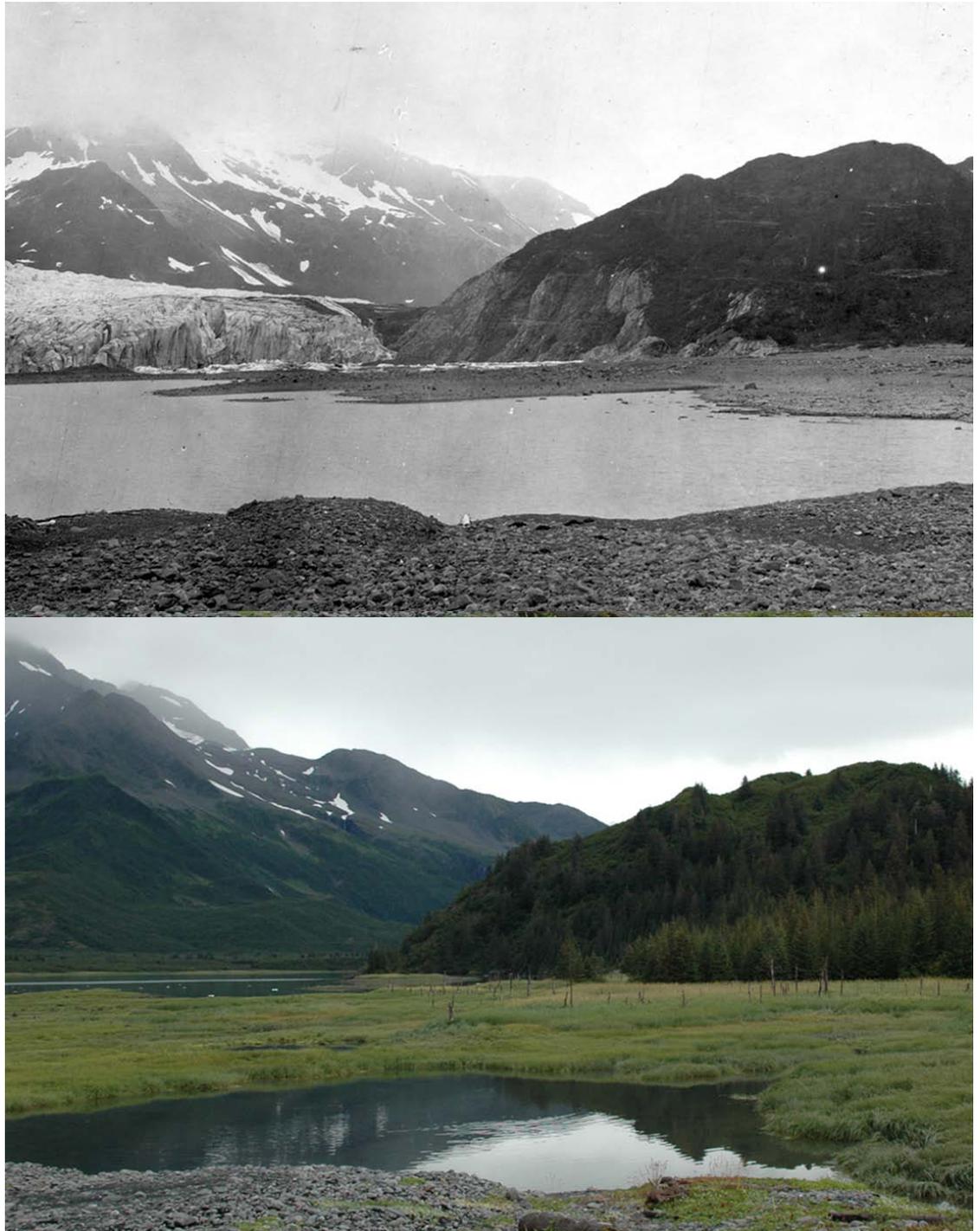




# National Park Service Climate Change Response Strategy

September 2010





Pederson Glacier in Kenai Fjords National Park, 1909 (top) and 2005 (bottom).

Suggested citation: National Park Service. 2010. National Park Service Climate Change Response Strategy. National Park Service Climate Change Response Program, Fort Collins, Colorado.

Background cover photo: Bighorn Canyon National Recreation Area courtesy of Pete Sawtell.

All photos courtesy of the National Park Service unless otherwise noted.

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# Climate Change Response Strategy

## September 2010

National Park Service  
Climate Change Response Program  
1201 Oakridge Drive, Suite 200  
Fort Collins, CO 80525

National Park Service  
U.S. Department of the Interior  
Washington, D.C.

## National Park Service Mission

*The National Park Service preserves unimpaired the natural and cultural resources and intrinsic values of the National Park System for the enjoyment, education, and inspiration of this and future generations. The National Park Service cooperates with partners to extend the benefits of natural and cultural resource conservation, and outdoor recreation throughout this country and the world.*

## National Park Service Organic Act of 1916

*“ . . . to promote and regulate the use of the . . . national parks . . . which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.”*



As temperatures rise, the habitat of species like the American pika is threatened.

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Grinnell Glacier in Glacier National Park has retreated dramatically in recent years.

# Letter from the Director

I believe climate change is fundamentally the greatest threat to the integrity of our national parks that we have ever experienced. The current science confirms the planet is warming and the effects are here and now. This is a high-priority issue for the current Administration, including the Department of the Interior and its individual bureaus. With the coordinated strategy put forward here, the National Park Service addresses what we are going to do about it.

We have a proud tradition of innovation and not shirking from a challenge. We shall not sit idle, because our 1916 Organic Act challenges us to conserve, “*by such manner and by such means as will leave them unimpaired for future generations.*” I have always liked those words “by such manner and by such means” as they give us latitude to use whatever resources we have to protect parks in a future that has been characterized as “hot, flat and crowded.”

The National Park Service Climate Change Response Strategy is an urgent call for collective and individual action. First and foremost, the NPS should be a leader in all aspects of recycling, alternative fuels, energy efficiency, and sustainable design and construction. I see great examples around the Service, but we are inconsistent in our goals and efforts. That change will take place when every employee gets on board and insists on recycling, when every building we build is LEED certified, and when every can of paint is non-VOC.

The NPS is an extraordinary educational institution where millions of people learn about the environment, conservation, and our rich and complex history. We have helped the public understand the essential role of predators in the environment by bringing back the wolf and we have shown them that fire is essential to ecosystem health. We are unafraid to discuss the role of slavery in the Civil War or the imprisonment of American citizens of Japanese ethnicity during WWII. We should not be afraid to talk about climate change. Yes, there will be those who question it, even within our own ranks. But we always try to base our decisions on the best available science and that science is documenting changes to our parks right now. So let’s talk about it with the public.

The young employees I have met who are just starting in this wonderful organization will be dealing with climate change their entire career. Anything as complex as climate change needs a comprehensive approach that includes budget,

organization, policy, science, and actions on the ground. We were successful in the FY2010 budget and have requested increases for the coming years. We have set policies for new construction to meet LEED Silver and are working to develop sustainability standards for historic structures. Our science initiative is designed to develop the best usable knowledge so each of you is equipped to make informed decisions. Our resource assessment program will develop standards for reporting on the condition of our natural and cultural resources as they are stressed by a changing climate.

To guide the new program, I am creating a NPS Climate Change Coordinating Group, made up of four Associate Directors: Natural Resource Stewardship and Science; Cultural Resources; Interpretation and Education; and Park Planning, Facilities and Lands. Advising this group will be the Science Advisor to the Director, one Regional Director and one Superintendent. They will report to me and address tough questions of policy, such as impairment, arrival of new species, or facilitated migration. They will also interact with the Climate Change Response Steering Committee representing the amazing field staff already working on many of these issues.

The old adage “may you live in interesting times” is appropriate here, as climate change has certainly made things interesting. How will we choose, as the sea rises, which cultural sites we save? How do we decide that the next site for the giant sequoias is hundreds of miles north? Are those warblers here for the first time treated as exotics? These are difficult questions. More than the future of the national parks hangs in the balance, but I am confident that the NPS will play a critical role.



Jonathan B. Jarvis  
Director, National Park Service  
August 2010

The NPS is using solar panel arrays to provide energy needs in remote areas.



## Executive Summary

### **Science:**

Conduct scientific research and vulnerability assessments necessary to support NPS adaptation, mitigation, and communication efforts. Collaborate with scientific agencies and institutions to meet the specific needs of management as it confronts the challenges of climate change. Learn from and apply the best available climate change science.

### **Mitigation:**

Reduce the carbon footprint of the NPS. Promote energy efficient practices, such as alternative transportation. Enhance carbon sequestration as one of many ecosystem services. Integrate mitigation into all business practices, planning, and the NPS culture.

