USFWS

CH.3 Climate Adaptation Goals, Strategies & Actions

SEVEN GOALS to help fish, wildlife, plants, and ecosystems cope with the impacts of climate change were developed collectively by diverse teams of federal, state, and tribal technical and management experts, based on existing research and understanding regarding the needs of fish, wildlife, and plants in the face of climate change.

*The **goals** represent tools within the conservation toolbox.*

*Their **strategies** and **actions** should be taken or initiated over the next five to ten years.*

*Each goal has helpful **checklists** to chart milestones.*

3.1 How It Works

It is important to emphasize that all seven of these goals describe types of conservation activities that management agencies have traditionally undertaken, some for much of their history. In this sense, these goals represent tools within the conservation toolbox. What this *Strategy* seeks to do is assist the management community to better understand the application of these tools that may be most effective in a period of climate change. In other words, this *Strategy* seeks to integrate with and build upon existing management programs. These goals are intended to be implemented with full recognition of the existing rights and obligations of those who implement and will be impacted by the activities. For example, United States treaties and federal court decisions require consultation with tribal governments to ensure activities do not inadvertently lead to a diminishment of natural resources located on Indian lands, or treaty-protected natural resources, or in a diminishment of tribal access to those resources. And the resilience and adaptation of species that depend on areas outside U.S. borders will require continued collaboration and action with international partners.

Each goal identifies a set of initial strategies and actions that should be taken or initiated over the next five to ten years. Actions under various individual goals are interrelated and interdependent. To the extent possible, actions within goals are listed in sequential order; but goals are not. It is more useful to think of goals as sectors within which the appropriate actions are progressing in logical sequence. The "Actions" were compiled from Technical Team submissions

determined to be broadly applicable to the eight major U.S. ecosystem types considered in this document. In addition, examples of more detailed "Ecosystem-specific Actions" were also developed by the Technical Teams, in order to illustrate how these approaches could be carried out in particular ecosystems. A set of these specific actions most relevant to each ecosystem is available in the eight ecosystem-specific background papers referenced in Appendix A and posted online at *www.wildlifeadaptationstrategy.gov*.

A short-term progress check list is offered under each goal. These checklists are composed of items that can serve as useful milestones of progress toward the achievement of the relevant goal. Not every action has a corresponding checklist item and not every item on the checklist is a specific action under that goal. Each of the items in these lists could be achieved or initiated over the next five to ten years by pursuing the strategies and actions under each goal. Accomplishing these items will show real progress in implementing the *Strategy*. While adaptation planning for biological resources is still a new endeavor, it is important to recognize that work on all of these goals is already underway. This *Strategy* attempts to build on the excellent work of pioneering state governments, federal agencies, tribes, conservation partners, private landholders, and others who have been leading the way on adaptation. Many of the Case Studies found throughout the *Strategy* highlight some of these ongoing efforts.

The management challenge will not be to keep current conservation areas as they are, but rather ensure there is a network of habitat conservation areas that maximizes the chances that the majority of species will have sufficient habitat somewhere.

ROGER SMITH

Goals-at-a-Glance

Goal 1: Conserve habitat to support healthy fish, wildlife, and plant populations and ecosystem functions in a changing climate.	Sustaining a diversity of healthy populations over time requires conserving a sufficient variety and amount of habitat and building a well-connected network of conservation areas to allow the movement of species in response to climate change.
Goal 2: Manage species and habitats to protect ecosystem functions and provide sustainable cultural, subsistence, recreational, and commercial use in a changing climate.	Incorporating climate change information into fish, wildlife, and plant management efforts is essential to safeguarding these valuable natural resources.
Goal 3: Enhance capacity for effective management in a changing climate.	Climate change adaptation requires new ways of assessing information, new management tools and professional skills, increased collaboration across jurisdictions, and a review of laws, regulations, and policies.
Goal 4: Support adaptive management in a changing climate through integrated observation and monitoring and use of decision support tools.	Coordinated observation, information management, and decision support systems can help management strategies to be adaptive and adjust to changing conditions.
Goal 5: Increase knowledge and information on impacts and responses of fish, wildlife, and plants to a changing climate.	Research must be targeted to address key knowledge gaps and needs, and findings must be rapidly incorporated into decision support tools available to natural resource managers and other decision makers.
Goal 6: Increase awareness and motivate action to safeguard fish, wildlife, and plants in a changing climate.	Climate change adaptation efforts will be most successful if they have broad popular support and if key groups and people (such as private landowners) are motivated to take action.
Goal 7: Reduce non-climate stressors to help fish, wildlife, plants, and ecosystems adapt to a changing climate.	Reducing existing threats such as habitat degradation and fragmentation, invasive species, pollution, and over-use can help fish, wildlife, plants, and ecosystems better cope with the additional stresses caused by a changing climate.

LARRY KRUCKENBERG

Goal 1

Conserve habitat to support healthy fish, wildlife, and plant populations and ecosystem functions in a changing climate.

STUDIES OF PAST PERIODS of climate change and their effects on species and ecosystems help us understand what may happen in the future. The major lesson from the recent fossil record of the transition from the last Ice Age to the current inter-glacial period is that when climate changes, each species responds in its own way (Hunter et al. 1988).

This Strategy *attempts to build on the excellent work of pioneering state governments, federal agencies, tribes, conservation partners, private landholders, and others who have been leading the way on adaptation.*

Species found living together in one climate may not live together in another, and vice versa. Thus, the natural community types recognized today, such as spruce-fir forests of the North, hemlock-beech forests of the Northeast, or tallgrass prairie of the Midwest, will not simply move northward or upslope. Instead, the species composition of these communities will change.

This observation has many implications for our conservation efforts in the current period of climate change. Many existing conservation areas, such as Sequoia National Park or the National Elk Refuge, were established largely to protect specific natural communities or species. As the climate continues to change and each species responds individually, these areas may lose the specific communities or species they were established to protect. For example, Joshua trees are projected to be virtually eliminated from most of the southern portions of its current range by the end of the century, including Joshua Tree National Park (Cole et al. 2011). Conservation areas will likely also gain new species, including in some cases, species equally in need of conservation. The management challenge will not be to keep current conservation areas as they are, but rather ensure there is a network of habitat conservation areas that maximizes the chances that the majority of species will have sufficient habitat somewhere. This will be a major challenge, both in knowing what will constitute "habitat" for any particular species in the future, and in dealing with biosphere scale dynamics that have now been unleashed that may be beyond management's ability to redress (e.g., ocean acidification).

Another lesson of past periods of climate change is that not all species will survive. Managers will need to come to terms with the need to make hard choices about the investment of limited resources and the likelihood of success.

Many of our nation's imperiled species (both those currently listed either as Threatened or Endangered as well as many other species that may eventually be considered for listing) do not occur in existing conservation areas. Indeed, the major threat to many species on the U.S. Endangered Species List is the loss of habitat caused when the habitat they depend on is converted to a different use. Climate change will make the problem worse—and will make the need for new conservation areas more urgent. The most robust approach to

helping fish, wildlife, and plants adapt to climate change is to conserve enough variety and amount of habitat to sustain diverse and healthy (e.g., viable, abundant) populations as landscapes and seascapes are altered by climate change. Major reviews of climate change conservation management options generally identify increased habitat conservation and/or establishing or restoring habitat connectivity as the top or among the top options to pursue (Mawdsley et al. 2009, Heller and Zavaleta 2009). We will need well-connected networks of conservation areas to allow for the movement of species in response to climate change. Selecting areas that will be both resilient and able to capture the broadest range of species is an important challenge.

It needs to be emphasized that, as used here, the term "conservation area" does not imply anything about ownership. A conservation area is simply any area that is managed, at least in part, to maintain some element of natural diversity. In this sense, a Conservation Reserve Program (CRP) lease on a farm in Iowa defines a conservation area as much as a conservation easement on privately owned timberland in Maine, a State Game Land in Pennsylvania, or a National Wildlife Refuge in Florida. These are examples of very different kinds of conservation areas, but each is an important component in the overall effort to conserve adequate habitat for our Nation's living resources. This *Strategy* makes no presumption about the best way of securing additional conservation areas (e.g., lease, conservation easement, fee acquisition, etc.), only that climate change will demand that we increase and perhaps accelerate collective efforts to do so. But simply creating new networks of conservation areas or acquiring more land to be protected in perpetuity will not be enough. Biologists and conservation land managers also must manage these conservation areas in innovative and flexible ways, as species and ecosystems respond and adjust (often in unpredictable fashion) to climate change. Flexible tools such as re-designation or exchanges of some existing public lands and the creation of additional types and/or numbers of conservation easements, leases, and incentives for private landowners will be essential.

The first step to meeting this challenge is identifying the best candidates for conservation areas. Given that natural community types will be changing as each species responds to climate change in its own way, identifying "future" habitat types and the best areas to represent them will prove challenging. Areas will need to be selected through the use of existing and new information and tools, such as inventories, gap analyses, mapping (including geophysical as well as biological features (Beier and Brost 2010, Anderson and Ferree 2010), vulnerability assessments, and geophysical and biological modeling (such as Species Distribution Models). Geographic Information Systems techniques, climate models, and inventory data can assist federal, state, tribal, and local agencies, as well as industry and private land owners in setting collective priorities for conservation and connectivity. Coordinating the efforts of many agencies and landowners will be a daunting process, but is a critical part of doing the job effectively and efficiently.

