
Chapter 3: Climate Adaptation Strategies and Actions

3.1 Goals, Strategies and Actions

5 This *Strategy* identifies seven Goals to help fish, wildlife, plants, and ecosystems cope with the impacts of climate change. As discussed in the Introduction, these Goals were developed collectively by diverse teams of federal, state, and tribal technical experts, based on existing research and understanding regarding the needs of fish, wildlife, and plants in the face of climate change.

15 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.

25 Each Goal identifies a set of initial strategies and actions that should be taken or initiated over the next five to ten years. 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 complete set of these specific actions most relevant to each ecosystem is available in the eight ecosystem-specific background papers described further in Appendix A and posted online at www.wildlifeadaptationstrategy.gov.

30 A short-term progress check list is offered under each 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 very 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.

40 **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.

Strategy Goals:

- Goal 1. Conserve & Connect Habitat
 - Goal 2. Manage Species & Habitats
 - Goal 3. Enhance Management Capacity
 - Goal 4. Support Adaptive Management
 - Goal 5. Increase Knowledge & Information
 - Goal 6. Increase Awareness & Motivate Action
 - Goal 7. Reduce Non-Climate Stressors
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45 **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.

50 **Goal 4:** Support adaptive management in a changing climate through integrated observation and monitoring and use of decision support tools. The impacts of climate change are uncertain. Coordinated observation, information management, and decision support systems can help management strategies to be adaptive and adjust to changing conditions.

55 **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.

60 **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 and political support and if key groups and people (such as private landowners) are motivated to take action.

65 **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.

GOAL 1: Conserve habitat to support healthy fish, wildlife and plant populations and ecosystem functions in a changing climate.

70 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. 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
75 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. For example, many existing conservation areas, such as Joshua Tree National Monument 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
80 communities or species they were established to protect. They 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.

85 Many of our nation’s imperiled species (both those currently listed as either 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 environment 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 90 enough variety and amount of habitat to sustain diverse and healthy (e.g., viable, sustainable, abundant) populations as landscapes and seascapes are altered by climate change. 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.

95 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 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 100 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 (lease, easement, acquisition, other), only that climate change will demand that we increase and perhaps accelerate our collective efforts to do so. But simply creating new networks of conservation areas or acquiring more land to be protected in perpetuity will not 105 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 conservation easements, leases, and incentives for private landowners will be essential.

110 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, and mapping (including geophysical as well as biological features), vulnerability assessments, 115 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.

120 Increasing the number, quality, and size of conservation areas can increase the opportunities for individual species to adapt to climate change, and also make it more likely that native biodiversity will be conserved. For some species, their required 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 125 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.

The Importance of Private Lands

Over 70 percent of the land area of the United States is in private ownership (Lubowski et al. 2006). The majority of this land is either in agricultural production or classed as agricultural land (crop, pasture, forest) (Lubowski et al. 2006). In much of the continental United States (especially in the East and Midwest), privately owned lands dominate the landscape and provide valuable habitat for native fish, wildlife, and plants.

The vast majority of the nation's publicly owned land is federal, and most of it is located in the eleven western states and Alaska. The bulk of America's federal estate is open to various forms of resource development such as mining, grazing, and timber and energy production that are not always compatible with the protection of all fish, wildlife, plants, or ecological processes. Only about five percent of the land area of the United States falls into the highest categories of protection, aimed primarily at maintaining natural values (IUCN 1998). However, public lands are generally protected from conversion to urban or suburban development, and they are typically more closely managed for conservation purposes than are private lands.

Private lands do and will continue to play a vital role in the conservation of our nation's fish, wildlife, and plant resources. For example, many listed threatened and endangered species are only known to occur on private lands. In addition, because most public lands occur in isolated blocks, especially in the East and Midwest, private lands often provide the only connections between protected areas. As the climate continues to change and the geographic distributions of species continue to shift in response, private lands may become even more important, especially for providing physical connectivity across the landscape.

There are many federal and state programs that provide incentives to private landowners to manage and maintain certain natural values on their lands. Principal among these are the many programs that make up the Conservation Title of the "Farm Bill," which constitute an important set of tools for maintaining wildlife values on private lands and a suite of landowner tools available under the ESA (see "For Landowners" at <http://www.fws.gov/endangered>). Although clearly essential to help manage existing stressors to our fish, wildlife, and plant resources, these programs may not be fully adequate to respond to climate change. It is likely that new challenges, especially the increasing need to provide connectivity between protected areas, may demand changes or additions to these existing programs.