### **Adaptation:**

Develop the adaptive capacity for managing natural and cultural resources and infrastructure under a changing climate. Inventory resources at risk and conduct vulnerability assessments. Prioritize and implement actions, and monitor the results. Explore scenarios, associated risks, and possible management options. Integrate climate change impacts into facilities management.

### **Communication:**

Provide effective communication about climate change and impacts to the public. Train park staff and managers in the science of climate change and decision tools for coping with change. Lead by example.

In 2016, the National Park Service (NPS) will begin its second century of preserving the Nation's natural and cultural heritage, a stewardship that now includes protection of more than 84 million acres within the National Park System. Global climate change threatens the integrity of our national parks. It challenges the NPS mission to leave park resources unimpaired for future generations unlike any threat in our history.

The NPS is moving rapidly beyond the question of whether the Earth is warming and is focused on what to do about it. This crisis is daunting, but national parks can provide redemption. For one of the most precious values of the national parks remains their ability to teach us about ourselves and how we relate to the natural world. How we move forward in the era of climate change is up to each of us, at all levels of the NPS, and as citizens of the United States.

The NPS Climate Change Response Strategy provides direction to our agency and employees to address the impacts of climate change. It describes goals and objectives to guide our actions under four integrated components: **science, adaptation, mitigation, and communication**. The NPS will collaborate with partners to identify and monitor climate change effects in parks and to apply accurate and relevant science to management and policy decisions. In a changing climate, the NPS will adapt through the development of feasible and actionable scenarios and create a flexible framework for dealing with impacts<sup>1</sup>. We will reduce the National Park Service carbon footprint (the amount of greenhouse gases emitted through NPS activities) through energy-efficient and sustainable practices and

integrate these practices into planning and operations. Finally, through clear directed communication, the NPS will raise employees' and the public's awareness of the implications of climate change and inspire them to take steps to address this challenge.

The four integrated components throughout the strategy call for an overarching legal and policy framework that will ensure the legality, consistency and appropriateness of management decisions. As climate change is likely to create conditions and ecosystems unlike any found today, upholding our mission may require updating interpretations of policy, mandates, and approaches to resource stewardship.

This is an ambitious coordinated strategy to understand, communicate, and respond to the impacts of rapid climate change. This issue's complexity and pervasiveness demand a scientific approach and an unprecedented level of cooperation, collaboration, and partnership across all directorates and divisions within the National Park System, partner organizations, other government agencies, and neighboring communities. A legacy of inspirational heritage hangs in the balance.

<sup>1</sup>The terms "effect" and "impact" are often used interchangeably to describe changes to physical, chemical, biological, or human systems as a result of climate change. In this document, a climate change effect refers to a consequence that may or may not be detrimental, while a climate change impact refers to an outcome that is unfavorable for park resources or visitor experience.

Glen Canyon National Recreation Area is experiencing drought and reduced water levels that affect many plants and animals. Photo courtesy of David Rankin.



# Climate Change and National Parks: Rising to the Challenge

Inaction may be the riskiest decision of all because climate change is a long term problem that carries a huge procrastination penalty.

The fourth and most recent report from the Intergovernmental Panel on Climate Change (*IPCC*) established with certainty that the Earth's climate is rapidly changing. The report states, "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." It also states, "Most of the observed increase in global average temperatures since the mid-20th century is 'very likely' due to the observed increase in anthropogenic greenhouse gas concentrations." The term "very likely" is defined in the report as having a 90 percent or greater probability. The planet is warming and scientists are 90 percent certain that human activities are the cause.

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## DEFINITIONS

### *IPCC:*

The IPCC is the leading body for the assessment of climate change, established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO). It is a scientific body that reviews and assesses the most recent scientific, technical, and socio-economic information produced worldwide relevant to climate change. It is an intergovernmental body and thousands of scientists from all over the world contribute to the work of the IPCC on a voluntary basis. By participating in the review process and endorsing the IPCC reports, governments acknowledge the authority of their scientific content (IPCC Organization 2010).

### *Cascading Effect:*

This term refers to a series of indirect effects triggered by an event or change. For example, warming temperatures have a direct effect on precipitation and soil moisture, which can in turn have cascading effects on many aspects of ecosystems, including wildfire, invasive species, and species migration.

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The physical infrastructure, natural and cultural resources, visitor experience, and intrinsic values of national parks are at risk from the effects of climate change. Some effects are already measurable. However, the long-range and *cascading effects* of climate change are just beginning to be understood. Warmer temperatures are accelerating the melting of mountain glaciers, reducing snow-pack, and changing the timing, temperature, and amount of streamflow. These changes are expected to result in the loss or relocation of native species, altered vegetation patterns, and reduced water availability in some regions. Wildfire seasons have expanded, and fires have increased in severity, frequency, and size. Conditions that favor outbreaks of pests, pathogens, disease, and nonnative species invasion occur more frequently than in the recent past. In Alaska, melting sea ice threatens marine mammals as well as coastal communities, while thawing permafrost disrupts the structural basis of large regions, jeopardizing the physical stability of natural systems as well as buildings, roads, and facilities. Rising sea levels, ocean warming, and acidification affect wildlife habitat, cultural and historic

features, coastal archeological sites, and park infrastructure, resulting in damage to and the loss of some coastal resources. Some studies suggest that extreme weather events such as thunderstorms, hurricanes, and windstorms that damage park infrastructure and habitat are increasing in frequency and intensity.

The uncertainty of how and when specific impacts will become evident makes responding to climate change a challenge. Many questions remain unanswered, such as: How quickly and how much will sea level rise on particular coastlines? How much temperature increase can species and ecosystems withstand before widespread and irreversible changes occur? How will the distribution, timing, and intensity of precipitation change in different regions? The lack of certainty about specific impacts does not mean we should not act. In fact, inaction may be the riskiest decision of all because climate change is a long-term problem that carries a huge procrastination penalty. The NPS must begin now to develop long-range plans and implement strategies for resource protection in the face of climate change.



One of the future effects of climate change will be longer fire seasons; fires have increased in severity, frequency, and size. Yellowstone National Park, July 2007.

## Building a Collaborative Response

“The management implications for protecting species, biological communities, and physical resources within finite land management boundaries in a rapidly changing climate are complex and without precedent.”

—Testimony by Jon Jarvis at Senate Energy and Natural Resources Committee hearing, October 28, 2009

Meeting the challenge of global climate change will require an unprecedented level of cooperation and collaboration. The NPS recognizes the risks of a changing climate and is committed to implementing a response initiative that will guide management actions and collaboration at national, regional, and park levels. Through the strategy presented here, the NPS will contribute to the scientific understanding of climate change and its effects, construct a framework for adaptation and mitigation and provide guidance on its use, and communicate broadly with NPS employees, partners, and the public. Some of the necessary actions to implement this strategy have already been initiated and others will require further planning and development.

Many national parks and regional offices began several years ago to reduce their carbon footprint and communicate the consequences of climate change through interpretive programs and educational materials. More than 70 parks are now participating in the “Climate Friendly Parks Program,” which the NPS initiated in collaboration with the Environmental Protection Agency in 2002. The branch for Sustainable Operations and Climate Change was subsequently created in the Park Planning, Facilities, and Lands Directorate, emphasizing the NPS commitment to reducing its carbon footprint and promoting effective adaptation response for facilities and infrastructure.

In 2007 the NPS Director established the Climate Change Response Program (CCRP) under the Natural Resource Stewardship and Science (NRSS) Directorate, which is responsible for working with parks, regions, other di-

rectorates, programs, and partners to develop a cross-cutting, interdisciplinary approach to dealing with climate change. To facilitate servicewide input, the Climate Change Response Steering Committee was created in early 2009. The committee serves as an advisory body to the CCRP and NPS leadership. The steering committee was preceded by several working groups formed ad hoc to foster communication and explore the needs and issues of parks and regions. Under guidance from the steering committee, the working groups continue to provide a mechanism for servicewide engagement in the development and implementation of the new program.

NPS response options will be developed and implemented in a manner consistent with NPS policy and Department of the Interior (DOI) guidelines set forth by Secretarial Order 3289 entitled *Addressing the Impacts of Climate Change on America’s Water, Land, and Other Natural and Cultural Resources*. Issued on September 14, 2009, the order calls upon all DOI bureaus to participate in a departmental climate change response initiative. Key organizational elements include: the establishment of a Climate Change Response Council within the Office of the Secretary; creation of eight Regional Climate Change Response Centers (now referred to as DOI Climate Science Centers) and a network of Landscape Conservation Cooperatives (to promote on-the-ground actions); and the initiation of the Carbon Storage Project (to promote removal of carbon dioxide from the atmosphere through biological and geological processes) and the Carbon Footprint Project (to promote energy-efficient operations).

“Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.”