Increasing the number, quality, and size of conservation areas can increase the opportunities for individual species to adapt to climate change, and also make

KENTKENUCKY DEPARTMENT OF FISH & WILDLIFE RESOURCES

it more likely that native biodiversity will be conserved. Some species' habitat under climate change may be well outside their current or historic range. Healthy and biologically diverse ecosystems are likely to better withstand or adjust to the impacts of climate change. Increasing the number (redundancy) and distribution of protected fish, wildlife, and plant populations is important for the same reason. Establishing larger and more hospitable conservation areas for species to transition to will also increase opportunities for species to create new assemblages of species that are better able to persist in a dynamic climate.[2, 3]

Another challenge will be providing corridors between conservation areas so that species can freely move to new locations with suitable habitat. Protecting and restoring large blocks of habitat and using linkages and corridors to develop networks for movement will facilitate connectivity. Riparian corridors, such as floodplains, are useful as a conduit

2 See "For Landowners" at <www.fws.gov/endangered>

3 See "Programs & Services" at <www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs>

for migratory species and for providing access to water. In addition, appropriate transitory or "stopover" habitat for migratory species can promote biological connectivity between non-physically connected areas. Private landowners, land trusts and government agencies such as energy, transportation, and water resources agencies will be critical partners in creating these ecological connections. At the same time, managers must also guard against enabling movement of invasive and overabundant species, pests and pathogens.

Because human development in the United States has been so extensive, some of the habitat necessary for a comprehensive network of conservation areas will need to be restored. In the context of a period of climate change, ecological restoration will not necessarily be about attempting to restore specific species or combinations of species, but rather about restoring the conditions that favor healthy, diverse, and productive communities of species. Key components of such restoration can include promoting or mimicking natural disturbance regimes like fire; managing issues like in-stream flows, water withdrawals, and stormwater runoff; and addressing poorly-sited infrastructure, such as roads in floodplains and sensitive coastal areas. Effective restoration will require applying protocols and techniques that anticipate a range of future conditions, including different species compositions, caused by climate change and that can facilitate adaptation.

Alternatively, cultural and structural conservation practices applied to working agricultural and forest lands can provide a means of helping some species adapt to climate change. For example, improving the sustainability of working ranchlands, such as is being done through the NRCS Sage-Grouse Initiative, can ensure that these lands remain in grass that supports both ranching livelihoods and wildlife species associated with grassland and shrubland habitats, rather than being degraded by development, tillage, woody species encroachment or other stressors.

Overall, single jurisdiction or single interest approaches to land and water protection are not sufficient to deal with the landscape-scale changes being driven by climate change, and in some instances, may even be counter-productive. Fish, wildlife, and plant conservation agencies, local governments, tribes, and private conservation interests must work together in a coordinated way to build an ecologically-connected network of conservation areas.

CASE STUDY

Making salmon populations more resilient

AS A SPECIES THAT REQUIRES COLD, fast flowing streams for spawning, salmon could be hard hit by climate change. Indeed, climate models project widespread, large increases in air and stream temperatures in Washington State (Mantua et al. 2009), where much of the nation's key salmon habitat is located. Combined with anticipated declines in stream flows, higher temperatures would threaten not just the salmon, but also the immensely valuable industries, cultural traditions, and ecosystems that depend on the species.

TIM TORRELL

As a result, there is a need to map streams throughout the salmon's range to figure out which ones are most likely to stay cold with sufficient water flow (Mantua et al. 2009). The Washington Climate Change Impacts Assessment describes steps that can be taken to maintain good salmon habitat even in a changing climate, including:

- limit the amount of water that can be withdrawn from streams for irrigation or other purposes, especially in times of high temperatures and low stream flow;
- protect undercut banks and deep stratified pools, where water temperatures are lower;
- restore vegetation along streams, which cools the water and reduces sediment and pesticide levels;
- release cold water from large storage reservoirs during summer; and
- remove dams and other barriers so that cooler, protected headwaters flow more swiftly downstream, and salmon can swim upstream farther and faster.

Some of these strategies are already being implemented as part of the effort to protect and restore endangered salmon species. For example, two aging dams on the Elwha River are being removed, giving salmon access to 60 miles of high elevation, coldwater rivers, and streams in Olympic National Park. The availability of that additional, diverse habitat will increase salmon resilience (Waples et al. 2009).

Meanwhile, the Columbia Basin Water Transactions Program is tackling the problem of low stream flows. By taking such actions as acquiring water rights and leasing water, the program is able to reduce water withdrawals at critical times. In another example, the USDA Conservation Reserve Enhancement Program (CREP) and National Oceanic and Atmospheric Administration's Pacific Coastal Salmon Recovery fund are helping to restore vegetation in riparian zones. This restoration not only helps protect streams from rising temperatures and sediment, it also provides greater inputs of leaf litter and large logs that support stream food webs and create habitat diversity.

Strategy 1.1: Identify areas for an ecologically-connected network of terrestrial, freshwater, coastal, and marine conservation areas that are likely to be resilient to climate change and to support a broad range of fish, wildlife, and plants under changed conditions.

ACTIONS

1.1.1: Identify and map high priority areas for conservation using information such as species distributions (current and projected), habitat classification, land cover, and geophysical settings (including areas of rapid change and slow change).

1.1.2: Identify and prioritize areas currently experiencing rapid climate impacts (e.g., the coastline of Alaska, low-lying islands, and high alpine tundra).

1.1.3: Assess the potential of species to shift ranges, and prioritize conservation efforts taking into account range shifts and accounting for ecosystem functions and existing and future physical barriers.

1.1.4: Establish and maintain a comprehensive, inter-jurisdictional inventory of current conservation areas and candidate high priority conservation areas in order to coordinate future conservation efforts.

1.1.5: Re-prioritize conservation targets of existing land and water conservation programs in light of areas identified in 1.1.1.and listed in 1.1.4 and 1.4.2.

Strategy 1.2: Secure appropriate conservation status on areas identified in Action 1.1.1 to complete an ecologically-connected network of public and private conservation areas that will be resilient to climate change and support a broad range of species under changed conditions.

ACTIONS

1.2.1: Conserve areas identified in Action 1.1.1 that provide high priority habitats under current climate conditions and are likely to be resilient to climate change and/or support a broad array of species in the future.

1.2.2: Conserve areas representing the range of geophysical settings, including various bedrock geology, soils, topography, and projected climate, in order to maximize future biodiversity.

CASE STUDY

Building connectivity in New Jersey

Climate change could threaten amphibian species through increased flooding as well as drying.

USFWS/GARY STOLZ

IF CURRENT LOW-LYING COASTAL AREAS in New Jersey are flooded by spring high tides, as expected with sea level rises caused by climate change (Titus and Richman 2001), many amphibians will no longer be able to migrate up the Cape May Peninsula. That could threaten the viability of species like the state-endangered eastern tiger salamander and Cope's gray treefrog.

The New Jersey Division of Fish and Wildlife is working to provide more habitat for these amphibians and to better connect habitats to allow migration. Such migration prevents small populations from becoming isolated, thus, preserving genetic diversity for key species (Marsh and Trenham 2001, Cushman 2006).

For many amphibians, the key habitat is the vernal pool, a temporary pond that is typically deepest in the spring. The state has been both working to preserve existing vernal pools and looking for sites where it could create new pools. The sites were picked based on such criteria as elevation above anticipated sea level rise, vicinity to other vernal pools and upland habitat, location on state protected land, proper soil characteristics, and use by a variety of species.

When the effort is complete, the state will have established a connected network of vernal pool "strongholds" that will give New Jersey's amphibians a far better chance to adapt and survive as sea levels rise.

1.2.3: Build back-up redundancy into the network of conservation areas by protecting multiple examples of the range of priority areas identified in Action 1.1.1.

1.2.4: Work with partners at landscape scales to strengthen and maximize use of existing conservation programs, particularly the conservation title of the Farm Bill, conservation easement tax incentives, the private lands programs focused on endangered species, and other federal and state private lands incentive programs to conserve private lands of high conservation value, to enhance habitat values and maintain working landscapes under climate change.

1.2.5: Identify and pursue opportunities to increase conservation of priority lands and waters by working with managers of existing public lands such as military installations or state lands managed for purposes other than conservation.

Strategy 1.3: Restore habitat features where necessary and practicable to maintain ecosystem function and resiliency to climate change.

ACTIONS

1.3.1: Develop and implement restoration protocols and techniques that promote ecosystem resilience and facilitate adaptation under a range of possible future conditions.

1.3.2: Restore degraded habitats as appropriate to support a diversity of species assemblages and ecosystem structure and function.

1.3.3: Restore or enhance areas that will provide essential habitat and ecosystem services during ecosystem transitions under a changing climate.

1.3.4: Restore disturbance regimes as appropriate to emerging conditions, including instituting human-assisted disturbance where necessary (e.g., prescribed fire).

1.3.5: Develop programs to encourage resilience through restoration of habitat features that provide natural buffers.