130 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. In addition, appropriate
transitory or "stopover" habitat for migrating species can promote biological connectivity between non-
physically connected areas. Private landowners and government agencies such as energy, transportation,
135 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
140 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 in floodplains and sensitive coastal
areas. Effective restoration will require applying protocols and techniques that anticipate a range of future
145 conditions caused by climate change and that facilitate adaptation.

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
150 network of conservation areas.

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 temperature 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.

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 also describes steps that can be taken to maintain good salmon habitat even in a changing climate. Those steps include:

- limiting 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;
- protecting undercut banks and deep stratified pools, where water temperatures are lower;
- restoring vegetation along streams, which cools the water and reduces sediment and pesticide levels;
- releasing cold water from large storage reservoirs during summer; and
- removing 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 U.S. Department of Agriculture Conservation Reserve Enhancement Program and NOAA's Pacific Coastal Salmon Recovery fund are helping to restore vegetation in riparian zones. That 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.



Photo: Amy Gulick

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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 on species distributions (current and projected), habitat classification, land cover, and geophysical settings (including areas of rapid change and slow change).

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- 1.1.2: Identify and prioritize for consideration areas currently experiencing rapid climate impacts (such as the coastline of Alaska, low-lying islands, and high alpine tundra).
- 1.1.3: Assess the migration potential of species, and prioritize conservation for areas with highest migration potential, considering ecosystem functions and existing and future physical barriers.
- 165 — 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.

170 **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:

- 175 — 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.
- 1.2.3: Build redundancy into the network of conservation areas by protecting multiple examples of the range of priority areas identified in Action 1.1.1.
- 180 — 1.2.4: Work with partners at landscape scales to maximize use of existing conservation programs (e.g., easement, management, mitigation), particularly the conservation titles of the Farm Bill, 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.
- 185 — 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.

190 **Strategy 1.3: Restore habitat features where necessary and practicable to maintain ecosystem function and processes 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.
- 195 — 1.3.2: Restore degraded habitats as appropriate to support 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 natural disturbance regimes as appropriate, including instituting human-assisted disturbance (e.g., prescribed fire) to augment natural processes and mimic natural patterns and recurrence for specific ecological systems.
- 200 — 1.3.5: Develop programs to encourage resilience through restoration of habitat features that provide natural buffers in coastal habitats.
- 1.3.6: Develop market-based incentives that encourage habitat restoration where appropriate.

BUILDING CONNECTIVITY IN NEW JERSEY

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 when sea levels rise.

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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:

- 210 — 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.
- 215 — 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 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.
- 220 — 1.4.6: Provide landowners and stakeholder groups with incentives to maximize use of existing conservation programs, such as the conservation titles of the Farm Bill and landowner tools under the ESA, to protect private lands of high connectivity value under climate change.

225 **PROGRESS CHECK LIST FOR GOAL 1:**

- 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;
- 230 Suite of land protection tools (designations, exchanges, acquisitions, easements, leases, incentives) evaluated and updated;
- Funding allocations reviewed/revised in light of climate change priorities;
- Begin conserving and/or rehabilitating high priority areas for fish, wildlife, and plants under climate change.

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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, and plants. 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.

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, but many 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.

Management plans and programs must consider species' abilities to adapt to climate change, including 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 migration 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. The development of ecosystem based approaches to natural resource management grew out of broad acknowledgement that successful natural resource 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 existing and new management plans and practices using the best available science regarding projected climate changes and trends, vulnerability and risk assessments, and scenario planning.
- 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., cool-water to warm-water fisheries or cool season to warm season grasslands) and develop management strategies and approaches for adaptation.
- 2.1.4: Conserve or create landscape patterns with many age classes, diverse species, and seed sources.
- 2.1.5: Review and revise as necessary techniques to maintain or mimic natural disturbance regimes and to protect vulnerable habitats.

- 280 — 2.1.6: 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 associated with climate change.
- 2.1.7: Review existing management frameworks and identify ways to increase the ability of stakeholders to adapt to climate variability and change while preserving the integrity and sustainability of natural resources, habitats, and ecosystems.
- 285 — 2.1.8: Utilize the principles of ecosystem-based management.
- 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).

290 **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.
- 295 — 2.2.2: Develop criteria and guidelines for the use of translocation, assisted migration, 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.

