

**DEPARTMENT OF THE INTERIOR
TASK FORCE ON CLIMATE CHANGE**

**REPORT OF THE SUBCOMMITTEE
ON LAND AND WATER MANAGEMENT**

**An Analysis of Climate Change Impacts and Options Relevant to the
Department of the Interior's Managed Lands and Waters**

Table of Contents

PREFACE.....	4
EXECUTIVE SUMMARY	6
INTRODUCTION	14
The Subcommittee’s Purpose	14
The Subcommittee’s Approach.....	15
Short Primer on Climate Change	15
Definitions Used in this Report.....	16
Subcommittee Organization.....	17
Guide to the Subcommittee’s Report.....	18
Criteria for Analysis.....	18
Institutional Approaches and DOI-Wide Options.....	20
ADAPTATION ISSUES AND OPTIONS	24
Common Themes and DOI-Wide Options	24
Issues and Options	35
Water Availability.....	35
Water Quality.....	44
Increased Flood Risk.....	48
Coastal Impacts Associated with Sea-Level Rise.....	52
Melting Permafrost and Sea Ice.....	60
Impacts on Native Peoples.....	63
Outbreaks of Pests, Invasive Species, and Diseases	74
Species Migration and Habitat Change.....	81
Threatened and Endangered Species	86
Wildland Fires.....	91
MITIGATION OPPORTUNITES AND OPTIONS	95
Opportunities and Options	95
Terrestrial Carbon Sequestration	95
Geologic Carbon Sequestration under Federal Lands	101
Development of Renewable Energy on DOI Lands	103
Fleet Management.....	108
Facility Operations.....	111
Education and Outreach.....	116
APPENDIX A: SUBCOMMITTEE CONTRIBUTORS.....	120
APPENDIX B: OPTIONS SUMMARY TABLE.....	129
APPENDIX C: ACRONYMS AND ABBREVIATIONS	150

Options Tables

Table 1-A: DOI-Wide Options	34
Table 2-A: Water Availability Options.....	39
Table 3-A: Water Quality Options.....	46
Table 4-A: Increased Flood Risk Options	50
Table 5-A: Coastal Impacts Associated with Sea-Level Rise Options.....	55
Table 6-A: Melting Permafrost and Sea Ice Options.....	62
Table 7-A: Impacts on Native Peoples, Contiguous 48 States, Options.....	66
Table 8-A: Impacts on Native Peoples, Alaska, Options.....	70
Table 9-A: Impacts on Native Peoples, United States (50 States and Insular Territories), Options.....	73
Table 10-A: Outbreaks of Pests, Invasive Species, and Diseases Options	77
Table 11-A: Species Migration and Habitat Change Options	83
Table 12-A: Threatened and Endangered Species Options	88
Table 13-A: Wildland Fires Options.....	93
Table 14-M: Terrestrial Carbon Sequestration Options.....	98
Table 15-M: Geologic Carbon Sequestration under Federal Lands Options.....	102
Table 16-M: Development of Renewable Energy on DOI Lands Options.....	107
Table 17-M: Fleet Management Options.....	110
Table 18-M: Facility Operations Options	114
Table 19-M: Education and Outreach Options	118

PREFACE

Last year, Secretary of the Interior Dirk Kempthorne established the DOI Climate Change Task Force, chaired by Deputy Secretary Lynn Scarlett. It was composed of a Steering Committee and three subcommittees. The Assistant Secretaries, Bureau and Service Directors, the Special Advisor for Alaska, and the Solicitor were members of the Steering Committee. The three subcommittees were made up of land managers, biologists, economists, climatologists, lawyers, policy analysts, and many others (approximately 100 employees in all). The tasks of the subcommittees were identified as follows:

- (1) The Land & Water Management Subcommittee was to identify issues and challenges that may be facing the Department of the Interior (DOI) as a consequence of predicted climate change and to suggest possible options for addressing them.
- (2) The Law & Policy Subcommittee to identify the legal and policy issues facing DOI and to suggest possible options for addressing them.
- (3) The Science Subcommittee to identify the science and information needed to assist DOI in addressing potential consequences of climate change and to suggest possible options for developing, coordinating, acquiring, and analyzing any additional scientific information that would be helpful for that purpose.

The objective was for the Task Force to canvas the existing information and expertise within the Department and suggest options for the Secretary to consider in ongoing management of the Department. By the nature of the process, these draft reports do not contain budget proposals, set priorities or policies, nor provide legal advice. Any such subsequent activities would be undertaken pursuant to Secretarial direction and be subject to the regular policy procedures, budgetary proposals, solicitor reviews, interagency coordination, and administration priorities. The three Draft DOI Climate Change Task Force subcommittee reports provide an organized means to collect views within the agency and highlight a series of questions and potential options for addressing them.

As drafted, the reports do not represent either Administration or Departmental positions on the issues discussed. But it is hoped that they will begin an informed process for the coordinated consideration of various climate change issues facing the Department and how to address them.

These reports are the product of brainstorming sessions presented in a fashion to organize the material while maintaining the dynamics of subcommittee participation. As such, the drafts do not attempt to prioritize the information presented either by the order of presentation or the length of the discussion associated with any particular issue, option, or grouping of information.

While it would have been consistent with standard operating protocols for the drafts to go to the Secretary without external consideration, it was felt that the Secretary and the decision-making process would be best served if the broader public had an opportunity to consider this information and have an opportunity to weigh in on the issues. Although the Department uses various processes to involve the public, such as public comment on regulations, Advance Notice of Proposed Rulemaking, and agency scoping meetings, the posting of these documents on the web does not fall into any of these or other existing categories. This is an informal process to provide knowledgeable members of the public an opportunity to provide additional insights into a subject of general concern.

The subject of climate change is being addressed in a wide variety of venues throughout the federal government. These reports are written in the context of that environment and with an acknowledgement that all comments in the reports are made with a strong realization that many efforts discussed therein are related both to activities already conducted by DOI and to actions being taken by other agencies.

For instance, fire management has long been a major focus for DOI in the western states. If future climate change is associated with extending or intensifying the fire season, the issues raised in these reports are an attempt to anticipate trends and adjust our readiness to respond to those threats. Options in the reports on such matters do not constitute new programs; they offer options for possible adjustments and improvements in existing programs to meet new conditions.

Likewise, although carbon sequestration is of major interest to DOI, and the reports highlight important options the Secretary may want to pursue, such programs also relate to the missions of the Department of Energy, the Environmental Protection Agency, the Forest Service, and the Department of Commerce. All options proposed in the DOI reports are in the context of coordination with the responsibilities of each of those agencies, where appropriate, and a desire to maximize the efficiency with which the government addresses the emerging issues.

Finally, the effort to address climate change is being organized and managed through various Administration organizations, including the Climate Change Science Program, the Council on Environmental Quality, and the National Economic Council. Congress is also placing an increasing focus on the issue with new committees, hearings, and legislation. The options presented in the draft subcommittee reports range from those which DOI can implement directly to those requiring Administration action or Congressional enactment. Some options would require coordination and leadership from state, local and private initiatives. Consequently, the reports discuss issues and propose options that are important to the Department but which may require many other stakeholders for effective implementation. The hope is that, by raising these issues and potential options in a timely manner, better solutions will be adopted.

EXECUTIVE SUMMARY

The Department of the Interior's (DOI) mission lies at the confluence of people, land, and water. The possible landscape changes resulting from a changing climate may directly affect how DOI fulfills its mission. DOI manages 1 in every 5 acres of the U.S. land mass. DOI operates dams and irrigation facilities that provide water to farmers who generate nearly two-thirds of the Nation's produce. DOI manages leases from which one-third of the Nation's domestic energy supplies are produced. DOI manages lands and waters that contribute significantly to alternative energies, such as wind, solar, geothermal, and biomass. DOI has a significant presence along the coast and manages extensive areas of shoreline. DOI lands are home to a wide array of the Nation's wildlife, many of which are rare, threatened, or endangered. Many of the nation's cultural and historical sites are under the jurisdiction of DOI. Further, DOI is greatly involved in the management of millions of acres of land and resources held in trust for American Indians.

Perhaps no subject relevant to managers of public lands and waters is as complex and multifaceted as climate change. According to the "Fourth Assessment Report" of the Intergovernmental Panel on Climate Change (IPCC), climate change manifests itself primarily as increased temperature, changes in precipitation patterns, and sea-level rise. A changing climate is expected to affect precipitation patterns, vegetation types and distribution, wildlife habitat and behavior, fire frequency, sea levels, and disease trajectories, as well as a broad range of human activities.

Climate change impacts will vary due to the different nature of the ecosystems on DOI-managed lands. Anthropogenic stressors—such as chemical pollution, overfishing, land-use changes, habitat fragmentation, population growth, and elevated ultraviolet radiation—are likely to interact synergistically and sometimes unpredictably with climate change, and together are likely to affect various DOI lands in different ways.