1.3.6: Develop market-based incentives that encourage habitat restoration where appropriate.

Strategy 1.4: Conserve, restore, and as appropriate and practicable, establish new ecological connections among conservation areas to facilitate fish, wildlife, and plant migration, range shifts, and other transitions caused by climate change.

ACTIONS

1.4.1: Identify species with special connectivity needs (i.e., those that are area-limited, resource-limited, dispersal-limited, or process-limited).

1.4.2: Assess and prioritize critical connectivity gaps and needs across current conservation areas, including areas likely to serve as refugia in a changing climate.

1.4.3: Conserve corridors and transitional habitats between ecosystem types through both traditional and non-traditional (e.g., land exchanges, rolling easements) approaches.

1.4.4: Assess and take steps to reduce risks of facilitating movement of undesirable non-native species, pests, and pathogens.

1.4.5: Assess existing physical barriers or structures that impede movement and dispersal within and among habitats to increase natural ecosystem resilience to climate change, and where necessary, consider the redesign or mitigation of these structures.

1.4.6: Provide landowners and stakeholder groups with incentives for conservation and restoration of key corridor habitats through conservation programs such as those under the conservation title of the Farm Bill and landowner tools under the ESA as well as other mechanisms such as conservation easement tax incentive programs designed to protect private lands of high connectivity value under climate change.

GOAL 1 PROGRESS CHECK LIST

- ☐ Areas resilient to climate change identified;
- ☐ Gap analysis of geophysical settings completed and priority candidate areas identified;
- ☐ Desired ecological connectivity among conservation areas identified;
- ☐ Baseline comprehensive inventory of conservation areas completed;
- ☐ Suite of land protection tools (designations, exchanges, acquisitions, easements, leases, incentives) evaluated and updated;
- ☐ Protocols for incorporating climate change into ecological restoration efforts developed and implemented;
- ☐ Begin conserving and/or restoring high priority areas for fish, wildlife, and plants under climate change.

USFWS/RYAN HAGERTY

Goal 2

Manage species and habitats to protect ecosystem functions and provide sustainable cultural, subsistence, recreational, and commercial use in a changing climate.

AS DESCRIBED IN CHAPTER 1, humans depend upon and derive multiple benefits from fish, wildlife, plants, and their habitats. Our living resources are vital for ceremonial, spiritual, and subsistence practices by indigenous peoples; recreational activities such as sport fishing, hunting, birding, and nature photography; and commercial interests such as fisheries, wood products, and food production. They are part of the core fabric of America, providing livelihoods, cultural identity, and boundless opportunities.

Maximizing the chances for species to adapt to climate change likely includes maintaining a full range of genetic diversity across managed plant and animal populations.

The United States has a highly developed set of management agencies and authorities that work to maintain our existing living resources and the many uses and benefits they provide. Virtually all of these agencies have sophisticated management plans for the species and areas under their jurisdiction. Some of these plans have incorporated climate change considerations. For example, some 17 states have already developed or are in the process of developing climate adaptation strategies for their fish, wildlife, and plant resources. At the federal level, the FWS, the National Park Service, and the U.S. Forest Service have all developed climate change strategies for their agencies (see Chapter 5 for a more detailed discussion of ongoing adaptation planning). Nonetheless, many other agencies and most of the specific resource plans agencies are responsible for do not yet take climate change into account. This deficiency must be addressed, because managing for the *status quo* is no longer sufficient. We must build on our legacy of conservation action and begin to integrate climate adaptation strategies and actions into existing species and conservation area management plans if species and ecosystems are to survive and thrive in an uncertain future (see Glick et al. 2011a and Poiani et al. 2011 for a discussion of applicable methods).

Management plans and programs must consider species' abilities to adapt to climate change. They must also consider the ability of habitats to be resilient in the face of climate change, not necessarily in the sense of maintaining their current species composition, but in the sense of their overall functionality. Maximizing the chances for species to adapt to climate change likely includes maintaining a full range of genetic diversity across managed plant and animal populations. Some species may need more direct management, such as captive breeding. In other cases, managers may need to consider whether human interventions such as translocation or assisted relocation are appropriate. Because some of these actions may be new and potentially controversial, they need to be fully explored before moving forward, and collaborative, deliberative, and flexible decision-making will be critical.

Continued development and application of ecosystem based approaches to natural resource management is also a key step in this process. This approach grew out of broad acknowledgement that successful management required multi-dimensional, multispecies, and multi-sector approaches across broader time and spatial scales than was previously practiced. The scale and scope of climate change impacts on natural and human communities make this type of approach even more essential for sustaining ecosystem functions in a changing world.

Strategy 2.1: Update current or develop new species, habitat, and land and water management plans, programs and practices to consider climate change and support adaptation.

ACTIONS:

2.1.1: Incorporate climate change considerations into new and future revisions of species and area management plans (e.g., North American Waterfowl Management Plan, National Forest Plans, State Wildlife Action Plans, and agency-specific climate change adaptation plans such as federal agency adaptation plans required by E.O. 13514) using the best available science regarding projected climate changes and trends, vulnerability and risk assessments, scenario planning, and other appropriate tools as necessary.

2.1.2: Develop and implement best management practices to support habitat resilience in a changing climate.

2.1.3: Identify species and habitats particularly vulnerable to transition under climate change (e.g., wetlands, cool-water to warm-water fisheries, or cool season to warm season grasslands) and develop management strategies and approaches for adaptation.

2.1.4: Review and revise as necessary techniques to maintain or mimic natural disturbance regimes and to protect vulnerable habitats consistent with emerging conditions.

2.1.5: Review and revise as necessary existing species and habitat impact avoidance, minimization, mitigation, and compensation standards and develop new standards as necessary to address impacts in a manner that incorporates climate change considerations.

2.1.6: Review permitting intervals in light of the scope and pace of climate change impacts.

2.1.7: Review existing management frameworks and identify ways to increase the ability of stakeholders to adapt their actions to climate variability and change while preserving the integrity and sustainability of natural resources, habitats, and ecosystems.

2.1.8: Utilize the principles of ecosystem-based management and green infrastructure.

2.1.9: Develop strategic protection, retreat, and abandonment plans for areas currently experiencing rapid climate change impacts (e.g., coastline of Alaska and low-lying islands).

Strategy 2.2: Develop and apply species-specific management approaches to address critical climate change impacts where necessary.

ACTIONS:

2.2.1: Use vulnerability and risk assessments to design and implement management actions at species to ecosystem scales.

2.2.2: Develop criteria and guidelines that foster the appropriate use, and discourage inappropriate use of translocation, assisted relocation, and captive breeding as climate adaptation strategies.

2.2.3: Where appropriate, actively manage populations (e.g., using harvest limits, seasons, translocation, captive breeding, and supplementation) of vulnerable species to ensure sustainability and maintain biodiversity, human use, and other ecological functions.

USFWS/DAVE MENKE

Strategy 2.3: Conserve genetic diversity by protecting diverse populations and genetic material across the full range of species occurrences.

ACTIONS

2.3.1: Develop and implement approaches for assessing and maximizing the potential for maintaining genetic diversity of plant and animal species.

2.3.2: Protect and maintain high quality native seed sources including identifying areas for seed collection across elevational and latitudinal ranges of target species.

2.3.3: Develop protocols for use of propagation techniques to rebuild abundance and genetic diversity for particularly at-risk plant and animal species.

2.3.4: Seed bank, develop, and deploy as appropriate plant materials for restoration that will be resilient in response to climate change.

2.3.5: Develop ex-situ living collections with partners such as botanic gardens, arboreta, zoos, and aquaria.

CASE STUDY

Seed banking in a changing climate

CLIMATE CHANGE MAY BRING THE LOSS of major populations of plants—or even entire species. One of the key approaches for boosting a species' chances of surviving in a changed world is maintaining the species' genetic diversity.

Both of these issues can be addressed by collecting and banking seeds and other plant materials. An extensive seed bank can save species that go extinct in the wild, preserve the genetic diversity needed for other species to cope with a changed environment, and provide the seed needed for restoration projects.

Such a preservation effort is now underway. In 2001, Congress directed the Interagency Plant Conservation Alliance to develop a long-term program to manage and supply native plant materials for various federal land management restoration and rehabilitation needs. Working with hundreds of partners in federal, tribal, and state agencies, universities, conservation groups, native seed producers, and others, the program has now collected seeds from more than 3,000 native plant species in the United Sates.

Global networks, such as the Global Strategy for Plant Conservation and the Gran Canaria Declaration on Climate Change and Plant Conservation, also exist to protect plants. These are both important documents that can be used in the development of criteria and guidelines for plants.

Graphic adapted from BLM/Interagency Native Plant Materials Development Program

GOAL 2 PROGRESS CHECK LIST

- ☐ Species requiring active intervention identified;
- ☐ Genetic conservation issues identified;
- ☐ Fire and other disturbance regimes managed to better suite emerging conditions;
- ☐ Criteria and guidelines developed for translocation, assisted relocation, and captive breeding;
- ☐ Vulnerability and risk assessments and scenario planning used to guide species management decisions;
- ☐ Best management practices developed and initiated;
- ☐ Species and area management plans updated;
- ☐ State Wildlife Action Plans updated to include climate adaptation;
- ☐ Agency specific climate change adaptation plans developed and integrated with other appropriate plans;
- ☐ Seed banks and living collections developed consistent with planning.