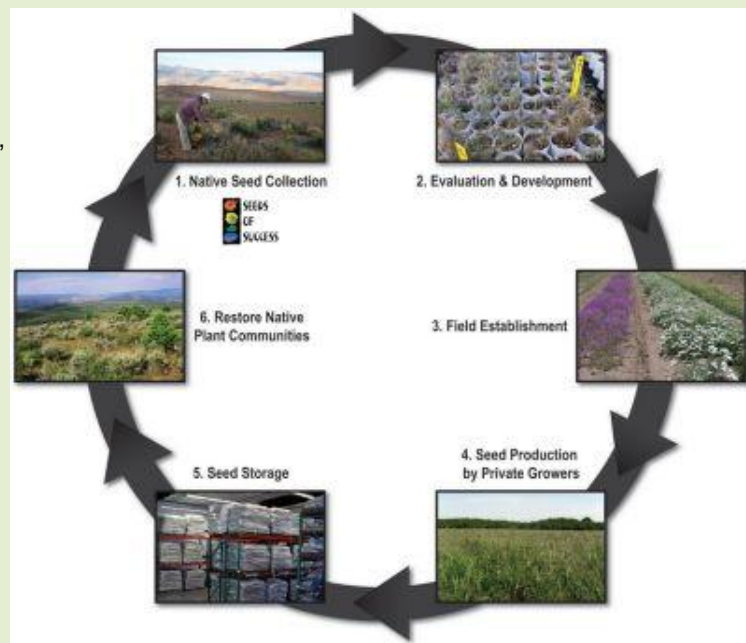
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SEED BANKING IN A CHANGING CLIMATE

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 on a changed planet 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



Bureau of Land Management 2009. Native Plant Materials Development Program: Progress Report for FY2001-2007.

more than 3,000 native plant species in the United States.

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

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

Actions:

- 305 — 2.3.1: Develop and implement approaches for assessing and maximizing the genetic diversity of 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.
- 310 — 2.3.3: Develop protocols for use of propagation techniques to rebuild abundance and genetic diversity for particularly at-risk 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 and arboreta.

GOAL 2 PROGRESS CHECK LIST:

- 315 Co-managers (state, federal, tribal, local, international) identified and engaged;
- Species requiring active intervention identified;
- Genetic conservation issues identified;
- Criteria and guidelines developed for translocation, managed relocation/assisted migration, and captive breeding;
- 320 Vulnerability and risk assessments and scenario planning used to guide species management decisions;
- Species and area management plans updated;
- Fire and other disturbance regimes managed to better simulate natural conditions;
- State Wildlife Action Plans updated to include climate adaptation;
- 325 Agency specific climate change adaptation plans developed;
- Agency specific climate adaptation plans and regional plans integrated;
- Seed banks and living collections developed consistent with planning.

GOAL 3: Enhance capacity for effective management in a changing climate.

- 330 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. While well-trained in ecology and applied resource management, many
- 335 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.

340 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. Landscape Conservation Cooperatives (LCCs), Climate Science Centers (CSCs), Migratory Bird Joint Ventures (JVs), Regional Integrated Sciences and Assessments (RISAs), National Fish Habitat Partnerships and other existing and emerging partnerships provide useful forums for multiple jurisdictions and partners to better work together to define, design, and deliver sustainable landscapes at a regional scale.

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355 Many fish, wildlife, and plant conservation laws, regulations, and policies were developed without the current understanding of climate change. These legal foundations should be reviewed to identify opportunities to improve, where appropriate, their utility for addressing 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 stresses 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.

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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.



Photo: NOAA

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, respond where necessary, and keep the public informed. Prime Hook National 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 stabilizing the shoreline.

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

365 **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 and delivery systems for natural resource professionals and decision makers.
- 370 — 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).
- 375 — 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.
- 380 — 3.1.6: Support and enhance web-based clearinghouses of information (e.g., www.CAKEX.org) 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.

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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:

- 390 — 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.
- 395 — 3.2.3: Integrate individual agency and state climate change adaptation programs and State Wildlife Action Plans with other regional conservation efforts such as the National Fish Habitat Action Plan (NFHAP), LCCs, JVs, and the Northeast Association of Fish and Wildlife Agencies regional application of State Wildlife Grant funds to foster collaboration.
- 400 — 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.
- 405 — 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.

