CH.1 About the *Strategy*

THE PURPOSE OF THE *National Fish, Wildlife and Plants Climate Adaptation Strategy* (hereafter *Strategy*) is to inspire and enable natural resource administrators, elected officials, and other decision makers to take action to help the nation's valuable natural resources and people that depend on them adapt to a changing climate.

The Strategy *identifies major goals and outlines strategies and actions needed to attain those goals.*

1.1 A Broad National Effort

Adaptation actions are vital to sustaining the nation's ecosystems and natural resources—as well as the human uses and values that the natural world provides. The *Strategy* explains the challenge ahead and offers a guide for actions that can be taken now, in spite of remaining uncertainties over how climate change will impact living resources. It further provides guidance on longer-term actions most likely to promote natural resource adaptation to climate change. Because climate adaptation cuts across many boundaries, the *Strategy* also describes mechanisms to increase collaboration among all levels of government, conservation organizations, and private landowners.

The *Strategy* focuses on preparing for and reducing the most serious impacts of climate change and related non-climate stressors on fish, wildlife, and plants. It places priority on addressing impacts for which there is enough information to recommend sensible actions that can be taken or initiated over the next five to ten years in the context of climate change projections through the end of the century. Further, it identifies key knowledge, technology, information, and governance gaps that hamper effective action. While the *Strategy* is focused on adaptation rather than mitigation (or reduction) of GHGs, it includes approaches that may also have mitigation benefits.

The *Strategy* is not a detailed assessment of climate science or a comprehensive report of the impacts of climate change on individual species or ecosystems; an abundant and growing literature on those

topics already exists (IPCC AR4 2007, USGCRP 2009, Parmesan 2006). It is not a detailed operational plan, nor does it prescribe specific actions to be taken by specific agencies or organizations, or specific management actions for individual species. Rather, this is a broad national adaptation strategy: it identifies major goals and outlines strategies and actions needed to attain those goals. It describes the "why, what, and when" of what the nation must do to assist our living resources to cope with climate change. The "who, where, and how" of these strategies and actions must be decided through the many existing collaborative processes for management planning, decision-making, and action. In addition, the development of strategies and actions for this document was not constrained by assumptions of current or future available resources. The implementation of recommended strategies and actions, and the allocation of resources towards them, are the prerogative of the *Strategy* audience, (e.g., decision makers).

Federal, tribal, state, and local governments and conservation partners have initiated a variety of efforts to help prepare for and respond to the impacts of climate change on the nation's natural resources and the valuable services they provide. This *Strategy* is designed to build on and assist these efforts across multiple scales and organizations. These entities are encouraged to identify areas of the *Strategy* that bear on their missions and work collaboratively with other organizations to design and implement specific actions to reduce the impacts of climate change on fish, wildlife, and plants.

In order for the *Strategy* to be effectively implemented, progress should be periodically evaluated and the *Strategy* reassessed and updated through the same sort of collaborative process as was employed in the production of this first effort. The *Strategy* calls for formation of a coordinating body with representation from federal, state, and tribal governments meet semi-annually to promote and evaluate implementation and to report progress annually.

1.2 Origin and Development

Over the past decade, there have been an increasing number of calls by government and non-governmental entities for a national effort to better understand, prepare for and address the impacts of climate change on natural resources and the communities that depend on them. These calls helped lay the foundation for development of this *Strategy*.

For example, in 2007, the U.S. Government Accountability Office (GAO) released a study entitled "Climate Change: Agencies Should Develop Guidance for Addressing the Effects on Federal Land and Water Resources," recommending that guidance and tools be developed to help federal natural resource managers address and incorporate climate change into their resource management efforts (GAO 2007). In 2008, the USGCRP released the report *Preliminary Review of Adaptation Options for Climate-Sensitive Ecosystems and Resources* that called for and identified new approaches to natural resource management to increase resiliency and adaptation of ecosystems and resources (CCSP 2008c). In addition, a coalition of hunting and fishing organizations published reports in 2008 and 2009 on the current and future impacts of climate change on fish and wildlife and called for increased action to help sustain these resources in a changing climate (Wildlife Management Institute 2008, 2009).

