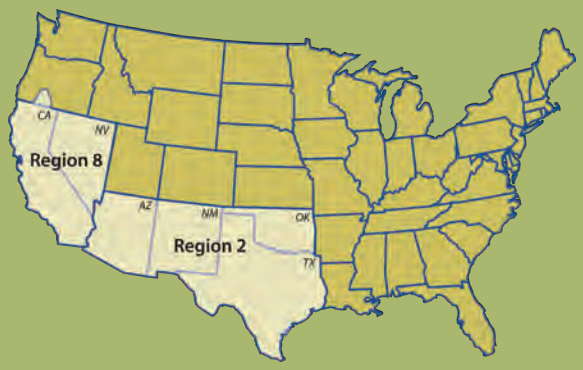
Putting Knowledge into Action:

Tapping the Institutional Knowledge of U.S. Fish and Wildlife Service Regions 2 and 8 to Address Climate Change



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Climate Assessment for the Southwest
The University of Arizona
In collaboration with the U.S. Fish and Wildlife Service

CLIMAS
Climate Assessment for the Southwest

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A synthesis of World Café discussion sessions during the FWS, USGS, and UA Sponsored Climate Change Workshop

August 18–20, 2008
Tucson, Arizona

Climate Assessment for the Southwest
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Table of contents

Executive summary

The Fish and Wildlife Service (FWS) partnered with the U.S. Geological Survey and The University of Arizona in August 2008 to host a climate change workshop in Tucson, Arizona. During this two-day event, the Climate Assessment for the Southwest (CLIMAS) facilitated four discussion sessions with participants divided into small groups. More than 200 people from 34 organizations participated in these sessions; more than 65 percent of these participants represented the Fish and Wildlife Service's regions 2 and 8. Participants discussed important issues related to climate change and natural resource management.

The discussions produced a wealth of information, spanning topics that included climate change priorities and concerns, needs, methods to incorporate climate change in decisions, institutional obstacles, and new opportunities. The following information is a synthesis of the recurring comments, suggestions, and recommendations of the participants.

Pervasive Themes

Priorities
According to participants, the four most important climate change actions were (1) climate change educational programs for the public; (2) landscape scale conservation planning; (3) scientific research to study climate and ecosystem connections; and (4) improved communication and collaboration with partners.

Partnerships
Participants repeatedly stated effective climate change planning will require fortifying existing partnerships and developing new ones, which includes collaborating more with non-traditional organization and universities.

Management
Participants often stated that clear climate change strategies and protocols will help managers and staff develop and implement climate change actions, and that conservation plans be at the landscape scale, concentrate more heavily on ecosystems than on individual species, include monitoring, and promote an interdisciplinary approach.

Staff Capacity
According to participants, recurring training for existing staff and increasing the institutional expertise through new hires will improve the capacity of the FWS to develop effective climate change planning strategies.

Challenges
Participants noted major barriers to climate change action, including a lack of partnership with other agencies and universities, poor communication within the agency and with other agencies, and underdeveloped staff capacity to interpret and use climate data and information.

Opportunities
Participants emphasized that climate change presents opportunities that include strengthening existing partnerships, teaming with new partners, and pooling resources and expertise to tackle climate change challenges.

Primary Recommendations

- Participants suggested a more vigorous public outreach effort to address climate change.
- Participants highlighted a need to improve the communication of science to the public and decision makers.
- Many participants recommended that creating accessible databases and data-use protocols will help improve communication among agencies and among FWS programs.
- Participants recommended improving staff expertise either through training or new hires; several groups suggested adding climatologists to FWS staff.
- Participants called for training on interpreting and using observational and model data.
- Many discussion groups suggested building new partnerships and fortifying existing ones. This involves increasing involvement with community programs and organizations, creating ambassadors to local communities, building new collaborations with existing partners, and leveraging citizen science activities.
- Participants indicated a need for more synthesized information, such as impact assessments and fact sheets.
- Many participants stated the FWS should make a commitment to monitoring and boost efforts to collect more climate change-related information.
- Participants requested guidance from upper-level management in the form of a climate change strategy with clear guidelines and protocols to help managers and scientists make proper decisions—participants called for guidance on interpreting uncertainty in climate model projections.
- Many participants asked the FWS to lead by example and reduce their carbon footprint.

Introduction: Putting knowledge and science into action

Climate change is unequivocal, according to the Intergovernmental Panel on Climate Change (IPCC) 2007 Fourth Assessment Report.[1] Within the scientific community, there is little doubt that climatic changes will continue, in large part sustained by the emissions of greenhouse gases generated from human activities. In many landscapes across the United States, the effects of climate change are already being observed. Increasing atmospheric surface temperatures and declining mountain snowpacks are a few changes that have been observed at an increasing rate since the 1970s. The future also looks warmer. According to state-of-the-art climate models that are driven by moderate increases in greenhouse gases, average summer temperatures in the Southwest may rise by 4 to 6 degrees Fahrenheit by mid-century, while the winter temperature range may be a degree less (Figure 3). At the end of the century, global average temperatures may increase between 2 and 12 degrees F, with the Southwest experiencing more radical changes.[2]

> *"The warming of the earth could potentially have more far-reaching impacts on wildlife and wildlife habitat than any challenge that has come before us,"*
>
> –Dale Hall, former director of the U.S. Fish and Wildlife Service[3]

Changes in temperature and precipitation have cascading effects, influencing the size and frequency of fires, the timing of plant and animal life-cycle events, the distribution and extinction of species, and many other ecosystem phenomena. Climate change will therefore challenge the primary responsibilities of the U.S. Fish and Wildlife Service (FWS), presenting obstacles as well as new opportunities for the conservation, protection, and enhancement of fish, wildlife, and habitats.

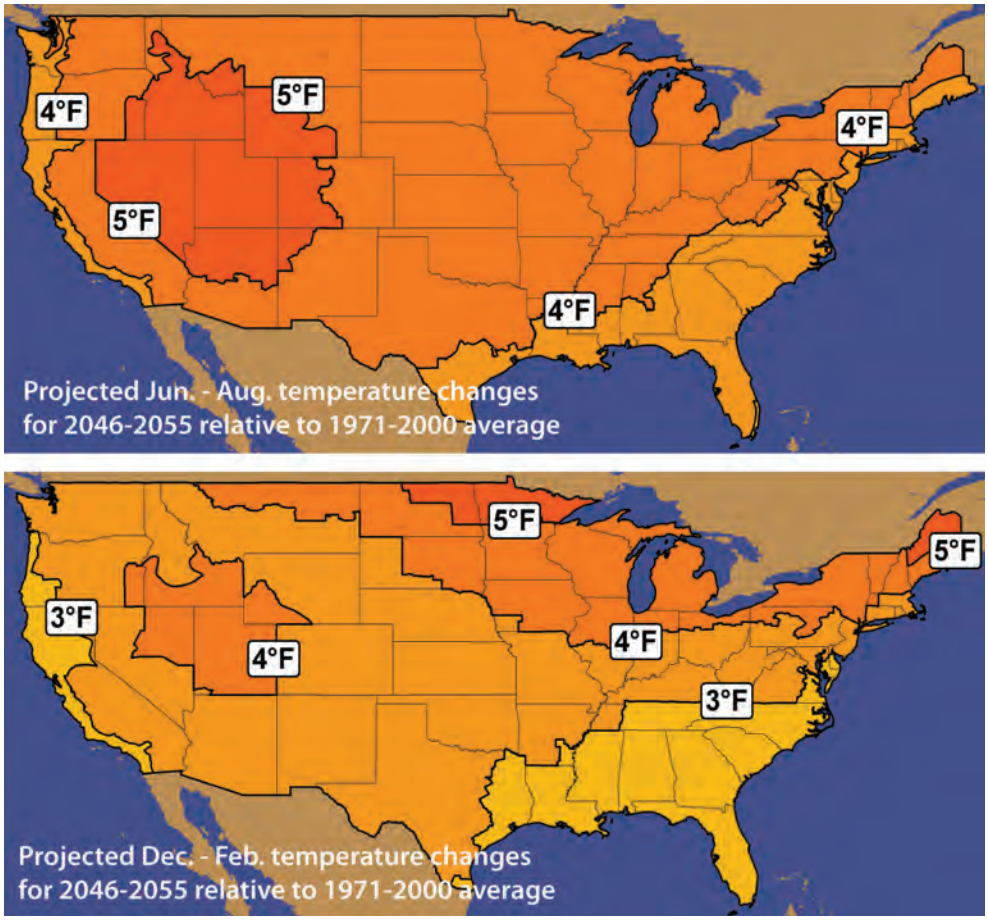
Natural resource organizations like the FWS realize effective management should incorporate strategies that address future climate change. Acknowledging the importance of climate change is a step forward. Planning for it, however, is more difficult. The challenges are great. They involve prioritizing research, filling knowledge gaps, understanding uncertainties, developing new partnerships and strengthening established ones, communicating science, and educating staff and public.

The FWS is well-situated to meet these challenges and advance management practices for adapting to a

changing climate by virtue of having authority to work across jurisdictional boundaries, conserve migratory and endangered species, and utilize the National Wildlife Refuge System to implement large-scale land conservation. Inserting climate change knowledge and science into action, however, requires the FWS to closely consider management strategies and seek ideas and suggestions from FWS personnel as well as from partner agencies and other collaborators.

The Southwest Region of the FWS recently began engaging the U.S. Geological Survey (USGS) and other natural resource management agencies, the academic community, and interest groups to translate science into action. The goal of these partnerships is to reduce the impacts of a changing climate on the diverse ecosystems of the Southwest, including California, Nevada, Arizona, and New Mexico. Part of this process involved convening the workshop, *Effects of Climate Change on Fish, Wildlife and Habitats in the Arid and Semiarid Southwestern United States: Putting Knowledge and Science into Action.* Held in Tucson, Arizona, in August 2008, the workshop brought together a diverse group of FWS and USGS employees, university scientists, and other interested parties. During this event, the FWS organized climate change discussion sessions, harnessing the knowledge and suggestions of its human resources and other participants to understand how to approach conservation from new perspectives, and to build institutional capacity and more effectively partner with the conservation community to meet the challenges of climate change.

Figure 3. Using 18 global climate models and the moderate "A1B" emissions scenario, researchers at the NOAA Earth System Research Laboratory (ESRL) predict warming across the U.S. by mid-century. The maps were produced by Jeremy Weiss of the University of Arizona, using data from Hoerling and Eischeid of NOAA ESRL.



Supplemental Text: Climate Change Impacts

Climate change and variability shape wildlife and landscapes. Research in the Southwest has documented climate-change related impacts and suggests that these changes will continue. Some of the impacts are summarized below. More details and corresponding citations can be found at the Southwest Climate Change Network access on the Web at: www.southwestclimatechange.org.




Temperature

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. The Intergovernmental Panel on Climate Change (IPCC) projects the world's average annual temperature this century will likely increase between 3 and 7 degrees. Projections for the Southwest show greater temperature increases than the global average, with summer temperatures rising even higher than winter ones.

Precipitation

Precipitation records for the Southwest contain a high degree of variability. The observational evidence shows some support for Global Climate Models (GCMs) projections of a poleward shift in the jet stream, a pattern that could mean El Niño events might often fail to bring rain and snow to the Southwest. Annual precipitation is projected to drop by 5 percent by century's end for much of Arizona and New Mexico, based on results from GCMs.