410 **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 utility to address climate change impacts.**

Actions:

- 415 — 3.3.1: Review existing legal, regulatory and policy frameworks that govern protection and restoration of habitats and ecosystem services and identify opportunities to improve, where appropriate, their utility 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.
- 420 — 3.3.3: Review existing legal, regulatory and policy frameworks and identify opportunities to improve, where appropriate, 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 utility to reduce risks and increase adaptation of natural resources and communities in a changing climate.
- 425 — 3.3.5: Review existing legal, regulatory and policy frameworks that govern floodplain mapping, flood insurance, and flood mitigation and identify opportunities to improve their utility to reduce risks and increase adaptation of natural resources and communities in a changing climate.
- 3.3.6: Continue the ongoing work of the Joint State Federal Task Force on Endangered Species Act (ESA) 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.
- 430 — 3.3.7: Initiate a dialogue among all affected interests about opportunities to improve the utility of existing legal, regulatory and policy frameworks to address impacts of sea level rise on coastal habitats.

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

Actions:

- 440 — 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.
- 445 — 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 within the Conservation Title of the Farm Bill and other vehicles.
- 450 — 3.4.5: Review existing conservation related federal grants to tribal agencies and revise as necessary to provide apportioned funding for tribal climate adaptation activities.
- 3.4.6: Develop a web-based clearinghouse of funding opportunities available to support climate adaptation efforts.

455 **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;
- 460 Interagency personnel assignments expanded;

- LCC Network engaged as primary venue for inter-jurisdictional collaboration;
- Criteria to include climate change adaptation in existing conservation grant programs developed;
- Laws, regulations, and policies regarding key conservation statues reviewed and as necessary, updated;
- 465 Floodplain maps, insurance laws, and regulations updated;
- Dialogue initiated to improve implementation of the Coastal Zone Management Act, Clean Water Act, and state wetland protection programs to respond to climate impacts such as sea level rise;
- Criteria for including climate change adaptation needs in resource allocation developed;
- 470 Funding and resource needs for climate adaptation identified.

GOAL 4: Support adaptive management in a changing climate through integrated observation and monitoring and use of decision support tools.

As discussed previously, there is uncertainty regarding the specific impacts of climate change on natural resources. In addition, there is much to be learned about the effectiveness of management actions to mitigate these impacts. To continue to minimize uncertainty and 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. 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.

Coordinated inventory, monitoring, and observation systems should be developed 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. 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. Such systems allow managers and other decision makers to evaluate the efficacy of management actions.

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.

In addition, decision support tools that facilitate 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

505 species, build habitat resilience, and help ensure that changes to the built environment need not conflict with ecosystem needs.

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

510 **Actions:**

- 4.1.1: Use available long term monitoring programs at appropriate scales (local to international) as baselines for population and migration changes that could be effected by climate change (e.g., International Waterfowl Surveys).
- 515 — 4.1.2: 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.
- 4.1.3: Conduct a gap analysis of existing observation networks, indicators, monitoring, and geospatial data to define priorities.
- 520 — 4.1.4: Work through existing distributed efforts (e.g., NCA, National Estuarine Research Reserve System -wide monitoring program, State Natural Heritage Programs, National Wildlife Refuge System, National Park Service) to support integrated national observation and information systems that inform climate adaptation.
- 4.1.5: Expand and develop as necessary networks of places for integrated climate change inventory, monitoring, research, and education.
- 525 — 4.1.6: 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.
- 4.1.7: Develop, refine, and implement monitoring protocols that provide key information needed for managing and conserving species and ecosystems in a changing climate.
- 530 — 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, etc.) needed for regional-scale monitoring and land management.
- 4.1.9: Collaborate with the National Phenology Network to facilitate monitoring of phenology and create an analogous National Population Network to catalog the changes in distribution and abundance of fish, wildlife, and plants that have been identified as most vulnerable to climate change.

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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, and adaptive management evaluation systems) via dialogue with scientists, managers (of natural resources and other sectors), and stakeholders.