Congress asked CEQ and DOI to develop a national strategy to "…assist fish, wildlife, plants, and related ecological processes in becoming more resilient, adapting to, and surviving the impacts of climate change" as part of the 2010 Appropriations Bill for the Department of the Interior and Related Agencies (U.S. Congress 2010). Acting for DOI, the U.S. Fish and Wildlife Service (FWS) and CEQ then invited the National Oceanic and Atmospheric Administration (NOAA) and state wildlife agencies, with the New York State Division of Fish, Wildlife, and Marine Resources as their lead representative, to co-lead the development of the *Strategy*. In October of 2010, the ICCATF endorsed the development of the *Strategy* as a key step in advancing U.S. efforts to adapt to a changing climate.[1]

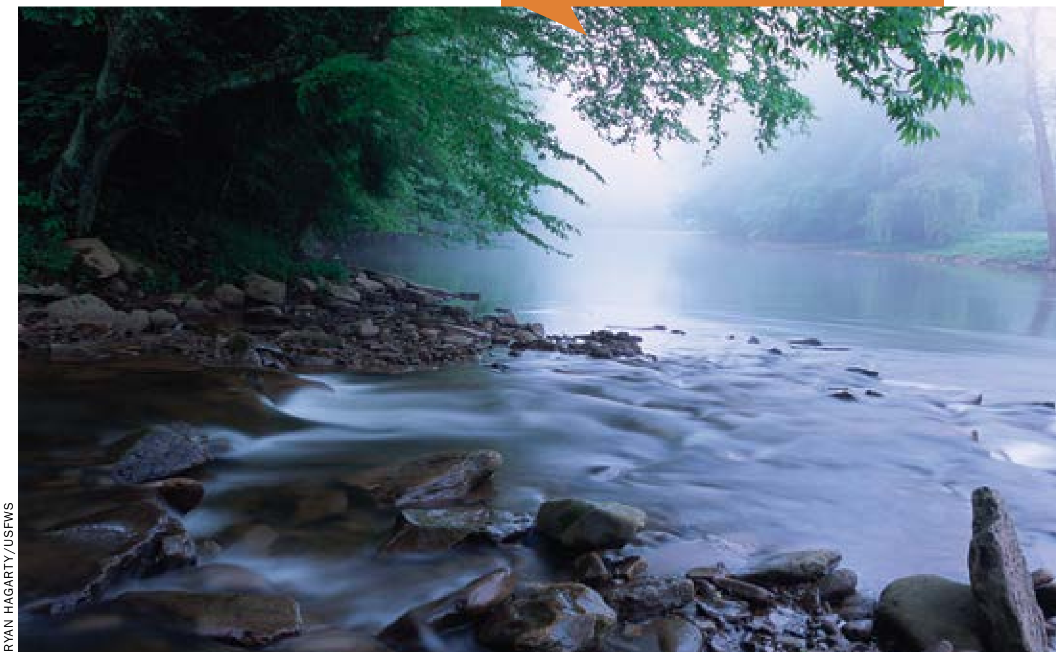
A 22-person Steering Committee was formed in January 2011, and includes representatives from 15 federal agencies with management authorities for fish, wildlife, plants, or habitat, as well as representatives from five state fish and wildlife agencies and two intertribal commissions. The Committee charged a small Management Team, including

1 See "Progress Report of the Interagency Climate Adaptation Task Force: Recommended Actions in Support of a National Climate Change Adaptation Strategy. <www.whitehouse.gov/sites/default/files/microsites/ceq/Interagency-Climate-Change-Adaptation-Progress-Report.pdf>

Unless the nation begins a serious effort to undertake adaptation efforts now, we risk losing priceless living systems—and the benefits and services they provide—as the climate changes.

representatives of the FWS, NOAA, the Association of Fish and Wildlife Agencies (AFWA, representing the states), and the Great Lakes Indian Fish and Wildlife Commission, to oversee the day-to-day development of the *Strategy*. The Management Team was asked to engage with a diverse group of stakeholders, as well as to coordinate and communicate across agencies and departments.

In March of 2011, the Management Team invited more than 90 natural resource professionals (both researchers and managers) from federal, state, and tribal agencies to form eight Technical Teams, each centered around a major U.S. ecosystem type. These Teams, which were co-chaired by federal, state, and tribal representatives, worked over the next eight months to provide technical information on climate change impacts and to collectively develop the strategies and actions for adapting to climate change. The Management Team worked to identify and distill the primary approaches common across ecosystems into the seven overarching goals, discussed in detail in Chapter 3.



RYAN HAGARTY/USFWS

1.3 The Case for Action

1.3.1 The Climate is Changing

Measurements and observations show unequivocally that the Earth's climate is currently in a period of unusually rapid change. The impacts of climate change are occurring across the United States. For example:

- » Average air temperature has increased two degrees Fahrenheit (°F) and precipitation has increased approximately five percent in the United States in the last 50 years;
- » Average global ocean temperatures have increased nearly 0.4°F since 1955;
- » The amount of rain falling in the heaviest storms is up 20 percent in the last century, causing unprecedented floods;
- » Extreme events like heat waves and regional droughts have become more frequent and intense;
- » Hurricanes in the Atlantic and eastern Pacific have gotten stronger in the past few decades;
- » Sea levels have risen eight inches globally over the past century and are climbing along most of our nation's coastline;
- » Cold season storm tracks are shifting northward;
- » The annual extent of Arctic sea ice is shrinking rapidly; and
- » Oceans are becoming more acidic.