Fire

In recent years, the number of acres burned and the frequency of fires have increased in the West. Temperature increases and possible reductions in winter precipitation will likely cause this trend to continue, although other factors may also influence future fires.

Snowpack

In comparison to time periods before 1950, winter snowpack is melting earlier in the year; rain is replacing some snow storms, especially at elevations of 5,000–8,000 feet; and the April snowpack contains less water. Higher projected future temperatures will likely continue these trends.

Streamflow

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 due in large part to declines in the amount of snow and higher evaporation.

Phenology

Studies document an advance in the date that flowers bloom in the West. Because the date and abundance of flower blooms are highly correlated with winter snowpack, projected declines in snowpack will decrease flower abundance and advance the date of flowering.

The Workshop

The FWS Southwest Region 2 and California and Nevada Region 8 (see map below), along with the central and western regions of the USGS, collaborated with The University of Arizona (UA) to sponsor a workshop on the effects of climate change on arid and semi-arid ecosystems. The three-day workshop was held at the Loews Ventana Canyon Resort in Tucson, Arizona, on August 18–20, 2008. At the event, renowned climate scientists and respected natural resources managers presented climate change information and stimulated discussion to help identify ways to reduce the impacts of climate change in the deserts of the southwestern U.S.

More than 200 people from 34 organizations attended the workshop, including representatives from federal and state agencies, universities, and non-governmental organizations (see participant list, Appendix 1). FWS employees accounted for 132 of the attendees, while 23 USGS employees participated.

Job responsibilities of workshop participants were diverse and included agency regional directors, regional coordinators, refuge managers, field supervisors, staff scientists, and toxicologists. The specific fields of expertise of participants were also diverse because FWS and USGS regions include coastal areas, desert ecosystems, riparian areas, mountain environments, and many other habitats.

The workshop consisted of a poster session, nine half-hour presentations by invited guests, two panel sessions, and four World Café group discussions. The guest presentations focused on three topics:

- climate change and ecosystem responses
- climate change as an ecological driver
- adaptive management: tools and strategies

The panels were devoted to federal land management and non-governmental organizations. Jonathan Overpeck, professor of geosciences at The University of Arizona, delivered the keynote address on August 19 (see Appendix 2, Workshop Agenda).

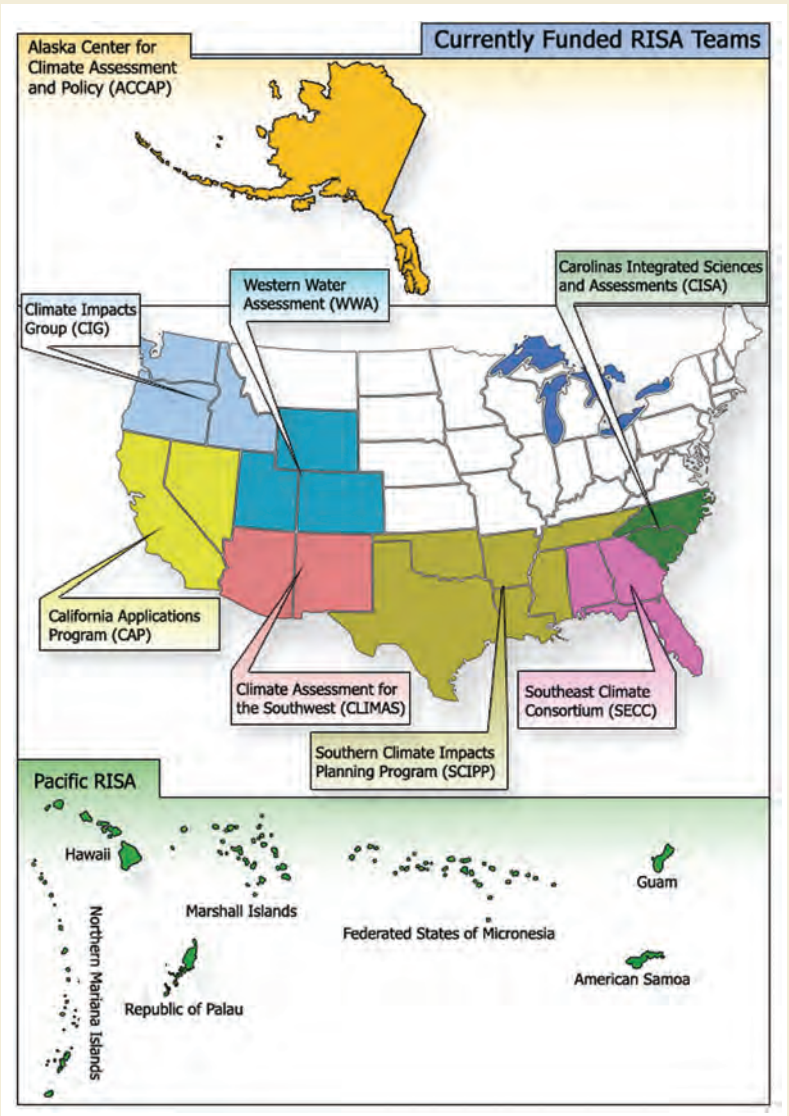
World Café participants discussed climate change questions in small groups. These sessions captured the ideas and knowledge of the FWS and other organizations, identifying scientific research and information needed to help resource managers plan for anticipated climate change impacts on wildlife and habitat in the Southwest. The Climate Assessment for the Southwest (CLIMAS) guided the World Café sessions. CLIMAS is part of the National Oceanic and Atmosphere Administration's (NOAA) Regional Integrated Sciences and Assessments program and has a mission to connect science with decision making.

Supplemental Text: The Climate Assessment for the Southwest

The Climate Assessment for the Southwest (CLIMAS) project is a leader in advancing climate research to address the unique human and ecological needs of the Southwest region. CLIMAS scientists work directly with stakeholders to generate useful knowledge and tools to improve the region's ability to prepare for and adapt to climate variability and change—and for creating opportunity in the face of uncertainty. Sustained dialogue between scientists and knowledge users is the cornerstone of CLIMAS partnerships.

CLIMAS began in 1998 to meet the societal challenges associated with climate change and variability at a regional level. It is one of nine Regional Integrated Sciences and Assessments (RISA) programs created by the National Oceanic and Atmospheric Administration (NOAA). Each RISA operates from the same perspective: a strong public, private, and academic partnership most effectively builds the region's knowledge and supports actions to understand and adapt to regional climate impacts.

Located at The University of Arizona, CLIMAS brings together a multidisciplinary team of social, ecological, and physical scientists to conduct research on climate and its impacts in Arizona, New Mexico, and the adjacent Mexico border area. Researchers collaborate with state and federal agencies, the private sector, communities, and individuals to develop science-based products useful for planning and decision making. CLIMAS projects have included providing research and guidance for the Arizona Drought Preparedness Plan, developing a Web-based climate forecast evaluation tool, researching the potential implications of climate variability and change for water policy, and co-organizing a multi-federal agency partnership to produce timely fire season forecasts. All of these projects have informed decision-makers.



www.climas.arizona.edu

CLIMAS
Climate Assessment for the Southwest

Methods: World Café—a method to mine intelligence

World Café discussions help build knowledge, form partnerships, and stimulate action by fostering group dialogs that focus on challenging questions. During group discussions, participants explore provocative questions in small groups, periodically changing groups to spread ideas. Advantages of the World Café are that small groups provide a comfortable setting to share opinions and knowledge and the intimate conversations build on each other as people move between groups, cross-pollinate ideas, and make new connections with people and ideas.[4] The most productive dialogues often occur in diverse groups and with provocative questions. During separate workshop sessions, World Café participants addressed questions related to the impacts climate change will have on species and habitat management. The order and content of the sessions were designed to elicit information that reflects the diverse ideas and knowledge of the participants.

During the workshop, attendees participated in four, 45-minute sessions. Two consecutive sessions occurred on Tuesday, August 19, and two on Wednesday, August 20. For each session, participants divided into different groups consisting of approximately 10 people. Each discussion group addressed the same set of questions; groups were asked 14 questions during the two days (see World Café Questions, page 10). Each group had a facilitator and a scribe. Facilitators ensured that the conversation stayed focused on the questions and encouraged everyone to speak, while scribes recorded salient aspects of the discussion on a notepad. At the end of the first session on each day, groups disbanded and participants assimilated into new groups to address new sets of questions.

A small committee made up of representatives from the FWS, USGS, and CLIMAS formulated the questions prior to the meeting. The questions focused on seeking possibilities rather than fixing problems. They were open-ended and thought-provoking, and did not focus on discovering an immediate answer (see Appendix 3, World Café Ground Rules). The questions on the first day related to participants' concerns and needs regarding climate change, institutional obstacles and opportunities for climate change planning, and their suggested strategies and priorities for addressing climate change challenges. The questions on the second day focused on predicting risk, dealing with uncertainty, and climate change research needs for southwestern ecosystems.

Some of the issues broached during the second day were also raised in the previous day's sessions and discussed by guest presenters. This enabled participants to assimilate previous conversations and presentations into the discussion. It also prompted participants to re-explore topics from different perspectives.

Most questions produced qualitative information. One question, the Priority Exercise, generated quantitative data. For this question, each participant chose their top three actions by allocating a virtual $100 between three of fifteen choices in a predefined list, which included an option to write-in an action not included in the list (see box, page 11). Allocating $100 revealed each individual's most important action–the one that received the most money–and the relative importance of the three most important actions to which they apportioned money. There were 151 valid responses; 16 were not analyzed because the exercise was not completed properly. Of the 151, 25 responses allocated an equal value to the top priority. For example,

Supplemental Text: World Café Questions

August 19, 2008

Discussion One (45 minutes): Concerns, Needs

1. What is your single most important issue related to the potential effects of climate change in your region and their biological components?
2. In order for you to apply climate change science to anticipate changes in your operations, what are the key questions you need to have answered?
3. What kind of climate change products would help facilitate desert ecosystem management decisions?

Discussion Two (50 minutes): Strategies, Priorities

1. What are some institutional/agency obstacles to moving forward with implementing climate change planning in the U.S. Fish and Wildlife Service's Regions 2 and 8?
2. What are some opportunities for moving forward with implementing climate change planning for the U.S. Fish and Wildlife Service?
3. Where should the science, management, and outreach communities put their efforts? Instructions: Assign a total of $100 to your top 3 priorities.
4. If you had to select only one of these actions to include in your budget planning for the FY-2010-2011 budget cycles, which one would you select and why?

August 20, 2008

Discussion One (45 minutes): Predicting risk and dealing with uncertainty

1. How do we decide if the available climate change data can be appropriately used to make a particular decision? What characteristics of the data must be considered (e.g., scale, specificity to species, or habitat type)?
2. What is the process used to determine if species are at risk from climate change? What are the most important factors in determining what species are at risk?
3. How do we interpret climate change data/models and make decisions using these data/models when they may have high levels of uncertainty?
4. Based on money, time, and effort, when do we—OR do we?—stop expending management energy on a species? When does human/artificial selection override natural selection?