This report provides a description of 10 adaptation issues (Water Availability, Water Quality, Increased Flood Risk, Coastal Impacts Associated with Sea-level Rise, Melting Permafrost and Sea Ice, Impacts on Native Peoples, Outbreaks of Pests, Invasive Species, and Diseases, Species Migration and Habitat Change, Threatened and Endangered Species, Wildland Fires) and 6 mitigation opportunities (Terrestrial Carbon Sequestration, Geological Carbon Sequestration under Federal Lands, Development of Renewable Energy on DOI Lands, Fleet Management, Facility Operations, Education and Outreach), a listing of some of the climate-induced effects, and an explanation of why the issue or opportunity is important to DOI. The descriptions of the issues are followed by options the Secretary may choose to consider to address each issue or opportunity. The options identify direct benefits and other analyses that the Subcommittee was able to complete within the timeframe given for this work. For each issue, a corresponding table shows the analyzed criteria for the options presented.

For this report, the following unranked criteria to analyze potential options were used:

- A. Scale. What is the scale of the option and its impact?
- B. Feasibility. Is the option under DOI control? Does DOI have a unique capacity to implement the option? Does acting on the option make a near-term difference? What is the time-scale for implementation? Does the technology currently exist to successfully implement the option?
- C. Direct & Ancillary Benefits. What are the benefits? Are there multiple benefits or co-benefits?
- D. Partnerships. Who are stakeholders? Is there a potential for partnerships?
- E. Demonstration effect. What are the opportunities for DOI to lead by example?
- F. Human dimension. What are the effects on human communities that depend on climate-affected DOI lands and resources?
- G. Cost estimates. What are the quantitative, if available, and qualitative costs?
- H. Legal Mandates. Are there statutes mandating these actions or making them illegal?

INSTITUTIONAL APPROACHES

The issue of managing for climate change is firmly on DOI's agenda. Most subgroups noted that the options set forth in this report to manage for climate change require that institutions and processes also be put in place that enable DOI to share updates and progress, to take appropriate and coordinated action, and to measure the results.

Climate change is a complex subject, encompassing a huge and varied body of scientific, social, economic, and political information. Implementing management tools to mitigate and adapt to climate change is a vast undertaking that will require sustained action and vision for decades to come.

- Establish a political-level Climate Change Coordination Council (like the Energy Coordination Council) that meets regularly to assure consideration of climate change issues at the highest levels of DOI.
- Establish a DOI headquarters-level office to support this council, to develop Departmental-level climate change policy, and to coordinate bureau activities related to climate change, as appropriate.
- Promote the establishment of an interagency-level Climate Change Land and Water Management Program akin to the interagency Climate Change Science Program. Members would meet regularly to assure consistent land- and water-use policy and

actions related to climate change on all Federal lands (e.g., DOI, U.S. Forest Service, or Department of Defense lands).

- Publish an Annual Report on DOI's management for climate change. This report would present scientific findings on climate change impacts on DOI lands and adaptation and mitigation measures; identify goals and objectives; and report on progress on the policies, regulatory actions, and adaptive management activities. DOI, with its vast land holdings and resources, is positioned to be a leader in managing climate change. This report could be used to record our actions so others can follow. The above office could be made responsible for this report.
- Hold a kickoff public conference, "Managing Lands and Waters for Climate Change," where scientists, land managers, private land owners, native peoples, and State and local policymakers can gather to obtain information, guidance, and feedback, and develop implementation plans that include adaptive management techniques. This meeting is paramount for DOI managers and others to begin developing strategies for climate change. Its success would highlight DOI's comprehensive analysis and jumpstart measures to deal with climate change. It could be organized around the issues and opportunities identified in the three task force subcommittee reports.
- Consider developing a unified climate change budget to demonstrate the extent of DOI resources and commitment to addressing the effects of climate change.

OPTIONS WITH DOI-WIDE APPLICATIONS

In addition to the issue-specific options presented in Appendix B, this section contains options at a broader level. These options appeared repeatedly throughout the subcommittee's efforts, appearing either in the written working group products or in the working papers, meeting notes, and personal discussions of the subcommittee members.

Option: Develop an Addendum to the *DOI Adaptive Management Technical Guide* that Focuses on Managing for Climate Change. Adaptive management provides a sound framework for decision making in the face of climate change.

Option: Issue a Secretarial Order that all future DOI resource management decisions (including operations and management plans at DOI lands) include considerations of, and adaptations for, expected changes in precipitation, temperature, and sea level. The order would state that, in many cases, historic conditions are no longer necessarily adequate for making future land management decisions.

Option: Define key DOI agency terms in the context of changing climate. Review, and where necessary, clarify guidance for agency land and resource managers, such as those concerning the conservation and restoration of "natural" ecosystems, fire regimes, or diversity; the minimization of "impairment" of natural systems; or the conservation of "unimpaired" select scenery, natural and historic objects, and wildlife. Clarification of

these concepts should involve DOI land managers, legal staff, partners, and stakeholders at the national level.

Option: Streamline the process and provide additional resources for acquiring local and regional data, decision support tools, and models. A new framework and process should be developed for resource managers to identify and acquire support for local- and regional-scale ecological research, data collection, and modeling.

Option: Develop a DOI-wide climate change training curriculum. A DOI-wide training curriculum could be developed to discuss the science of climate change, the anticipated effects as enumerated by the IPCC report (and others), and DOI's response, including both adaptation and mitigation responses.

Option: Develop a DOI Climate Adaptation Partners (ICAP) Program that provides guidance and possible financial incentives for developing cross-jurisdictional, public/private partnerships that contribute to the conservation of species, natural communities, and lands and waters placed at risk by changing climate conditions.

Option: Using existing bureau personnel, create two DOI Emergency Response All-Hazards Teams and two Associated Natural/Cultural Response Teams to respond to disasters induced by climate change. These teams would help DOI to be adequately prepared to deal with the future impacts of climate change such as the frequency or intensity of storms, floods, droughts, wildland fires, and other disruptive events near many DOI facilities.

ADAPTATION ISSUES AND MITIGATION OPPORTUNITIES

The following 10 adaptation issues represent the issues that the Subcommittee believes need to be addressed due to the effects of climate change. All adaptation options and mitigation opportunities can be found in Appendix B.

Water Availability

The availability of water is critical for many purposes, including water supply for native peoples, towns, cities, and DOI facilities; ecological health of riparian and aquatic habitat; irrigation; wildlife and livestock survival; and hydropower production. Climate change has the potential to decrease supply and increase demand, creating new water scarcity problems and exacerbating existing ones.

Water Quality

Water quality in reservoirs, lakes, and rivers will likely change as atmospheric heat is transferred to these bodies of water. Higher water temperature, by itself, can affect habitat suitability and the chemical properties of water. In addition, decreases in the volume of water, whether due to reduced precipitation or increased evapotranspiration, can increase the concentration of dissolved solids and chemical contaminants in rivers and lakes. Any increase in high-intensity storms may also wash from the land and transport more contaminants to bodies of water or cause more treatment plants to overflow.

Increased Flood Risk

More intense rain storms, earlier melting of seasonal snowpack, and more events of rain or snow are expected consequences of climate change and may create more frequent and severe flooding associated with lakes and rivers. Similarly, glacial outburst floods (sudden releases of water stored within or at the base of glaciers) may also occur more often. Floods can adversely affect local populations of plant and animal species, especially threatened or endangered species that may be concentrated in a particular area. In addition, cultural and historical sites located in the path of floods will clearly be greatly affected.

Coastal Impacts Associated with Sea-level Rise

Expected sea-level rise, combined with storm surge effects, will have a profound effect on DOI coastal systems, with the most dramatic effects being wetland loss, loss in the productivity of our estuaries, changes in our barrier islands, loss of coastal cultural and historical sites, and increased vulnerability to coastal erosion and flooding. The possible increase in the intensity of coastal storms would increase this vulnerability along the Gulf, Arctic, and South Atlantic coastal margins. Independently or combined, sea-level rise and more intense storms foreshadow extensive changes.

Melting Permafrost and Sea Ice

The melting of the cryosphere—the frozen part of the Earth’s surface, including polar ice caps, mountain glaciers, sea ice, snow cover, lake and river ice, and permafrost—from climate change poses serious threats to human and natural communities and infrastructure located in or near these areas. Moreover, potential impacts on resource development activities could have significant adverse impacts not only on local economies but also on the U.S. economy as a whole.

Impacts on Native Peoples

Many American Indian and Alaska Native groups are highly vulnerable to the effects of climate change. The Secretary of the Interior exercises fiduciary responsibility for the lands and resources of Indian country and supports American Indians through funding of programs in such areas as education, housing, and law enforcement. The Secretary is also a partner with tribes and Alaska Native corporations in land management. For these reasons, the potential effects of climate change on American Indians and Alaska Natives are highly relevant to DOI’s strategic mission areas of resource management, resource use, recreation, and serving communities.

