541) 607-6722

Colby Henley
Biologist
RECON Environmental, Inc.
chenley@recon-us.com
520-325-9977

Triska Hoover
Wildlife Specialist
Arizona Game and Fish Department
(623) 236-7619

Robert Jenks
Deputy Director
New Mexico Department of Game and Fish
Robert.Jenks@state.nm.us
505-476-8008

Chris Jones
Extension Agent
University of Arizona Gila County
Cooperative Extension
ckjones@cals.arizona.edu
(928) 402-8586

Larry Jones
Biologist
USFS Coronado National Forest
ljones02@fs.fed.us
520-388-8375

William Kepner
Research Ecologist
US EPA, Office of Research and
Development
kepner.william@epa.gov
702-798-2193

Matt Killeen
Southeast Arizona Preserves Assistant
Manager
The Nature Conservancy
mkilleen@tnc.org
520-378-2785 x113

Dee Korich
Hydrologist
Tucson Water
dee.korich@tucsonaz.gov
520-837-2238

Mark Lambert
Manager
Ironwood Forest National Monument, BLM
Mark_Lambert@blm.gov
520-258-7242

Melanie Lenart
Environmental Writer and Scientist
University of Arizona
mlenart@email.arizona.edu
(520) 792-8736; (520) 465-6877

Ries Lindley
Planner
Tucson Water
Ries.Lindley@tucsonaz.gov
520-837-2164

Brian Manwaring
Program Manager
U.S. Institute for Environmental Conflict
Resolution
Manwaring@ecr.gov
520-901-8529

Maggie McCaffrey
Program Manager
U.S. Institute for Environmental Conflict
Resolution
mccaffrey@ecr.gov
520-901-8524

Chris McCreedy
Terrestrial Division Biologist
Point Reyes Bird Observatory, University of
Arizona
cmccreedy@prbo.org
415-717-7426

Kimberlie McCue
Program Director, Conservation of
Threatened Species and Habitats
Desert Botanical Garden
kmccue@dbg.org
480-481-8137

Leslie Meyers
Bureau of Reclamation
lmeyers@usbr.gov
623-773-6276

Pamela Nagler
Research Physical Scientist
USGS Southwest Biological Science Center
pnagler@usgs.gov
520-626-1472

Louise Misztal
Conservation Policy Program Coordinator
Sky Island Alliance
louise@skyislandalliance.org
520-624-7080

Jenny Neeley
Conservation Policy Director
Sky Island Alliance
jenny@skyislandalliance.org
520-624-7080

Laura Monti
Program Manager, The Greater Southwest
The Christensen Fund
laura@christensenfund.org

Larry Norris
Southwest Research Coordinator
National Park Service
lnorris@ag.arizona.edu
520-621-7998

Gary Paul Nabhan
Research Scientist
University of Arizona Southwest Center
gpnabhan@email.arizona.edu
520-394-0026

Ken Nussear
Research Wildlife Biologist
USGS
knussear@usgs.gov
702 564-4515

Joanna Nadeau
Research Analyst
University of Arizona Water Resources
Research Center
jnadeau@cals.arizona.edu
520-621-7292

Laura Olais
Ironwood Forest National Monument, BLM
Laura_Olais@blm.gov

Chris Nadeau
Wildlife Biologist
University of Arizona, School of Natural
Resources and the Environment
cnadeau@email.arizona.edu
520-730-6885

Liz Petterson
Director, Land and Water Program
Arizona Land and Water Trust
lpetterson@alwt.org
520-577-8564

Brian Powell
Program Manager
Pima County Office of Conservation
Science and Environmental Policy
brian.powell@pima.gov
520-740-6440

Adrian Quijada-Mascareñas
Research Assistant Scientist/ Adjunct
Professor
University of Arizona, School of Natural
Resources and the Environment
aquijada@cals.arizona.edu
520-626-7621

William Radke
Wildlife Refuge Manager
USFWS San Bernardino National Wildlife
Refuge
bill_radke@fws.gov
(520) 364-2104 ext 101

Marcos Robles
Conservation Scientist
The Nature Conservancy
mrobles@tnc.org
520-622-3861

Dennis Rule
Manager Inter-Agency Relations
Central Arizona Project
drule@cap-az.com
623-869-2667

Eva Sargent
Director Southwest Program
Defenders of Wildlife
esargent@defenders.org
520-623-9653 x4

David Schaller
Principal Climate Expert
Westmoreland Associates
daschalelr@me.com
520-269-7523

Cecil Schwalbe
Ecologist
USGS Southwest Biological Science Center
cecils@email.arizona.edu
520-621-5508

Ray Schweinsburg
Research Supervisor
Arizona Game and Fish Department
rschweinsburg@azgfd.gov
(623) 236-7251

Karen Simms
Ecosystem Planner
BLM Tucson Field Office
karen_simms@blm.gov
(520) 258-7210

Linda Stitzer
Regional Planner
Arizona Department of Water Resources
lsstitzer@azwater.gov
602-686-0035

Don Swann
Biologist
Saguaro National Park
Don_Swann@nps.gov
520-366-5177

Thomas Swetnam
Director and Professor of Dendrochronology
University of Arizona Tree Ring Lab
tswetnam@lrr.arizona.edu
520-621-2112

Scott Wilbor
Arizona Important Bird Areas (IBA)
Conservation Biologist
Tucson Audubon Society
swilbor@tucsonaudubon.org
520-629-0510 x7004

Darrell Tersey
Ironwood Forest National Monument, BLM
Darrell_Tersey@blm.gov

Jeff Williamson
President
Arizona Zoological Society
jwilliamson@thephxzoo.com
602-914-4325

Willem van Leeuwen
Assistant Professor
University of Arizona
leeuw@ag.arizona.edu
520-626-0058

Christina Vojta
Desert LCC Science Coordinator
U.S. Fish and Wildlife Service
christina_vojta@fws.gov
(928) 310-6995

Christa Weise
Borderlands and Latin American
Coordinator
Bat Conservation International
cweise@batcon.org
520-955-4164

Jake Weltzin
Executive Director, Ecologist
USA National Phenology Network, USGS
jweltzin@usgs.gov
520-626-3821