Discussion Two (45 minutes): What next? Climate change research needs for southwestern ecosystems

1. For which southwestern ecosystems and processes (e.g., fire) are climate change data already available? What Southwest ecosystems are under-studied with respect to climate change?
2. Looking at the research questions identified yesterday, what criteria should be used to prioritize research questions? Which of the previously identified questions are most important and why?
3. How will climate change issues alter how we engage and seek partners to meet future research and management needs?

one response awarded $40 dollars to two actions and $20 to a third, while another awarded $33.3 to each of three actions. For these responses, each of the actions receiving the most dollars was considered a top priority. The total number of top priority responses was therefore 189, not 151.

The responses from the Priority Exercise generated two results: the highest priority action and the relative importance of the top three priorities. The highest priority was defined as the number of times each action received the most allocated dollars, which resulted in a simple tally of how many times an action was given the highest dollar allocation by a participant (Figure 1). The top three priorities were defined as the three actions that received allocated dollars. From this, the relative importance of the top three priorities was determined by tallying the 151 responses and finding the average amount of dollars allocated to each action (Figure 2).

All other questions generated qualitative information. To analyze this information, CLIMAS staff transcribed each question's responses and initially sorted them by question and by topic. The responses were then synthesized into the similar topics: *priorities and concerns, knowledge gaps, making decisions, institutional obstacles,* and *opportunities.*Participant responses to these topics are presented in the following Institutional Knowledge section. The information in each section draws most heavily upon common responses and the responses that provided specific information. Some responses were excluded as a result of unclear language.

Supplemental Text: Priority Exercise

Instructions:
Assign a total of $100 to your top 3 priorities to guide the U.S. Fish and Wildlife Service in moving ahead on climate change adaptation. Write your dollar amounts in the boxes to the right of your choices. For example:

- **$50 Improve climate monitoring**
- **$30 Improve communication**
- **$20 Pilot projects**

BALLOT

Action	$$$	Action	$$$
Climate change education and training programs for resource managers		Improve model projections	
Climate change education programs for the public		More science to study climate-ecosystem connections (including species responses to climate)	
Climate change education and training programs for agency decision makers (regional or national levels)		Pilot projects to demonstrate climate change adaptation strategies at a landscape scale	
Gather or improve quality of baseline data		Identify practical climate change adaptation options for natural resource managers	
Improve climate monitoring		Habitat conservation and/or restoration	
Improve data access and climate change information sharing		Landscape scale conservation planning (e.g., looking across ownership boundaries)	
Improve ecosystem monitoring		Improve communication and collaboration with partners	
Write-in:			

Figure 1. The percent and number (located to the right of the bars) of participants who selected each of the actions as their highest priority. For example, 28 participants, or about 15 percent allocated more money to "Public climate change education" and "scientific research to study climate-ecosystems connections" than the other options. The total number of responses was 189, which includes 25 responses that had more than one top priority—the same amount of dollars was allocated to two or three actions.

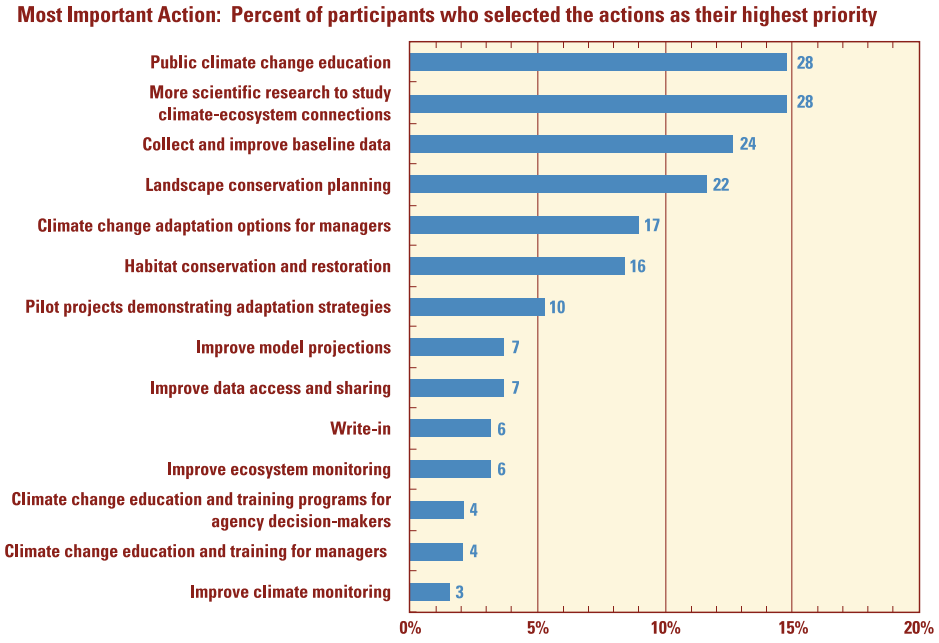
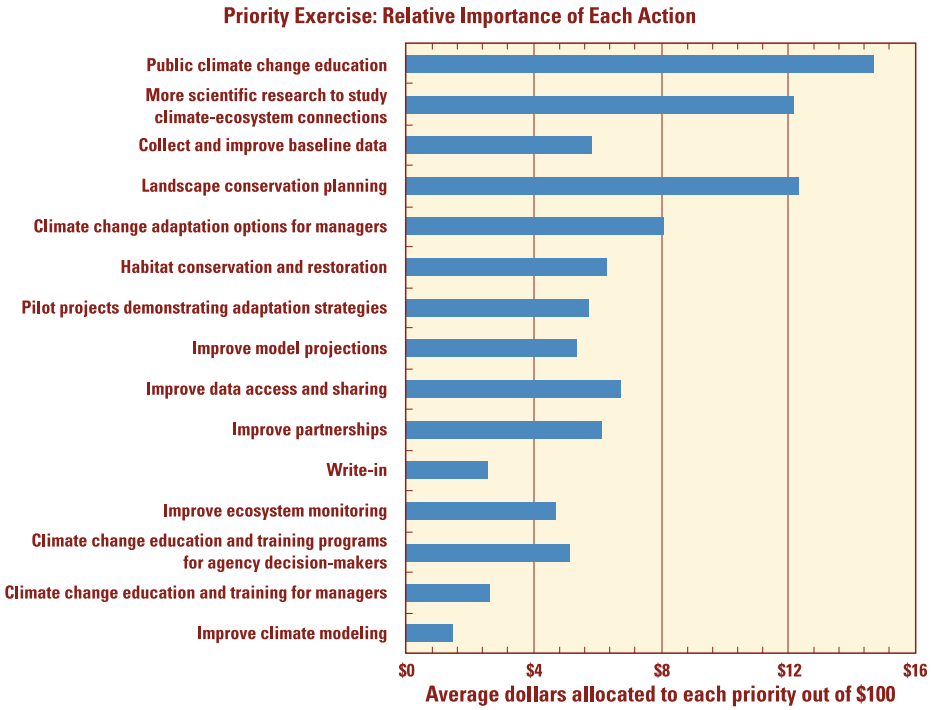


Figure 2. The relative importance of each of the actions was determined by the average dollar amount that was allocated to each action. During the Priority Exercise, each participant allocated $100 to only three of the fifteen actions listed, participants had an option to write in an action that was not on the list. The average was found from analyzing 151 responses. The actions were chosen by the workshop planning committee.



Institutional Knowledge: Information gleaned from World Café sessions

The World Café sessions generated a wealth of information. The responses document many perspectives of FWS, USGS, and other participants about climate change. They reveal climate change priorities and concerns, resources needed to address priorities, the ways to incorporate climate change in decisions, institutional obstacles, and new opportunities.

This section summarizes responses to the 14 World Café questions. The information collected represents the ideas of more than 200 people from 34 organizations. Most participants are involved in land management, and about 60 percent of the workshop attendees work for the FWS.

Priorities and Concerns: Directing science, management, and outreach efforts

Priorities

Important findings based on participant discussions

- *Public education about climate change and more scientific research to study climate-ecosystem connections received the same number of "highest priority" votes and more than any other action.*
- *The four "most valued" actions were climate change educational programs for the public, landscape scale conservation planning, more scientific research to study climate and ecosystem connections, and improved communication and collaboration with partners.*

The Priority Exercise enabled a quantitative assessment of the important actions participants felt the FWS should emphasize in science, management, and outreach. This exercise provided insight into the most important action and the relative importance of each to each other.

The actions *"Climate change education programs for the public"* and *"more scientific research to study climate and ecosystems connections"* had the same number of top priority votes. About 15 percent of the participants, or 28 people, allocated more money to these two options than the other 13 choices, which included topics related to education, data acquisition, scientific research, and communication (Figure 1). Figure 1 reports the ranking of the most important action.

The Priority Exercise required that each participant allocate money to only three actions, which revealed the relative importance of the actions. In Figure 2, the top three priorities selected by individuals are similar to the results presented in Figure 1. *"Climate change education programs for the public"* has the most dollars allocated and *"landscape scale conservation planning"* is slightly more important than *"more scientific research to study climate and ecosystem connections."* These results provide insight into the value participants assigned to their top three choices; viewed collectively, the results demonstrate a hierarchy of the actions.

The most notable differences between the hierarchy of the highest priority and the top three priorities is the difference in the ranking of "collect and improve baseline data." While participants selected it as the highest priority 24 times—the third highest number—it received only the eighth highest average dollars allocation. Participants allocated twice as much or more dollars to the top three highest priorities than to "collect and improve baseline data." This suggests

that although many people thought this action was the most important it received less value than other choices (Figure 2). This would be analogous to a community that agrees education is the most important priority for the community but is less willing to fund school improvements than improvements to roads.

The differences between Figures 1 and 2 are subtle, and can be best understood as a simple decision tree. For example, if the FWS can only choose one action to pursue, Figure 1 provides guidance. However, if the FWS can undertake more than one action, consulting figure two is more appropriate.

Participants also added six actions that were not included in the list, four of which were the highest priority of the response. These four responses included more federal action to solve the problem; communicate with the public about the biological effects of climate change; tie [climate change] information to community, economic, and lifestyle impacts; and more budget allocation to address climate change activities.

Although participants allocated substantially more money to three actions, every action was selected at least once. Nine of the actions formed a second tier, with average allocations ranging between $5 and $8 (Figure 2). Only two actions were revealed to be relatively unimportant, based on the average amount that participants allocated: improve climate monitoring and climate change education and training programs for resource managers. In response to other questions, however, many participants discussed the importance of these actions.

After participants individually listed their top priorities, each group discussed the priorities and collectively chose the three most important, providing explanations for the hierarchy. The groups' results were similar to the individual responses. The highest collective priority was climate change education programs for the public. Several groups justified this ranking with comments like, "Without public support we don't have backing." Landscape scale conservation planning was the second priority. One group's comment that "with limited financial resources, landscape conservation gets the most bang for the buck" summarized the feelings of several groups. The collective third priority, however, was different from the individual responses. Collectively, the groups stated that improved communication and collaboration with partners, which includes federal and state organizations and private stakeholders, was very important. No group gave an explanation for this priority ranking.

The analysis of the top priority and the top three priorities suggests that the two most important actions are public education and more scientific research for climate and ecosystem connections. The results also convey that many actions are important to FWS and other participants. This suggests that a resource management plan that addresses the impacts of climate change will include at least some of them and emphasize public education, scientific research, and landscape-scale conservation practices.