In addition to responsibilities in the contiguous 48 states and Alaska, DOI bureaus manage lands and resources on the State of Hawaii and on other Pacific and Caribbean islands. The Secretary has certain administrative responsibilities regarding these U.S. insular territories. Climate change is likely to significantly affect these locations. Such effects are also relevant to DOI’s mission.

Outbreaks of Pests, Invasive Species, and Diseases

Climate changes may contribute to pest outbreaks and increases in invasive species populations, potentially simplifying or homogenizing ecosystems. Climate change may also lead to increases in endemic and exotic diseases among plant and animal species on DOI lands.

Species Migration and Habitat Change

Climate change causes species and natural communities to shift in latitude and/or elevation (primarily northward or upward) across the landscape, perhaps away from DOI-managed lands. Plants and animals only reproduce, grow, and survive within specific ranges of climate and environmental conditions. Predicted climate changes will make the current ranges inhospitable for many resident species on DOI lands. Following suitable habitat conditions, these species will generally attempt to migrate northward or upward.

Threatened and Endangered Species

The loss of habitat resulting from climate change may increase the number of species classified as threatened or endangered as well as the potential for extinction of species already designated as threatened or endangered.

Wildland Fires

As temperatures rise, the duration, frequency, intensity, and extent of wildland fires increase. Conditions contributing to the incidence of wildland fires, such as prolonged droughts and shifts of fire-prone invasive species into new areas, are expected to increase as a result of climate change.

Examples of issue-specific adaptation options include:

- Re-evaluating reservoir operating strategies
- Updating drought plans for DOI lands
- Updating flood frequency estimates and flood plain maps
- Developing an interagency agreement with the Army Corp of Engineers regarding coastal restoration
- Modifying legal instruments to reflect effects of melting permafrost and sea ice
- Creating a geospatial local knowledge database in the Arctic
- Developing predictive models of climate change effects on invasive and other species responses
- Identifying and highlighting species migration case studies
- Accelerating and enhancing the Hazardous Fuel Reduction Program
- Improving smoke management practices

MITIGATION OPPORTUNITIES

Terrestrial Carbon Sequestration

Terrestrial carbon sequestration is the process through which carbon dioxide (CO₂) from the atmosphere is absorbed by trees, plants, and crops through photosynthesis and stored

as carbon in biomass (i.e., tree trunks, branches, foliage, and roots) and soils.¹ Enhancing the natural processes that remove CO₂ from the atmosphere is thought to be one of the most cost-effective means of reducing atmospheric levels of CO₂, and deforestation abatement and forestation efforts are already under way.

DOI is poised to play a key role in reducing the amount of CO₂ in our atmosphere through terrestrial carbon sequestration. There is an opportunity to reduce DOI's carbon footprint through specific mitigation actions, such as minimizing or offsetting residual carbon emissions through a comprehensive terrestrial carbon sequestration program, and to partner with outside entities to reduce their carbon output while restoring high-priority wildlife habitat across the country.

Geologic Carbon Sequestration under Federal Lands

Geologic carbon sequestration is the isolation and/or removal of CO₂ from industrial processes and its long-term storage underground to reduce or prevent increasing levels of CO₂ in the atmosphere. There is potential for significant emission reductions in the United States if this can be implemented on a large, commercial scale. The Department of Energy continues to conduct research and develop technologies to support carbon sequestration.

DOI owns or has a material interest in over 500 million acres of land in the United States. Beneath these Federal lands there is the potential to geologically sequester CO₂ in oil and gas reservoirs, deep saline reservoirs, and unmineable coal seams.

Development of Renewable Energy on DOI Lands

Renewable energy directly offsets fossil fuel-based energy. Some of DOI's lands could provide renewable energy opportunities. Some of these lands fall within the urban interface or are within close proximity to highly dense populations. Some DOI-managed lands also have renewable resources, such as geothermal resources, on them. By providing access for renewable energy development, the DOI could play a major role in increasing the use of these climate-friendly renewable energy sources.

The use of renewable energy and its required developmental impacts create much lower amounts of greenhouse gas emissions than use of traditional fossil fuels. Increasing the use of renewable energy can significantly reduce greenhouse gas emissions.

DOI's Renewable Energy Program portfolio is built around geothermal, wind, solar, tidal, hydropower, and biomass resources. Some of the biomass resources on these lands would offset the need to import equivalent amounts of energy from foreign sources.

Fleet Management

Motor vehicle emissions from DOI's vehicle fleet contribute to greenhouse gas emissions. Reducing the number of vehicles in the fleet, acquiring more fuel efficient

¹ From U.S. EPA Web site <http://www.epa.gov/sequestration.html>

vehicles, improving vehicle efficiency, and using alternative fuels could significantly reduce these emissions.

Facility Operations

Because facility operations contribute to CO₂ emissions primarily through the consumption of energy produced by the combustion of fossil fuels, improving the efficiency of DOI facilities will reduce the associated emissions.

The effects of climate change, such as warmer temperatures and extended visitor seasons, will increase the consumption of fossil fuels to cool and operate DOI facilities. Facility CO₂ emissions can be reduced by energy conservation and incorporating green building practices.

Education and Outreach

Climate change and the impacts of greenhouse gas emissions are complex issues. DOI could work to educate its many visitors and employees on both the impacts of climate change and the actions they can take to reduce their greenhouse gas emissions.

Examples of mitigation opportunity options include:

- Developing terrestrial carbon sequestration policy
- Inventorying geologic sequestration opportunities on DOI lands
- Coordinating renewable energy policy across DOI bureaus
- Expediting acquisition of alternative and high fuel efficiency vehicles
- Expanding DOI alternative fuel infrastructure
- Expediting use of energy efficient technologies
- Expanding the use of renewable energy in DOI facilities
- Developing a climate change outreach program for visitors
- Explore use of Energy Savings Performance Contracts

DOI has a unique opportunity to educate visitors and showcase the effects of climate change. Helping others to understand the issues and benefits/costs of addressing greenhouse gas emissions would have far-reaching impacts on climate change.

INTRODUCTION

THE SUBCOMMITTEE'S PURPOSE

The Department of the Interior's (DOI) mission lies at the confluence of people, land, and water. The possible landscape changes resulting from a changing climate may directly affect how DOI fulfills its mission. DOI manages 1 in every 5 acres of the U.S. land mass. DOI operates dams and irrigation facilities that provide water to farmers who generate nearly two-thirds of the Nation's produce. DOI manages leases from which one-third of the Nation's domestic energy supplies are produced. DOI manages lands and waters that contribute significantly to alternative energies, such as wind, solar, geothermal, and biomass. DOI has a significant presence along the coast and manages extensive areas of shoreline. DOI lands are home to a wide array of the Nation's wildlife, many of which are rare, threatened, or endangered. DOI is also greatly involved in the management of land and resources held in trust for American Indians.

Perhaps no subject relevant to managers of public lands and waters is as complex and multifaceted as climate change. A changing climate is expected to affect precipitation patterns, vegetation types and distribution, wildlife habitat and behavior, fire frequency, sea levels, and disease trajectories, as well as a broad range of human activities.

The Subcommittee on Land and Water Management is one of three subcommittees that make up the DOI Climate Change Task Force. DOI Deputy Secretary Lynn Scarlett described the subcommittee's purpose on April 26, 2007, before the House Appropriations Subcommittee on Interior, Environment, and Related Agencies. She testified:

The second subcommittee focuses on land and water management. We will be cataloguing the types of impacts relevant to Interior managed lands and waters. The subcommittee will evaluate current and prospective options for addressing the effects of climate change. They will also examine our role in carbon sequestration. Finally, they will evaluate the management of Interior's facilities and fleet to identify opportunities for energy conservation and a broadening of the mix of energy resources we use.

A DOI press release on May 31, 2007, also described the Climate Change Task Force and identified many activities that this subcommittee would undertake:

The task force is examining how possible climate changes would affect disaster management, water resource management and habitat management and devising new management responses for changing landscapes.

For example, many parks, refuges and other conservation areas were created to preserve a specific mix of species within specific boundaries. Is *in situ* conservation possible within current, fixed boundaries, if species composition is changing or does DOI need additional conservation strategies? Will DOI need to

adopt a new definition of invasive species if the ranges of plant and animal species shift on the landscape in response to climate change?

DOI's presence along the coast is significant, with extensive areas of shoreline managed by parks and refuges. The task force will cover what steps should be taken as freshwater coastal habitats turn more saline if ocean levels rise. For example, how can DOI help the Nation manage its water resources if rainfall patterns change and which streams produce the water that our cities and farms rely on for drinking water and irrigation?