540 **Actions:**

- 4.2.1: Develop regional downscaling of Global Climate models to conduct vulnerability assessments of living resources.
- 4.2.2: Engage scientists, resource managers, and stakeholders in climate change scenario planning processes, including identification of a set of plausible future scenarios associated with climate phenomena likely to significantly impact fish, wildlife, and plants.
- 545 — 4.2.3: Define national standards and criteria to identify fish, wildlife, plants, and ecosystems most vulnerable to climate change impacts.
- 4.2.4: Conduct vulnerability and risk assessments for priority species (threatened and endangered species, species of greatest conservation need, species of socioeconomic and cultural significance).
- 550 — 4.2.5: Synthesize vulnerability assessments across jurisdictions to provide regional assessments.
- 4.2.6: Identify actions that can be implemented by a variety of sectors and are beneficial given a range of climate futures and desired future conditions (e.g., “no regrets” options).

- 555 — 4.2.7: Ensure the availability of and provide guidance for decision support tools (e.g., NOAA's Digital Coast, 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, information, assessment, and decision support systems to monitor and determine the effectiveness of specific management actions to analyze the potential for maladaptation and adapt management approaches appropriately.

560 **GOAL 4 PROGRESS CHECK LIST:**

- Public/private collaborative to build nationally integrated climate change inventory, monitoring, observation and information systems convened;
- Existing public and private inventory, monitoring, observation, and information systems assessed for use in detecting climate change;
- 565 Existing public and private inventory, monitoring, observation, and information systems linked and interoperable;
- 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;
- 570 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;
- 575 Evaluation of existing and new climate adaptation plans linked to integrated observation and information systems;
- Regionally downscaled climate projections produced;
- Standardized climate change scenarios developed;
- Framework of tools for managing under uncertainty developed;
- Vulnerability and risk assessments conducted for priority species.

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SENTINEL SITE MONITORING

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 50 years ago after an inlet was built to Moss Landing harbor, creating a permanent connection to the open ocean. Now, sea level rise is further threatening this valuable estuarine ecosystem. At the same time, the Reserve 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 and groundwater 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 combination of rising sea levels and the loss of marshes is increasing 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.

GOAL 5: Increase knowledge and information on impacts and responses of fish, wildlife and plants to a changing climate.

585 In addition to the need for data management, integration, and decision support tools, the design and
 delivery of fish, wildlife, and plant climate change adaptation programs has also been hampered by lack
 of detailed knowledge about specific impacts of climate change on fish, wildlife, plants, and habitats and
 their adaptive capacity to respond. Existing research collaborations such as the USGCRP can enable
 natural resource managers to focus and prioritize research. There are many critical areas where increased
 understanding is needed to anticipate and help reduce the impacts of climate change on fish, wildlife, and
 590 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 and made available to managers, as well as into
 climate change adaptation planning, delivery, and evaluation.

595 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 changes in climate variables (e.g., temperature, humidity, atmospheric CO₂), habitat and fish,
 wildlife and plant abundance and distribution is a priority and should initially focus on processes that are
 600 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
 605 value of ecosystem services and to understand potential impacts from climate change to these important
 services.

610 **Strategy 5.1: Identify knowledge gaps and define research priorities via a collaborative process
 among federal, state, and tribal resource managers and research scientists working with the
 National Science Foundation (NSF), USGCRP, NCA, USDA Extension, Cooperative Ecosystem
 Study Units (CESUs), CSCs, LCCs, JVs, and RISAs.**

Actions:

- 5.1.1: Increase coordination and communication between resource managers and researchers
 615 through existing forums (e.g., NSF, USGCRP, NCA, USDA, CESUs, CSCs, LCCs, JVs, RISAs, and
 others) to ensure research is connected to management needs.
- 5.1.2: Bring managers and scientists together to prioritize research needs that address resource
 management objectives under climate change.

- 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.
- 620 — 5.1.4: Participate in research planning for relevant programs of agencies such as the NSF, NOAA, National Air and Space Administration, and the Department of Energy, and intergovernmental forums such as the 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.
- 625 — 5.1.5: Based on priority conservation needs identified by resource managers, develop a national research agenda identifying key high level questions for which more fundamental research is needed to enable development of 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.
- 630 — 5.1.6: Prioritize research on questions relevant to managers of near-term risk environments (e.g., low-lying islands and glaciated areas) or highly vulnerable species.

PLANTS AND THEIR POLLINATORS

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 shift when they bloom. That raises a high-stakes question: Will pollinators follow? If they cannot, then vital ecological relationships could be severed.

The FWS'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.

The initial results show that bees are the major pollinators at lower elevations, while flies are more important at higher elevations. The researchers also discovered a greater than expected diversity of bees. There are at least 85 species at the five plots, including five species found at all elevations. This is significant given the differences in vegetation of lower altitude deserts compared to higher altitude mixed conifer and aspen forests.