Concerns

Important findings based on participant discussions

- *Participants highlighted three areas of concern: FWS policy and management, water issues, and impacts on species and habitat.*

Among these, participants specified numerous concerns, including:

- *Adapting Habitat Conservation Plans to accommodate climate change*
- *Expanding staff capabilities in science and public outreach*
- *Coping with the impacts of reduced and changing water resources*
- *Managing habitat that becomes destroyed or fragmented*

In addition to priorities, groups identified issues in which the effects of climate change on ecosystems create concern. The responses highlighted three areas of concern: **(1) FWS policy and management, (2) water issues,** and **(3) impacts on species and habitat.** These concerns offer a more focused appraisal of important climate change issues than the broader action categories identified above.

According to participants, new management challenges will arise as a result of climate change. The most prominent concerns are related to policy. Participants posed numerous policy questions, implying that more direction is needed. Common questions were:

- How does FWS adapt habitat conservation plans (HCP) to accommodate climate change?
- How does FWS use Safe Harbor Agreements and other tools to facilitate species and habitat recovery?
- How does FWS allocate resources?
- How does FWS identify species most vulnerable to climate change?
- How does FWS prioritize which vulnerable species are managed?
- When does FWS begin assisted movement?

Several of these issues were addressed in subsequent World Café discussions and are summarized in the section "Making Decisions."

Participants also noted that climate change will require more public outreach, staff, employee training and expertise, and effective interagency communication and information sharing. They also stated that funding has been limited for research, outreach, administration, and resource management, suggesting a need for more financial resources for these activities.

Water issues were also a central concern. Participants expressed concern that climate change will likely reduce groundwater recharge, cause changes in the seasonality of river flows, dry sections of perennial streams, reduce snowpack and accelerate melting, increase extreme precipitation events that cause flooding, and alter water quality. Several responses also specified that adapting to future Colorado River management will be challenging and additional obstacles will arise because some wildlife refuges have junior water rights.

Participants also highlighted concern that climate change will destroy and fragment habitat. Participants mentioned that challenges associated with these disturbances will affect species' ability to move between habitats, altering their interactions and disrupting migratory paths, to name a few effects. Addressing this concern will require, according to participants, better understanding species' sensitivity to climate change and how species' ranges will change in a warming world. Related to these concerns is the issue of invasive species management in the context of climate change, which is also a central concern for participants.

Knowledge gaps: Research and decision-support resources needed to improve management

Incorporating climate change information into public education, institutional research, conservation planning, and collaborative relationships are the most important priorities, according to workshop participants. Several questions prompted the participants to expand on these answers and discuss the resources needed to help the FWS effectively address the priorities and concerns. According to many discussion groups, climate change training and education for existing staff and new personnel with climate expertise is needed. This recommendation may seem contradictory to the results from the Priority Exercise, which assigned a low value to climate change education for FWS managers and decision makers. However, this recommendation emphasized that managing for climate change requires many strategies, including increasing FWS staff capacity in addition to the ones given a higher preference in the Priority Exercise. While increasing staff capacity is important, many responses also revealed that specific ecological information is missing, models need improvements, and decision-support resources for FWS staff need to be acquired.

Research

Important findings based on participant discussions

- *Many people are unaware what climate change data are available and where to obtain them.*
- *There are needs for finer resolution climate models and less uncertainty in the large-scale global circulation models.*
- *Knowledge of and capacity to integrate climate and ecological models will help resource management.*

According to participants, many people do not know what kinds of data—climate, biological, or other—are available, the extent to which they are available, and where to obtain them (see Supplemental Text: Climate Data and Monitoring). This relates to a common theme permeating most discussions—a call for better communication between agencies and among FWS programs. Participants indicated that improving these communication issues would require more effective information sharing and the creation of data protocols and commonly accessible databases.

Supplemental Text: Climate Data and Monitoring

There are many active weather and climate monitoring networks that have been collecting data for more than 100 years. While some networks electronically bounce information off satellites every minute, others require people to physically read thermometers. Some networks have stations in sunny, windy places to monitor fire risk, others are located in rural areas to assess conditions for agriculture. But data are not created equal. Every data set has issues—some more than others. Knowing the details of observations and data quality control help match the proper data set to the application.

Details of Climate and Weather Monitoring Networks

Network	Data Source	Climate Variables	Recording Intervals	Record Length	Primary Application	Quality Control	Web Host
Coop	12,000 active Coop stations; ~170 in AZ and ~180 in NM	1. Maximum temp. 2. Minimum temp. 3. Daily total precip. 4. Daily total snow 5. Others	Once a day	1880 – present; varies by station	Support public services with near real-time data	Some quality control after data acquisition	1. National Climatic Data Center 2. Western Regional Climate Center
HCN	1,221 stations selected from Coop network	1. Maximum temp. 2. Minimum temp. 3. Daily total precip. 4. Daily total snow	Once a day	Most stations have data for 80 years or more	Detect and monitor changes in regional climate	Extensive quality control after data acquisition	1. National Climatic Data Center 2. Carbon Dioxide Information Analysis Center
RAWS	2,200 remote automated stations; 130 in AZ and NM	1. Temperature 2. Precipitation 3. Wind speed 4. Relative humidity 5. Others	Minute to hourly	Many stations became active in the mid-1980s	Monitor fire-risk	No quality control	1. University of Arizona
AZMET	28 automated stations in rural and urban areas in AZ	1. Temperature 2. Precipitation 3. Evapotranspiration 4. Others	Hourly	1986 – present; varies by station	Support agriculture and horticulture in southern and central Arizona	Some quality control after data acquisition; routine station maintenance	1. Desert Research Institute
PRISM	Coop, SNOTEL, local stations, and statistically generated data	1. Maximum temp. 2. Minimum temp. 3. Average temp. 4. Precipitation	Monthly	1895 – present	Produce detailed, high-quality spatial climate datasets	Depends on data source	1. Western Regional Climate Center

Coop: Cooperative Observer Program; HCN:Historical Climate Network; AZMET: Arizona Meteorological Network; PRISM: Parameter-elevation Regressions on Independent Slopes Model; RAWS: Remote Automated Weather Stations; SNOTEL: snow telemetry

The discussions also revealed a diverse array of potential research targets, with some specific examples of understudied ecosystems. Table 1 summarizes the results.

The discussions included a common refrain that climate models need to be improved in order for their output to be valuable for FWS management decisions. Several responses highlighted the desire for less uncertainty in the large-scale global circulation models (GCM) and for finer resolution climate models. Participants noted that improved models would enhance confidence in climate change impacts on species and habitats. The numerous comments about inadequate model performance underscore the feeling that data generated from the current climate models are not ready to be incorporated into landscape-scale planning. Several responses can be summed up in a quote from one group: "We need climatologists to make predictions that they have confidence in." These remarks suggest the FWS should develop guidance on uncertainty in climate model projections. This may include training in understanding uncertainty and developing methods or protocols for using estimates that have high uncertainty in planning processes. A subsequent discussion question, summarized in the succeeding section, "Using Uncertain Information," addresses the utility of uncertain information.

Many participants recognized that assessing the impacts of climate change on ecosystems is an interdisciplinary process. The need to better integrate climate and ecological models was explicitly mentioned by some groups. Other groups stated that a broader ecosystem management picture needs to be addressed, in part by "combining ecological, sociological, and economical models." These comments relate to the emerging field of integrated assessments, which has the ability to enhance conservation practices.

Table 1. Research Gaps Identified by Workshop Participants

Habitats	Species	Geographic Locations	Climate Phenomena
Habitat that is available for threatened and endangered	Species' ranges and migrational limits	Short grass prairies in eastern New Mexico and west Texas	Temperature extremes
Climate change impacts on grasslands	Baseline data on species distribution	Data for tribal lands which is currently not available	Precipitation extremes
Latitudinal changes that occur within an ecosystem	Temperature and precipitation thresholds for species	Data for northern Mexico	Effects of drought and fire on species migration
The size of wildlife reserves (are they large enough to absorb changes?)	Changes to avain migrational paths	Data from private lands	Groundwater: temperature, quality, salt-water intrusion, intrusion, and climate impacts on springs
The impact of invasive species on ecosystems	Impact of invasive species on ecosystems	Lowland desert ecosystems	–
Knowledge about habitats without endangered species	Vulnerability assessments	–	–
Vulnerabiility assessments	–	–	–

During a World Cafe session, participants were asked to identify what southwest ecosystems are under-studied with respect to climate change. This table summarizes the common responses.

Supplemental Text: Downscaling Models

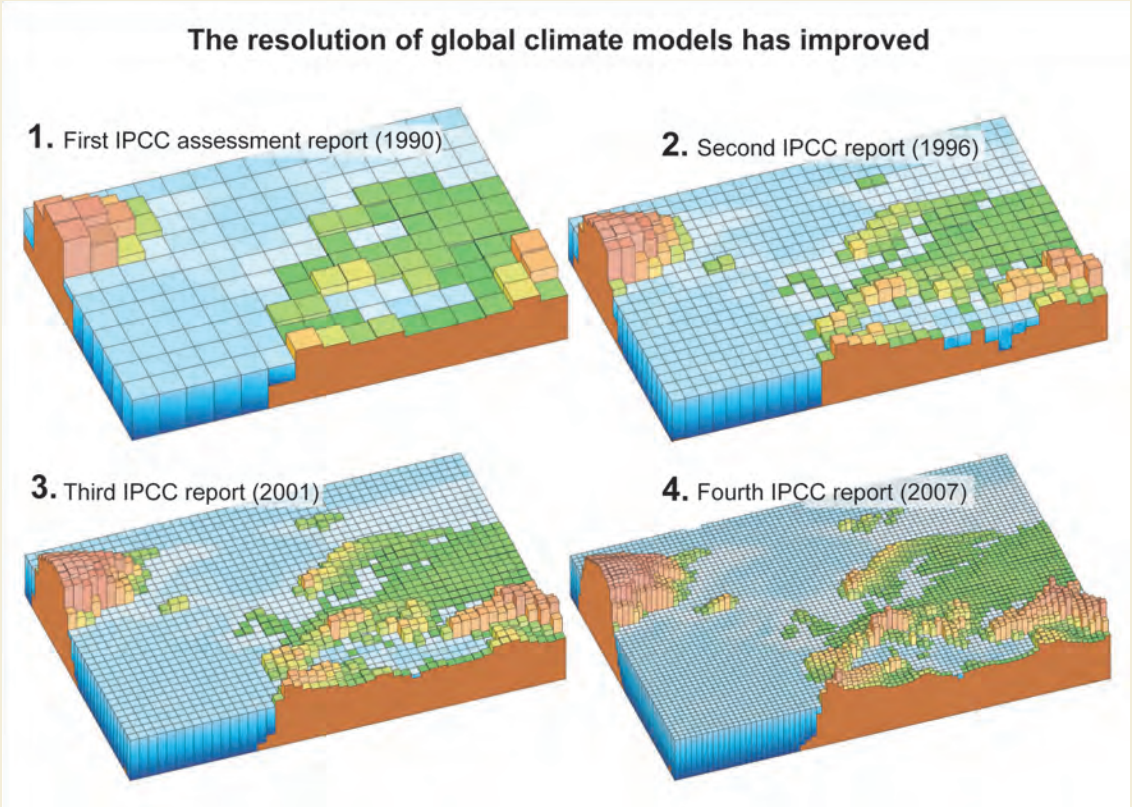
While climate change projections are most reliable at the global level, people seeking to adapt and respond to the projected changes need to know about climate change impacts where they live. Fortunately, increasing resolution and other advances honing Global Climate Models (GCMs) are helping improve regional scale modeling as well.