All of these changes have been well documented and described in the report: *Global Climate Change Impacts in the United States* (USGCRP 2009), the primary scientific reference on climate change science for this document. Moreover, the changes are harbingers of far greater changes to come.

The science strongly supports the finding that the underlying cause of today's rising temperatures, melting ice, shifting weather, increasing ocean acidification and other changes is the accumulation of heat-trapping carbon dioxide (CO_2) and other greenhouse gases (GHGs) in the atmosphere (IPCC AR4 2007, USGCRP 2009, NRC 2010). Because CO_2 remains in the atmosphere for many years, CO_2 that has already been emitted will continue to warm the Earth (and contribute to ocean acidification) for decades or centuries to come (Wigley 2005). Meanwhile, GHG emissions continue, increasing the concentrations of these gases in the atmosphere. Our future climate will be unlike that of the recent past. Traditional and proven approaches for managing fish, wildlife, plants, ecosystems, and their human uses may no longer be effective given the scale and scope of climate-driven changes.

Observed Changes to Ecosystems and Species

AFWA

Species are **shifting their geographic ranges**, often moving poleward or upwards in elevation. For instance, geese that formally wintered along the Missouri River in Nebraska and South Dakota now seem to migrate only as far south as North Dakota, to the dismay of waterfowl hunters (*Wildlife Management Institute 2008*). These shifts may also bring wildlife into more densely populated human areas, creating situations of human-wildlife conflict. In addition, some marine species are also shifting both location and depth (Nye et al. 2009).

BILL LYNCH

The phenology, such as **spring blooming, is changing** (Post et al. 2001). This could affect whether or not plants are successfully pollinated (the pollinators might come at the wrong time), or whether or not food is available when needed. For example, in the Rocky Mountains, the American robin (see Appendix D for a list of scientific names of species mentioned in the text) is now arriving up to two weeks earlier than it did two decades ago. However, the date of snow melt has not advanced, so food resources may be limited when the birds arrive (Inouye et al. 2000).

NOAA

Since water absorbs CO2, the **oceans are becoming more acidic**, affecting the reproduction of species such as oysters (Feely et al. 2008). The pH of seawater has decreased since 1750, and is projected to drop much more by the end of the century as CO2 concentrations continue to increase (USGCRP 2009). Although not technically climate change, this additional impact of the accumulation of CO2 in the atmosphere is expected to have major impacts on aquatic ecosystems and species.

SHELLEY ELLIS/NWF

Different species are responding differently to changes in climate, leading to **decoupling of important ecological relationships** (Edwards and Richardson 2004). For example, changes in phenology for Edith's checkerspot butterfly are leading to mismatches with both caterpillar host plants and nectar sources for adult butterflies, leading to population crashes in some areas (Parmesan 2006).

JOHN LYONS

Habitat loss is increasing due to ecological changes associated with climate change, such as sea level rise, increased fire, pest outbreaks, novel weather patterns, or loss of glaciers. For example, habitat for rainbow trout in the southern Appalachians is being greatly reduced as water temperatures rise (Flebbe et al. 2006).

BROME MCCREARY

Declines in the populations of species, from mollusks off the coast of Alaska to frogs in Yellowstone, are being attributed to climate change (Maclean and Wilson 2011).

TIM TORRELL

The **spread of non-native species** as well as diseases, pests, contaminants, and parasites are becoming more common. For instance, warmer temperatures are enabling a salmon parasite to invade the Yukon River, causing economic harm to indigenous peoples and the fishing industry (Kocan et al. 2004). Also, the increasing threats of wildlife diseases due to non-native species include diseases transmissible between animals and humans, which could negatively impact native species, domestic animals, and humans (Hoffmeister et al. 2010).

1.3.2 Impacts to Fish, Wildlife, and Plants

Given the magnitude of the observed changes in climate, it is not surprising that fish, wildlife, and plant resources in the United States and around the world are already being affected. The impacts can be seen everywhere from working landscapes like tree farms and pastures to wilderness areas far from human habitation (Parmesan 2006, Doney et al. 2012). Although definitively establishing cause and effect in any specific case can be problematic, the overall pattern of observed changes in species' distributions and phenology (the timing of life events) is consistent with biologists' expectations for a warming climate (Parmesan 2006, Doney et al. 2012). As the emissions of GHGs and the resulting climate changes continue to increase in the next century, so too will the effects on species, ecosystems, and their functions (USGCRP 2009). Human responses to the challenge of climate change will also affect, perhaps substantially, the natural world. Furthermore, climatic change and the human response to it are also likely to exacerbate existing stressors like habitat loss and fragmentation, putting additional pressure on our nation's valued living resources (USGCRP 2009).