USFWS

Goal 3

Enhance capacity for effective management in a changing climate.

CLIMATE CHANGE ADAPTATION REQUIRES altering existing or developing new ways of assessing information, new management tools, and new professional skills. Natural resource agency professionals need accessible opportunities to learn about climate-related species, habitat, and ecosystem changes as well as how to identify the most promising strategies to conserve fish, wildlife, and plant populations and functioning ecosystems.

It is becoming increasingly important to train wildlife professionals on how to incorporate climate change into their management practices.

While well-trained in ecology and applied resource management, many managers have not yet had the opportunity to learn about and understand how climate change "changes the rules" about conservation of fish, wildlife, and plants. These professionals require training to enhance their capacity and confidence to understand the impacts of climate change and to design and deliver effective climate adaptation programs.

Climate change impacts are occurring at scales much larger than the operational scope of individual organizations and agencies, and successful adaptation to climate change demands a strong collaboration among all jurisdictions charged with fish, wildlife, and plant conservation, both domestic and international.

Although some regionally integrated, multi-jurisdictional climate change adaptation programs and plans exist, more are needed. Collaborative efforts will result in more informed, relevant, and creative solutions for all stakeholders. Federal, state, and tribal resources managers should work together with their partners across jurisdictions and regional scales (including international borders) to provide context and coordination for species and conservation area management in the context of climate change scenarios. Current institutional disconnects and barriers can hamper our ability to manage fish, wildlife, plants, and ecosystems across jurisdictions. This is an opportunity for practitioners to network their capacities to be more effective and efficient in terms of monitoring, data sharing, data development, and adaptive management. Existing and emerging partnerships and organizations (e.g., LCCs, Climate Science Centers (CSCs) JVs, Regional Integrated Sciences and Assessments (RISAs), NFHPs, regional ocean governors' alliances, AFWA, the Association of State Wetland Managers, and others) provide useful forums for multiple jurisdictions and partners to better work together to define, design, and deliver sustainable landscapes at a regional scale.

Many fish, wildlife, and plant conservation laws, regulations, and policies were developed without the current understanding of climate change. These legal and policy foundations should be reviewed to identify opportunities to improve, where appropriate, their usefulness to address climate change considerations. This review process should assure that these legal foundations assist, and do not impede, adaptation efforts. Appropriate regulatory tools and

adequate enforcement will be important to reduce existing stressors on fish, wildlife, and plants. It is also essential that programs are reviewed to maximize the utility of existing conservation funding and to increase the priority of climate change adaptation work.

Strategy 3.1: Increase the climate change awareness and capacity of natural resource managers and other decision makers and enhance their professional abilities to design, implement, and evaluate fish, wildlife, and plant adaptation programs.

ACTIONS

3.1.1: Build on existing needs assessments to identify gaps in climate change knowledge and technical capacity among natural resource professionals.

3.1.2: Build on existing training courses and work with professional societies, academicians, technical experts, and natural resource agency training professionals to address key needs, augment adaptation training opportunities, and develop curricula, a common lexicon, and delivery systems for natural resource professionals and decision makers.

3.1.3: Develop training on the use of existing and emerging tools for managing under uncertainty (e.g., vulnerability and risk assessments, scenario planning, decision support tools, and adaptive management).

3.1.4: Develop a web-based clearinghouse of training opportunities and materials addressing climate change impacts on natural resource management.

3.1.5: Encourage use of interagency personnel agreements and interagency (state, federal, and tribal) joint training programs as a way to disperse knowledge, share experience and develop interagency communities of practice about climate change adaptation.

3.1.6: Support and enhance web-based clearinghouses of information (e.g., www.CAKEX.org, etc.) on climate change adaptation strategies and actions targeted towards the needs of resource managers and decision makers.

3.1.7: Increase scientific and management capacity (e.g., botanical expertise) to develop management strategies to address impacts and changes to species.

3.1.8: Develop training materials to help managers and decision makers apply climate knowledge to the administration of existing natural resource and environmental laws and policies.

CASE STUDY

Sea level rise in Delaware

A RISING SEA COMBINED with sinking land creates a watery future. The state of Delaware is experiencing both, with relative sea levels to rise at the rapid rate of one inch every eight years (NOAA 2009). That is a big problem in a state where more than 10 percent of the land lies less than eight feet above sea level and no spot is farther than 35 miles from the Atlantic Ocean, Delaware Bay, or Delaware River. Residences, communities, and industries are at risk. In fact, the state is already experiencing worrisome coastal flooding. Breaches in the sandy shoreline at Prime Hook National Wildlife Refuge, for instance, have allowed saltwater into freshwater marshes that provide important waterfowl habitat.

Keenly aware of the threat, the state of Delaware has created a Sea Level Rise Initiative to understand the impacts of sea level rise, prepare for inundation in some areas, respond where necessary, and keep the public informed. Prime Hook National

GREG THOMPSON / USFWS

Wildlife Refuge is collaborating with the state of Delaware to implement short-term adaptation strategies to address inundation and saltwater intrusion into freshwater impoundments by re-establishing the shoreline.

Strategy 3.2: Facilitate a coordinated response to climate change at landscape, regional, national, and international scales across state, federal, and tribal natural resource agencies and private conservation organizations.

ACTIONS

3.2.1: Use regional venues, such as LCCs, to collaborate across jurisdictions and develop conservation goals and landscape/seascape scale plans capable of sustaining fish, wildlife, and plants.

3.2.2: Identify and address conflicting management objectives within and among federal, state, and tribal conservation agencies and private landowners, and seek to align policies and approaches wherever possible.

3.2.3: Integrate individual agency and state climate change adaptation programs and State Wildlife Action Plans with other regional conservation efforts, such as LCCs, to foster collaboration.

3.2.4: Collaborate with tribal governments and native peoples to integrate traditional ecological knowledge and principles into climate adaptation plans and decision-making.

3.2.5: Engage with international neighbors, including Canada, Mexico, Russia, and nations in the Caribbean Basin, Arctic Circle, and Pacific Ocean to help adapt to and mitigate climate change impacts in shared trans-boundary areas and for common migratory species.

3.2.6: Foster interaction among landowners, local experts, and specialists to identify opportunities for adaptation and to share resources and expertise that otherwise would not be available to many small landowners.

CASE STUDY

Traditional ecological knowledge

JEFF NICHOLS

INDIGENOUS COMMUNITIES POSSESS traditional ecological knowledge (TEK) and relationships with particular resources and homeland areas, accumulated through thousands of years of history and tradition, which make them highly sensitive to, and aware of, environmental change. TEK can be defined as the "holistic, evolving practices and beliefs passed down through generations about the relationships of living beings to their environment" (Swinomish 2010). This knowledge is place-specific and includes the relationships between plants, animals, natural phenomena, landscapes, and phenology that are used for regular practices like hunting, fishing, trapping, and forestry (Rinkevich et al. 2011).

Because of the dependence of American Indians and Alaska Natives on their natural resources for their economic and cultural identity, climate change is a threat not only to those natural resources, but also to the traditions, the culture, and ultimately, the very health of the communities themselves. TEK holds great value with respect to climate change assessment and adaptation efforts, by helping to understand climatic impacts on a wide variety of ecological processes and ecosystems, at various scales (Nabhan 2010). Governments and organizations, from the Intergovernmental Panel on Climate Change to DOI, are increasingly recognizing the value of TEK as a complement to research for developing a comprehensive response to climate change impacts, both in indigenous and non-indigenous communities (DOI 2010, Anisimov et al. 2007). Despite this gradually increasing acknowledgement, the status and trust obligations related to TEK have yet to receive comprehensive treatment.

Alaska Natives are already facing the effects of climate change head on. For example, due to erosion rates and increased climate change effects (e.g., sea ice retreat, permafrost melt, storm effects) the village of Newtok, home to the Qaluyaarmiut people, has begun relocation plans (Feifel and Gregg 2010). The Qaluyaarmiut are avid fishermen and depend on the natural environment for subsistence. The American Indian Alaska Native Climate Change Working Group represent a broad alliance of indigenous communities, tribal colleges, scientists, and activists, who work together to empower indigenous climate change adaptation. Indigenous educational institutions are critical vehicles for nurturing indigenous environmental knowledge and scientific capacity, and can be leaders of regional indigenous responses to climate change (Upham 2011).

In addition to working groups that focus on indigenous climate issues, TEK is already being utilized by other management entities in Alaska. The U.S. Fish and Wildlife Service and the State of Alaska Department of Fish and Game collect and use TEK for research and monitoring fish populations and their responses to climate and environmental change (Rinkevich et al. 2011). The response to certain environmental disasters and the justification of listing the polar bear as a threatened species both relied on the inclusion of TEK to understand and document historical ecological characteristics (Rinkevich et al. 2011). The relationships developed in Alaska are an excellent example of not only how TEK can be successfully integrated into management activities, but also how this knowledge can be collected, used, and protected in a respectful and culturally-sensitive manner.