635 **Strategy 5.2: Conduct research into ecological aspects of climate change, including likely impacts and the adaptive capacity of species, communities and ecosystems, 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.
- 640 — 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/rewards of assisted migration; climate change synergy with existing stressors; etc.).
- 645 — 5.2.4: Accelerate research on establishing the value of ecosystem services and potential impacts from climate change such as loss of pollution abatement or flood attenuation, etc.
- 5.2.5: Conduct research on the propagation and production of native plant materials to identify species or genotypes that may be resilient to climate change.

650 **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.
- 655 — 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.

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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;
- 665 Research agenda developed;
- Research to address priority knowledge gaps initiated;
- Regional and subregional projections of climate change impacts completed;
- Protocols and metrics for valuing ecosystem services developed;
- 670 Approaches to improve validity of projections of future climate and improve linkage of atmospheric/climate models to ecological impact models developed;
- Novel anticipatory strategies for adapting to climate change developed.

GOAL 6: Increase awareness and motivate action to safeguard fish, wildlife and plants in a changing climate.

675 Adaptation efforts will be most successful if they have broad public and political support and if key groups and people are motivated to take action themselves. Limited 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. Helping stakeholders understand the concept of uncertainty, and managing/decision making in the context of uncertainty is also

680 important and an integral part 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.

685 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.

690 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.

695 **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:

- 700 — 6.1.1: Develop focused outreach efforts and materials aimed at local, state, tribal, and federal government authorities; land and water managers; zoning and transportation officials; etc. on ecosystem services, climate impacts to fish, wildlife, plants, and ecosystems, 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.
- 705 — 6.1.3: Identify and partner with key stakeholder groups (e.g., conservation and environmental organizations, hunting and angling groups, trade associations) 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.

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

Actions:

- 715 — 6.2.1: 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.
- 6.2.2: Develop specific programs and/or modify existing programs (e.g. bird and amphibian surveys) to 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.).
- 720 — 6.2.3: Make research and monitoring information regarding climate impacts to species and natural systems accessible to the public and other partners (e.g., commercial fisheries, etc.).
- 6.2.4: Develop educational materials and teacher trainings for K-12 classrooms on impacts and responses to climate change.
- 725 — 6.2.5: Develop collaborations with museums, aquariums, botanic gardens, arboreta, and other organizations to increase communication and awareness of impacts and responses to climate change.
- 6.2.6: Develop core messaging and recommended strategies to communicate the NFWPCAS within participating organizations and with the public.

Strategy 6.3: Coordinate climate change communication efforts across jurisdictions.

Actions:

- 730 — 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 like the LCCs, and create new forums and channels as needed.
- 735 — 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.

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☑ **GOAL 6 PROGRESS CHECK LIST:**

- Focused outreach to key decision makers initiated;
- Stakeholder representatives engaged in working groups related to climate change messaging;
- 745 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;
- Programs designed to engage citizens in monitoring impacts of climate change developed;
- Educational curricula developed;
- 750 Collaborations with zoos, aquaria, museums, and botanic gardens initiated;
- Traffic to the *Strategy* web site and other electronic climate change adaptation resources increased;
- Workshops and communication programs increasing awareness of climate change related issues regarding fish, wildlife, and plants across agencies developed.

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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 and fragmentation, degradation, invasive species, disease, pollution, over-harvesting, 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). Thus reducing these stressors can be some of the most effective – and doable – ways to increase resilience of fish, wildlife, and plants in a changing climate.

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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 with land-use planners as well as major sectors such as agriculture, transportation, and water resource interests to identify common concerns and shared solutions should be actively pursued.

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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 between 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. Also, decisions regarding increasing connectivity and repairing corridors will have to be weighed with the threat of invasives and the consequences of choosing one adaptation strategy over another.

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Strategy 7.1: Slow and reverse habitat loss and fragmentation.
Actions:

- 7.1.1: Work with local land-use planners to identify shared interests and potential conflicts in reducing and reversing habitat fragmentation and loss through comprehensive planning and zoning.
- 790 — 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: 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.
- 795 — 7.1.4: 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.
- 7.1.5: 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.
- 800 — 7.1.6: Bridge the gap between ecosystem conservation and economics, and consider market-based incentives that encourage conservation and rehabilitation of ecosystems for the full range of ecosystem services including carbon storage.
- 7.1.7: Minimize impacts from alternative energy development by focusing siting options on already
- 805 — 7.1.8: Identify options for redesign and removal of existing structures/barriers where there is the greatest potential to restore natural processes.