The task force subcommittees will report their initial priorities and activities to the steering committee by mid-June. These priorities will provide the basis for a longer-term action plan.

This report follows the initial listing of priorities and activities that was provided to the Steering Committee in June and is the initial contribution of the Subcommittee on Land and Water Management to this longer-term action plan. Based on the above guidance, the Subcommittee saw its charge as responding to the following two overarching questions:

- What actions, practices, and adaptations should DOI consider as the effects of climate change unfold?
- What role does or should DOI have in mitigating (reducing) greenhouse gas emissions?

THE SUBCOMMITTEE'S APPROACH

Short Primer on Climate Change

According to the "Fourth Assessment Report" of the Intergovernmental Panel on Climate Change (IPCC), climate change manifests itself primarily as increased temperature, changes in precipitation patterns, and sea-level rise. Further, although some of the warming effects may be caused by other factors, most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic (human-caused) greenhouse gas concentrations, including those from carbon dioxide (CO₂), methane, nitrous oxide, perfluorocarbons, hydrofluorocarbons, and sulfur hexafluoride. For the next two decades, an average warming of about 0.2°C (.36°F) per decade is projected. By the end of this century, the best estimate for average warming ranges from 1.8 to 4°C (3.24 to 7.2°F). By the end of this century, sea level is expected to rise 0.19 to 0.59 meters (7 to 23 inches). In North America, rainfall is expected to increase in the East and North, but decrease across most of the Southwest. Finally, even if greenhouse gas concentrations were to stabilize, anthropogenic warming and sea-level rise would continue for centuries due to time scales associated with climate processes.

Climate change may manifest itself in other ways that could impact DOI lands and resources. These could include the following:

- changes in storm frequency and intensity;
- altered runoff due to changes in the hydrologic cycle resulting in more extreme streamflows, longer periods of high and low flows, changes in flow volumes, and seasonal shift in streamflows (changes in the timing of spring snowmelt and a shift from snow events to rain events);
- increased marine and inland water temperature affecting corals, lowering dissolved oxygen levels due to harmful algal blooms, and reducing salmon survival, among other issues;
- increased number of invasive and exotic species;
- enhanced dust storm events; and
- increased number and intensity of fires.

Climate change impacts will vary due to the different natures of the ecosystems on DOI-managed lands. Anthropogenic stressors—such as chemical pollution, overfishing, land-use changes, habitat fragmentation, population growth, and elevated ultraviolet radiation—are likely to interact synergistically and sometimes unpredictably with climate change, and together are likely to affect various DOI lands in different ways.

Definitions Used in this Report

In this report, the Subcommittee has used the following definitions:

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.”²

Mitigation (of greenhouse gases): “an anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce sources and emissions and enhancing greenhouse gas sinks.”³

DOI lands: all lands, waters, and facilities managed by the Bureau of Land Management (BLM), Bureau of Indian Affairs (BIA), Bureau of Reclamation (BOR), U.S. Fish and Wildlife Service (FWS), and National Park Service (NPS); and the Federal government’s offshore mineral estate managed by the Minerals Management Service.

Several DOI bureaus also significantly influence resource use and protection on non-DOI lands. For example, the Office of Surface Mining Reclamation and Enforcement (OSM) in partnership with States and tribes, regulates the environmental effects of coal mining on all lands nationwide and supports restoration of land and water degraded by past coal

² Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007: Impacts, Adaptation and Vulnerability—Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. M.L. Parry *et al.*, Eds., Cambridge University Press, Cambridge. 2007. p. 869.

³ *Ibid.* p. 871.

mining. Further, the Endangered Species Act also gives the FWS substantial influence over activities on private lands where a threatened or endangered species may reside. Much of this report is also pertinent to the lands and waters influenced by these DOI responsibilities. In addition, while having no land-management responsibilities, the U.S. Geological Survey (USGS) conducts much of the research and provides much of the data and modeling needed to inform land-and water-management decisions.

Subcommittee Organization

This subcommittee comprises 39 individuals (see Appendix A listing all the members with their affiliation and a short bio) representing each bureau and service in DOI (with the exception of the Bureau of Indian Education). Their varied professional backgrounds include engineering, resource management, biology, and economics—to name just a few. Their jobs include park superintendents, refuge managers, deputy and associate State directors, regional directors, fire managers, and river area managers—again, to name just a few. Few are climate change experts. They each bring unique, real-world experiences and backgrounds to the task, often providing perspectives not usually captured in climate change analyses.

This group met numerous times by phone and a few times, with about 65 percent participation, in person. The initial list of priorities presented to the steering committee of the Climate Change Task Force was primarily developed by the June deadline at a meeting in Menlo Park, CA (May 21–24, 2007). The group worked on clarifying the issues by formulating options in Fort Collins, CO (June 25–28, 2007), and in Seattle, WA (August 20–23, 2007), and through many mid-summer communications. Much time and effort was put into this effort; however, due to the short timeframe, and the fact that this work was done in conjunction with the continuing responsibilities of the subcommittee members, this report should be considered a beginning step in the process of developing a long-range climate change plan for DOI.

The subcommittee broke into six working groups: five groups dealing with adaptation to climate change effects, primarily organized along landform and resource lines (e.g., coastal and marine, terrestrial, cryosphere, extreme events, and water), and one group dealing with opportunities to mitigate or reduce the emissions of greenhouse gasses and to enhance sinks. Each adaptation working group identified potential effects from climate change on DOI lands and other resources, relying heavily on personal observations, discussions with peers, and work done by others (e.g., the IPCC, recent publications by the Government Accountability Office, and general literature on climate change). The adaptation working group developed potential priorities among these effects and identified and analyzed (to the extent possible) options for addressing them.

Each working group presented their work to the whole subcommittee to assure that ideas were shared among the groups and that all viewpoints would be considered. As a consequence of this approach, this report represents the product of every subcommittee member's input.

GUIDE TO THE SUBCOMMITTEE'S REPORT

This report provides a description of 10 adaptation issues and 6 mitigation opportunities, a listing of some of the climate-induced effects, and an explanation of why the issue or opportunity is important to DOI. The descriptions of the issues are followed by options the Secretary may choose to consider to address each issue or opportunity. The options identify direct benefits and other analyses that the Subcommittee was able to complete within the timeframe given for this work. For each issue, a corresponding table shows the analyzed criteria for the options presented.

Criteria for Analysis

In analyzing the options, the Subcommittee considered several specific criteria. We used our professional judgment when assessing these criteria. Some of the options that might ultimately be selected would benefit from additional analysis prior to implementation. When answers to the criteria below are unknown or not applicable, no information is provided.

In many instances, the effect of climate change is to exacerbate effects already seen as a consequence of other factors (e.g., wildland fires or loss of wetlands). In its analysis, the Subcommittee emphasized the interrelationship of climate change and DOI resources, and we tried to deal with the predicted changes. However, in some instances where the appropriate response would be strictly more of the same, the option was not included in this report.

For this report, the Subcommittee used the following unranked criteria to analyze potential options:

A. Scale. What is the scale of the option and its impact?

Options are applicable at different scales. The Subcommittee rated the options on whether they could be applied nationally, regionally, locally, or at all levels. Further, the size of the effect of an option can differ, and we rated the potential effect of the options on a range from large to medium to small.

B. Feasibility. Is the option under DOI control? Does DOI have a unique capacity to implement the option? Does acting on the option make a near-term difference? What is the time-scale for implementation? Does the technology currently exist to successfully implement the option?

Options can be more or less under the control of DOI. For example, DOI may be more successful in implementing an option if it is to be implemented entirely on DOI lands. The Subcommittee rated the degree of DOI control on a range from high to medium to low, usually following whether the option was directly within the confines of DOI management or was one in which DOI had indirect management responsibility. The

timeframe for the adoption of each option was also considered. The Subcommittee rated the issues using the following time-scales: short (1–2 years), medium (2–5 years), and long (5+ years).

C. Direct and Ancillary Benefits. What are the benefits? Are there multiple benefits or co-benefits?

All of the options in this report have direct benefits, and these are described in the option analysis sections. Many also have ancillary benefits. For example, many of the mitigation options that reduce emissions also contribute positively to DOI’s mission, whether by improving wildlife habitat or enhancing visitor experiences.

D. Partnerships. Who are stakeholders? Is there a potential for partnerships?

Many of the options cover more than DOI lands and would be more successful if adopted by a wider array of participants. Therefore, the Subcommittee identified potential partners, where applicable. Potential partners included States, other Federal agencies, tribes, and non-governmental organizations; however, at the scale of this report, we could not identify all possible partners.

E. Demonstration effect. What are the opportunities for DOI to lead by example?

DOI is the Nation’s premier conservation agency. More than 440 million visitors come to DOI lands annually. Many of the options would have larger impacts if adopted by the public, other agencies, States, and tribes. Opportunities to serve as an example of conservation in the face of climate change are noted where applicable.