A general rule holds that a regional model's resolution should not surpass about one-twelfth of the resolution of the model feeding into it, typically a GCM. Currently, GCM resolution is about 4,000 square miles per grid square (about 65 miles by 65 miles), and regional models can drop down to resolutions of about 350 square miles (approximately 20 miles by 20 miles), roughly twice the area of Albuquerque.

Bringing the results of GCM projections down to the size of a watershed, however, remains challenging. One approach to "downscale" global projections to regional geographic extents is with statistical methods. Statistical downscaling uses a series of equations to relate variations in global climate output to variations in local climate. There are several other downscaling techniques, such as dynamical downscaling (feeding GCM output into regional models such as hydroclimatic models that simulate movement of groundwater and soil-water and evapotranspiration).

Scientists are confident the model resolution will continue to improve as computational power increases.

The geographic resolution of global climate models used in the IPCC's Assessment Reports has improved over time. Figure credit: IPCC, 2007



Decision Support Resources

Important findings based on participant discussions

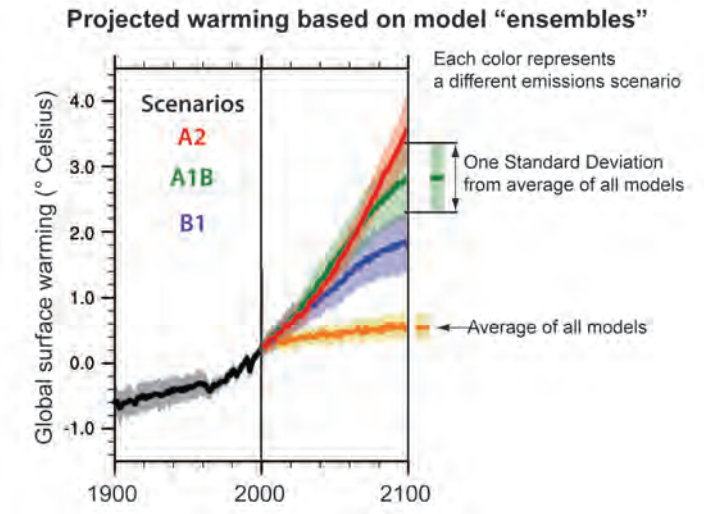
- *Climate scenarios can help planning purposes.*
- *Better access to synthesized climate-related information will improve decisions.*
- *Better information sharing capabilities will improve decisions.*

In addition to improvements in model performance and use, participants expressed a need for other resources that would aid in decision support. Responses revealed an interest in climate scenarios that could be used for planning purposes. Scenario-planning offers some promise of placing boundaries on expected climate impacts. Data generated by GCMs, for example, may serve as a resource for scenario planning. GCM data that was used in the IPCC latest assessment report published in 2007 is available on the Web to the public. Using this data, however, requires detailed knowledge about the models used, the greenhouse gas emission scenarios that drive the models, and the appropriate use of the GCM data output, among other technical expertise (see Suppletmental Text: Best Practice Approaches for Incorporating

Supplemental Text: Global Climate Model Data

Data generated by global climate models (GCM) for future climate estimates are available to the public.

The Program for Climate Model Diagnosis and Intercomparison (PCMDI) grants access to data generated by GCMs used in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. The models simulate present, past, 20th century, and future climates that may occur in response to various scenarios of future greenhouse gas emissions. The data from these simulations include temperature, precipitation, relative humidity, and many other variables including extreme temperatures and precipitation.



Multi-model means of surface warming (compared to the 1980–1999 base period) for the high, medium, and low IPCC SRES scenarios shown as continuations of the 20th-century simulation. An additional experiment, in which the forcing is kept at the year 2000 level, is also shown in orange. Lines show the multi-model means, shading denotes the ±1 standard deviation range. Figure was adapted from the IPCC, 2007.

The data archived at PCDMI are complex and require familiarity with modes and modeling jargon, such as "experiments for doubling of CO_2." Each model is crafted differently and model simulations are based on greenhouse gas emission scenarios. Taking advantage of GCM data requires knowledge of these and other issues.

Web access: www.pcmdi.llnl.gov

GCM data has also been statistically downscaled by collaborators at Lawrence-Livermore National Laboratory, Santa Clara University, and the U.S. Bureau of Reclamation using a peer-reviewed methodology. This data are also available on the Web. It has been used in the study of potential climate change impacts on various resource systems, including watershed hydrology, habitat migration, and air quality.

Accessing and using this data also requires knowledge of modeling and familiarity with modeling language.

Web access: http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections

Scientific Uncertainty, page 20). Utilizing this resource requires climate science capacity. Numerous comments during the group discussions referred to the need for the FWS and other organizations to enhance their climate science expertise.

To complement climate scenarios, participants identified a variety of resources they felt were either unavailable or insufficiently available. These additional resources range from access to information to needed human resources and equipment. Many participants requested:

- access to peer reviewed articles
- access to modeled future climates, in which the data include extreme values as well as average values
- accessible databases that catalog FWS and other agency knowledge
- more synthesized climate-related information
- more monitoring equipment
- more volunteers to collect data

Making Decisions: Incorporating climate change into the decision process

Limited financial resources and widespread impacts to ecosystems will require the FWS to make difficult choices. Which species should be a management priority? What is an acceptable level of uncertainty? When does the FWS stop managing a species? These are a few of the hard decisions that will need to be made based on consideration of future climate changes.

Five World Café questions—more than any other issue—were devoted to understanding how the FWS should incorporate climate change into decisions. The five questions asked workshop participants to describe how to prioritize issues, in what circumstances climate change data is useful, how uncertain information should be used, what species and habitats will be negatively impacted by climate change, and when it is appropriate to stop managing a species.

Climate Change as an Emerging Priority

Important findings based on participant discussions

- *Climate change priorities should focus on ecosystems and not on individual species.*

Participants identified the most important climate change actions in the Priority Exercise (Figures 1–2). A subsequent question sought the underlying considerations that lead to the identification and prioritization of these main issues.

According to participants, for actions to become priorities the mission of the FWS must encompass climate change issues and FWS authority must enable effective action. For example, some groups noted that climate change does not stop at refuge borders, and they questioned whether conservation plans will be successful if surrounding lands are not included in the plans.

The groups expressed a strong belief that the focus of climate change priorities should be on ecosystems and not on individual species. The notion that priorities should be grounded in practicality underlined many responses. Participants favored programs and projects that have high chances of success and large returns on investment, and that take into account economic considerations and can leverage resources from other organizations. Practical considerations also should be blended with ecological factors. According to discussion summaries, priority should be given to:

- species and habitats vulnerable to climate change
- species in decline and at risk of becoming endangered
- keystone species
- species with limited dispersal
- biodiversity hotspots

Quality Control of Climate Change Data

Important findings based on participant discussions

- *Important data characteristics that help determine the quality of the data includes the duration and continuity of the record.*
- *More climate change-related data need to be collected to help improve data quality.*

All climate data—modeled or observed—have uncertainties associated with their measurement or estimation. For example, some types of rain gauges underestimate winter precipitation totals because they do not adequately capture snowfall. Also, historical data span a relatively short period, less than 100 years, calling into question the use of trend analysis. Model-generated estimates of future climates can contain even greater uncertainties associated with, for example, a lack of detail in a model's topography of the western U.S. How, then, does the FWS decide if the quality of the data is sufficient to shape decisions?

According to some discussion groups, the quality of data is in part determined by the duration and continuity of the record. However, participants followed this statement with the forewarning that the record length must be weighed with other considerations, such as proximity to the management area of concern. In addition, scale also needs to be considered. Coarse-scale data obtained from GCMs might not be adequate to answer questions pertaining to small ecosystems, like those at the highest elevations on isolated mountain ranges. Finally, extrapolating data must be done cautiously, particularly data from distinct habitats. Data collected in the Sonoran Desert, for example, might not be a suitable proxy for the neighboring Mojave Desert.

Participants made repeated statements that more climate change-related data need to be collected. This corroborates information gleaned from the Priority Exercise, which revealed that conducting more scientific research to investigate the climate and ecosystems connections and collecting more baseline data are high priority actions.

While additional data often improve use, participants also stated that more needs to be done with what is available. "Lots of data exist, but many data sets have not been analyzed," stated one group. However, participants noted that vetting the data currently available is critical, especially data that are older and are from networks that employ only minimal quality control measures.

Critical review of the data is not always easy. In some instances, participants suggested FWS may need to turn to outside scientists and reports to help determine information quality. Peer-reviewed literature should be consulted, stated one group, while another response indicated that the IPCC is a good place to start.

Using Uncertain Information

Important findings based on participant discussions

- *Although participants are wary of using model output because it is uncertain, they find it unavoidable and therefore urge cautious and well-informed use.*
- *Models and observations can be used to "help frame thinking," as oppose to singularly directing it.*
- *Partnering with the scientific community facilitates the most supportable use and interpretation of data.*
- *Climate experts on staff or with partners can help communicate climate model uncertainties.*
- *Consistent monitoring will help inform FWS about changing conditions and follow adaptive management methods.*

While observations made in the past 100 years and pre-historical records spanning millennia reveal historical climate change and variability, climate models are likely the best source for future climate estimates. However, no matter how robust or complete the science is, model output contains uncertainties. In light of this, participants discussed how to cope with the uncertainties in model data and observational data.

Many factors that go into FWS decisions contain uncertainties, according to some discussion groups. FWS "should not use the lack of [certainty] to avoid making decisions." Several groups suggested that model information should not be the sole evidence for a decision, but rather one part of a suite of information that informs decision making. These comments and others suggest that participants felt a heavy reliance on models to provide answers was problematic. A more fruitful approach, articulated by one group, was to use models and observations to "help frame thinking."

Responses from discussion groups indicated an understanding that modeled data are useful, but should be used in particular ways. There was a consistent call for all models to incorporate state-of-the-art science, implying out-of-date models or inputs may be an issue of concern. There was some consensus in a multi-model approach, which avoids, as one group stated, putting "all the eggs in one basket." This helps quantify

Supplemental Text: Best Practice Approaches for Incorporating Scientific Uncertainty

Benjamin Franklin wrote that "...in this world nothing is certain but death and taxes."

The sentiment in this statement certainly applies to climate change. This has created challenges for decision makers who want to incorporate climate change into planning but who are wary of the uncertainties. As a result, policy makers, public and private parties making long-lived capital investment decisions, and many others including managers in the FWS, need to better understand the nature and extent of the uncertainties associated with aspects of climate change.

The Climate Change Science Program (CCSP) published a report in January 2009 that provides a summary of tools and strategies available to characterize, analyze, and address uncertainty in science and impacts of climate change . The CCSP formed in 2002 to coordinate government activities from more than 12 agencies that produce and use climate change data and research.