CASE STUDY

Hotter summers threaten eastern brook trout

Heat stress is the biggest threat to cold water fish species and brook trout are particularly sensitive.

CHUCK KRUEGER/GREAT LAKES FISHERY COMMISSION

THE WEST FORK OF THE KICKAPOO RIVER in western Wisconsin is an angler's paradise. Its cool, shaded waters and pools abound with native brook trout. But brook trout require cold water to reproduce and survive—and water temperatures are already rising. By the end of this century, the self-sustaining population in the West Fork could be gone. In fact, up to 94 percent of current brook trout habitat in Wisconsin could be lost with a 5.4 °F increase in air temperature (Mitro et al. 2010). Although climate change has not caused the loss of any brook trout populations to date, the warming effects on air temperature is projected to significantly reduce the current range of brook trout in the eastern United States.

The threat is not limited to Wisconsin or to brook trout. Climate change is viewed as one of the most important stressors of fish populations, and coldwater fish species are especially susceptible to rising temperatures. Declining populations would have serious ecological and economic consequences, since these fish are key sources of nutrients for many other species and provide major fishing industries in the Northeast, Northwest, and Alaska (Trout Unlimited 2007).

In some cases, adaptation measures may help reduce the threat. The first step is measuring stream water temperatures and flow rates to identify which trout habitats are at greatest risk. Monitoring efforts have already shown that some trout streams are at lower risk because they have water temperatures far below lethal limits, while other streams are not likely to see increases in water temperatures even when air temperatures rise, since adequate amounts of cool groundwater sustain the stream's baseflow in summer. This information enables fisheries managers to focus on the streams and rivers that are at greater risk from climate change and from changing land use that would decrease groundwater discharge rates. In some streams, these deteriorating conditions are unlikely to be reversed.

In other streams, adaptation strategies can be implemented to reduce stream water temperatures such as planting trees and other streambank vegetation for shade, or restoring stream channel morphology to reduce solar heating. For example, managing stream corridors to preserve functional processes and reconnect channels with well-vegetated floodplains may help to ensure a steady supply of groundwater recharge that maintains coldwater species even when air temperatures rise. Floodplains serve as vital hydrologic capacitors, and may become even more important in many parts of the country as more precipitation falls as rain instead of snow.

Protecting and enhancing water infiltration rates on land is another adaptation strategy that can increase cooler groundwater discharge rates during the critical summer low flow conditions.

This "triage" stream assessment approach is similar to how accident or battlefield responders work, where efforts are focused on those most likely to respond to treatment. Thus, limited funding is directed toward streams that are at higher risk from the effects of rising temperatures, and on streams where adaptation actions are more likely to have a positive impact.

Natural environments provide enormously valuable services and goods that benefit humans and other species.

1.3.3 Ecosystem Services

Natural systems are of fundamental value and benefit to people. Natural environments provide enormously valuable, but largely unaccounted for, services that support people as well as other species (NRC 2004, NRC 2012, PCAST 2011). The materials and processes that ecosystems produce that are of value to people are known as "ecosystem services" and can be organized into four general categories (Millennium Ecosystem Assessment 2005):

- *Provisioning Services*, including food, water, medicines, and wood.
- *Regulating Services*, such as climate regulation, flood suppression, disease/pest control, and water filtration.
- *Cultural Services*, such as aesthetic, spiritual, educational, and recreational services.
- *Supporting Services*, such as nutrient cycling, soil formation, pollination, and plant productivity.

Economic contributions of ecosystem services have been quantified in some areas. For example, hunting, fishing, and other wildlife-related recreation in the United States (an example of provisioning and cultural services) is estimated to contribute $122 billion to our nation's economy annually (DOI and DOC 2006). The U.S. seafood industry—most of which is based on wild, free-ranging marine species—supported approximately 1 million full-and part-time jobs and generated $116 billion in sales impacts and $32 billion in income impacts in 2009 (NMFS 2010). Marine recreational fishing also contributes to coastal areas as an economic engine; in 2009, approximately 74 million saltwater fishing trips occurred along U.S. coasts, generating $50 billion in sales impacts and supporting over 327,000 jobs (NMFS 2010). Aquatic habitat and species conservation alone contributes over $3.6 billion per year to the economy in the U.S., and supports over 68,000 jobs (Charbonneau and Caudill 2010). Americans and foreign visitors made some 439 million visits to DOI-managed lands in 2009. These visits (an example of a cultural service) supported over 388,000 jobs and contributed over $47 billion in economic activity.