F. Human dimension. What are the effects on human communities that depend on climate-affected DOI lands and resources?

Cultural systems, economic activities, and social practices—the “human dimension”—are fundamental to understanding and responding to the challenges of climate change.

The list of potential human impacts of climate change is vast. Most of the categories of social and economic impacts identified in global or national climate change assessments can occur on the lands and resources administered by DOI. Given the preliminary character of this assessment, there are more potential human impacts relevant to DOI operations than can be identified for management action at this point. However, a brief description of some of these impacts suggests the scope of the challenge.

- Climate change may adversely affect forestry operations in several ways. Drought, increased wildfire intensity, and spreading insect infestations—all driven by rising temperatures—will decrease timber yields and affect the economy of timber-dependent communities. However, carbon dioxide fertilization may increase yields.

- In the western United States, more severe drought, warmer temperatures, and other effects on water supplies will contribute to making the future level of grazing on some Federal lands less productive than currently, in some cases decreasing the financial viability of ranch operations and hastening land fragmentation as marginal properties convert to non-agricultural uses.
- Native peoples depend upon a number of animal and plant species whose habitat will be reduced or will be displaced by the effects of climate change. These effects will be particularly noticeable in Alaska.
- Climate change will put industrial infrastructure at risk. This includes energy and mining facilities developed on Federal leases and rights-of-way. For example, this includes pipelines jeopardized by thawing permafrost in Alaska and oil platforms at risk from possible intense storms in the Gulf of Mexico.
- Rising sea levels will put human settlements and infrastructure, including DOI facilities, at greater risk in coastal locations. Changing sea levels and storm patterns will also have significant effects on many of the Pacific Island states and territories and Caribbean islands for which DOI has responsibility.
- Recreational uses of Federal lands are likely to shift. Many sites depending on adequate surface water flows for recreation, such as lakes and reservoirs in the southwest used for boating and fishing, may lose visitors, resulting in declines in employment and income in adjoining gateway communities. Other areas, however, may gain.

G. Cost estimates. What are the quantitative, if available, and qualitative costs?

Implementation of options, for the most part, costs money. There was insufficient time to do in-depth cost analyses for this report. The Subcommittee chose instead to give our best “guess.” We rated costs on a range from low (less than \$1 million), to medium (between \$1 million and \$10 million), and high (more than \$10 million), recognizing that the same option may have varied costs depending on where it is applied and the scale to which it is applied.

H. Legal Mandates. Are there statutes mandating these actions or making them illegal?

Some of the options may need to be further reviewed by the DOI Office of the Solicitor to obtain a legal opinion. Where legal considerations are an issue, these are highlighted.

Institutional Approaches and DOI-Wide Options

It is also very clear to us that a number of potential options are common across the identified issues. The Subcommittee decided to group these as DOI-wide options. In particular, the Subcommittee believes an overall framework for addressing climate change should be considered, and that the adaptive management framework, already endorsed by the Secretary in March 2007, would be appropriate. A short discussion of the

application of this framework to climate change, along with some suggested next steps for applying this methodology, is the first DOI-wide option.

The Subcommittee also considered a number of institutional options dealing with interagency and Departmental coordination, budget, and reporting, and these commence the report.

Appendix A is the list of the subcommittee contributors previously mentioned.

Appendix B is a summary table that includes all the criteria for all options in this report.

Appendix C is a list of acronyms used in this report.

INSTITUTIONAL APPROACHES

The issue of managing for climate change is firmly on DOI's agenda. Most subgroups noted that the options to manage for climate change that are set forth in this report require that institutions and processes also be put in place that enable DOI to share updates and progress, to take appropriate and coordinated action, and to measure the results.

Climate change is a complex subject, encompassing a huge and varied body of scientific, social, economic, and political information. Implementing management tools to mitigate and adapt to climate change is a vast undertaking that will require sustained action and vision for decades to come. DOI can consider the following options to achieve this vision and oversight:

- Establish within DOI a political-level Climate Change Coordination Council (like the Energy Coordination Council) that meets regularly to assure consideration of climate change issues at the highest levels of DOI.
- Establish a DOI headquarters-level office to support this council, to develop Departmental-level climate change policy, and to coordinate bureau activities related to climate change, as appropriate.

The director of this office could also serve as the point person for DOI-wide climate-change-related questions, interagency coordination, and testimony. Some agencies, such as the Department of Energy, have such an office established by law. At the current time, each bureau conducts climate-related activities with limited coordination or information sharing. As climate change actions, responses, and policies broaden, an office to provide policy guidance and coordination would help to ensure that DOI speaks with one voice and acts in a coordinated fashion. This office would track the bureaus' policies and decisions to ensure optimal use of resources in addressing climate change. As climate change actions overlap the jurisdictions of multiple DOI bureaus, the office also would provide bureaus with timely feedback to better ensure success. This office could also provide information on climate change to the public.

Such an office could be located in the Office of the Deputy Secretary or in the Office of the Assistant Secretary for Policy, Management, and Budget (e.g., in the Office of Policy Analysis or in the Office of Environmental Policy and Compliance). Access and visibility to DOI leadership would be important for such an office to succeed in its mission. It could also hold an annual conference of DOI bureaus and partners as a means of promoting cooperation and coordination. This office would coordinate acquisition of climate change data and model development for data on a land-management (local) scale among bureaus. This would not preempt any bureau from managing and developing its own data; rather, it would help to coordinate support for bureaus as they fund some data and

model development themselves and find that additional resources are needed to acquire other data and model development.

It would likely be a small office, with up to six staff. The total estimated annual budget, including contractor support and travel, would be approximately \$2.5 to \$3.0 million. Each bureau would appoint a liaison to this office.

- Promote the establishment of an interagency-level Climate Change Land and Water Management Program akin to the interagency Climate Change Science Program. Members would meet regularly to assure consistent land- and water-use policy and actions related to climate change on all Federal lands (e.g., DOI, U.S. Forest Service, or Department of Defense lands).
- Publish an Annual Report on DOI's management for climate change. This report would present scientific findings on climate change impacts on DOI lands and adaptation and mitigation measures; identify goals and objectives; and report on progress on the policies, regulatory actions, and adaptive management activities. DOI, with its vast land holdings and resources, is positioned to be a leader in managing climate change. This report could be used to record our actions so others can follow. The above office could be made responsible for this report.
- Hold a kickoff public conference, "Managing Lands and Waters for Climate Change," where scientists, land managers, private land owners, native peoples, and State and local policymakers can gather to obtain information, guidance, and feedback, and develop implementation plans that include adaptive management techniques. This meeting is paramount for DOI managers and others to begin developing strategies for climate change. Its success would highlight DOI's comprehensive analysis and jumpstart measures to deal with climate change. It could be organized around the issues and opportunities identified in the three task force subcommittee reports.
- Consider developing a unified climate change budget to demonstrate the extent of DOI resources and commitment to addressing the effects of climate change.

ADAPTATION ISSUES AND OPTIONS

COMMON THEMES AND DOI-WIDE OPTIONS

As the products of the work groups were compiled, the Subcommittee found that a number of ideas, concerns, and needs showed up repeatedly, either in the written working group products or in the working papers, meeting notes, and personal discussions of the subcommittee members. We captured these ideas and highlighted them as “Common Themes.” As the Subcommittee analyzed these common themes, it developed seven “DOI-Wide Options.” However, there is not a DOI-wide option for every common theme because some were adequately addressed under the issue-specific options that follow this section. The 11 common themes and 7 DOI-wide options are presented below.

Common Themes with DOI-Wide Options

Theme 1: Adaptive Management as a Model for Managing in an Uncertain and Changing Climate. Climate change presents significant new challenges as DOI’s bureaus and employees make complex management decisions, often with uncertain or incomplete information. While climate change experts have predicted global increases in temperature, sea level, storm intensity and frequency, and changes in regional precipitation patterns, in most cases they have not scaled these predictions down to a level usable by DOI employees for making specific, local resource-management decisions. In addition, as climate predictions continue to be refined, management decisions will need to adapt to new information and analysis.

Resource management decisions at DOI bureaus rely heavily on a mix of scientific historic, economic, cultural, and human preference information. With a changing climate, we will find that, in many instances, the historic record associated with many of these factors is less reliable and in some cases completely invalid. Resource managers will need to rely instead on predictions of sea level, temperature, moisture, and the human and biotic responses to those new climate conditions and to our management responses. As the effects of climate change progress, the uncertainties of managing in changing conditions will require a new decision model or framework for DOI managers to use when making decisions.