The report is written to serve the needs of climate scientists, experts assessing the likely impacts and consequences of climate change, and technical staff supporting private and public decision makers. Topics include sources of uncertainty, methods of estimating uncertainty, propagating uncertainty, making decisions in the face of uncertainty, and effectively communicating uncertainty, among other important issues. The CCSP report also provides simple guidance for researchers. This report, however, is not the definitive reference and this topic is relatively new in climate science.

The report is available online: www.climatescience.gov/Library/sap/sap5-2/sap5-2-final-report-all.pdf

potential errors as well as reduce the importance of one specific model, which may have unknown biases that make use of the model inappropriate in some geographic regions. Models were seen as effective because they can provide estimates for scenarios, such as the best case, worst case, and intermediate case outlooks. Models used in this fashion help constrain future possibilities, and as suggested above, frame thinking about an issue or decision. Finally, for some applications the only alternative to model data is "wild guesses," which is not a defensible position.

Although models have utility, participants counseled that FWS "must be extremely cautious with the use of models." Models should be peer reviewed, according to some groups. Partnering with the scientific community will "facilitate the most supportable use and interpretation of data." Several groups also suggested that adding climatologists to FWS staff can help with data interpretation. Climate experts were also identified as necessary in helping FWS communicate climate model uncertainties. Participants called for an effort to articulate details about models to stakeholders in ways they can understand.

Finally, throughout the World Café sessions there was a call for a commitment to monitoring. Participants recognized the need for consistent monitoring data to inform FWS about changing conditions and therefore help with decision processes. Participants consistently advocated for an adaptive management approach where new data is periodically fed into models so that managers can revisit initial decisions and make appropriate adjustments.

Determining Species' and Habitats' Sensitivity to Climate Change

Important findings based on participant discussions

- *Using integrated assessments of species and habitat risks, which includes climate change as well as other threats.*
- *Determining species' and habitats' sensitivity to climate change requires an ecosystem approach, while some believe focusing on endangered species is a better strategy.*

Responses revealed that most workshop participants believe that climate change will have few benefits for species and habitats. No responses from the World Café questions mentioned species that may profit from changes to habitat.

Observational data and models can help determine if species are at risk from climatic changes. One group captured this notion when they suggested that the FWS should "look at it from both ends to understand how climate change affects existing threats and how it creates new ones." However, the risk posed to species is not simply determined by climate, according to responses. There "needs to be integrated assessment of the risks from multiple threats, one of which is climate change."

Participants noted that determining the risk to species and habitats starts where FWS has a legal mandate to act. Legality aside, several groups suggested assessing risk should involve an ecosystem approach and not be focused on individual species. A few groups, however, made a countervailing suggestion that argued for the initial risk assessments to focus on endangered species. These divergent views have the potential to roadblock action if they are not reconciled by FWS policy.

World Café responses noted that determining risk includes understanding if:

- habitats will be reduced to unsustainable sizes;
- climate change will accelerate population decline or create other negative impacts;

- keystone species are impacted, which would cause cascading effects; and
- species can adapt to climate changes suggested in various scenarios.

Table 2 summarizes the responses related to those factors that contribute to species and habitat risk from climate change.

Determining When to Stop Managing Species

Important findings based on participant discussions

- *FWS should be selective in directing management resources, focusing on species that have the highest chance for success.*
- *It might be best not to manage a species if there is inadequate habitat.*
- *Management efforts should be directed to systems that benefit multiple species and to species that are in decline but still recoverable.*

Climate change will likely jeopardize the existence of some species and may increase the number of endangered and at-risk species, according to responses. As a consequence, financial and human resources may become over-extended by climate change. This begs the questions: should the FWS stop expending management efforts on some species in favor of others, and which species should receive concentrated management efforts? Participants tussled with these questions on the final day of the conference.

Divergent views on whether FWS should stop managing a species are evident in World Café responses. Some participants believe the current FWS management principle—"extinction is not an option"—should be replaced with—"the FWS should give up on certain species." Others suggested that the FWS "should never stop protecting species," while one group stated there are "species we can't save with existing funding."

The majority of the responses, however, implied that the FWS should be selective in directing management resources. Several common answers were time, money, and effort should be focused on species that have the highest chance for success, and it might be best not to manage a species if there is inadequate habitat. One response stated that it depends on whether "species declines are anthropogenic or not," implying that human-caused impacts take precedence. One theme that emerged from these discussions related to the relevance of cost-benefit analyses when it comes to making protection decisions. One group said there is a

Table 2. Factors Influencing the Sensitivity of Species and Habitats to Climate Change

Species	Habitats
Sensitivity to changes in temperature, precipitation, and other climate factors	Size of current and future habitat (Will habitat be created or destroyed?)
Population number and distribution	Health of current and future habitat
Ranges	Habitat fragmentation
Ability to move and opportunities for dispersal	Barriers to movement
Requirements for food—dependence on other species that may be at-risk	Occurence of natural extreme events, such as fire and drought
Ability to adapt to changing climate	Susceptibility to invasive species

During a World Cafe session, participants were asked to identify the most important factors that determine which species are at risk to climate change. Responses predominantly centered on the factors that influence the sensitivity of both species and habitat to climate change. The table summarizes the common responses.

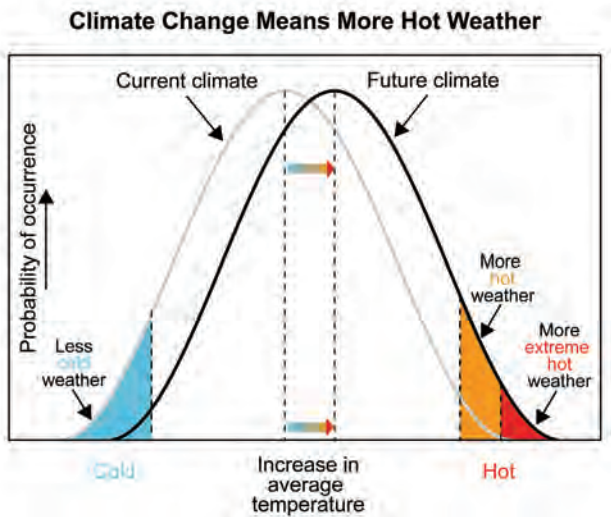
"need to weigh the money and effort spent to perpetuate a species with the benefits" to help decide when species management stops.

Another group stated that this decision is "not something FWS can deal with alone—FWS needs societal guidance." This may mean that "society dictates saving some species at all costs" and charismatic species become focal points. In addition to public opinions, the groups suggested that management efforts should be directed to systems that benefit multiple species rather than a single species and to species that are in decline but still recoverable.

Institutional Obstacles: Perceived barriers to effective climate change planning and action

Throughout the World Café session responses, there was a sense from participants that climate change will present numerous challenges, including prioritizing research, expanding partnerships, invigorating outreach, and deciding when to continue or suspend species management. Meeting the challenges will require the FWS to address many institutional obstacles mentioned by participants as barriers to climate change planning and actions. The institutional obstacles identified by participants can be classified into four categories: management and administration, science, policy, and staff capacity.

Climate change will likely shift the distribution of temperatures and other climate parameters, affecting the average and extremes. Figure was adapted from IPCC, 2007.



Management and Administration

Important findings based on participant discussions

- *A major barrier to climate change action is a lack of partnership with universities and other agencies.*
- *Poor communication both internally and with other agencies curtails actions.*
- *Limited financial resources are a major obstacle to climate change actions.*

Many discussion groups discussed the lack of partnerships between agencies. For example, one group felt that the FWS is "not well connected with universities." Another group noted that "there is a lack of agreement within and between agencies," referring to climate change planning and action strategies. Several responses stated that different regulations in different agencies can be barriers to cooperation, implying the need for streamlined collaboration.

Communication within the FWS and with other agencies was also highlighted as a barrier. One group said the "lack of communication at the directorate level among agencies [leads] to disorganization and no real ecosystem management." Several groups noted a lack of internal communication between FWS programs, which may result from "a lack of cross-programmatic experience." Between agencies, participants consistently mentioned insufficient data sharing among agencies and incompatibility between databases are barriers.

Limited financial resources were almost universally cited by all groups as a barrier. One group mentioned that "general operating funds comprise the majority of the budget" and another suggested that "managers have too much on their plate." Several groups noted a lack of staff dedicated to climate change planning, which may be related both to limited financial resources and to a prioritization of climate change planning that is lower than other considerations.

Science

Important findings based on participant discussions

- *To improve resource management, increased efforts to collect climate change data is needed.*
- *The resolution of climate models often do not match with the scale of FWS management, presenting challenges associated with incorporating them into decisions.*

Discussion group responses repeatedly made reference to the need for collecting more climate change-related data. Common themes included the lack of baseline data, the need for more local data to monitor responses of species, and the lack of data to supplement climate change information (e.g., species population data). Although improving climate monitoring was not highlighted as an important concern (Figure 1), many people stated that monitoring of all sorts is a vital component of adaptive management.

Other barriers related to science that emerged from the group discussions include an absence of high-resolution climate models, which highlights the mismatch between large-scale climate model data and smaller-scale needs of FWS management, and the need for more information on temperature and precipitation extremes. In addition, participants stated that a lack of interdisciplinary focus and the difficulty associated with making decisions based on uncertain data and information present difficult management challenges—their issues were already discussed in some detail above.

Policy

Important findings based on participant discussions

- *To deal with new challenges, the FWS will have to maneuver around or amend current policy such as the Endangered Species Act, which does not explicitly deal with climate change.*
- *The border between Mexico and the U.S. will expose different objectives between different agencies.*

Addressing climate change through current FWS policy will present numerous challenges primarily because the Endangered Species Act (ESA) does not directly address climate change, according to participants. The FWS will have to maneuver around or amend current policy to deal with new challenges. For example, the ESA does not allow "assisted migration unless the FWS calls upon the 10(j) section of the ESA," which provides the government authority to designate populations of listed species as experimental (and the population is wholly separate geographically from nonexperimental populations of the same species), and thereby reduce legal protections otherwise required by the ESA. This provision is one regulatory mechanism that allows FWS to reintroduce animal species. Under this section the Secretary may authorize the release of any population of an endangered or threatened species outside the current range of such species if the Secretary determines that such release will further the conservation of the species. However, there have been some species reintroductions and introductions that

have taken place without using a 10(j) rule, especially for plants because they do not have the same section 9 prohibitions as animal species.

In addition, "ESA translocation currently has to be within the historical range of the species." Several other responses noted elsewhere in this report imply that climate change may cause future ranges of species to be different from historical ranges, suggesting that the ESA will not be an effective management tool in certain situations. Finally, workshop participants said the Habitat Conservation Plan part of the ESA does not directly address climate change, although it does deal with uncertainty and unforeseen circumstances which likely encompass the effects of climate change.

The FWS will face other policy challenges as well, particularly as climate change issues are confronted by geographic and political boundaries. The border between Mexico and the U.S. will expose different objectives between different agencies, according to participants. For example, ecological issues central to the FWS are not primary concerns of the Department of Homeland Security. One group also mentioned that "land trust responsibilities might need to be changed to accommodate climate change studies. "Another group stated that FWS "lacks policy to deal with shifts in critical habitat," while another response noted that "static boundaries don't reflect climate change effects."