Strategy 3.3: Review existing federal, state and tribal legal, regulatory and policy frameworks that provide the jurisdictional framework for conservation of fish, wildlife, and plants to identify opportunities to improve, where appropriate, their usefulness to address climate change impacts.

ACTIONS

3.3.1: Review existing legal, regulatory and policy frameworks that govern protection and restoration of habitats and identify opportunities to incorporate the value of ecosystem services and improve, where appropriate, the utility of these frameworks to address climate change impacts.

3.3.2: Review existing legal, regulatory and policy frameworks and identify opportunities to develop or enhance, where appropriate, market-based incentives to support restoration of habitats and ecosystem services impacted by climate change. Identify opportunities to eliminate disincentives to conservation and adaptation.

3.3.3: Review existing legal, regulatory and policy frameworks and identify opportunities to improve, where appropriate, compensatory mitigation requirements to account for climate change.

3.3.4: Review existing legal, regulatory and policy frameworks that govern floodplain mapping, flood insurance, and flood mitigation and identify opportunities to improve their usefulness to reduce risks and increase adaptation of natural resources and communities in a changing climate.

3.3.5: Review existing legal, regulatory and policy tools that provide the jurisdictional framework for conservation of fish, wildlife, and plants to identify existing provisions that provide climate change adaptation benefits.

3.3.6: Continue the ongoing work of the Joint State-Federal Task Force on Endangered Species Act Policy to ensure that policies guiding implementation of the ESA provide appropriate flexibility to address climate change impacts on listed fish, wildlife, and plants and to integrate the efforts of federal, state, and tribal agencies to conserve listed species.

3.3.7: Initiate a dialogue among all affected interests about opportunities to improve the usefulness of existing legal, regulatory, and policy frameworks to address impacts of sea level rise on coastal habitats.

Strategy 3.4: Optimize use of existing fish, wildlife, and plant conservation funding sources to design, deliver, and evaluate climate adaptation programs.

ACTIONS

3.4.1: Prioritize funding for land and water protection programs that incorporate climate change considerations.

3.4.2: Review existing federal, state, and tribal grant programs and revise as necessary to support funding of climate change adaptation and include climate change considerations in the evaluation and ranking process of grant selection and awards.

3.4.3: Collaborate with state and tribal agencies and private conservation partners to sustain authorization and appropriations for the State and Tribal Wildlife Grants Program and include climate change criteria in grant review process.

3.4.4: Collaborate with agricultural interests and businesses to identify potential impacts of climate change on crop production and identify conservation strategies that will maintain or improve ecosystem services through programs under the conservation title of the Farm Bill or other vehicles.

3.4.5: Review existing conservation related federal grants to tribal agencies and revise as necessary to provide funding for tribal climate adaptation activities.

3.4.6: Develop a web-based clearinghouse of funding opportunities available to support climate adaptation efforts.

GOAL 3 PROGRESS CHECK LIST

- ☐ Natural resource professional training needs identified;
- ☐ Climate adaptation training collaboratives established;
- ☐ Core curricula for climate adaptation established;
- ☐ Training opportunity and accessibility increased;
- ☐ Interagency personnel assignments expanded;
- ☐ Regional collaboratives engaged to serve as venues for inter-jurisdictional collaboration on climate change adaptation;
- ☐ Legal, regulatory, and policy frameworks regarding key conservation statues reviewed and as necessary, updated;
- ☐ Floodplain maps updated;
- ☐ Dialogue initiated to improve implementation of existing legal policy frameworks, regulations, and policies to respond to climate impacts;
- ☐ Criteria to include climate change adaptation in existing conservation grant programs developed;
- ☐ Criteria for including climate change adaptation needs in resource allocation developed;
- ☐ Funding allocations reviewed/revised in light of climate change priorities.

JENNY LEFF

Goal 4

Support adaptive management in a changing climate through integrated observation and monitoring and use of decision support tools.

THERE IS UNCERTAINTY REGARDING the specific impacts of climate change on natural resources. There is also much to be learned about the effectiveness of management actions to mitigate these impacts. To improve understanding of adaptation options, it is important to support the development and use of long-term data series, information systems, and decision support tools.

Vulnerability assessments and scenario planning can inform and enable management planning and decision-making under uncertainty.

The use of these tools, best professional judgment, and stakeholder involvement is critical to the design and implementation of management approaches to promote climate change adaptation. The continuous learning principles of adaptive management should be used to monitor the response to management actions, evaluate effectiveness, gain new knowledge, and improve and inform future management decisions. When coupled with research on specific impacts to fish, wildlife, plants, and habitats and their response to climate change (Goal 5), managers will be better equipped to implement effective management actions.

Inventory, monitoring, and observation systems should be maintained, addressed, and where needed, coordinated to enable resource managers to monitor and identify changes in ecological baselines from the species to the ecosystem level, and to prioritize and develop adaptation plans and actions. Monitoring and tracking key ecological variables can provide early warnings of pending change, and is essential to evaluating and improving adaptation responses over time. The National Ecological Observatory Network is an example of such an effort to deploy instrumentation at sites to measure key ecosystem variables arrayed across important environmental gradients. Other such systems include, but are not limited to, the Forest Inventory and Analysis, the Natural Resource Assessment, the Breeding Bird Survey, the National Wetlands Inventory, Integrated Ecosystem Assessments, the Integrated Ocean Observing System and many others. Monitoring systems, especially those that meet local to regional needs, will allow managers and other decision makers to evaluate the efficacy of management actions. International efforts are critical to monitor and track climate impacts on species that migrate to and depend on areas beyond U.S. borders. Where existing systems do not meet all management needs, additional programs may need to be developed.

While observation systems provide critical data for resource managers, those data have far greater utility when processed, analyzed, and made available as readily useable information. The need for information management and increased access to information is well-documented (Glick et al. 2011b). A multi-disciplinary approach to link and

make available data currently developed by separate agencies or groups will increase access to and use of this information by resource managers, planners, and decision makers.

Vulnerability assessments are important science-based tools that inform adaptation planning by identifying, quantifying, or evaluating the degree to which natural resources or other values are likely to be affected by changing climatic conditions. They may focus on natural resources, communities, species, sites, regions, sectors, or other values or targets, and should consider both current and future impacts. Vulnerability is generally defined as a combination of sensitivity to change, likely exposure to changing conditions, and the capacity to adapt to those changes over time (IPCC AR 4 2007). Vulnerability assessments should address all three factors. These types of assessments can help managers develop and prioritize adaptation strategies as well as inform management approaches.

Tools, such as vulnerability and risk assessments and scenario planning, can inform and enable management planning and decision-making under uncertainty. Identifying, developing, and employing these types of tools will help managers facilitate adaptation of individual species, increase habitat resilience, and help identify where changes to the built environment may conflict with ecosystem needs.

Strategy 4.1: Support, coordinate, and where necessary develop distributed but integrated inventory, monitoring, observation, and information systems at multiple scales to detect and describe climate impacts on fish, wildlife, plants, and ecosystems.

ACTIONS

4.1.1: Synthesize existing observations, monitoring, assessment, and decision support tools as summarized by the U.S. Global Change Research Program Ecosystem Working Group. Conduct a knowledge-gap analysis of existing observation networks, indicators, monitoring programs, remote sensing capabilities, and geospatial data necessary to define priorities.

4.1.2: Use available long-term monitoring programs at appropriate scales (local to international) as baselines for population and migration changes that could be affected by climate change (e.g., International Waterfowl Surveys).

4.1.3: Work through existing distributed efforts (e.g., NCA, National Estuarine Research Reserve System's system-wide monitoring program, State Natural Heritage Programs, National Wildlife Refuge System and National Park Service inventory and monitoring programs) to support integrated national observation and information systems that inform climate adaptation.

4.1.4: Expand and develop as necessary a network of sentinel sites (e.g., tribal lands, National Estuarine Research Reserves, and National Wildlife Refuges) for integrated climate change inventory, monitoring, research, and education.

4.1.5: Develop consensus standards and protocols that enable multi-partner use and data discovery, as well as interoperability of databases and analysis tools related to fish, wildlife, and plant observation, inventory, and monitoring.

4.1.6: Develop, refine, and implement monitoring protocols that provide key information needed for managing and conserving species and ecosystems in a changing climate.

4.1.7: Use existing or define new indicators at appropriate scales that can be used to monitor the response of fish, wildlife, plants, and ecosystems to climate change.

4.1.8: Promote a collaborative approach to acquire, process, archive, and disseminate essential geospatial and satellite-based remote sensing data products (e.g., snow cover, green-up, surface water, wetlands) needed for regional-scale monitoring and land management.

4.1.9: Collaborate with the National Phenology Network to facilitate monitoring of phenology; create an analogous National Population Network to catalog changes in distribution and abundance of fish, wildlife, and plants that have been identified as most vulnerable to climate change.

4.1.10: Identify and develop a lessons learned/success stories list of multi-partner data development, analysis, and dissemination efforts.

USFWS/GREG WANNER

Strategy 4.2: Identify, develop, and employ decision support tools for managing under uncertainty (e.g., vulnerability and risk assessments, scenario planning, strategic habitat conservation approaches, forecasting, and adaptive management evaluation systems) via dialogue with scientists, managers (of natural resources and other sectors), economists, and stakeholders.