—IPCC 2007

**Changes in temperature, sea level and Northern Hemisphere snow cover**

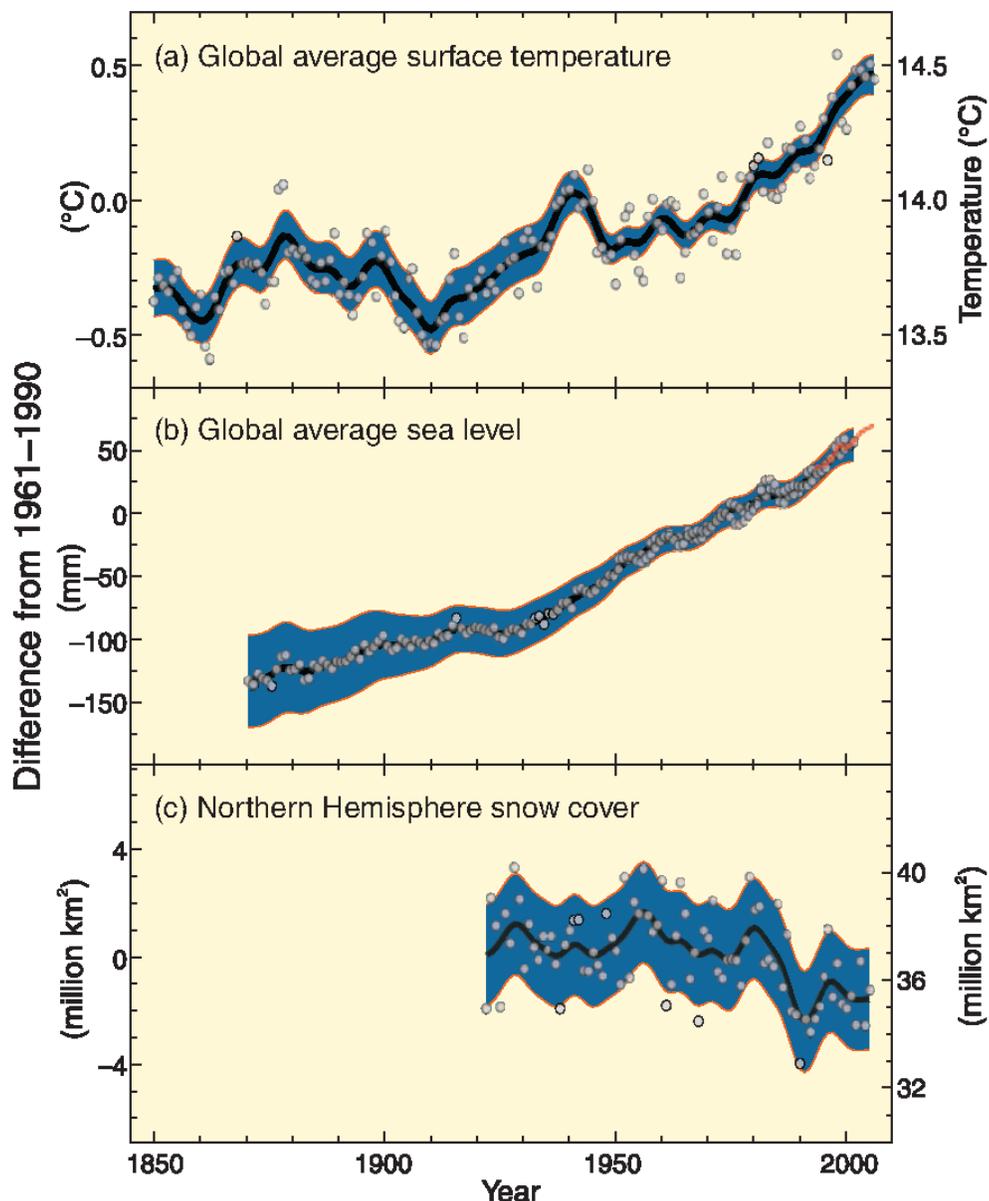
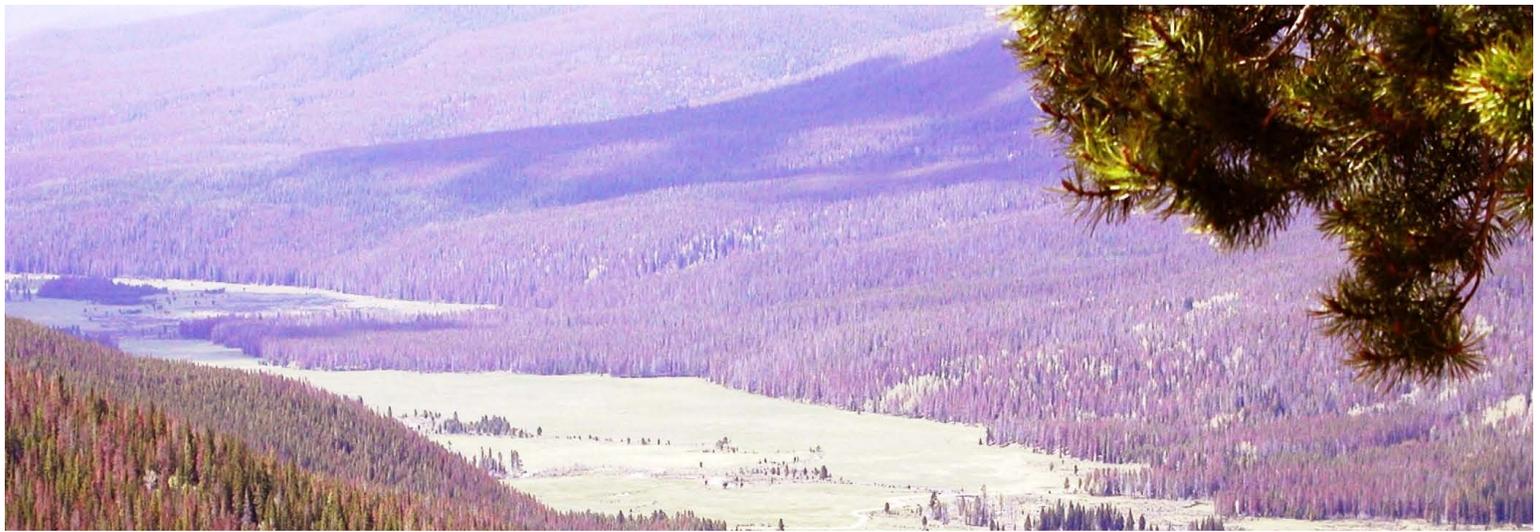


Figure 1. Observed changes in (a) global average surface temperature; (b) global average sea level from tide gauge (blue) and satellite (red) data; and (c) Northern Hemisphere snow cover for March–April. All differences are relative to corresponding averages for the period 1961–1990. Smoothed curves represent decadal averaged values while circles show yearly values. The shaded areas are the uncertainty intervals estimated from a comprehensive analysis of known uncertainties (a and b) and from the time series (c). {WGI FAQ 3.1 Figure 1, Figure 4.2, Figure 5.13, Figure SPM.3} (from IPCC 2007).



There is growing evidence that rising temperatures increase insect infestations. An outbreak of mountain pine beetles is killing most large lodgepole pines in Rocky Mountain National Park.

## Principles for Effective Decision Making in a Changing Climate

As conditions and ecological relationships shift, effective decision making will require a flexible approach for incorporating new and relevant science.

Climate change will create novel communities and environments (conditions and ecosystems unlike any found today). Sometimes called “no analog” conditions, the future will be characterized by climatic and seasonal patterns for which we have no modern or historical reference. Current NPS planning processes establish baseline conditions and explore alternative futures that assume continuation of historical patterns in climate, weather, vegetation, and animal behavior. Planning for climate change cannot make those assumptions. As conditions and ecological relationships shift, effective decision making will require a flexible approach for incorporating new and relevant science. The National Research Council<sup>2</sup> conducted a study in 2009 to explore the elements and organizational practices necessary for ensuring such a flexible approach. The resulting report entitled *Informing Decisions in a Changing Climate* calls for federal agencies and academic institutions to embrace six basic principles in building an effective and sustained capability for climate change **decision support**. The NPS Climate Change Response Strategy has adopted these six principles to guide in the development and implementation of an integrated science-management response capacity for NPS and its partners.

### Principle 1

#### *Begin with managers’ needs*

Effective decision support must begin with collaborative problem definition. In this way, tools and products for managers can be developed specifically to assist in decision outcomes rather than as by-products of established research programs. While much of the needed knowledge will come from physical and ecological sciences, decision making also involves social, economic, cultural, and political considerations. Questions about what information is needed and why should be asked at the outset of building decision-support systems.