Institutional Capacity

Important findings based on participant discussions

- *The ability to use information from climate science and knowledge about solutions is currently underdeveloped in the FWS.*
- *While training of current staff is necessary, acquiring new talent is also needed.*

Many of the responses highlighted that the FWS will need to improve employee understanding of climate issues to set climate change planning into action. Although participant responses to the Priority Exercise did not place a high value on climate change education and training for agency decision makers and managers—they ranked 11th and 13th of 15 in Figure 2—it is clear from other World Café discussions that this is needed. According to participants, for example, the ability to use information from climate science and knowledge about solutions is currently underdeveloped. This seems to be at both the staff and managerial level, according to responses. "The lack of access to information" and "the lack of synthesis or interpretation of information" were cited as contributing to underdeveloped climate change knowledge. Finally, while some FWS employees may need training on, for example, using data generated from climate models, other technical ability may need to be imported—put clearly and succinctly by one group: "[the FWS] lacks people to translate science to managers."

Opportunities

World Café responses make it clear that many participants feel that climate change will likely impact most, if not all, of the ecosystems in which FWS works and will challenge staff in new ways. Although the sense that climate change is "overwhelming" and "the problems [associated with climate change] are too large and too complex" is present in the responses, workshop participants clearly believe that the agency should lead by example. Many of the groups suggested that the FWS is well positioned to provide leadership in dealing with climate change issues. Specifically, participants mentioned the extensive expertise and experience in public outreach and education of the FWS, which will help the FWS lead on these fronts. One comment, reflected through many group responses, is that the FWS should begin by reducing its carbon footprint.

There was also a call to exploit the opportunities presented by this daunting issue to improve management and conservation practices, strengthen partnerships, and build institutional capacity. One group discussed climate change as an opportunity to break down existing political and agency barriers.

Revise Policies

Important findings based on participant discussions

- *Some participants suggested expanding the critical habitat definition of the ESA.*
- *Broadening existing conservation measures to include climate change issues will help resource management.*

Several discussion groups suggested rethinking existing policies and laws. For example, one group suggested deregulating HCPs as a consequence of environmental changes from climate change, while another group commented that HCPs can "serve as corridors between protected areas."

In several discussion sessions, participants mentioned that climate change will likely expand the number of species endangered or at risk of endangerment. To plan for this, it may be "time to expand the critical habitat definition of the ESA."

Finally, participants offered several specific policy ideas, including:

- expediting permits for companies using energy conserving measures
- broadening existing conservation measures to include climate change issues
- building on existing policies to form more effective partnerships

Strengthen Partnerships

Important findings based on participant discussions

- *Effective climate change action requires building new partnerships and fortifying existing ones.*
- *More involvement with community programs and organizations is necessary.*

Most participants agreed that effective climate change action requires building new partnerships and fortifying existing ones. Specifically, participants mentioned the need for the FWS to strengthen partnerships with academia and federal agencies such as NASA, the Department of Interior, and USGS. As noted above, participants felt that data and information sharing with these agencies is one aspect of planning and acting in a collaborative effort to address climate change issues.

From the responses it is clear that opportunities exist for more collaboration with private land owners, Indian tribes, and the Western Governors Association. Participants suggested that effective planning and action also will "require non-traditional partners such as oil and gas companies, alternative energy development companies, gardening groups, humane societies, and zoos." It also was noted that expanding partnerships across social and physical scientific disciplines underscores the need to emphasize interdisciplinary collaborations.

Strong partnerships between FWS and communities where the FWS works are also imperative because "without public support [the FWS] doesn't have backing." According to participants, involvement with community programs and organizations needs to be enhanced. One group stated there "needs to be more liaisons to public," while another group suggested "redefining external affairs—some field personnel should be ambassadors to local communities." The FWS also needs to develop new, and leverage existing, citizen science activities. This could address the need, at least in part, for "more volunteers to collect data."

Expand Staff Capacity

Important findings based on participant discussions

- *Many of those who participated in the workshop do not know how to integrate climate change research and knowledge into management actions.*
- *Developing clear climate change strategies and protocols will help managers and staff develop and implement climate change actions.*
- *Training will help FWS interpret and use observational and model data.*

The World Café sessions revealed many of those who participated in the workshop do not know how to integrate climate change research and knowledge into management actions. While overcoming this requires that FWS build greater staff capacity, participants also suggested the need for a clear climate change strategy, guidelines, and protocols to help managers and scientists make proper decisions. There was a general sense in the responses that improving climate science capacity in the FWS is a necessary component of successful efforts.

Specifically, the methods and protocols mentioned by participants included: decision trees, methods to help prioritize climate change over other issues, and cost-benefits analyses that address dealing with specific species and habitats in context of climate change.

Requests for training centered on improving FWS capacity to use observational and model data. Participants also requested education to improve understanding of climate science, which has contributed to "the FWS lack of capacity to translate the science to the decision makers." Responses suggest that managers need help interpreting climate data. There was also a call for more synthesized information such as fact sheets that summarize in non-jargon language the salient information about a topic—as opposed to reading peer-reviewed journal articles which can be too time-consuming and written for a specific scientific audience (see Southwest Climate Change Network, page 28).

Supplemental Text:
Southwest Climate Change Network–A network of experts and a source for climate change information

The Southwest Climate Change Network (SWCCN) is an interactive Web site built to connect scientists, experts, decision makers, and the public to accelerate understanding of climate change issues and collaborate with others on climate change adaptation.

SWCCN accelerates understanding of climate change in the Southwest. The Web site houses syntheses of climate change impacts from seminal research published in peer-reviewed journals, written in non-scientific language. This enables readers without ample time or access to academic literature to understand the state-of-knowledge comprehensively and quickly. The Web site also houses an extensive and growing library of peer-reviewed article abstracts, helping direct people to scientific research. Other resources include breakthrough news about climate change written for the site by experts and up-coming events such as conferences and workshops. Future resources will include Power Point presentations and podcasts.

SWCCN fosters collaboration between academics, agencies, nonprofit organizations, and the public by creating an online, interactive forum. This network component combines professional networking and climate science, enabling users to discover people and organizations with shared interests. Users can form groups to communicate, spread information quickly, and work with others to help advance planning and solutions.

The Southwest Climate Change Network can help meet some needs identified by FWS personnel, such as providing synthesized climate change information. As the network develops and expands, SWCCN can also facilitate communication and information sharing and help connect FWS personnel with other groups and experts.

Access: www.southwestclimatechange.org

Discussion

Climate change is likely to present many new challenges, requiring the FWS to modify existing strategies and create new ones to manage wildlife and habitat. The comments and suggestions recorded by World Café participants catalog the institutional knowledge of the FWS and other organizations about the impact climate change will have on resource management.

It is also vital to look outside the FWS to learn how other institutions view and understand the problems and solutions associated with climate change. In recent years, many reports have been published, including the U.S. Climate Change Science Program synthesis reports, that broach similar concerns and issues articulated by World Café participants. This similarity suggests that FWS employees and other participants have a high degree of knowledge about climate change issues.

Comparing participant responses to the U.S. Climate Change Science Program synthesis report

During the four brainstorming sessions, the World Café participants documented diverse management and conservation issues that will be affected by climate change and needed to inform FWS climate change policies. They highlighted important strengths and weaknesses of the FWS to meet challenges created by climate change. Many of the participants' comments echoed ideas propounded in other synthesis reports, including the U.S. Climate Change Science Program (CCSP) synthesis and assessment report, *Preliminary Review of Adaptation Options for Climate-Sensitive Ecosystems and Resources.* Chapter Five of this report centers on adaptation options for climate-sensitive ecosystems and resources, and which focuses on the National Wildlife Refuge Systems (NWRS), is germane to FWS activities and policy; the FWS was a contributing author to this chapter.

According to this CCSP chapter, "conservation challenges include habitat conversion and fragmentation." The report also states that "the historical concept of refuges as fixed islands of safe haven for species is no longer viable." These notions that climate change will alter habitats and that management strategies once deemed sustainable may no longer be effective is highlighted in World Café participant remarks. Indeed, central to concerns identified by participants is the notion that habitats will be destroyed or fragmented by climate change, and species habitat ranges and migration patterns will be disrupted. Participants also suggested expanding the critical habitat definition part of the ESA and revising other policies to accommodate new challenges that arise from a changing climate.

While some topics were common to the CCSP report and the World Café discussions, the report contained some issues not highlighted by participants. For example, climate-related changes in the distribution and timing of resource availability may cause species to become separated from their resource requirements, according to the report. This can cause mismatches in lifecycle events. In the northeastern U.S., for example, nectar producing trees currently bloom 25 days earlier than in the past. As a result, honey bees have switched

their source of nectar from the tulip poplar tree to black locust tree, impacting the pollination of tulip poplars and causing their numbers to crash. In the Southwest, the bloom date of some Sonoran Desert shrubs advanced about 20 to 41 days between 1894 and 2004, according to a 2007 study by Janice Bowers.[8] This study also concluded earlier flower blooms can have substantial impacts on plant and animal communities in the Sonoran Desert, which will likely impact FWS management.

The CCSP report also stressed that climate change will require diverse and innovative adaptations, effective application of the experimental concepts fundamental to adaptive management, and enhanced collaboration with public and private stakeholders. This finding mirrors comments from World Café participants. Workshop participants called for clear strategies to help FWS employees develop and implement climate change actions, adaptive management protocols, and stronger working partnerships.

In addition, the report called for building stronger partnerships, which was perhaps the most common refrain among workshop participants. Participants called for stronger communication within the FWS and between agencies. They also called for improved collaborations that tap the expertise of climate scientists and build bridges with institutions that harness activities of citizen scientists. Climate change affects all regions, and budget limitations frequently exclude vital research and data collection; thus, teaming up with or utilizing University of Arizona citizen science projects, such as the National Phenology Network—which amasses observations made of the timing of plant and animal lifecycle events such as flowering dates—and Arizona DroughtWatch—which catalogs drought impacts on the landscape—will enhance FWS information gathering.

In addition, both the CCSP report and World Café participants suggested using climate change modeling to help conservation. A key finding in the CCSP report, for example, stated "responding to ecological effects may be improved by projecting the possible futures of trust species, their NWRS habitats, and management options at all relevant management scales using the most rigorous scientific modeling tools, climate change scenarios, and suite of expected non-climate stressors." Anticipating future change is a vital component of conservation strategies, particularly in light of the scientific notion that historic climate variability will not serve as an adequate analogue to future, human-caused, climate change fluctuations. This idea, communicated in the scientific literature as "stationarity is dead," is one of the most important emerging concerns of water managers, who seek to avoid the pitfalls of planning assumptions that may no longer hold true. For ecosystem managers, new mean and extreme values of climate parameters (e.g., maximum temperatures) and expanded ranges of variability may result in an array of impacts to plant, animal, and human behavior that differ from those experienced in the past. Thus, in addition to modeling, enhanced climate and ecosystem observations and data access are essential to applying adaptive management approaches to deal with non-stationarity in the climate system.