> *The U.S. seafood industry—most of which is based on wild, free-ranging marine species—annually supports approximately 1 million full-and part-time jobs.*

This economic output represents about eight percent of the direct output of tourism-related personal consumption expenditures for the United States for 2009 and about 1.3 percent of the direct tourism related employment (DOI 2011). Every year, coastal habitats such as coral reefs, wetlands, and mangroves help protect people, infra-structure and communities from storms, erosion, and flood damage worth billions of dollars (DOI and DOC 2006, CCSP 2009a).

The continuance or growth of these types of economic activities is directly related to the extent and health of our nation's ecosystems and the services they provide.

Natural resources provide a wide variety of other types of benefits and services to people and communities every day, many of which are not traded in markets and are sometimes difficult to monetize. For example, forests help provide clean drinking water for many cities and towns. Coastal habitats such as coral reefs, wetlands, and mangroves help protect people and communities from storms, erosion, and flood damage (DOI and DOC 2006, CCSP 2009a). For many people, quality of life depends on frequent interaction with wildlife. Others simply take comfort in knowing that the wildlife and natural places that they know and love still survive, at least somewhere.

For many Native Americans and rural Americans, wild species and habitats are central to their very cultural identities as well as their livelihoods. The animals and plants that are culturally important to these communities have values that are difficult to quantify and weigh in monetary terms; but this makes them no less valuable to people.

Over the past two decades the emerging environmental marketplace has been delivering evidence that at least some ecosystem services can be partially captured in markets. The buying, selling, and trading of ecosystem services as commercial commodities is now routinely occurring. Carbon credits, wetland credits, emission reduction credits, and species credits represent voluntary improvements in air and water quality and supply, land use and waste management, as well as biodiversity protection. These commodities are now exchanged across a number of recognized regional, national, and international platforms. Because these credits have achieved measureable monetary value representing incremental improvements in ecological health and integrity, they shed some light on the overall value of ecosystem services. For example, the total global value of tradable ecological assets (water, carbon, and biodiversity) exceeded $250 billion in 2011 (Carroll and Jenkins 2012).

Despite growing recognition of the importance of ecosystem functions and services, they are often taken for granted, undervalued, and overlooked in environmental decision-making (NRC 2012). Thus, choices between the conservation and restoration of some ecosystems and the continuation and expansion of human activities in others have to be made in recognition of this potential for conflict and of the value of ecosystem services. In making these choices, the economic values of the ecosystem goods and services must be known so that they can be compared with the economic values of activities that may compromise them (NRC 2004, NRC 2012).

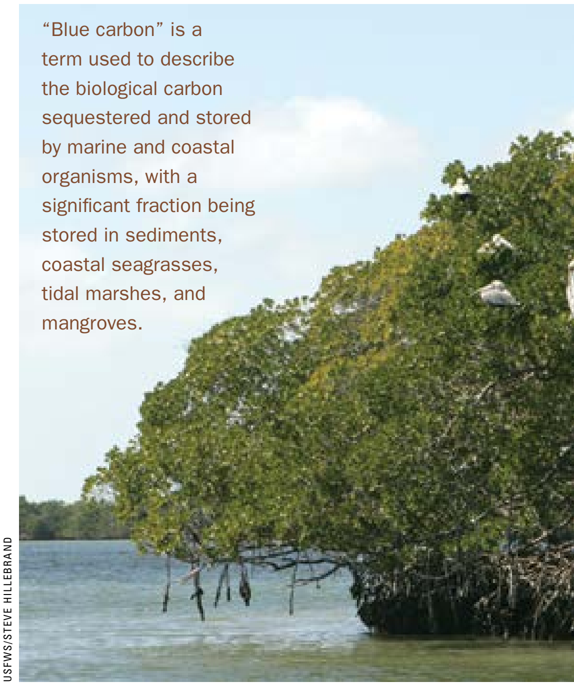
Where an ecosystem's services and goods can be identified and measured, it will often be possible to assign values to them by employing existing economic valuation methods. However, some ecosystem goods and services resist valuation because they are not easily quantifiable or because available methods are not appropriate, reliable, or fully developed. Economic valuation methods can be complex and demanding, and the results of applying these methods may be subject to judgment, uncertainty, bias, and market imperfections. There is also the risk that, where not all values can be estimated, those that can be valued lead to management that harms the overall system in pursuit of maximizing only that portion of its values (e.g., replacing natural wetland communities with monotypic wetlands to maximize water purification).

However, if policymakers consider benefits, costs, and trade-offs when making policy decisions, then monetization of the value of ecosystem services is essential. Failure to include some measure of the value of ecosystem services in benefit-cost calculations will implicitly and erroneously assign them a value of zero. In brief:

» If the benefits and costs of an adaption action or policy are to be evaluated, the benefits and costs associated with changes in ecosystem services should be included along with other impacts to ensure that ecosystem effects are adequately considered in policy evaluation.