### Principle 2

#### *Give priority to process as well as products*

Interpersonal interactions are critical to effective decision support. By starting with engagement processes that bring together the relevant stakeholders (e.g., managers, planners, park specialists, scientists, and the public), we can encourage the development of scientific and other products that are relevant to decision making and supportive of a shared vision. In order to create flexible and adaptive

#### DEFINITIONS

##### **Decision-Support:**

Climate change decision support refers to organized efforts to produce, disseminate, and facilitate the use of data and information in order to improve the quality and efficacy of climate-related decisions (NRC 2009).

<sup>2</sup>The National Research Council (NRC) is a U.S. science advisory body administered jointly by the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine. It was established in 1916 to advance scientific knowledge and advise the U.S. government.

decision-support systems, opportunities and processes for engagement need to be ongoing, participatory, transparent, and iterative.

**Principle 3**  
*Link information providers and users*

Scientific and decision-making communities have different purposes, norms, and standards for accountability, which can challenge communication between them. Networks are needed that link science providers with the managers and their staffs who use the information. Existing networks, such as the Cooperative Ecosystem Studies Units, Inventory and Monitoring Networks, and other collaborations can be efficiently enhanced to facilitate climate change decision support, while the capacity for new partnerships is improved through establishment of the DOI regional Climate Science Centers and Landscape Conservation Cooperatives.

**Principle 4**  
*Build connections across disciplines and organizations*

Well-informed responses to climate change will require combining information from different disciplines, sectors, and organizations. This includes building connections at local to regional scales and among people with a wide

range of technical expertise within the bureau and the department, other agencies, and existing partners and stakeholders.

**Principle 5**  
*Enhance institutional capacity*

Climate change decision-making systems need stable and evolving support. This can be achieved through establishing dedicated funding of climate change programs and personnel, adding flexibility to existing fund sources, network building with partners and knowledge providers, and establishing new decision-making practices. Enhancing our capacity in these areas at park, network, regional, and national scales is necessary if we are to meet the goals outlined in this strategy.

**Principle 6**  
*Design for learning*

The NPS needs to be an organization that is structured for adaptability, grounded in experience, and supports (1) the development of personnel, (2) the exploration of alternative explanations and scenarios, (3) team learning and implementation, (4) the innovation of ideas across an institution, and (5) approaches to learning and management that evolve as knowledge increases.

In Yellowstone National Park, long-term drought has caused tributaries to disconnect from Yellowstone Lake, negatively affecting native fish species, August 2004.





Low water levels at the confluence of the Pecos River and the Rio Grande, Amistad National Recreation Area.

# Charting a Course for Action: The Vision

“One of the most precious values of the national parks remains their ability to teach us about ourselves and how we relate to the natural world.”

—Testimony by Jon Jarvis at Senate Energy and Natural Resources Committee hearing, October 28, 2009

The NPS adapts to climate change and effectively preserves and restores park resources and opportunities for visitor enjoyment. Through collaboration with our employees, partners, and the public the NPS teaches and promotes climate change science and applies the best management practices and sustainable behaviors toward reducing climate change and its impacts.

The NPS will:

- Participate fully in partnerships that increase scientific understanding of climate change and its effects
- Analyze potential climate change impacts and adaptively apply the information to improve planning, resource conservation, and visitor experience
- Set high standards for energy efficiency and greenhouse gas emissions reduction
- Communicate broadly about climate change science and its impacts and the actions that can be taken to mitigate and adapt

## ***An Integrated Approach***

The NPS Climate Change Response Strategy features four integrated components: science, adaptation, mitigation, and communication. This approach is consistent with Secretarial Order 3289 and complements strategies proposed by other DOI bureaus and other agencies. The NPS will work with local, state, tribal, regional, national, and international efforts and other bureaus and partners to implement the components of the strategy.

This moat at Dry Tortugas National Park is the last layer of protection between Fort Jefferson, a 19th-century coastal fortification, and sea level rise.





A USGS scientist collects GPS points along the terminus of Grinnell Glacier, September 2003. Photo by Lisa McKeon, USGS.

## Science

NPS scientific activities have already begun to help increase the institutional capacity and scientific literacy of park visitors and the broader public related to climate change.

NPS climate change science is a multidisciplinary “stewardship science” that involves biophysical, socioeconomic, and cultural disciplines. Stewardship science considers national parks and surrounding areas as integrated human-ecological systems and focuses on ecosystem, landscape, and regional scales to inform natural and cultural resources and facility management. Key elements include the synthesis of existing information, research, inventory and monitoring, and delivery of relevant information to managers and stakeholders to support decision making. Science in the NPS is conducted by professional staff scientists, USGS scientists, university faculty, and non-governmental partners through cooperative agreements, contracts, and other collaborations and mechanisms. NPS scientific activities have already begun to help increase the institutional capacity and scientific literacy of park visitors and the broader public related to climate change.

The following climate change science goals and objectives direct the NPS to expand its scientific capacity to (1) develop and apply climate change science, (2) collaborate with scientific agencies and institutions to advance climate change science from local to international levels, and (3) identify and conduct scientific studies and resource monitoring activities necessary to support NPS mitigation, adaptation, and communication efforts.

### DEFINITIONS

#### **Climate Change Models:**

A climate model is a quantitative way of representing the interactions of the atmosphere, oceans, land surface, and ice. Models are representations of a system that allow for investigation of the properties of the system and, in some cases, prediction of future outcomes (EPA 2010).

### Goal 1

*Use the best available scientific data and knowledge to inform decision making about climate change.*

**Objective 1.1:** Integrate climate change considerations into all science activities where appropriate, including research, assessments, planning, reporting, and operational evaluations.

**Objective 1.2:** Develop an integrated data system that allows efficient discovery and sharing of climate change data and information with other agencies and the public.

State-of-the-art technology will be used to efficiently manage and report NPS data and information. The NPS will share resource information and data management technology with partners and will use this technology to ensure current scientific information is available to inform management decisions and educational efforts.

### Goal 2

*Collaborate with partners to develop, test, and appropriately apply climate change models to NPS activities.*

**Objective 2.1:** Identify and characterize the climate attributes and variables that are most important to park resources, infrastructure, and visitor experience.

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## DEFINITIONS

### **Adaptive management:**

This is a process that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process (CCSP 2008).

### **Resilience:**

Resilience is the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change (IPCC 2007).

### **Carbon Footprint:**

A carbon footprint is “the total set of greenhouse gases (GHG) emissions caused by an organization, event or product” (UK Carbon Trust 2010).

### **Carbon Sequestration:**

The uptake and storage of carbon. Trees and plants, for example, absorb carbon dioxide, release the oxygen, and store the carbon. Fossil fuels were at one time biomass and continue to store the carbon until burned (EPA 2010).

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Conceptual models, natural resource priority vital signs and the associated ecological monitoring framework, and other existing databases can be accessed to help identify the most important climate variables to inform decision making.

**Objective 2.2:** Characterize the locations and severity of change expected for key climate attributes.

To the extent possible, managers need details regarding the spatial distribution of projected changes in key climate attributes along with information about which areas are likely to experience relatively rapid or severe changes. Evaluation and interpretation of these kinds of data are important to inform place-based management of park resources.

**Objective 2.3:** Facilitate development of models that can be used by managers to plan for and adapt to climate change impacts.

Ecological models can project effects of climate change on plants, animals, communities, and other systems and can be used by managers to understand how these effects will impact park resources. Through science partnerships the NPS can acquire the expertise to help design such models, ensure that NPS data and knowledge are incorporated into modeling activities, and evaluate the usefulness of modeling results toward decision making.

## **Goal 3**

*Inventory and monitor key attributes of the natural systems, cultural resources, and visitor experiences likely to be affected by climate change.*

**Objective 3.1:** Evaluate and enhance existing cultural and natural inventory and monitoring programs to address climate change and establish new programs as needed.

Some individual park or network programs (e.g., Inventory and Monitoring) will be enhanced to monitor climate-sensitive indicators and selected natural and cultural resources, including ethnographic resources and infrastructure. Work with partners may include monitoring important vital signs by increasing the number of monitored sites, frequency of observations, or monitoring new variables.

**Objective 3.2:** Monitor, evaluate, and report the status and trends of park resources to facilitate adaptation planning.

Long-term monitoring of park resource conditions is necessary to understand the rate and

magnitude of climate effects and to support adaptation to rapid climate change. Monitoring to evaluate the effectiveness of management actions is a key component of *adaptive management*.

**Objective 3.3:** Develop criteria with other federal, state, and local partners and programs to measure and evaluate core concepts that may be used to direct adaptation strategies.

The U.S. Climate Change Science Program Synthesis and Assessment Product 4.4: Preliminary Review of Adaptation Options for Climate-Sensitive Ecosystems and Resources (CCSP SAP 4.4) recommends specific approaches for adaptation, such as increasing ecosystem *resilience* (the ability of a system to recover from stress), redundancy (maintaining more than one example of an ecosystem or population), connectivity (the ability for organisms to move from one area to another), and protecting refugia (places that are relatively unaffected by climate change). The NPS needs to verify the scientific foundation of these concepts and identify criteria to evaluate their performance so that they may be applied appropriately in restoration and protection of park resources.