ACTIONS

4.2.1: Develop regional downscaling of Global Climate models to conduct vulnerability assessments of living resources.

4.2.2: Develop, disseminate, and utilize geophysical and biological modeling (such as Species Distribution Models).

4.2.3: Conduct vulnerability and risk assessments for habitats and priority species (threatened and endangered species, species of greatest conservation need, and species of socioeconomic and cultural significance).

4.2.4: Define national standards and criteria to identify fish, wildlife, plants, and ecosystems most vulnerable to climate change impacts.

4.2.5: Synthesize vulnerability assessments across jurisdictions to provide regional assessments.

4.2.6: Engage scientists, resource managers, economists, and stakeholders in climate change scenario planning processes, including identification of a set of plausible future scenarios associated with climate phenomena and socio-economics likely to significantly impact fish, wildlife, and plants.

4.2.7: Ensure the availability of and provide guidance for decision support tools (e.g., NOAA's Digital Coast, Sea Level Affecting Marshes Model (SLAMM), etc.) that assist federal, state, local, and tribal resource managers and planners in effectively managing fish, wildlife, and plants in a changing climate.

4.2.8: Use observation and monitoring systems in an adaptive management framework to evaluate the effectiveness of specific management actions and adapt management approaches appropriately.

4.2.9: Develop a central repository for sharing experiences and reporting progress in implementing the Strategy in order to share information across implementing agencies and partners and to inform future iterations of the Strategy.

GOAL 4 PROGRESS CHECK LIST

- ☐ Public/private collaborative convened to build nationally integrated inventory, monitoring, observation and information systems to inform climate change adaptation actions;
- ☐ Existing public and private inventory, monitoring, observation, and information systems linked and information systems assessed, linked, and made available;
- ☐ Data collection standards for common set of climate change metrics established;
- ☐ Coordinated sentinel sites identified, linked, and as necessary, established to monitor climate change impacts and responses;
- ☐ Targeted monitoring of fish, wildlife, plants, and their habitats for the effects of climate change initiated;
- ☐ Federal, state, and tribal managers provided with access to natural resources information and other necessary data;
- ☐ Evaluation of existing and new climate adaptation plans uses observation and monitoring systems;
- ☐ Regionally downscaled climate projections produced where appropriate;
- ☐ Standardized climate change scenarios developed;
- ☐ Models for climate change impacts to species and habitats improved or developed;
- ☐ Framework of tools for managing under uncertainty developed;
- ☐ Vulnerability and risk assessments conducted for priority species.

CASE STUDY

Sentinel site monitoring

The innovative approaches to sentinal site monitoring provide a framework that can be applied to inform the climate change management dialogue.

GABI ESTILL/ELKHORN SLOUGH NERR

CRAFTING AN EFFECTIVE CLIMATE adaptation strategy is difficult without having good data on the impacts of climate change. Collecting that vital information, in turn, requires observing and measuring what is happening at specific locations over many years. In 2008, the National Estuarine Research Reserve System (NERRS) began establishing such so-called "sentinel sites" to learn how estuarine habitats respond to sea level change.

One of those sentinel sites is the Elkhorn Slough Reserve in California's Monterey Bay. The area began losing some of its tidal wetlands more than 100 years ago when dikes and water control structures began to decrease tidal exchange and to many portions of the estuary. An artificial mouth to the estuary created in 1946 to accommodate a new harbor also contributed to wetland loss. Now, sea level rise is further threatening this valuable estuarine ecosystem. At the same time, the estuary is under stress from eutrophication, groundwater withdrawals, and other factors.

To understand the complex effects of these stressors, the NERRS is intensely monitoring the ecosystem. Researchers are recording surface water levels, testing water quality, and measuring changes occurring in tidal marsh plants, and submerged aquatic vegetation. They are also monitoring the amounts of sediment in the wetlands and changes in land elevation.

So far, the project has documented a worrisome trend. The marshes appear to be sinking, and this subsidence greatly decreases their resilience to future sea level rise. Eventually, rising sea levels will increase the vulnerability of a railroad line, a power plant, and a number of adjacent farms to flooding and coastal erosion. The monitoring data will be informing the adaptation measures that are taken to reduce vulnerability.

USFWS/LARRY JERNIGAN

Goal 5

Increase knowledge and information on impacts and responses of fish, wildlife, and plants to a changing climate.

THE DESIGN AND DELIVERY of fish, wildlife, and plant climate change adaptation programs is also hampered by lack of detailed knowledge about specific impacts of climate change on fish, wildlife, plants, and habitats and their adaptive capacity to respond.

The services associated with healthy ecosystems, including clean water, healthy habitats, and desirable living and recreational environments are invaluable.

It is important to note that despite a growing foundation of information, many uncertainties and gaps remain in our understanding about the current and future impacts of climate change and ocean acidification on natural resources and ecosystems.

Focused research on developing a clear set of indicators that could be used to track and assess the impacts of climate change and the effectiveness of adaptation efforts over time is still in its infancy but has been growing in recent years. Additional basic research to develop, improve, and integrate information from physical monitoring systems, satellites, and national weather service systems is needed to better understand how the climate is changing.

Knowledge gaps regarding impacts on species and ecosystems will need to be addressed. Existing research collaborations such as the USGCRP can enable natural resource managers and other decision makers to focus and prioritize research. There are many critical areas where increased basic understanding is needed to anticipate and help reduce the impacts of climate change on fish, wildlife, and plants including how climate change will alter the effects of pollutants and other existing stressors in ecosystems, and how species will respond to changes in climatic and non-climatic factors. New findings should be rapidly incorporated into decision support tools (e.g., state-and-transition models) and made available to managers, as well as into climate change adaptation planning, delivery, and evaluation. By improving the state of knowledge, managers can better develop novel and anticipatory adaptation strategies.

The use of models to project potential changes in weather patterns and natural systems has already generated a great deal of useful information to help us plan for future climate impacts, especially at large scales. Additional and more refined models at temporal and spatial scales appropriate to climate adaptation objectives established by natural resource managers are required. Development of models to predict how changes in climate variables (e.g., temperature, humidity, atmospheric CO_2) impact habitat and fish, wildlife, and plant abundance and distribution is a priority and should initially focus on processes that are already occurring and that act on short (i.e., decadal) time scales.

Most Americans appreciate the aesthetic values that healthy populations of fish, wildlife, and plants offer, and many have a cultural, recreational, or economic association with wildlife and wild places. Few, however, fully understand the services that well-functioning ecosystems provide to society or what the full cost of replacing those services would be. Methods should be developed to objectively quantify the value of ecosystem services and to understand potential impacts from climate change to these important services. Once these values are quantified, they can be considered in better economic decision-making processes.

Strategy 5.1: Identify knowledge gaps and define research priorities via a collaborative process among federal, state, tribal, private conservation organization, and academic resource managers and research scientists.

ACTIONS

5.1.1: Increase coordination and communication between resource managers and natural and social scientists through existing forums (e.g., National Science Foundation (NSF), USGCRP, NCA, USDA, Cooperative Ecosystem Studies Units, CSCs, LCCs, JVs, RISAs, Associations of Fish and Wildlife Agencies, State Wetlands Managers, State Floodplain Managers, Coastal States Organization, National Estuarine Research Reserve Association, and others) to ensure research is connected to management needs.

5.1.2: Bring managers and scientists together at the appropriate scales to prioritize research needs that address resource management objectives considering a changing climate.

5.1.3: Encourage agencies with scientific assets and expertise to participate in and contribute to regional dialogues about actions needed to meet management-driven science needs.

5.1.4: Participate in research planning for relevant programs of agencies (e.g., NSF, NOAA, state agencies, and local governments), and intergovernmental forums (e.g., Conservation of Arctic Flora and Fauna working group of the Arctic Council) to ensure inclusion of research relevant to missions of agencies and resource managers.

5.1.5: Based on priority conservation needs identified by resource managers, develop national, and as appropriate, regional research agendas identifying key high level questions for which more fundamental research is needed to enable development of management applications or decision support tools; and facilitate consultation among major science funding agencies to maximize incorporation of these needs into funding opportunities and work plans.

5.1.6: Prioritize research on questions relevant to managers of near-term risk environments (e.g., low-lying islands, alpine systems and high-elevation headwaters, coral reefs, and glaciated areas) or highly vulnerable species.

5.1.7: Prioritize research and methods development for the valuation of ecosystem services and the role these services play in ameliorating climate change impacts on people and communities.

CASE STUDY

Plants and their pollinators

USFWS/LAURA PERLICK

MORE THAN 75 PERCENT OF FLOWERING plants, which provide a bounty of fruits, seeds, nuts, and nectar for wildlife, depend on pollinators. As the climate changes, plants will grow in different places and bloom at different times. That raises a high-stakes question: Will pollinators follow? If they cannot, then vital ecological relationships could be severed.

The U.S. Fish and Wildlife Service's Arizona Ecological Services Field Office and the Merriam-Powell Center for Environmental Research at Northern Arizona University are trying to answer this question. In the mountains of San Francisco Peaks north of Flagstaff, Arizona, teams of researchers are conducting extensive surveys of plant-pollinator relationships at five different sites.