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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
- 815 — 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.
- 7.2.4: Work with water resource managers to identify, upgrade, or remove outdated sewer and
- 820 — 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: Reduce impacts of impervious surfaces and stormwater runoff in urban areas to improve water quality, groundwater recharge, and hydrologic function.
- 825 — 7.2.7: Promote water conservation, reduce water use, and promote increased water quality via proper waste disposal.
- 7.2.8: Develop and implement protocols for considering the carbon sequestration and storage services of forest, grassland, coastal, and other habitats in decisions affecting these areas.

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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: 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) to address.
- 7.3.2: Develop national standards for collecting and reporting invasive species data to facilitate information sharing and management response.
- 7.3.3: Apply risk assessment and scenario planning to identify actions and prioritize responses to invasive species that pose the greatest threats to natural ecosystems.
- 7.3.4: Implement existing strategies and where necessary, develop strategies for rapid response to contain, control, or eradicate invasive species.
- 7.3.5: Assess risks and vulnerability to identify high priority areas and/or species for monitoring of invasive species and success of control methods.
- 7.3.6: Monitor pathogens associated with fish, wildlife, and plant species for increased understanding of distributions and to minimize introduction into new areas.
- 7.3.7: Apply integrated management practices, share innovative control methodologies, and take corrective actions when necessary to manage fish, wildlife, and plant diseases and invasives.

FIGHTING THE SPREAD OF WATER HYACINTH

Introduced into the United State 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). 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.



The red areas indicate the range of water hyacinth as of 1999. The Green line is potential expansion if average winter temperature increase by 9 °F (USGS).

☑ **GOAL7 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;
- 855 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.

860 **3.2 Opportunities For Multiple Sectors In Fish, Wildlife and Plant Climate Adaptation**

Climate change poses significant challenges for more than our nation’s ecosystems. Its impacts also will be felt in cities and towns and in sectors such as agriculture, energy, transportation, and other infrastructure and water resource use. The anticipated impacts to those sectors have been well documented (see box) and the threat of climate change has already prompted important adaptation efforts. Chicago is installing ‘green’ roofs that put vegetation on top of buildings and ‘cool’ pavement that reflects light to tamp down anticipated heat waves (Hayhoe and Wuebbles 2010). Keene, New Hampshire, has upgraded stormwater systems and other infrastructure after being hit by devastating floods (City of Keene, New Hampshire 2007). Native Americans are moving entire villages in Alaska and making trout habitat more resilient in Michigan (Buehler 2011). Overall, at least 15 states have completed a climate adaptation plan or are in progress. At the federal level, adaptation efforts are being coordinated by the ICCATF and are described in the October 2011 Progress Report to the President on climate change adaptation (CEQ 2011).

875 All of these affected interests will respond to climate change impacts in their own way and the decisions made in these sectors will ultimately impact our nation’s fish, wildlife, and plants. At times, adaptation efforts taken by these sectors can conflict with the needs of ecosystems (maladaptation). For example, southwestern cities diversifying their water supplies may take vital water away from wildlife and farmers. But far more often, climate change adaptation can benefit multiple sectors. Restoring wetlands to provide 885 more resilient habitats also can improve water quality and slow floodwaters helping downstream cities, for instance. Protecting coastal ecosystems also helps protect communities and industries along the coast. Moreover, research on the economics of climate adaptation shows that it can 890 be far cheaper to invest in becoming more resilient now than to pay for damages caused by climate change later (ECA 2009).

Sample Reports Documenting Impacts to Other Sectors:

National Action Plan: Priorities for Managing Freshwater Resources in a Changing Climate (ICCATF 2011)

The effects of climate change on agriculture, land resources, water resources, and biodiversity in the United States (CCSP 2008c)

Effects of Climate Change on Energy Production and Use in the United States (CCSP 2007)

Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I (CCSP 2008a)

Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region (CCSP 2009a)

The Washington Climate Change Impacts Assessment (Climate Impacts Group 2009)

Wisconsin Initiative on Climate Change Impacts (WICCI 2011)

895 In working to reduce climate change impacts on fish, wildlife, and plants, it is important to consider not only the impacts of other sectors on these species and their ecosystems, but also to look for opportunities for coordinated adaptation strategies. These sectors also can take actions that reduce non-climate stressors on ecosystems. For instance, precisely matching fertilizer amounts to the differing needs of each section of a field can cut overall fertilizer use and nutrient runoff, thus reducing the algal blooms that stress aquatic ecosystems and increase their vulnerability to climate change.