## **Goal 4**

*Use best available science to evaluate and manage greenhouse gas storage and emissions in national parks.*

**Objective 4.1:** Develop and apply a scientifically valid, standardized approach for reducing the National Park Service’s *carbon footprint*.

In collaboration with other agencies, develop a replicable and verifiable process for measuring emissions and continuously evaluate the process to ensure that it is effective and uses advanced science, technologies, and procedures.

**Objective 4.2:** Collaborate with partners to evaluate biological carbon accounting tools and their appropriate application to NPS units.

NPS scientists and policy analysts will participate with cooperating bureaus and agencies to evaluate the potential for *carbon storage and sequestration* on NPS lands. We will also consider the possible ecological consequences that may accompany direct efforts to increase biological carbon sequestration on park lands and the compatibility of sequestration options with the NPS mission.



In Yosemite National Park, the range of pika has contracted, and the lower elevation of their ranges has moved uphill by an average of 500 feet (Moritz et al. 2008).

## Adaptation

It is in this realm that science is applied and action taken.

In the context of climate change, adaptation is an adjustment in natural or human systems that moderates harm or exploits beneficial opportunities in response to change. It may include a variety of social, economic, or ecological responses, some of which are triggered naturally and others that are planned. It is in this realm that science is applied and action taken. This is a critical arena for the NPS as the ability to identify and implement effective actions in anticipation of climate change effects may determine the continued existence of cultural and natural resources and infrastructure on both a local and regional basis. Adaptation will affect virtually all NPS operations. This section of the strategy is divided into four subsections (1) adaptation planning, (2) promoting ecosystem resilience, (3) preserving cultural heritage, and (4) protecting facilities and infrastructure.

### Adaptation Planning

Adaptation planning and implementation will require collaboration and coordinated actions among and across many jurisdictions. Therefore, the NPS approach to climate change adaptation and planning, illustrated in Figure 2, emphasizes steps and activities that are multidisciplinary and cross institutional boundaries. The generalized planning framework is constructed in the form of a logic model that aligns with the six principles for effective decision making (outlined in an earlier section of

the strategy) and identifies specific products, tools, and approaches (such as down-scaled climate models, vulnerability assessments, and *scenario planning*) that can be developed for on-the-ground adaptation planning. This is an adaptive framework that incorporates current knowledge with tools for exploring future uncertainty. With an increased focus on adaptive management and scenario planning, the NPS will be better equipped to respond to the rapid pace of decisions demanded by climate change.

### Goal 5

*Incorporate climate change considerations and responses in all levels of NPS planning.*

**Objective 5.1:** Complete guidance for anticipating, evaluating, and addressing climate change in planning products and identify resources needed to fully implement new planning guidelines.

This will involve identifying, developing, and linking resource databases, scenario planning templates, and other planning aids in addition to training materials for NPS managers and staff.

**Objective 5.2:** Incorporate the DOI adaptive management framework into routine planning to facilitate flexible responses to climate change as new information arises.

#### DEFINITIONS

##### **Scenario Planning:**

Scenarios are plausible and often simplified descriptions of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships (IPCC 2007).

Resilience refers to “the amount of change or disturbance that a system can absorb without undergoing a fundamental shift to a different set of processes and structures.”

—CCSP 2008, page 2

**Objective 5.3:** Evaluate legal and policy considerations for planning and climate adaptation and revise guidance where appropriate.

Modification to existing laws and policies may be necessary to clarify roles, responsibilities, and authorities for enacting climate change response actions (see following section on Legal and Policy Considerations).

**Objective 5.4:** Conduct scenario planning to explore the range of potential conditions that parks may experience and the possible consequences associated with particular actions.

Scenario planning can help managers explore assumptions, test hypotheses, and ultimately develop robust strategies and actions to manage the uncertainties of climate change.

### ***Promoting Ecosystem Resilience***

Many best-management practices for conventional ecosystem stressors also reduce the tendency of these stressors to intensify climate change effects. Therefore, one approach to adaptation is to reduce the risk of adverse outcomes by increasing the resilience of systems and supporting the ability of natural systems and species to adapt to change. The NPS will apply adaptation actions to support resilience in a scientifically rigorous manner (see Objective 3.3). By focusing on resilience, NPS ecosystem adaptation goals and practices reflect current understanding of ecosystem dynamics, which allows managers to accommodate and respond to emerging knowledge of climate change effects and alternative management strategies that can lessen the impacts.

## **Goal 6**

***Implement adaptation strategies that promote ecosystem resilience and enhance restoration, conservation, and preservation of park resources.***

**Objective 6.1:** Collaborate with federal, state, and local partners and programs to acquire, evaluate, and develop tools, such as vulnerability assessments and scenario planning, to inform the development of adaptation plans at appropriate scales.

Vulnerability assessments and scenario planning are two tools for adaptation that are of considerable interest to the NPS and other managers. For many NPS resources and scales, methods to conduct vulnerability assessments and apply scenario planning techniques have not yet been established. NPS scientists and managers need to be engaged in developing and testing the appropriate methodologies.

**Objective 6.2:** Develop methods to prioritize resources that are threatened by climate change using scientific assessments, policy, management capacity, and information from stakeholders.

Because the NPS cannot address all climate change impacts, multi-step and multi-scale (species, communities, ecosystems, and key ecosystem processes) prioritization is needed to efficiently allocate limited resources. All prioritization relies on best available science but must also consider legal mandates, stakeholder values, and other non-scientific attributes.

The Inupiat village of Shishmaref, Alaska, is surrounded by the 2.6-million-acre Bering Land Bridge National Preserve. Severe storms have been eroding the shoreline, and in July 2002, residents voted to relocate the community. ©Shishmaref Alaska Erosion and Relocation Coalition.



**Objective 6.3:** Collaborate to develop cross-jurisdictional conservation plans to protect and restore connectivity and other landscape-scale components of resilience.

Protecting and restoring corridors (passageways that connect habitat patches) and connectivity across landscapes will require strong collaboration with partners and programs to share knowledge, develop repositories of genetic resources, and, where appropriate, develop cross-jurisdictional conservation.

**Objective 6.4:** Establish management guidance for applying adaptation recommendations put forward by the U.S. Climate Change Science Program Synthesis and Assessment Product 4.4.

The CCSP SAP 4.4 makes numerous recommendations for adaptation options but there is little guidance about how these options might be implemented or whether they are consistent with management policies. This section of

the strategy addresses the need for this guidance, including a rigorous evaluation of the scientific basis for these recommended actions (see Objective 3.3).

### Preserving the Nation's Heritage

The preservation and protection of cultural resources is a core part of the National Park Service mission. The 2006 *NPS Management Policies* define cultural resources as “archeological resources, cultural landscapes, ethnographic resources, historic and prehistoric structures, and museum collections.” The NPS fulfills its responsibility to preserve such resources by working beyond park boundaries with State Historic Preservation Offices, other preservation partnerships, and community assistance programs. Significant cultural resources are disappearing rapidly due to high rates of erosion, intense weather events, and other factors related to climate variability and change. Unlike plants and animals that may