» Economic valuation of changes in ecosystem services should be based on the total economic value framework, which includes both use and nonuse values.

» The valuation exercise should focus on changes in ecosystem goods or services attributable to a policy action, relative to a baseline.



"Blue carbon" is a term used to describe the biological carbon sequestered and stored by marine and coastal organisms, with a significant fraction being stored in sediments, coastal seagrasses, tidal marshes, and mangroves.

USFWS/STEVE HILLEBRAND

Some actions, like strategies that preserve or enhance the carbon sequestration capacity of an ecosystem, can serve to mitigate or reduce the emission of GHGs while also improving the adaptive capacity of the ecosystem (i.e., providing multiple ecosystem services). While the *Strategy* is not focused on mitigation per se, it includes strategies and actions that serve mitigation as well as adaptation goals. Unlike actions to mitigate the impacts of climate change (which often require coordinated actions at various levels of government), adaptation decisions are largely decentralized. They will be made to a large extent in well-established decision-making contexts such as private sector decision-making or public sector planning efforts. Some adaptations will benefit the public and as such, may be provided by the local, state, tribal,

or federal government. These adaptation decisions can be evaluated using traditional tools such as cost-benefit analysis. In certain circumstances, ethnographic research may prove more useful than cost-benefit analysis in understanding perceived public benefits. Private sector decisions are likely to be evaluated using standard investment appraisal techniques, for example, calculating the net present value of an adaptation investment, analyzing its risks and returns, or determining the return on capital invested.

A full accounting of ecosystem services has yet to be done for any ecosystem. Nevertheless, as climate change influences the distribution, extent, and composition of ecosystems, it will also affect the spectrum of services and economic value those ecosystems provide.

1.3.4 Adaptation to Climate Change

While addressing the causes of climate change (i.e., mitigation) is absolutely necessary, mitigation will not be sufficient to prevent major impacts due to the amount of GHGs that have already been emitted into the global atmosphere. Society's choices of what actions to take in the face of climate change can either make it harder or easier for our living resources to persist in spite of climate change. Effective action by managers, communities, and the public is both possible (see Chapter 3) and crucial.

Adaptation in the climate change context has been specifically defined as an "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC WGII 2007). Adaptation in the biological context has a somewhat different meaning. In essence, biological adaptation refers both to the process and the products of natural selection that change the behavior, function, or structure of an organism that makes it better suited to its environment. The factors that control the rate of biological adaptation (e.g., population size, genetic variability, mutation rate, selection pressure, etc.) are rarely under full control of human action. Much as people might like, human intervention will not be able to make species adapt to climate change. But our actions can make such adaptation more or less likely.

CASE STUDY

What happens to Tribal identity if birch bark vanishes?

CLIMATE CHANGE MODELS SUGGEST that by 2100, the paper birch tree may no longer be able to survive throughout its range in the United States (Prasad et al. 2007). This would be not just an ecological loss, but a devastating cultural loss as well. Some species are so fundamental to the cultural identity of a people through diverse roles in diet, materials, medicine, and/or spiritual practices that they may be thought of as cultural keystone species (Garibaldi and Turner 2004). The paper birch is one such example.

Paper birch bark has been indispensable for canoes, sacred fires, and as a substrate to grow fungi for medicines. It was used for food storage containers to retard spoilage, earning it the nickname of the "original Tupperware™".

CHARLIE RASMUSSEN

It is an extremely durable material and is still used as a canvas on which traditional stories and images are etched, contributing to the survival of Native culture and providing a source of revenue. Indeed, birch bark is crucial for the economic health of skilled craftspeople who turn it into baskets and other items for sale to tourists and collectors. Paper birch is central to some of the great legends of the Anishinaabe or Ojibwe peoples (also known as Chippewa).

These rich cultural and economic uses and values are at risk if the paper birch tree disappears from the traditional territories of many U.S. tribes. Already, artisans in the Upper Midwest are concerned about what they believe is a diminishing supply of birch bark.

Until adaptive management strategies are developed and implemented, managers will have to rely on identifying suitable areas to serve as refugia where culturally significant numbers of the species can survive.

The science and practice of adaptation to climate change is an emerging discipline that focuses on evaluating and understanding the vulnerability and exposure that natural resources face due to climate change, and then preparing people and natural systems to cope with the impacts of climate change through adaptive management (Glick et al. 2011a). The ability of populations, species, or systems to adapt to a changing climate is often referred to as their adaptive capacity.

Because climate change is a long-term problem, both the level and timing of adaptation decisions is important. Both sets of decisions—level and timing—will be made under uncertainty about the precise impacts of climate change. Timing decisions should recognize the following:

» Early action may be more cost effective in situations where long-lived infrastructure investments such as water and sanitation systems, bridges, and ports are being considered. In these cases, it is likely to be cheaper to make adjustments early, in the design phase of the project, rather than incur the cost and inconvenience of expensive retrofits.