A number of the issue-specific options in this report suggest using adaptive management as a framework for managing DOI lands in a changing climate. The National Research Council defines adaptive management as a decision 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.” The recently published *DOI Adaptive Management Technical Guide* suggests that adaptive management is most useful in situations in which there is a high level of uncertainty about the natural environment and the consequences of management decisions, but where there is also a high level of

controllability of our actions. The Subcommittee believes that these two conditions will be present in many of the situations faced by DOI resource managers as we make management decisions in a world with a changing climate.

Adaptive management is a structured decision-making process that explicitly builds uncertainty and the opportunity to obtain additional scientific information into the decision-making process. As climate predictions improve over time, and as human and ecological responses are observed and measured, adaptive management allows us to adjust our management responses in an iterative decision-making process. Through adaptive management, decisions can also be prioritized based on comparisons of the expected impact of various responses. Management actions can be taken and the results of those actions used to develop future management actions. In addition, DOI managers can compare the expected results of taking immediate actions to the results of delaying actions, which will help managers to prioritize alternatives based on their associated costs and benefits.

DOI-Wide Option 1: Develop an Addendum to the *DOI Adaptive Management Technical Guide* that Focuses on Managing for Climate Change. Adaptive management could provide a sound framework for making decisions in the face of climate change. The *DOI Adaptive Management Technical Guide* provides a model for implementing adaptive management across DOI. However, it does not provide specific guidance on developing strategies for response and adaptation to the ecological consequences of climate change. Given the potential of using adaptive management as a framework for this effort, the Subcommittee recommends that the DOI Adaptive Management Working Group develop an addendum to the technical guide that focuses specifically on managing for climate change. This addendum would provide a more detailed strategy for using adaptive management as a framework for developing DOI's response strategy to climate change, including climate-specific examples and case studies, and would be a first step in developing a structured decision-making process for planning a DOI response.

Theme 2: Land, Resource, and Species Management Plans Need to be Revised to Reflect Climate Change Effects. Nearly all of the working groups of the Subcommittee on Land and Water Management identified a need to revise management plans to reflect effects of predicted climate conditions. Most resource management actions at DOI facilities are controlled by management plans created through coordination with partners, stakeholders, and bureau managers. In order to incorporate climate change considerations into day-to-day operations, DOI lands and facilities need to revise and operate under management plans that reflect climate change projections based on the best available science. Included in this theme are endangered species status determinations, recovery plans, and other endangered species management actions.

DOI-Wide Option 2: Issue a Secretarial Order Regarding Management of DOI Lands and Water in Light of Climate Change. Issue a Secretarial Order that all future DOI resource management decisions (including operations and management plans for DOI lands) include considerations of, and adaptations for, expected changes in precipitation, temperature, and sea level. Particular attention could be given to Alaskan resource management plans due to recent scientific observations that temperature and ecological changes in the Arctic are exceeding predictions. The order would state that, in many cases, historic conditions are no longer adequate for making future land management decisions. By considering both future climate predictions and historical conditions in our management strategies, this action would result in changing the underlying assumptions upon which local operation and management plans are created or modified. This option would benefit DOI bureaus by strategically and decisively setting a new direction for managing DOI lands that considers climate change as future management plans are developed.

This option would incorporate climate change into the existing ecological management structure of the bureaus and, consistent with DOI-Wide Option 1, would further instruct personnel to consider the use of adaptive management as an appropriate tool in their climate change toolbox. By managing in this way, results are expected to be positive overall, but as the mix of values and services for any specific location changes over time, some stakeholders may individually benefit and others lose. Many stakeholders will resist and object to any proposed changes because of the uncertain nature of climate change and the adaptations proposed.

While the cost of issuing the Secretarial order is low, and can be done in a short time, the cost of implementation will vary based on two important factors: whether the order instructs managers to immediately begin review and revision of all management plans or allows managers to update their plans following schedules already in place; and whether revising the management plan requires local- and regional-scale climate data and ecological models that currently do not exist. The speed at which managers desire to update plans for climate change predictions would affect the annual cost for developing new predictive data and models. See DOI-Wide Option 4 below.

Theme 3: Definitions for Key DOI Agency Terms, such as “Natural” And “Unimpaired.” A number of the working groups struggled with how the current interpretations of agency terms, such as “natural” and “unimpaired,” are affected by climate change. These terms are particularly significant to the National Parks, Historic Sites, and National Wildlife Refuges.

The National Park System was created by the National Park Service Organic Act to conserve “unimpaired” select scenery, natural and historic objects, and wildlife for the enjoyment of future generations. Many National Wildlife Refuges were also established to protect specific species or examples of unique “natural” systems. Climate changes will modify many of these parks and refuges, possibly threatening even some signature species with extinction or loss of local populations due to shifting habitats.

Park managers will be challenged to either “fight” climate change to maintain these historic features, animals, uses, and landscapes or to redefine objectives to optimize outcomes from changing climate conditions within expected budgets. This will call for clarification or redefinition of the concepts of “natural” and “unimpaired” in the face of some times subtle and other times dramatic climate shifts. Without clear programmatic guidance, DOI managers will be challenged by park patrons, wildlife stakeholders (e.g., hunters, hikers, photographers, etc.), and benefactors (e.g., concessionaires and gateway communities) when those parties perceive management changes as threats to their economic stability, recreational opportunities, or desired use.

DOI-Wide Option 3: Define Key DOI Agency Terms in the Context of a Changing Climate. The Department could review, and where necessary, clarify guidance for agency land and resource managers, such as guidance concerning the conservation and restoration of “natural” ecosystems, fire regimes, or diversity; the minimization of “impairment” of natural systems; or the conservation of “unimpaired” select scenery, natural and historic objects, and wildlife. Clarification of these concepts should involve DOI land managers, legal staff, partners, and stakeholders at the national level. The cost of clarifying or redefining these terms would be quite low, even when including costs for national coordination meetings or a national symposium to facilitate agreement on new definitions. Alternatively, the cost of not tackling these terms and concepts at a national level could be quite high as individual parks, public lands, and refuges make their own interpretations and face legal actions by park users or other stakeholders who feel harmed by revised management practices.

Theme 4: Timely Local and Regional Data are Needed. During our deliberations, members questioned whether the current process that DOI managers use to acquire the research, data, and modeling needed to inform their decisions would be effective in the new paradigm of managing for climate change. The two common concerns about the existing systems for acquiring research and modeling are scale and timeliness. Most of the climate data and ecological models available make predictions at the global and continental scales. Data associated with both climate predictions and the implications those predictions have for specific resources at the management-unit level will be critical for implementing new resource protection and management strategies.

DOI will need a more effective mechanism for parks, refuges, and other management units to identify and acquire needed science support (e.g., research, data collection, and model development) in a timely manner. Field managers express strong concerns about the number of layers between the field research needs and the decisions on when and where research is conducted within DOI. These concerns suggest that a new, restructured process may be needed to meet the new science needs of managing America’s natural and cultural resources in a changing climate.

Finally, the adaptive management process demands timely predictions, decisions, and feedback on the results of management decisions. While local feedback monitoring can normally be done within local budgets or with assistance of regional partnerships, the

research, predictive capabilities, and model development needed in the future are beyond the budgets and other resource bases of all but the largest DOI facilities.

DOI-Wide Option 4: Streamline the Process and Provide Additional Resources for Acquiring Local and Regional Data, Decision-Support Tools, and Models. A new framework and process should be developed for resource managers to identify and acquire support for local- and regional-scale ecological research, data collection, and modeling. Field managers need direct input into the selection of research on their respective sites to ensure that data are available in a timely manner to inform DOI land and water planning and management decisions. This framework would need to be flexible and rapidly responsive to the needs of resource managers operating under the adaptive management framework. Consideration should be given to enhancing the research capacity of the individual bureaus.

Additional resources will be needed to conduct these activities so that the data and tools needed by local managers can be provided in a timely manner. Regional coordination of local data networks could enhance the consistency, availability, and applicability of the collected data. Developing rapid mechanisms for acquiring and delivering data to meet the needs of land and water managers would take somewhat longer than 1 or 2 years and would require considerable annual funding. Without a commitment of new funds or a significant redirection of current science program funds, managers will be unable to fully implement many of the options presented in this report.

Theme 5: Education and Technology Transfer within DOI is Needed. Education and technology transfer were common topics of discussion during subcommittee meetings. We suggest that we begin to adapt our processes by first educating our own staff and our partners on the already observed and predicted effects and implications of climate change on DOI lands. There are many departmental employees that, like the general public, are still confused by the rhetoric and sometimes conflicting reports on climate change and its environmental effects. DOI bureaus could initiate training programs, curriculum, and technology-transfer tools to educate employees about climate change, how it affects DOI lands and operations, and the various strategies that employees may use to manage in a world with a changing climate. (There is an additional discussion of DOI's role in educating the public on climate change under the "Mitigation Opportunities and Options" section of this report.)