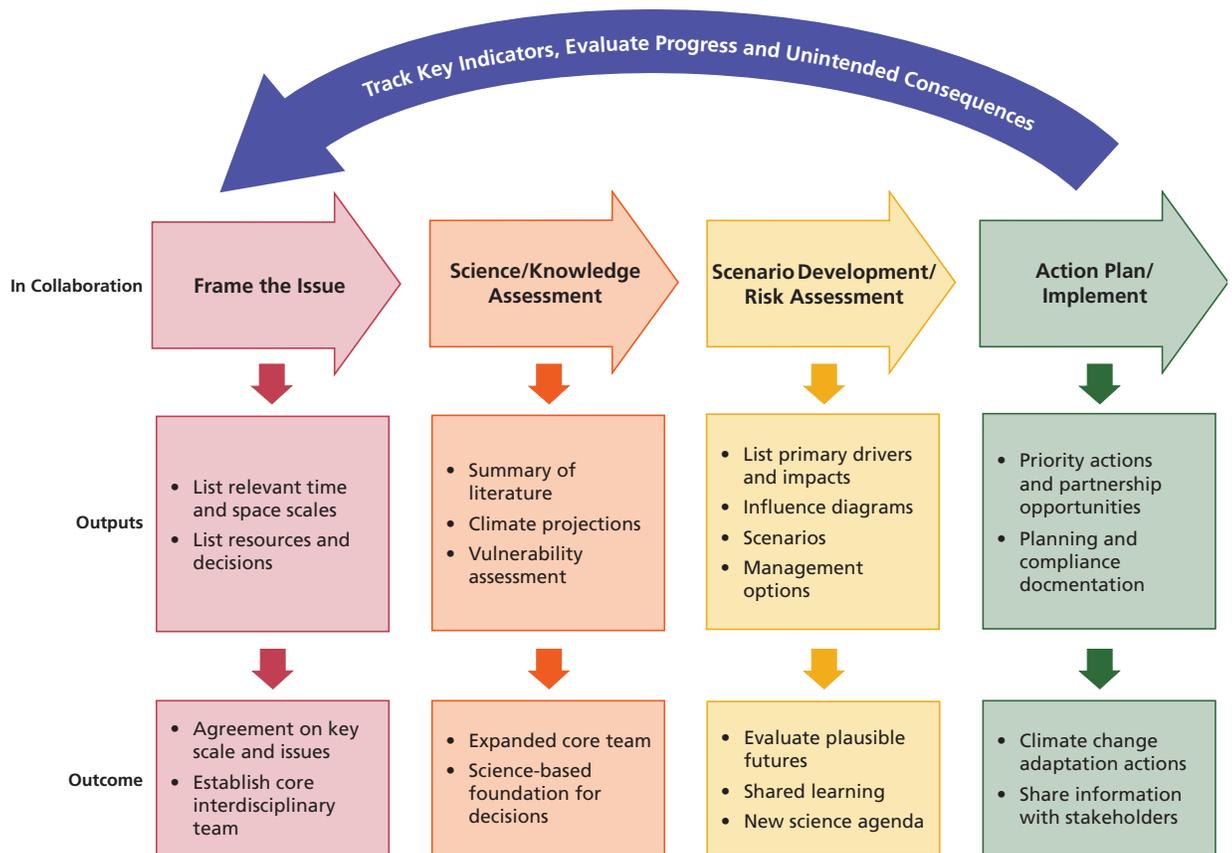
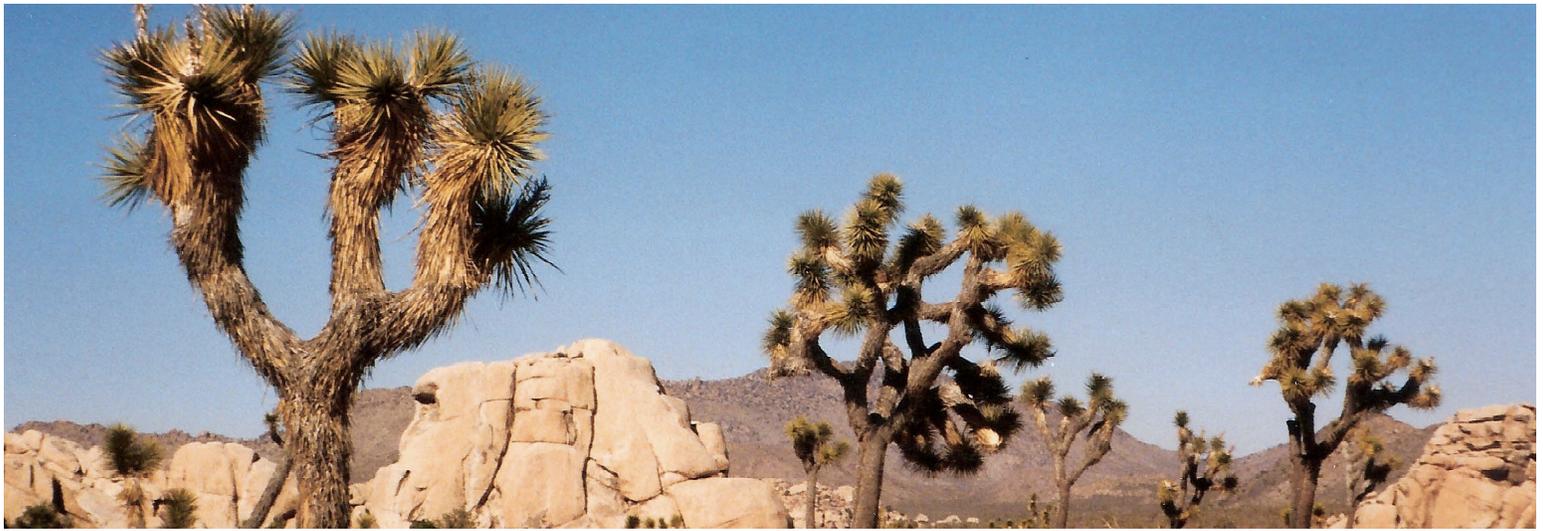


Figure 2. Conceptual approach for collaborative adaptation planning. This approach complements existing programs for acquiring science by effectively engaging partners and incorporating results from monitoring the effectiveness of actions as a routine part of park management.



In a warmer future, the Joshua tree may not be able to survive in much of its current range, including all or major parts of Joshua Tree National Park. Photo by Becky Augustine.

Consultation with indigenous groups and partners is a critical element of any adaptation plan or strategy.

adapt to changing circumstances by migrating, many cultural resources are fixed in place on the landscape. Most cannot be moved except at great cost and by incurring severe damage and loss of integrity. Cultural resources are unique: they do not reproduce; once lost, they are lost forever. As leaders in cultural resource preservation, the NPS must contribute to a larger national effort to aggressively seek short- and long-term solutions to ensure the preservation of cultural resources most at risk to the adverse effects of climate change.

NPS resource adaptation decisions could particularly affect traditionally associated peoples, for whom there is little distinction between natural and cultural resources. Many natural resources—animals, plants, water, and air quality—are considered ethnographically significant resources to many people and play important roles in supporting social, cultural, and economic systems. Therefore, consultation with indigenous groups and partners is a critical element of any adaptation plan or strategy.

**Goal 7**  
*Develop, prioritize, and implement management strategies to preserve climate-sensitive cultural resources.*

**Objective 7.1:** Use the best available science to develop and apply a process to prioritize cultural resource adaptation projects that combine established management tools with newer methods, such as vulnerability assessments.

Management decision-making tools that consider long-term treatment options for archeological sites, historic structures, and other cultural resources to increase resilience and

capacity should be utilized for this end.

**Objective 7.2:** Increase the capacity and utility of the NPS Museum Program to preserve and protect resources.

Museum collections provide unique data for understanding the genetic diversity of populations, past community and ecosystem structure, and past climate variability. Such information provides critical, cost-effective scientific evidence to guide management decisions.

**Objective 7.3:** Strengthen partnerships with traditionally associated peoples through consultation and civic engagement to ensure the preservation of ethnographically significant resources and continued access to these resources.

Federal law, executive orders, and NPS policy recognize certain resources have special significance for traditionally associated peoples, and the NPS response to climate change must include consultation and civic engagement regarding such cultural resources

**Objective 7.4:** Expand NPS capacity to conduct inventory and monitoring of archeological sites in anticipation of climate change impacts and support curation of artifacts and associated documentation.

Archeological data provide insight into climatic changes over the long term as well as the human responses to such alterations. The NPS will work with partners to form strategies to document significant sites before their destruction and make the results available to a broad constituency.



The Kaloko fishpond kuapā (seawall) of Hawai'i is threatened by rising sea levels related to climate change.

## ***Protecting Facilities and Infrastructure***

Adaptation efforts for facilities and infrastructure will focus on (1) incorporating climate change science information into facilities decision processes, (2) enhancing collaborations, (3) inventory and risk assessment, (4) incorporating sustainable design and adaptation actions into new projects and major renovations, (5) taking actions to address park operations that contribute to climate change, and (6) ensuring all projects meet minimum sustainability standards. This will involve changing employee behavior.

### **Goal 8** ***Enhance the sustainable design, construction, and maintenance of park infrastructure.***

**Objective 8.1:** Consider climate change vulnerability assessments and scenarios in decision processes for project approval and funding.

The NPS will evaluate the best use of limited funds as an increasing number of buildings and structures are affected by climate change. For example, some critical structures must be protected, but managers may choose to defer major investments in infrastructure located in areas known to be the most vulnerable to the effects of climate change.

**Objective 8.2:** Collaborate with federal, state, and local partners and programs to identify sustainability and adaptation designs for planning, design, and construction documents.

Efforts will include maintenance of central offices as well as park facilities, concessions, and jointly managed resources. Particular attention will be paid to working with State Historic Preservation Offices, tribes, and preservation

groups to develop technical guidance for increasing efficient, strategic, adaptive reuse or green rehabilitation techniques and materials and promotion of federal and state tax credits.

**Objective 8.3:** Inventory high-risk facilities, assets, infrastructure, and utilities servicewide; determine priorities for protection and adaptation; and implement actions.