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COASTAL HABITAT CONSERVATION ON AGRICULTURAL LANDS

Enhanced management of agricultural wetlands along our coasts represents an important opportunity to accommodate waterbirds displaced by wetland loss from sea-level rise.

For example, the wet coastal prairie along the Gulf Coast of Texas and Louisiana is extremely important for wetland wildlife, as are farmland such as rice fields which also provide wet, early successional habitat. But rising sea levels are expected to inundate many of these lands. Conservation programs authorized under the Farm Bill such as the Wildlife Habitat Incentives Program, Environmental Quality Incentives Program, and Wetlands Reserve Program are able to compensate landowners willing to amend tillage and flooding practices to accommodate targeted waterbirds such as fall-migrating shorebirds and wintering and spring-migrating waterfowl. These programs work with landowners to ensure critical wildlife habitat on private lands is not lost when species need it most.

Another approach is to proactively protect land that lies next to important coastal wetlands. In Pacific Northwest estuaries, for instance, Ducks Unlimited is leading an effort to protect farmland adjacent to tidal wetlands to allow for future marsh migration inland by purchasing easements (development rights) from a willing farmer. Restoring wetlands on lands like farmlands that have not been filled and developed with buildings and hard infrastructure is a cost effective and feasible adaptation strategy.

905 It is outside the scope of this *Strategy* to describe in detail either the climate change impacts on other sectors or the sectors' adaptation needs. Instead, this chapter simply recommends actions for managers in these sectors to ensure that the needs of fish, wildlife, and plants are considered in their climate adaptation efforts.

There are eight overarching climate adaptation strategies that have been identified as common to all sectors:

1. **Improve the understanding of impacts to fish, wildlife, and plants from sectoral climate adaptation options and improve communication of those impacts**
- 910 2. **Enhance coordination between sectors and natural resource managers, land-use planners, and decision makers regarding climate change adaptation.**
3. **Use integrated planning to engage all levels of government (local, state, federal, and tribal) and multiple stakeholders in multi-sector planning.**
- 915 4. **Make best available science on the impact of climate change on fish, wildlife, and plants accessible and useable for planning and decision-making across all sectors.**
5. **Explicitly incorporate fish, wildlife, and plants into sector-specific climate adaptation planning.**

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6. **Improve, develop, and deploy decision support tools, technologies, and best management practices that incorporate climate change information to reduce impacts on fish, wildlife, and plants.**
7. **Focus linear development (e.g., energy transmission, water pipelines, transportation) along corridors already developed for those purposes where doing so would minimize barriers to migration.**
8. **Expand compensatory mitigation requirements for projects that reduce ecosystem resilience.**

STORMWATER RUNOFF

A major nonpoint source of pollution related to development along the coastline is stormwater runoff. Runoff degrades water quality, making it an important stressor affecting resilience and sustainability of coastal habitats and species. As a result of increasing development, impervious surfaces that do not allow rain to penetrate the soils (such as parking lots, roads, and rooftops) increase the amount and peak flow of stormwater runoff. Changing precipitation patterns, especially increased frequency and intensity of heavy rains, will have a compounding effect on the amount of stormwater released into surrounding ecosystems.

NOAA's National Centers for Coastal Ocean Science at Hollings Marine Laboratory has developed a stormwater runoff-modeling tool to project the local impacts of development in a changing climate (Blair et al. 2011). Urbanized watersheds were compared with less-developed suburban and undeveloped forested watersheds to examine the relationship between land-use change and stormwater runoff and how this will be amplified under climate change.

This user-friendly and flexible tool provides a mechanism to quantify the volume of runoff and peak flow estimates under different land-use and climate change scenarios. It provides an improved understanding of the impacts of development on stormwater runoff as well as the potential impacts associated with climate change in urbanized communities. Moreover, this research provides coastal resource managers with a tool to protect coastal habitat resiliency from both non-climatic stressors such as development as well as climate-associated stressors such as changing patterns of precipitation.