» Early adaptation actions will be justified if they have immediate benefits, for example, by mitigating the effects of climate variability. In addition, adaptation actions that have ancillary benefits such as measures to preserve and strengthen the resilience of natural ecosystems might also be justified in the short-term.

Three general types of adaptation responses illustrate points along a continuum of possible responses to climate change:

Resistance	Resilience	Transformation
Ability of a system to remain essentially intact or unchanged as climate changes	Ability of a system to recover from a disturbance, returning to its original state.	The change in a system's composition and/or function in response to changes in climate or other factors.

STEVE HILLEBRAND/USFWS

Uncertainties regarding the future of climate change are inherent and unavoidable but this should not stop us from taking action now.

Application of the adaptation approaches described in this *Strategy* must carefully consider whether the desired outcome in any given situation should be to try to increase the resistance of a natural system to climate change, to attempt to make it more resilient in the face of climate change, or to assist its transformation into a new and different state—or to achieve some combination of all three outcomes (Hansen and Hoffman 2011).

CASE STUDY

Climate change on the Kenai Peninsula

RICHEY/USFWS

FOR A GLIMPSE OF THE DRAMATIC changes that a warming climate may bring to the entire nation, look no farther than Alaska's seven million-acre Kenai Peninsula. Here, warmer temperatures have increased over-winter survival and boosted populations of spruce bark beetle, enabling the pest to devastate four million acres of forest on the peninsula and south-central Alaska over a 15-year period (Berg et al. 2006).

Meanwhile, the treeline has risen an unprecedented 150 feet (Dial et al. 2007); the area of wetlands has decreased by six to 11 percent per decade (Klein et al. 2005, Berg et al. 2009, Klein et al. 2011); the Harding Icefield, the largest glacial complex in the United States, has shrunk by five percent in surface area and 60 feet in height (Rice 1987, Adageirsdottir et al. 1998); and available water has declined 55 percent (Berg et al. 2009). The fire regime is also changing: late summer canopy fires in spruce are being replaced by spring fires in bluejoint grasslands, and a 2005 wildfire in mountain hemlock was far different from any previous fire regime (Morton et al. 2006).

While these changes are already sobering, even greater changes lie ahead, according to projections from spatial modeling. As the climate continues to warm and dry, the western side of the peninsula could see an almost catastrophic loss of forest. Salmon populations—and the communities that depend on salmon—are projected to suffer because of higher stream temperatures (Mauger 2011) and increased glacial sediment (Edmundson et al. 2003). Overall, 20 percent of species may vanish from the peninsula in the worst case scenario.

Is adapting to this rapidly changing climate possible? Some communities are already taking positive steps. For instance, state and local agencies are replanting beetle-killed areas that have become grasslands with white spruce and non-native lodgepole pine to reduce fire hazards for nearby cities and communities.

The Kenai National Wildlife Refuge, Kenai Fjords National Park, Chugach National Forest, and the University of Alaska Anchorage are developing a climate vulnerability assessment in 2012 for the Kenai Peninsula and adjacent mainland. Plans are underway to develop interagency strategies for developing retrospective and prospective options (Magness et al. 2011) for adapting to climate change effects on the Kenai Peninsula. The geographic discreteness of the peninsula, the substantial lands under federal management, and the documentation of dramatic climate change impacts combine to make Kenai an ideal laboratory to explore the effectiveness of various adaptation measures.

Deciding what to do requires examining the institutions, laws, regulations, policies, and programs that our nation has developed to maintain our valuable resources and the many benefits they provide.

It requires evaluating the management techniques that the conservation profession and other sectors (such as agriculture, energy, housing and urban development, transportation, and water resources) have developed over time, as well as considering new approaches where necessary

Perhaps most of all, it requires communicating our shared social values for wild living things and the ecosystems in which they live. Those social values can form the basis of cooperative intervention.

1.4 Purpose, Vision, and Guiding Principles

In 2009, the FWS launched a series of Conservation Leadership Forums to bring together leaders in the conservation community to discuss what a *Strategy* should include and how it should be developed. That effort, and others, produced a purpose, a vision, and guiding principles for developing this first national climate change adaptation strategy.

PURPOSE

Inspire and enable natural resource professionals and other decision makers to take action to conserve the nation's fish, wildlife, plants, and ecosystem functions, as well as the human uses and values these natural systems provide, in a changing climate.

VISION

Ecological systems will sustain healthy, diverse, and abundant populations of fish, wildlife, and plants. These systems will provide valuable cultural, economic, and environmental benefits in a world impacted by global climate change.