Where appropriate and feasible, critical park infrastructure and operations vulnerable to the effects of climate change will be protected or relocated; where inappropriate, NPS will identify and implement alternative actions.

**Objective 8.4:** Incorporate sustainable designs in new construction and substantial restoration or rehabilitation of facilities where feasible.

Examples include decisions on climate-vulnerable locations, design of movable or resilient structures, consideration of non-traditional operating schedules, non-structural alternatives to accommodate visitor and employee use or appreciation of the park, and co-location of facilities with gateway communities and other agencies or partners in more resilient locations.

**Objective 8.5:** Incorporate sustainability and climate change adaptation into the maintenance and operation of existing facilities and programs.

Review and revise all relevant NPS facilities operations, rehabilitation, and maintenance programs, practices and policies to consider increased climate variability and environmental events.

**Objective 8.6:** Revise the Development Advisory Board (DAB) guidelines to require LEED (Leadership in Energy and Environmental Design) certification on all NPS projects.



One way that parks demonstrate their commitment to environmentally sustainable practices is through the use of hybrid vehicles, Great Smoky Mountains National Park, June 2007.

## Mitigation

Park managers and staff can take steps to reduce greenhouse gas emissions generated within park boundaries as well as through NPS activities outside park boundaries.

Most NPS activities, decisions, and planning affect greenhouse gas emissions and storage. Therefore, responding to climate change begins with limiting NPS emissions and incorporating mitigation practices into all aspects of NPS management and operations. Reducing the carbon footprint of NPS operations can often be implemented through low-cost opportunities, such as efficiency and conservation measures that generate high returns on investment. Park managers and staff can take steps to reduce greenhouse gas emissions generated within park boundaries as well as through NPS activities outside park boundaries. The result will be to demonstrate leadership by example to park visitors, partners, and communities.

The NPS can also promote land management that enhances carbon storage and other ecosystem services, provided approaches are scientifically valid (see Goal 4) and remain consistent with NPS policies. The Energy Independence and Security Act of 2007 gave the DOI responsibility to assess the potential for geological (underground) and biological (within soil and vegetation) carbon sequestration to mitigate greenhouse gas emissions. *NPS Management Policies* (2006) require the agency to “preserve naturally evolving ecosystems.” Therefore, management actions that sequester biological carbon on NPS lands must be linked to restoration or enhancement of ecological integrity.

### Goal 9

*Substantially reduce the National Park System’s carbon footprint from 2008 levels by 2016 through aggressive commitment to environmentally preferable operations.*

**Objective 9.1:** Implement a servicewide 2008 baseline inventory of greenhouse gas emissions that accounts for all National Park System activities within the parks and NPS activities outside the parks.

Greening the NPS extends beyond making park operations more sustainable. Central office activities, business travel by NPS staff, and myriad bureau activities that take place in communities across the nation will be inventoried as part of NPS greenhouse gas accounting.

**Objective 9.2:** Develop Climate Friendly Action Plans so that every park, park concession, and administrative office promotes energy and water conservation; supports alternative transportation, infrastructure, programs, and policies; and eliminates waste.

Action plans will guide the NPS to use sustainable facility design and operation, behavior change, new technology, environmentally preferable procurement, recycling, and wastewater recovery and treatment—a whole systems approach—to guide the agency toward a climate-friendly National Park System.



In Glacier National Park ongoing efforts are reducing emissions of park and concessions operations and developing sustainable green practices.

**Objective 9.3:** Participate in the Department of the Interior’s Carbon Footprint Project to develop and implement a unified greenhouse gas emission reduction program.

**Objective 9.4:** Support the development and application of renewable energy and the use of renewable energy technology in a manner consistent with the NPS mission.

Actively engage with neighbors and other stakeholders regarding renewable energy development where there is a potential benefit to NPS conservation. Develop guidance to assist NPS field managers in fulfilling the Secretary of the Interior’s commitment to transform the Nation’s energy system “in a thoughtful and balanced way. . . . that allows us to protect our signature landscapes, natural resources, wildlife and cultural resources” (Salazar 2009).

**Objective 9.5:** Investigate the effectiveness, applications, and verification for using carbon offset programs in NPS operations and visitor recreation.

Carbon neutrality for the NPS cannot occur without offsetting some greenhouse gas emissions. The NPS will support creative and effective greenhouse gas reduction projects in gateway communities and investigate the development of an internal “market” for carbon credits.

**Goal 10**  
*Integrate climate change mitigation into NPS business practices.*

**Objective 10.1:** Identify and evaluate greenhouse gas reduction options in general management plans and other planning and environmental compliance documents and processes.

The greenhouse gas impacts of management alternatives need to be considered and fac-

tored into planning strategies and decision making at all levels. Develop direction for consistent evaluation through the NPS planning and environmental compliance process.

**Objective 10.2:** Mandate integration of greenhouse gas reduction strategies that are consistent with NPS resource stewardship responsibilities into current operational practices.

This will include all new construction, renovations, and the rehabilitation of historic buildings when it can be accomplished in conformance with the Secretary of Interior’s Standards for the Treatment of Historic Properties.

**Objective 10.3:** Integrate greenhouse gas reduction into Environmental Management Systems (EMS), procurement, design and construction contracts, and new commercial services contracts and agreements.

Automating EMS and energy reporting will allow the NPS to streamline reporting, track progress, increase accountability, and make better servicewide decisions for greenhouse gas management in park operations

**Objective 10.4:** Aggressively promote the expanded use of flexible schedule and telecommuting arrangements for NPS employees where it will save energy and improve productivity without compromising public services.

**Goal 11**  
*Promote biological carbon sequestration as a function of healthy ecosystems.*

**Objective 11.1:** Leverage participation in the DOI Carbon Storage Project to evaluate the science, develop policies, provide technical guidance, and promote best management practices for carbon sequestration where it is consistent with NPS policies and mission (see Goals 4 and 6).



The NPS strives to raise public awareness about the implications of climate change for national parks.

## Communication

“There is a great need at this time for messages that communicate the complexities of climate change and the actions that can be taken.”

—Jon Jarvis  
Field hearing  
at Joshua Tree,  
April 7, 2009

Known internationally for excellence in communicating about natural and cultural resources and national park values, to more than 300 million visitors every year, the NPS is uniquely positioned to raise awareness of the effects of climate change on our parks. New information on climate science, ecological and social responses, adaptation planning, management strategies, and associated topics is proliferating rapidly. The volume, technical nature, and diversity of this information requires the NPS to lead a structured and coordinated effort to identify information most relevant to the NPS mission and make it accessible to all NPS employees, volunteers, partners, and gateway communities. To increase awareness, NPS communication professionals will learn effective strategies for conveying accurate climate change information to a wide range of audiences. Agency personnel will facilitate dialogue about possible climate change scenarios, encourage practices that support sustainability, and provide programs and services that enable individuals to achieve solutions.

**Goal 12**  
*Coordinate and distribute climate change information throughout the National Park Service.*

**Objective 12.1:** Provide public access to the climate-related research and expertise of NPS staff and other agencies through a web-based portal and other appropriate communication methods.

**Objective 12.2:** Collaborate with technical experts to produce and distribute summaries of relevant research on climate change and management response strategies.

**Objective 12.3:** Develop capacity to communicate within the NPS about the impacts and significance of climate science and related aspects of natural and cultural resources.

**Goal 13**  
*Increase climate change knowledge and understanding within the National Park Service.*

**Objective 13.1:** Train employees in climate change literacy to enhance leadership and decision making at all agency levels and with partners and the public.

Expand existing climate change education programs such as “Earth to Sky,” a collaboration between NPS interpreters and the scientists of the National Aeronautics and Space Administration (NASA) and develop new seminars and courses to provide information about climate change and its consequences for park management and staff.

**Objective 13.2:** Routinely emphasize and highlight climate change information in internal communications.



NPS ranger interacting with a group of children at Exit Glacier in Kenai Fjords National Park.

**Key NPS messages:**

Climate change is happening and human activities are contributing to and accelerating it.

Changing climate has consequences for parks, people, and the planet.

The NPS is responding with practices that address climate change.

The choices we make now may help to avoid catastrophic impacts in the future.

**Goal 14**

*Provide external communications about the implications of climate change and the National Park Service response*

**Objective 14.1:** Develop key agency messages about climate change and provide guidance on their use.

The complexities of climate change policy, science, and management challenge the ability to identify and communicate clear, consistent, and compelling messages. Messages based on best available science will help parks engage the public and develop media in collaboration with communities, tribes, and other stakeholders in ways that are consistent servicewide.

**Objective 14.2:** Create interpretive products and programs that educate general audiences about the impacts of climate change and climate friendly technologies and practices.

**Objective 14.3:** Create opportunities for teachers and students to learn about climate change in the national parks and how their actions make a difference in the parks and at home.