This collaborative study is looking across ecosystems from the desert foothills up to the highest mountain peaks, collecting both ecological and climate data, and capturing changes in ecological relationships over time.

Strategy 5.2: Conduct research into ecological aspects of climate change, including likely impacts and the adaptive capacity of species, communities and ecosystems, and their associated ecosystem services, working through existing partnerships or new collaborations as needed (e.g., USGCRP, NCA, CSCs, RISAs, and others).

ACTIONS

5.2.1: Produce regional to subregional projections of future climate change impacts on physical, chemical, and biological conditions for U.S. ecosystems.

5.2.2: Support basic research on life histories and food web dynamics of fish, wildlife, and plants to increase understanding of how species are likely to respond to changing climate conditions and identify survival thresholds.

5.2.3: Identify and address priority climate change knowledge gaps and needs (e.g., species adaptive capacity, risk and rewards of assisted relocation, climate change synergy with existing stressors).

5.2.4: Conduct research on the propagation and production of native plant materials to identify species or genotypes that may be resilient to climate change.

5.2.5: Accelerate research on establishing the value of ecosystem services and potential impacts to communities from climate change (e.g., loss of pollution abatement or flood attenuation; climate regulation by forests and wetlands through carbon sequestration, oxygen production, and CO_2 consumption; and pollination by insects, birds, and mammals).

5.2.6: Identify pollutants likely to be affected by climate change and accelerate research on their effects on fish, wildlife, and their habitats, including contaminant effects that will likely increase vulnerability to climate change.

Strategy 5.3: Advance understanding of climate change impacts and species and ecosystem responses through modeling.

ACTIONS

5.3.1: Define the suite of physical and biological variables and ecological processes for which predictive models are needed via a collaborative process among state, federal, and tribal resource managers, scientists, and model developers.

5.3.2: Improve modeling of climate change impacts on vulnerable species, including projected future distributions and the probability of persistence.

5.3.3: Develop models that integrate the potential effects of climate and non-climate stressors on vulnerable species.

5.3.4: Develop and use models of climate-impacted physical and biological variables and ecological processes at temporal and spatial scales relevant for conservation.

5.3.5: Provide access to current climate data and ensure alignment with data management and decision support tools at agency and departmental levels.

GOAL 5 PROGRESS CHECK LIST

- ☐ Working groups are developed that share data, expertise, and responsibilities for addressing research needs;
- ☐ Initial inventory of knowledge gaps completed;
- ☐ Research agenda developed;
- ☐ Research to address priority knowledge gaps initiated;
- ☐ Regional and subregional projections of climate change impacts completed;
- ☐ Protocols and methods for valuing ecosystem services developed;
- ☐ Approaches to improve validity of projections of future climate and improve linkage of atmospheric/climate models to ecological impact models developed.

BILL LYNCH

KEITH WELLER/USDA

Goal 6

Increase awareness and motivate action to safeguard fish, wildlife, and plants in a changing climate.

ADAPTATION EFFORTS WILL BE MOST SUCCESSFUL if they have broad support and if key groups and people are motivated to take action themselves. Resources should be targeted toward elected officials, public and private policy makers, groups that are interested in learning more about climate change issues, private landowners, and natural resource user groups.

Engaging stakeholders early and repeatedly is key to making this Strategy work.

Helping stakeholders understand the concept of uncertainty and decision-making in the context of uncertainty are also important and integral parts of adaptive management.

Engaging stakeholders early and repeatedly to increase awareness of the threats from climate change, to gather input in developing appropriate, integrated adaptation responses, and to motivate their participation and action is key to making this *Strategy* work.

The concept of ecosystem services is gaining traction among elected officials and policy makers, but not enough is being done to translate the concept into action. Communicating science-based information on the socio-economic value of ecosystem services to public and private decision makers and opinion leaders should be accomplished by using real examples.

Development and implementation of effective adaptation policies and practices requires that interested constituencies and key stakeholders understand the fundamentals of climate change adaptation. Practical education and outreach efforts and opportunities for participation should be developed and implemented whenever possible.

Strategy 6.1: Increase public awareness and understanding of climate impacts to natural resources and ecosystem services and the principles of climate adaptation at regionally- and culturally-appropriate scales.

ACTIONS

6.1.1: Develop focused outreach efforts and materials aimed at local, state, tribal, and federal government authorities; land and water managers; economic policy decision makers; zoning and transportation officials; etc. on ecosystem services, climate impacts to fish, wildlife, plants, and ecosystems, the impacts of other local stressors, and the importance of adaptation planning.

6.1.2: Develop outreach efforts and materials to other key audiences, such as the private sector (e.g., agriculture, forestry, etc.), cultural leaders, and private land managers that provide information on existing conservation incentive programs.

6.1.3: Identify and partner with key stakeholder groups (e.g., conservation and environmental organizations, hunting and angling groups, trade associations, outdoor manufacturers and retailers) to help develop and distribute key climate change and adaptation messages tailored for their interest groups as well as the broader public.

6.1.4: Incorporate information about potential climate change impacts to ecosystem services in education and outreach activities.

6.1.5: Increase public awareness of existing habitat conditions and the benefits of building resiliency of those habitats.

Strategy 6.2: Engage the public through targeted education and outreach efforts and stewardship opportunities.

ACTIONS

6.2.1: Identify and make opportunities available for public involvement to aid in the development of focused outreach materials.

6.2.2: Use public access points, nature centers, and hunting and fishing regulation guides to inform tourists, visitors, and recreational users of climate change impacts to and adaptation strategies for fish, wildlife, and plants.

6.2.3: Develop specific programs and/or modify existing programs (e.g., bird and amphibian surveys) to motivate action and engage citizens in monitoring impacts of climate change on the landscape (e.g., citizen science monitoring for detection of invasive species, nature center programs, etc.).

6.2.4: Make research and monitoring information regarding climate impacts to species and natural systems accessible and easily understood to the public and other partners (e.g., commercial fisheries, etc.).

6.2.5: Develop educational materials and teacher trainings for K-12 classrooms linked to state education standards on impacts and responses to climate change.

6.2.6: Develop collaborations with zoos, museums, aquariums, botanic gardens, arboreta, and other organizations and universities to increase communication and awareness of impacts and responses to climate change.

6.2.7: Develop core messaging and recommended strategies to communicate the *Strategy* within participating organizations, local associations and clubs (e.g., garden clubs), and with the public.

6.2.8: Develop strategy to assess effectiveness of communication efforts and modify as appropriate.

Strategy 6.3: Coordinate climate change communication efforts across jurisdictions.

ACTIONS

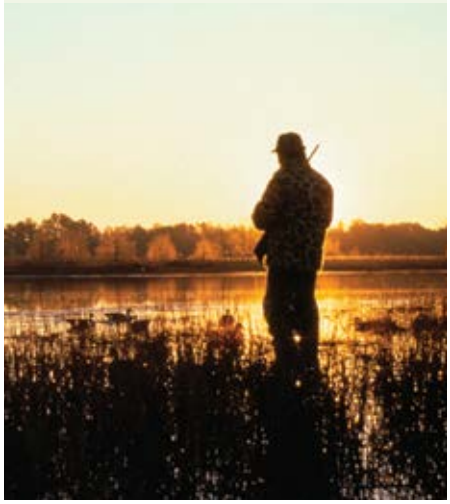
6.3.1: Develop, implement, and strengthen existing communication efforts between federal agencies, with states and tribes to increase awareness of the impacts and responses to climate change.

6.3.2: Engage employees from multiple agencies in key climate change issues by expanding existing forums for information sharing and idea exchange, and create new forums and channels as needed.

6.3.3: Provide access to tools (web-based and others) that promote improved collaboration, interactive dialog, and resource sharing to minimize duplication of effort across jurisdictions.

GOAL 6 PROGRESS CHECK LIST

- ☐ Focused outreach to key decision makers initiated;
- ☐ Stakeholder representatives engaged in working groups related to climate change messaging;
- ☐ Improved messaging and targeting of information on fish, wildlife, and plants, ecosystem services, and climate change to key audiences developed;
- ☐ Agency-produced educational and interpretive materials and papers are developed and distributed;
- ☐ Tools designed to engage citizens in monitoring impacts of climate change developed;
- ☐ Educational curricula developed;
- ☐ Collaborations with zoos, aquaria, museums, and botanic gardens initiated;
- ☐ Workshops and communication programs increasing awareness of climate change related issues regarding fish, wildlife, and plants across agencies developed;
- ☐ Effectiveness of communications assessed.



USFWS/PAT HAGAN

USFWS/RYAN HAGERTY

Goal 7

Reduce non-climate stressors to help fish, wildlife, plants, and ecosystems adapt to a changing climate.

THIS *STRATEGY* IDENTIFIES ACTIONS THAT natural resource managers and others can take to address the impacts of climate change on fish, wildlife, and plants and the human uses and benefits that living systems provide. One of the most important actions is to reduce the negative impacts of existing stressors to help increase the capacity of fish, wildlife, and plants to cope with changing climate conditions.

Addressing existing stressors has been the focus of natural resource conservation and management efforts for decades, often with notable successes.