GUIDING PRINCIPLES

An unprecedented commitment to collaboration and communication is required among federal, state, and tribal governments to effectively respond to climate impacts. There must also be active engagement with conservation organizations, industry groups, and private landowners. These considerations and the following principles guided the development of the Strategy:

Build a national framework for cooperative response.
Provide a nation-wide framework for collective action that promotes collaboration across sectors and levels of government so they can effectively respond to climate impacts across multiple scales.

Foster communication and collaboration across government and non-government entities.
Create an environment that supports the development of cooperative approaches among government and non-government entities to adapting to climate change while respecting jurisdictional authority.

Engage the public.
To ensure success and gain support for adaptation strategies, a high priority must be placed on public outreach, education, and engagement in adaptation planning and natural resource conservation.

Adopt a landscape/seascape based approach that integrates best available science and adaptive management.
Strategies for natural resource adaptation should employ: ecosystem-based management principles; species-habitat relationships; ecological systems and function; strengthened observation, monitoring, and data collection systems; model-based projections; vulnerability and risk assessment; and adaptive management.

Integrate strategies for natural resources adaptation with those of other sectors.
Adaptation planning in sectors including agriculture, energy, human health, and transportation may support and advance natural resource conservation in a changing climate.

Focus actions and investments on natural resources of the United States and its Territories.
But also acknowledge the importance of international collaboration and information-sharing, particularly across our borders with Canada and Mexico. International cooperation is important to conservation of migratory resources over broad geographic ranges.

Identify critical scientific and management needs.
These may include new research, information technology, training to expand technical skills, or new policies, programs, or regulations.

Identify opportunities to integrate climate adaptation and mitigation efforts.
Strategies to increase natural resource resilience while reducing GHG emissions may directly complement each other to advance current conservation efforts, as well as to achieve short- and long-term conservation goals.

Act now.
Immediate planning and action are needed to better understand and address the impacts of climate change and to safeguard natural resources now and into the future.

WHAT IS...?

Risk Assessment

A risk assessment is the process of identifying the magnitude or consequences of an adverse event or impact occurring, as well as the probability that it will occur (Jones 2001).

Vulnerability Assessment

Vulnerability assessments are science-based activities (research, modeling, monitoring, etc.) that identify or evaluate the degree to which natural resources, infrastructure, or other values are likely to be affected by climate change.

Adaptive Management

Adaptive management involves defining explicit management goals while highlighting key uncertainties, carefully monitoring the effects of management actions, and then adjusting management activities to take the information learned into account (CCSP 2009b).

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Deciding how best to address ecosystem changes due to climate change will require a cooperative effort by federal, state, and tribal government agencies.

1.5 Risk and Uncertainty

Climate change presents a new challenge to natural resource managers and other decision makers. The future will be different from the recent past, so the historical record cannot be the sole basis to guide conservation actions. More is being learned every year about how the climate will change, how those changes will affect species, ecosystems, and their functions and services, and how future management and policy choices will exacerbate or alleviate these impacts. This uncertainty is not a reason for inaction, but rather a reason for prudent action: using the best available information while striving to improve our understanding over time.

An important approach for dealing with risk and uncertainty is the iterative process of adaptive management. Adaptive management is a structured approach toward learning, planning, and adjustment where continual learning is built into the management process so that new information can be incorporated into decision-making over time without delaying needed actions. Carefully monitoring the actual outcomes of management actions allows for adjustments to future activities based on the success of the initial actions.

A variety of tools and approaches can help managers deal with risk and reduce uncertainty, thus, informing managers about how climate change may affect particular systems or regions. Improved climate modeling and downscaling can help build confidence in predictions of future climate, while climate change vulnerability assessments can help to identify which species or systems are likely to be most affected by climate changes. Well-designed monitoring of how species and natural systems are currently reacting to climate impacts and to adaptation actions will also be a critical part of reducing uncertainty and increasing the effectiveness of management responses. These tools and approaches can all inform scenario planning, which involves anticipating a reasonable range of future conditions and planning management activities around a limited set of likely future scenarios. In addition, other approaches aim to identify actions that are expected to succeed across a range of uncertain future conditions such as reducing non-climate stressors or managing to preserve a diversity of species and habitats.

Another important component of managing risk and uncertainty is to better integrate existing scientific information into management and policy decisions. This requires that research results be accessible, understandable, and highly relevant to decision makers. In addition, decision support tools that help connect the best available science to day-to-day management decisions should continue to be developed, used, and improved, and research priorities should be linked to the needs of managers on the ground.

It is important to remember that natural resource management has always been faced with uncertainty about future conditions and the likely impacts of a particular action. The adaptation strategies and actions in this *Strategy* are intended to help natural resource managers and other decision makers make proactive climate change-related decisions today, recognizing that new information will become available over time that can then be factored into future decisions.