DOI-Wide Option 5: Develop a DOI-Wide Climate Change Training Curriculum. A DOI-wide training curriculum could be developed to discuss the science of climate change, the anticipated effects as enumerated by the IPCC report (and others), and DOI's response, including both adaptation and mitigation responses. An initial introduction to climate change could be offered as a web-based class. Advanced classes could include topics like "understanding and characterizing the uncertainties of climate change predictions" or "revising resource management plans in a changing climate." The curriculum could be distributed as both web-based and instructor-led courses. Individual bureaus would likely use the basic curriculum to create specialized classes for their employees and their lands and waters.

Theme 6: Encouraging and Supporting Partnerships for Adapting to Climate Change. Another common theme involved the desire to address climate challenges to DOI resources in collaboration with our neighbors and partners. Options for addressing water availability, water quality, coastal impacts of sea-level rise, impacts on native peoples, species migration, and endangered species all include partnerships to accomplish shared goals. While many resource management partnerships will be initiated and conducted at the local level by the national parks, wildlife refuges, and public lands management units, there are valuable actions that DOI leaders can take to encourage and support increased partnering to minimize costs and maximize benefits. Several options can be found in the topic-specific sections in this report.

DOI-Wide Option 6: Develop an Interior Climate Adaptation Partners Program. Develop a DOI Climate Adaptation Partners (ICAP) Program that provides guidance and possible financial incentives for developing cross-jurisdictional, public/private partnerships that contribute to the conservation of species, natural communities, and lands and waters placed at risk by changing climate conditions.

Most Americans will be impacted in one way or another by the effects of climate change on DOI resources, making everyone a potential partner in DOI adaptation strategies. One large group, in particular, is those people who depend directly on the plants and animals that reside on DOI lands. Park concessionaires, marinas, canoe and scuba outfitters, hunting lodge owners, ranchers, conservation organizations, State and tribal governments, timber and energy companies, even regional economies—all feel the effects when species move away or disappear and traditional ecosystem services and functions are lost. The scale of ecosystem changes predicted by the IPCC calls for a new initiative, one that encourages and facilitates cooperative conservation principles as we adapt natural resource programs to climate change. A DOI climate adaptation partnership program could provide three important tools that DOI managers need to successfully navigate the coming changes:

1. Public/Private Partnerships. Appropriate regional partnerships and associated conservation incentives could enhance flexibility in habitat conservation across jurisdictional boundaries. An ICAP program would dedicate human resources within and across DOI bureaus to help develop and facilitate species survival strategies through effective partnerships at local and regional levels. The option could include additional financial resources to support collateral duty facilitators, along with their travel, training materials, and other support expenses.
2. Private Landowner Incentives. Private and other non-DOI lands will be essential to implementing successful adaptation strategies as plants and animals migrate on or off DOI lands or as other issues are encountered. ICAP would expand the use of existing partnership and grant programs within DOI to encourage private and non-DOI landowners to participate in projects that offset the impacts of species migration. Examples of existing programs

include the North American Wetlands Conservation Act Grant Program, the FWS Partners for Fish and Wildlife Grant Program, and the National Fish and Wildlife Foundation Grant Program. ICAP would find new ways to couple these with programs in other Federal agencies, such as the Department of Agriculture's Natural Resources Conservation Service Environmental Quality Incentives Program and the FWS Habitat Partnerships Program, to leverage existing human and financial resources in those programs. Additional budgetary resources in the out-years could expand the effectiveness of this program.

3. National Climate Change Adaptation Awards Program. A national awards program would promote these climate adaptation partnerships and demonstrate to the Nation and the world how effective partnerships can save U.S. natural treasures by fostering creative thinking and collaboration to adapt to climate change impacts. A Web site and annual print publication would help inform people around the Nation how to achieve successful adaptation strategies. If selected, the option would not require a long start-up period.

Individual costs of developing partnerships would be relatively low and benefits high, but many DOI managers would need the assistance of trained facilitators to assist in their development. Smaller parks and refuges, in particular, do not have the spare manpower to investigate and fully develop partnerships without negative impacts on their other activities. DOI would benefit substantially from an available corps of trained facilitators to help individual parks and refuges identify and develop partnerships to protect threatened resources. A financial incentives fund could increase the ability of individual management units to work with private partners who need compensation to take lands out of agricultural production, delay timber harvest, or take other actions in order to maintain a corridor or protected area. Use of existing bureau private lands programs and the U.S. Department of Agriculture (USDA) conservation programs to encourage species protection partnerships would require no new money. The costs of training and maintaining a corps of facilitators and redefining or redirecting existing wildlife habitat incentive programs for private lands would be small considering the cost savings from minimizing additional direct land acquisition or other options that DOI might take independently to adapt to climate change.

Theme 7: Enhancing Emergency Preparedness and Early Warning Systems. The working groups had numerous discussions about whether to include options for strengthening emergency preparedness to deal with climate change related disasters. Preparedness is, after all, an existing component of DOI operations plans. DOI facilities already conduct regular emergency response drills, maintain Continuity of Operations Plans, and continually train to deal with emergencies. Despite this, the Subcommittee chose to include emergency/disaster response options in this report to accomplish three objectives: (1) to reiterate the importance of protecting our visitors, our facilities, our neighbors and our natural and cultural resources; (2) to highlight the fact that climate change will likely increase emergencies due to an increase in the frequency or intensity of storms, floods, droughts, wildland fires, and other disruptive events near many DOI

facilities; and (3) to emphasize that emergency response involves rapidly assessing and meeting the needs of our protected natural and cultural resources as well as our human and economic resources.

Within the National Response Plan, DOI is the primary Federal agency for the protection of natural, cultural, and historic resources under the Emergency Support Function (ESF) #11. This responsibility is led by the Office of Environmental Policy and Compliance through the Environmental Safeguards Group. During emergencies, DOI has the lead to coordinate appropriate response actions to conserve, rehabilitate, recover, and restore the natural, cultural, and historical resources. The Office of Environmental Policy and Compliance also co-chairs the action team for natural disaster protection of historic resources under the White House initiative “Preserve America”⁴ together with the Department of Homeland Security.⁵

The options contained in the issue-specific sections of this report are intended to strengthen the resolve and enhance the toolbox of DOI land and resource managers to prepare for such challenges. An additional DOI-wide option is provided below to strengthen the capacity of DOI as a whole to respond to the increased threats of climate change on DOI resources now clearly recognized.

DOI-Wide Option 7: Create Emergency Response All-Hazards Teams and Associated Natural/Cultural Response Teams. Using existing bureau personnel, create two DOI Emergency Response All-Hazards Teams and two Associated Natural/Cultural Response Teams to respond to disasters induced by climate change.

- A. Recruit and develop two DOI Incident Command System (ICS) All-Hazards Teams, at the Departmental level, similar to those in the NPS, providing training, equipment, and support costs to respond to disasters induced by climate change. ICS All-Hazards Teams provide the organizational structure for managing emergencies and other incidents affecting one or more DOI bureaus in any region of the Nation. After initial training, these collateral duty teams would conduct annual training exercises to better prepare them for emergency response in managing storm events, multi-agency incidents, or other events. They would provide cross-bureau coordination of the many discipline-specific teams (e.g., communications specialists, sawyers, roofers, electricians, emergency medical technicians, natural resource specialists, etc.) needed at any emergency site so that DOI’s response is coordinated and synergistic rather than bureau-specific.
- B. Recruit and develop two natural resource and cultural resource response teams, which would be able to make critical initial assessments and take initial stabilization action to better protect fragile resources in response to disasters

⁴ “ESF #11—Agriculture and Natural Resources.” *National Response Plan*. Department of Homeland Security. December 2004.

⁵ “ESF #14—Long-Term Community Recovery.” *National Response Plan*. Department of Homeland Security. December 2004.

induced by climate change. DOI has thousands of resource professionals and an identified cadre of people who are trained for emergency assessment and protection efforts when natural or cultural resources are threatened by an emergency situation. At present, these individuals are identified annually to the DOI Environmental Safeguards Group and kept on a roster by NPS Emergency Incident Coordination Center–Shenandoah. This option would organize these individuals into pre-identified teams and provide funding, training, and equipment for resource professionals to be collateral duty incident responders working under the guidance of the ICS All-Hazards teams.

Establishing these teams would reinforce DOI’s commitment and capabilities under the DOI’s Environmental Safeguards Plan for All-Hazards Emergencies, May 2005. This option would cost relatively little and would provide substantial benefits to DOI and its bureaus. Beneficiaries include DOI bureaus and all affected parties in the vicinity of emergency incidents. Collateral benefits include building emergency response capabilities in all bureaus because response team members would be recruited from all bureaus. These teams would help DOI to be adequately prepared to deal with the future impacts of climate change such as the frequency or intensity of storms, floods, droughts, wildland fires, and other disruptive events near many DOI facilities.