While this *Strategy* does not attempt to catalog all of those critical efforts, it is important to note that some of these existing stressors (such as habitat loss, fragmentation, and degradation, invasive species, disease, pollution, over-harvesting, destructive harvest practices (e.g., fisheries bycatch and illegal trade) are not only some of the things decision makers can control, they are also likely to interact with climate change to magnify negative impacts on fish, wildlife, and plants (Negri and Hoogenboom 2011). Indeed, the cumulative effects of these existing stressors is already a major threat to many species, some of which may not survive long enough to have a chance of adapting to climate change if existing stressors are not adequately addressed. Thus, reducing these existing stressors is both essential to maintain short-term survival for some species, but also may be some of the most effective ways to increase resilience of fish, wildlife, and plants in a changing climate. Where possible, reducing non-climate stressors should be approached with a changing climate in mind to prioritize actions and discourage maladaptive decisions.

Continued application of ecosystem based approaches to natural resource management is also a key step in this process given the scale and scope of climate change impacts on natural and human communities. The importance of conserving, restoring, and connecting suitable habitats as a way to enhance fish, wildlife, and plant resiliency has been discussed previously, and reducing and mitigating the ongoing degradation associated with human development such as pollution and loss of open space is also critical. Opportunities for collaboration should be actively pursued with land-use planners as well as major sectors such as agriculture, transportation, and water resource interests to identify common concerns and shared solutions.

As described previously, invasive species are pervasive in our environment and becoming more so every day. There are no easy ways to combat invasive species, but coordinating efforts across jurisdictions, international borders and among terrestrial and aquatic resource managers and citizen scientists can help. Greater coordination in stepping up efforts at prevention, enhancing early detection and rapid response programs, and avoiding accidental movement of invaders is essential (National Invasive Species Council 2008). Moreover,

decisions regarding increasing connectivity and restoring corridors will have to be weighed with the threat of invasives and the consequences of choosing one adaptation strategy over another. In addition to the threats from invasive species, climate stresses are causing some native pests and pathogens as well as pollution exposure to become increasingly problematic and this will need to be considered when management plans are developed.

CASE STUDY

Fighting the spread of water hyacinth

INTRODUCED INTO THE UNITED STATES in the late 1890s from South America, water hyacinth has spread rapidly across the southeastern United States, and today is already a major pest. This floating plant produces vast, thick mats that clog waterways, crowding out native plants and making boating, fishing, and swimming almost impossible.

Because water hyacinth cannot survive when winter temperatures drop below freezing, climate change will only make the problem worse. Rising temperatures will allow this pest to invade new areas, and the plant will likely spread north. Fortunately, there are some effective measures for fighting invasions of water hyacinth, such as utilizing weevils along with some herbicides (Mallya et al. 2001).

PHIL WHITEHOUSE

But these steps must be taken before the plant gets established, emphasizing the vital importance of planning for invasions projected in a changing climate and constantly monitoring vulnerable ecosystems for the first telltale signs of such invasions.

Strategy 7.1: Slow and reverse habitat loss and fragmentation.

ACTIONS

7.1.1: Work with local land-use planners, flood-plain administrators, and others to identify shared interests and potential conflicts in reducing and reversing habitat fragmentation and loss through established planning and zoning processes.

7.1.2: Work with farmers and ranchers to apply the incentive programs in the conservation title of the Farm Bill as well as the landowner tools under the ESA and other programs to minimize conversion of habitats, restore marginal agricultural lands to habitat, and increase riparian buffer zones.

7.1.3: Provide landowners with appropriate incentives for conservation and restoration of key habitats, such as conservation easement tax incentive programs, designed to protect private lands of high habitat connectivity value under climate change.

7.1.4: Work with water resource managers to enhance design and siting criteria for water resources infrastructure to reduce impacts and restore connectivity in floodplains and aquatic habitats.

7.1.5: Work with local and regional water management agencies to evaluate historical water quantities and base flows and develop water management options to protect or restore aquatic habitats.

7.1.6: Consider application of offsite habitat banking linked to climate change habitat priorities as a tool to compensate for unavoidable onsite impacts and to promote habitat conservation or restoration in desirable locations.

7.1.7: Consider market-based incentives that encourage conservation and restoration of ecosystems for the full range of ecosystem services including carbon storage.

7.1.8: Minimize impacts from alternative energy development by focusing siting options on already disturbed or degraded areas.

7.1.9: Identify options for redesign and removal of existing structures or barriers where there is the greatest potential to restore natural processes.

Strategy 7.2: Slow, mitigate, and reverse where feasible ecosystem degradation from anthropogenic sources through land/ocean-use planning, water resource planning, pollution abatement, and the implementation of best management practices.

ACTIONS

7.2.1: Work with local and regional land-use, water resource, and coastal and marine spatial planners to identify potentially conflicting needs and opportunities to minimize ecosystem degradation resulting from development and land and water use.

7.2.2: Work with farmers and ranchers to develop and implement livestock management practices to reduce and reverse habitat degradation and to protect regeneration of vegetation.

7.2.3: Reduce existing pollution and contaminants and increase monitoring of air and water pollution as necessary.

7.2.4: Work with water resource managers to identify, upgrade, or remove outdated sewer and stormwater infrastructure to reduce water contamination.

7.2.5: Increase restoration, enhancement, and conservation of riparian zones and buffers in agricultural and urban areas to minimize non-point source pollution.

7.2.6: Work with federal, state, and tribal environmental regulators to address potential pollution threats, including impairments to water quality.

7.2.7: Reduce impacts of impervious surfaces and stormwater runoff in urban areas to improve water quality, groundwater recharge, and hydrologic function.

7.2.8: Reduce ground and surface water withdrawals in areas experiencing drought and/or increased evapotranspiration.

7.2.9: Promote water conservation, reduce water use, and promote increased water quality via proper waste disposal.

7.2.10: Develop and implement protocols for considering carbon sequestration and storage services of natural habitats in management decisions.

7.2.11: Incorporate the recommendations and actions from the National Action Plan for Managing Freshwater Resources in a Changing Climate into water resource planning.

7.2.12: Consider the impact of logging practices on fire risk and ecosystem diversity and function.

Strategy 7.3: Use, evaluate, and as necessary, improve existing programs to prevent, control, and eradicate invasive species and manage pathogens.

ACTIONS

7.3.1: Use, integrate, and implement existing pest and pathogen risk assessment methodologies for imported organisms and establish appropriate regulations to prevent deliberate importations of pests, pathogens, or other species that are predicted to be harmful or invasive.

7.3.2: Employ a multiple barriers approach to detect and contain incoming and established invasive species, including monitoring at points of origin and points of entry for shipments of goods and materials into the United States and for trans-shipment within the country. Utilize education, regulation, and risk management tools (e.g., the Hazard Analysis and Critical Control Point process).

7.3.3: Develop national standards for collecting and reporting invasive species data to facilitate information sharing and management response.

7.3.4: Apply risk assessment and scenario planning to identify actions and prioritize responses to invasive species that pose the greatest threats to natural ecosystems.

7.3.5: Implement existing national, state and local strategies and programs for rapid response to contain, control, or eradicate invasive species, and develop new strategies as needed.

7.3.6: Assess risks and vulnerability to identify high priority areas and/or species for monitoring of invasive species and success of control methods.

7.3.7: Monitor invasive species and pathogens associated with fish, wildlife, and plant species for increased understanding of distributions and to minimize introductions.

7.3.8: Apply integrated management practices, share innovative control methodologies, and take corrective actions when necessary to manage fish, wildlife, and plant diseases and invasives.

7.3.9: Work with federal, state, regional, and county agricultural interests to identify potentially conflicting needs and opportunities to minimize ecosystem degradation resulting from pests, pathogens, and invasive species eradication, suppression, and control efforts.

Strategy 7.4: Reduce destructive capture practices (e.g., fisheries bycatch, destructive fishing gear), over-harvesting and illegal trade to help increase fish, wildlife, and plant adaptation.

ACTIONS

7.4.1: Reduce the unintentional capture (such as fisheries bycatch) of species in fishing and other capture activities.

7.4.2: Implement the 2011 U.S. National Bycatch Report recommendations (NMFS 2011) to increase information of bycatch levels, identify fisheries and/or species with potential bycatch concerns, and improve monitoring of bycatch levels over time.

7.4.3: Reduce negative impacts of capture practices and gear on important habitats for fish, wildlife, and plants.

7.4.4: Determine sustainable harvest levels in changing climate, and design, implement, and evaluate management plans and practices to eliminate over-harvest of fish, wildlife, and plants.

7.4.5: Increase efforts to monitor and reduce illegal species trade in the United States.

GOAL 7 PROGRESS CHECK LIST

- ☐ Regional and local land-use, water resource, coastal, and marine planners engaged;
- ☐ Collaboration with farmers and ranchers to review/revise livestock management practices begun;
- ☐ Nationwide inventory of outdated legacy infrastructure initiated;
- ☐ Disruptive floodplain infrastructure reduced/removed;
- ☐ Coordinated invasive species and disease monitoring system established;
- ☐ Multiple barriers to invasive species introduction in place;
- ☐ Strong import screening protocols established;
- ☐ Coordinated national invasives management actions implemented;
- ☐ Pollution/contaminant monitoring improved;
- ☐ Destructive capture practices identified and reduced.