Finally, the CCSP report stated "a clearly elucidated vision of the desired state of the NWRS on the 150th anniversary of the system in 2053 would enhance the development of a framework for adaptation." Whereas World Café participants commented that they lack a clear directive on how to incorporate climate change into conservation, this three-day workshop and the solicitation of ideas from FWS staff during the World Café discussion session are a step toward developing a framework. The high degree of synergy between the concerns of FWS World Café participants and CCSP recommendations demonstrates the internal capacity of agency personnel to zero in on the most pressing FWS needs and to identify credible solutions that can be applied broadly across resource management actions.

Summary

FWS and other participants provided insightful comments and recommendations during the four World Café discussion sessions. All of these were previously discussed in the Institutional Knowledge sections. They organized and highlighted the following Key Findings and Recommendations sections to help guide the FWS in formulating strategies to address climate change.

Key findings

Priorities and Concerns:

- The four most important climate change actions were climate change educational programs for the public, landscape scale conservation planning, scientific research to study climate and ecosystem connections, and improved communication and collaboration with partners.
- Participants are most concerned about FWS policy and management, water issues, and impacts on species and habitat, which include concerns about expanding staff capabilities in science and public outreach and managing ecosystems that become destroyed or fragmented by climate change.

Partnerships:

- Participants repeatedly stated effective climate change planning will require fortifying existing partnerships and developing new ones, which includes collaborating more with non-traditional organizations and universities.

Management:

- Clear climate change strategies and protocols will help managers and staff develop and implement climate change actions, and that conservation plans be at the landscape scale, concentrate more heavily on ecosystems than on individual species, include monitoring, and promote an interdisciplinary approach.
- Consistent monitoring will help inform FWS about changing conditions and follow adaptive management methods.

Decision Making:

- Participants stated that although many people are wary of using model output—because it is uncertain—they find it unavoidable and therefore urge cautious and well-informed use.
- Integrated assessments of species and habitat risks, which includes climate change as well as other threats, will improve resource management.
- The resolution of climate models often does not match with the scale of FWS management, causing difficulties associated with incorporating them into decisions.

Staff Capacity and Resources:

- Recurring training for existing staff and increasing the institutional expertise through new hires will improve the capacity of the FWS to develop effective climate change planning strategies.
- Climate scenarios can help planning purposes.
- Training will help FWS interpret and use observational and model data.

Institutional Challenges:

- Major barriers to climate change action include a lack of partnership with other agencies and universities, poor communication within the agency and with other agencies, and underdeveloped staff capacity to interpret and use climate data and information.
- Limited financial resources are also a major obstacle to climate change actions.

Opportunities:

- Climate change presents opportunities that include strengthening existing partnerships, teaming with new partners, and pooling resources and expertise to tackle climate change challenges.
- Participants noted FWS has expertise in outreach, which can be leveraged to lead conservation activities.

Recommendations

Public Outreach:

- A more vigorous public outreach effort will be needed to address climate change.
- Improving the capacity to translate science to the public and decision makers is necessary.

Staff Expertise:

- Improving staff expertise either through training or new hires is needed and adding climatologists to FWS staff is a possible strategy to accomplish this.

Staff Training:

- More climate change training and education for existing staff, specifically training on interpreting and using observational and model data.

Partnerships:

- Building new partnerships and fortifying existing ones is necessary. This includes more involvement with community programs and organizations, creating ambassadors to local communities, building new collaborations with existing partners, and leveraging citizen science activities.

Communication:

- Participants called for enhanced efforts to effectively communicate climate science—and specifically climate models—to stakeholders.
- Participants recommended improving communication between agencies and among FWS programs, which included creating accessible databases and data use protocols.

Staff Resources:

- This is a need for more synthesized information, such as impact assessments and fact sheets written in non-jargon language.

Data Collection:

- Participants stated the FWS should make a commitment to monitoring species and habitats and boost efforts to collect more climate change-related information.

FWS Management:

- Participants encouraged the FWS to be selective in directing management resources, suggesting that efforts focus on species that have the highest chance for success and on an ecosystem approach to conservation.
- A climate change strategy and clear guidelines and protocols will help managers and scientists make proper decisions; this included providing guidance on interpreting uncertainty in climate model projections.
- Many participants also asked the FWS to lead by example in reducing its carbon footprint.

Appendices

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Appendix 2. Workshop Agenda

Effects of Climate Change on Fish, Wildlife and Habitats in the Arid and Semiarid Southwestern United States: Putting Knowledge and Science into Action

August 19-20, 2008
Loews Ventana Canyon Resort
Tucson, Arizona

Co-sponsored by:
U.S. Fish and Wildlife Service's Regions 2 and 8
U.S. Geological Survey's Central and Western Regions and
The University of Arizona

August 19, 2008

Climate Change and Ecosystem Responses
Mima Falk, Moderator

8:30 a.m.	Introduction, Dr. Benjamin Tuggle, U.S. Fish and Wildlife Service, Region 2, Regional Director
8:45 a.m.	Opening Remarks, Dr. Lisa Graumlich, School of Natural Resources, University of Arizona
9:00 a.m.	Regional Climate Predictions, Dr. Gregg Garfin, CLIMAS/ISPE, University of Arizona
9:30 a.m.	Species Distributions/Shifts, Dr. Camille Parmesan, University of Texas
10:15 a.m.–2:00 p.m.	World Café (Topics: climate change concerns, barriers to action, opportunities for action, action priorities)
12:00 p.m.–1:30 p.m.	Lunch at Loews Ventana Kiva Ballroom Luncheon Speaker: Dr. Jonathan Overpeck, Director, Institute for the Study of Planet Earth (ISPE), University of Arizona
1:30 p.m. –2:00 p.m.	Press Conference, Sabino Room
1:30 p.m.–3:00 p.m.	Climate Change as an Ecological Driver: Grand Ballroom, Dr. Gregg Garfin, Moderator
1:30 p.m.	Exotic Species, Dr. Travis Huxman, Director, University of Arizona Biosphere 2
2:00 p.m.	Water Issues, Dr. Kathy Jacobs, Director, Arizona Water Institute
2:30 p.m.	Vegetation Die-off/Regional Drought, Dr. Neil Cobb, Director, Merriam-Powell Center for Environmental Research, Northern Arizona University
3:15 p.m.	Landscape Disturbances, Dr. Don Falk, School of Natural Resources, University of Arizona
3:45 p.m.	National Phenology Network, Dr. Jake Weltzin, U.S. Geological Survey

August 20, 2008

Day 2 Focus: Adaptive Management - Tools and Strategies

Dr. Paul Barrett, Moderator

8:00–8:15a.m.	Opening Remarks: Ken McDermond, U.S. Fish and Wildlife Service, Region 8, Acting Regional Director
8:15–8:45a.m.	Assisted Migration, Dr. Mark Schwartz, University of California, Davis
9:00–9:45 a.m.	World Café: (Workshop attendees will be divided into two groups, Group 1 will start in World Café session 1, and switch to session 2 after the break; Group 2 will do the reverse)
Group 1: 9:00–9:45 a.m.	World Café 1(Climate change research needs for southwestern ecosystems)
Group 2: 9:00–9:45 a.m.	World Café 2 (Predicting risk and dealing with uncertainty)
Group 1: 10:00–11:00 a.m.	World Café 2 (Predicting risk and dealing with uncertainty)
Group 2: 10:00–11:00 a.m.	World Café 1 (Climate change research needs for southwestern ecosystems)
11:00 a.m.–12:15 p.m.	Federal Land Manager's Panel: Dr. Jay Hestbeck, Moderator
	Bureau of Indian Affairs: Mo Baloch, Senior Water Rights Specialist, Washington, DC
	Bureau of Land Management: Dr. Ron Huntsinger, National Science Coordinator, Washington, DC
	Bureau of Reclamation: Dr. Levi Brekke, Hydrologist
	National Park Service: Peter Holm, Ecologist, Ajo, AZ
	U.S. Forest Service: Bob Davis, Director, Ecosystem Analysis, Planning, Watershed, and Air, Albuquerque, NM
	U.S. Fish and Wildlife Service: Andy Yuen, Project Leader, San Diego National Wildlife Refuge, Carlsbad, CA
1:45–3:00 p.m.	Non-governmental Organization Panel: Charles Ault, Moderator
	American Fisheries Society: Dr. Colleen Caldwell, Unit Leader, NM Cooperative Research Unit
	The Nature Conservancy of New Mexico: Carolyn Enquist, Senior Ecologist
	Defenders of Wildlife: J. Christopher Haney, Chief Scientist
	California Audubon Society: William Monahan, Conservation Science Fellow
3:15–4:15 p.m.	Leading for Change: Dr. Doug Inkley, Senior Scientist, National Wildlife Federation
	Dr. Ellie Cohen, Executive Director, Point Reyes Bird Observatory
4:15–5:00 p.m.	Wrap-up "Where Do We Go from Here?"
	Anne Kinsinger, U.S. Geological Survey Western Regional Director
	Dr. Benjamin Tuggle, U.S. Fish and Wildlife Service, Region 2, Regional Director
	Kenneth McDermond, U.S. Fish and Wildlife Service, Region 8, Acting Regional Director

Appendix 3. World Café ground rules

The World Cafe is designed to foster participation from everyone here. Each of your perspectives, opinions and thoughts are valuable and will significantly contribute to the larger issue of how the U.S. Fish & Wildlife Service will cope with climate change and how the climate-science community can support the U.S. Fish & Wildlife Service in this context. To help us accomplish this, there are three ground rules to the activity.

1. Everyone's contribution is valuable and important. Please encourage everyone's participation.
2. Active listening is just as important as active speaking. The speaker has a responsibility to speak concisely and the listeners have the responsibility to actively listen and not interrupt.
3. The discussion topics are meant to serve as a guide, please follow this outline to limit the potential for a discussion to get off-track.

How It Works:

1. We have identified volunteers to lead discussion at each table.
2. The discussion leader will ask for a volunteer to take notes. Default plan: If no one volunteers, the person nearest the pad will take notes.
3. Read all of the questions, first, so you can see where we are headed.
4. At the end of the first session, 40 minutes, please move, randomly, to another table. We encourage you to not move as a group, but to meet others, make new connections, develop new creative mixes.
5. After the second session, we will have a brief wrap-up, in order to get a sense of the highest priorities for action.

For facilitators:

The World Café works best as conversations about provocative issues. The format that we have chosen for Day 1 (Tuesday, August 19) is built for brainstorming and bouncing ideas off each other. We do not expect to resolve any of the questions raised, but we do expect to get a sense of the participants' concerns, priorities, key questions. For Day 2 (Wednesday, August 20), brainstorming is still the key activity, but there is a chance to go a little deeper, as many of the issues will have been raised in the Day 1 World Café, and discussed by plenary speakers.

Please instruct the note takers to record key ideas as best they can, and to note with an asterisk the ideas that generated the most animated discussion or controversy.

Day 1 – Tuesday, August 19, 2008

- 10:15–10:20 Preamble
- 10:20–11:00 Session 1
- 11:00–11:05 Transition
- 11:05–11:45 Session 2
- 11:45–12:00 Report Back

Day 2 – Wednesday, August 20, 2008

- Give a full 45 minutes to discussion each time
- We will use 15 minutes at the end of the 2nd session, in order to hear about the most interesting aspects of the discussions and insights offered by participants – Where did we generate heat? Where did we generate light?

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Credits

Page 4: Courtesy Jeremy Weiss, University of Arizona.

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