The NPS will leverage existing programs for science communication such as the Research Learning Centers to engage young people in climate change projects, greenhouse gas inventories, and other park-based communication activities.

**Goal 15**

*Model and communicate sustainable practices that lead by example.*

**Objective 15.1:** Demonstrate how the public can reduce the impacts of climate change in their own lives and in national parks by interpreting NPS sustainable practices including agency operations, facilities, and use of technologies.

Through the Climate Friendly Parks Program an education campaign called “Do Your Part” has been initiated that encourages visitors to reduce their carbon footprint. Best practices can be communicated through this program to encourage action and resource stewardship.

## Legal and Policy Considerations

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Most resource protection laws with which the NPS must comply were not written considering a changing climate. As a result, it is necessary to reestablish servicewide consistency in interpreting the NPS mission and mandates within the context of climate change in order to uphold the mission and comply with all relevant laws and regulations while implementing response actions. Before committing to certain actions, especially with regard to climate change adaptation, several overarching questions must be addressed:

1. How does the NPS reconcile its definition of “natural” (absence of human dominance over the landscape) with the effects on resources resulting from climate changes that are understood to be caused, at least in part, by human activities? How does the NPS comply with mandates and policies for conservation and maintenance of natural conditions?
2. How does the NPS comply with mandates and policies for protection of cultural resources as climate change threatens the integrity and even existence of some resources?
3. How does the NPS respond in cases where climate change results in the loss of resources specifically listed in a park’s enabling legislation? Should the NPS change a park’s purpose as a result?
4. How does the NPS comply with the “no impairment” mandate when the geographic range and even existence of resources is threatened by climate change?
5. How will the NPS comply with laws and regulations that do not take into account climate change?
6. Under what circumstances is active manipulation/intervention (e.g., assisted migration or colonization) desirable or warranted to save a species?

7. How can managers design ecosystem restoration treatments in consideration of climate change?

8. What strategies (e.g., develop or purchase renewable energy, utilize carbon credits, receive carbon offset investments) and carbon-accounting methods can and should the NPS use to reduce its carbon footprint and/or achieve carbon neutrality in the future?

Present NPS management policies are probably sufficient to guide many potential climate change response actions, provided the best available science is used, decisions are transparent and carefully documented, and comply with all applicable legal requirements. As the number and variety of climate change response actions rises, however, increased importance will be placed on working within a legal and policy framework that ensures the legality, consistency, and appropriateness of management decisions in this context.

Continued development of strategic, adaptive, and collaborative climate change responses to support the NPS mission remains a priority. Actions will promote strong cooperation and global leadership, and build on collective knowledge to create innovative solutions to protect resources and provide for the enjoyment of America’s national parks during this unprecedented global challenge. The NPS is committed now, more than ever, to protecting the Nation’s irreplaceable natural and cultural resources by providing leadership to reduce consumption of resources and provide outstanding educational examples as it approaches its centennial anniversary of successful stewardship in 2016.

Alternative fuel shuttle buses at Glacier National Park provide alternative transportation to park visitors and reduce traffic.



This *National Park Service Climate Change Response Strategy* articulates an ambitious plan to address the consequences of climate change for the National Park System through objectives based on science, mitigation, adaptation, and communication.

## Conclusion and Next Steps

Stewardship takes on special significance within the National Park Service. Preserving and enhancing natural and cultural resources and maintaining and improving park facilities involves caring for a legacy—an inheritance that inspires people today and will stir the imaginations of future generations.

Strategic planning to address the effects of climate change requires careful consideration of how environmental factors affect long-term goals, objectives, and actions. This *National Park Service Climate Change Response Strategy* articulates an ambitious plan to address the consequences of climate change for the National Park System through objectives based on science, mitigation, adaptation, and communication. Advanced outcomes and general

objectives are included that describe specific results and rationales defined by the National Park Service. This approach will be complemented by an additional implementation plan, developed over the following 18 months, that describes how the NPS will meet these goals through a collaborative and coordinated set of actions.

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# Glossary

**Adaptation:** Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation:

**Anticipatory adaptation:** Adaptation that takes place before impacts of climate change are observed. Also referred to as proactive adaptation.

**Autonomous adaptation:** Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. Also referred to as spontaneous adaptation.

**Planned adaptation:** Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state. (IPCC 2007:869)

**Adaptive management:** A process that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. It also recognizes the importance of natural variability in contributing to ecological resilience and productivity. (CCSP 2008:1)

**Carbon footprint:** A carbon footprint is the total set of greenhouse gases (GHG) emissions caused by an organization, event or product. (UK Carbon Trust 2010)

**Carbon sequestration:** The uptake and storage of carbon. Trees and plants, for example, absorb carbon dioxide, release the oxygen and store the carbon. Fossil fuels were at one time biomass and continue to store the carbon until burned. (EPA 2010)

**Cascading effects:** refer to a series of indirect effects triggered by an event or change. For example, warming temperatures have a direct effect on precipitation and soil moisture, which can in turn have cascading effects on many aspects of ecosystems, including wildfire, invasive species, and animal migration.

**Climate change:** Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), which defines ‘climate change’ as: ‘a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. (IPCC 2007:871).

**Climate friendly action plan:** A description of the actions—policies, programs, and measures—the park will take to reduce its greenhouse gas emissions. (NPS Climate Friendly Parks Program 2010)

**Climate Friendly Parks Program:** The Climate Friendly Parks program provides parks with the tools and resources to address climate change. The program aims to provide national parks with comprehensive support to address climate change both within park boundaries and the surrounding community. (Climate Friendly Parks Program 2010)

**Climate Model:** A quantitative way of representing the interactions of the atmosphere, oceans, land surface, and ice. Models can range from relatively simple to quite comprehensive. (EPA 2010)

**Decision Support:** Organized efforts to produce, disseminate, and facilitate the use of data and information in order to improve the quality and efficacy of climate-related decisions. (NRC 2009:S-1)

**Ecosystem services:** Ecological processes or functions having monetary or non-monetary value to individuals or society at large. There are (i) supporting services such as productivity or biodiversity maintenance, (ii) provisioning services such as food, fibre, or fish, (iii) regulating services such as climate regulation or carbon sequestration, and (iv) cultural services such as tourism or spiritual and aesthetic appreciation. (IPCC 2007:874)

**Greenhouse gas:** Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth’s surface, the atmosphere, and clouds. This property causes the greenhouse effect. Water vapour (H<sub>2</sub>O), carbon dioxide (CO<sub>2</sub>), nitrous oxide (N<sub>2</sub>O), methane (CH<sub>4</sub>)

and ozone (O<sub>3</sub>) are the primary greenhouse gases in the Earth's atmosphere. As well as CO<sub>2</sub>, N<sub>2</sub>O, and CH<sub>4</sub>, the Kyoto Protocol deals with the greenhouse gases sulphur hexafluoride (SF<sub>6</sub>), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs). (IPCC 2007:875)

**Intergovernmental Panel on Climate Change:**

The IPCC is the leading body for the assessment of climate change, established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO). It is a scientific body that reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to climate change. It is an intergovernmental body and thousands of scientists from all over the world contribute to the work of the IPCC on a voluntary basis. By participating in the review process and endorsing the IPCC reports, governments acknowledge the authority of their scientific content. (IPCC Organization 2010)

**Landscape Conservation Cooperatives:**

Landscape Conservation Cooperatives are management-science partnerships that inform integrated resource management actions addressing climate change and other stressors within and across landscapes. (USFWS 2010)

**Mitigation:** An anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks. (IPCC 2007:878)

**Refugia:** Physical environments that are less affected by climate change than other areas (e.g., due to local currents, geographic location, etc.) and are thus a "refuge" from climate change for organisms. (SAP 4.4)

**Resilience:** The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change. (IPCC 2007:880)

**Scenario:** A plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Scenarios may be derived from projections, but are often based on additional information from other sources, sometimes combined with a 'narrative storyline'. (IPCC 2007:881)

**Scenario Planning:** Scenario planning is a vehicle for taking an imaginative look into the future by creating stories about several equally plausible futures. The purpose of scenario planning "is to make strategic decisions that will be sound for all plausible futures." Scenarios are not predictions and the end result is not an accurate picture of tomorrow – but they can result in better decisions for the future. (Schwartz 1996:xiv)

**Stewardship science:** Stewardship science is place-based, mission-driven, disciplinary, multi- and interdisciplinary, often at landscape and ecosystem scale, and increasingly focused on coupled natural/human systems that include cultural and natural resources and that extend beyond individual park boundaries. (Machlis 2010)

**Vulnerability:** Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. (IPCC 2007:883)

For additional information, please contact the NPS Climate Change Response Program Office  
[climate\\_change@nps.gov](mailto:climate_change@nps.gov) or visit the website at [www.nps.gov/climatechange](http://www.nps.gov/climatechange).

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