Table 1-A provides a tabular look at the analyzed criteria for these options.

Other Common Themes in the Report

Theme 8: Vulnerability Assessments. Throughout the development of this report, participating resource managers voiced concerns about how much we still do not know about the effects of climate change, and how great the task of identifying and addressing these effects across all DOI resources remains. As the Subcommittee pulled together the issues and options you will read in the “Adaptation” section, we found that almost every issue included some form of vulnerability assessment as a starting point for other actions. Where it seemed to make sense, the Subcommittee titled the options similarly as “Assess Vulnerabilities.” In other cases, where the vulnerability assessment was described as part of a larger option, we did not rename it. The Subcommittee chose not to create a DOI-wide option to assess vulnerabilities because an attempt to combine them all into one overarching vulnerability assessment would have made the actions so generic that each might lose its individual vitality and effectiveness.

Theme 9: Safeguarding DOI Facilities and Resources. The theme of safeguarding DOI facilities, infrastructure, and physical resources will be found in various report sections including those dealing with wildfires, floods, coastal impacts, and melting of permafrost and sea ice. We list these ideas separately from emergency preparedness because they focus more on our long-range planning and management actions. In the new paradigm of climate change and its expected impacts, such as sea-level rise and loss of permafrost, DOI managers will need to change the assumptions they have historically used to place new facilities on the landscape. Questions such as “should we repair a structure in place

or rebuild in another area?” will need to consider whether the flood plain maps are likely to change with predictions of increasing or decreasing precipitation and severity of storms, or whether loss of permafrost will make the existing foundation of a structure unstable. We did not try to create a common option because the issues are unique.

Theme 10: Species Inventory and Monitoring. Species inventory and monitoring is another common theme throughout this report. Managing for climate change requires a thorough understanding of what species and habitats make up the ecological landscape of a park, refuge, or other management unit. Without an inventory of species and natural communities, we cannot begin to predict the ecosystem response to a changing climate, or to develop actions to deal with those responses. Adaptive management requires monitoring to determine the success of individual management actions in order to learn from them and adjust the course for subsequent actions. Throughout this report, the Subcommittee emphasizes the need to increase local and regional ecological inventory and monitoring activities through cooperative partnerships in order to improve cost effectiveness and overall efficacy of monitoring actions.

Theme 11: Reducing Other Stressors. Every working group on the Land and Water Subcommittee discussed the importance of reducing existing stressors on natural communities to soften the effects of climate change. We did not include a “Reduce Other Stressors” option in every section or as a common option because DOI bureaus already have policies and practices in place to deal with many of the recognized ecological stressors. While additional resources would be helpful in dealing with these, the need for resources alone was not a topic of this report. We did specifically include it as an option in the Endangered Species section because the Endangered Species Act places responsibilities on DOI that extend far beyond the borders of our lands, waters, and energy/mineral interests.

Table 1-A: DOI-Wide Options

Options	Timescale to Implement	Degree of DOI Control	Scale of Impact	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Low–High, Indirect, or Brief Description	Brief Description	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Option 1: Develop an Addendum to the Adaptive Management Technical Guide	Short	High	National	Facilitation of decision-making process	N/A	Recreation, Economy, Native peoples, Subsistence
Option 2: Issue a Secretarial Order Regarding Management of DOI Lands and Water in light of Climate Change	Short	High	National	Reduced legal challenges to changing land management plans		Recreation, Economy, Native peoples, Subsistence
Option 3: Define Key DOI Agency Terms in the Context of a Changing Climate	Short	High	Local–National	Reduced legal challenges to changing land management plans	States, Tribes, Fish and wildlife organizations, Other Federal agencies	Recreation, Economy, Esthetics
Option 4: Streamline Process and Provide Additional Resources for Acquiring Local and Regional Data, Decision-Support Tools, and Models	Short	High	Local–National	Better support to individual parks and refuges		Better data means better results for all parties
Option 5: Develop a DOI-Wide Climate Change Training Curriculum	Short	High	Local–National		Other Federal agencies	Education leads to more effective decisions affecting people
Option 6: Develop Interior Climate Adaptation Partners Program	Medium	Medium–High	Local–National	Substantially increases regional partnerships	Numerous	Recreation, Economy, Esthetics
Option 7: Create Emergency Response All-Hazards Teams and Associated Natural/Cultural Response Teams	Short	High	Local–National	Public safety and resource protection	Other government agencies and emergency personnel	Enhanced safety, Recreation, Historic preservation, Economy

ISSUES AND OPTIONS

The following 10 adaptation issues (a recombination of the original 14 catalogued issues presented on June 20, 2007, to the Climate Change Task Force Steering Committee) represent the issues that the Subcommittee believes need to be addressed due to the effects of climate change. Following each issue, we present one or more options that the Secretary may consider in addressing the climate change issue within DOI.

Water Availability

STATEMENT OF ISSUE

The availability of water is critical for many purposes, including water supply for native peoples, towns, cities, and DOI facilities; ecological health of riparian and aquatic habitat; irrigation; wildlife and livestock survival; and hydropower production. Climate change has the potential to decrease supply and increase demand, creating new water scarcity problems and exacerbating existing ones.

DESCRIPTION OF ISSUE

Water availability is already a significant concern in parts of the United States. The IPCC reports a number of potential climate change impacts to the hydrologic cycle.⁶ Predicted climate change effects vary across regions of the Nation, and have the potential to create or exacerbate problems with water scarcity.

Precipitation changes may differ across the country, with the Southwest likely to experience less precipitation. The intensity of individual rainfall events is projected to increase during the 21st century. There may also be changes in the frequency of precipitation events and shifts in the seasonal patterns of precipitation and runoff. Higher temperatures may also impact water supply as stream runoff is lost to evaporation and transpiration. These impacts to the flow regime may affect ecological systems. In addition, existing water infrastructure may not be able to accommodate different temporal patterns of streamflow and still serve their intended purposes. Many reservoirs serve multiple purposes, and balancing different purposes such as flood control and drought storage may be more difficult in an altered climate.

Increased temperatures are expected to change the mix of rain and snow and shift the timing and amount of snowmelt runoff in high-latitude or high-elevation areas. These

⁶ IPCC, *Climate Change 2007: Impacts, Adaptation and Vulnerability—Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. M.L. Parry *et al.*, Eds., Cambridge University Press, Cambridge.

shifts have already been reported in northern New England and in the western United States.⁷ Increasing temperature will also increase potential evapotranspiration from vegetation, decreasing the amount of water that then reaches streams, lakes, and reservoirs. Increasing temperature will also increase demand for irrigation water as crops will also increase transpiration in response to higher temperatures and may have an extended growing season. Municipal demand for water may also increase as individuals use more water on their lawns and gardens. By affecting runoff processes and evapotranspiration, changes to the landscape from a changing climate may also have indirect effects on water availability.

Overall, the West and Southwest are most likely to see climate-change-induced decreases in water availability due to a combination of less precipitation, earlier snowmelt, and increased evapotranspiration. Late summer low flows, in particular, are likely to decrease.

As water availability decreases, competition for water will likely increase among parks, refuges, public lands, native peoples, and uses such as municipal and industrial supply and irrigated agriculture. Users with the lowest priority water rights are most likely to experience problems. In these areas, decreased water supplies could adversely affect economic development, recreational opportunities, or habitat. For example, in the Lower Colorado Region of Reclamation, agricultural users have higher priority water rights than municipal and industrial users, including the Southern Nevada Water Authority, the Central Arizona Project, and the Metropolitan Water District of Southern California.

The BOR is the largest wholesale provider of water in the western United States. DOI manages reservoirs and maintains contracts for water delivery for municipal and industrial use and irrigation. Reservoir storage and controlled releases are also used to maintain biologically important instream flows. In a changing climate, these reservoirs may no longer be able to supply enough water to meet all needs, resulting in shortages.

Aquatic ecosystems may be affected by changes in streamflow, changes to flow from springs and seeps, and loss of wetlands. The surrounding wildlife or grazing animals that depend on these water sources for drinking water may also be affected. Risks to aquatic ecosystems and neighboring animal communities may be especially pronounced in snowmelt-dominated watersheds. Glacier meltwater contributes to summer streamflow in many basins in Alaska, the Rockies, and the Northwest. As glacier melt accelerates, there will be short-term increases in summer streamflow until permanent glacial ice disappears.⁸ The loss of glaciers will depress summer flows and potentially render some

⁷ Stewart, I.T., D. R. Cayan, and M. D. Dettinger. "Changes toward earlier streamflow timing across western North America." *Journal of Climate*, 18. 2005. p. 1136–1155.

Hodgkins, G. A., R.W. Dudley, and T. G. Huntington. "Changes in the timing of high river flows in New England over the 20th century." *Journal of Hydrology*, 278. 2003., p. 242–250.

⁸ Fountain, A.G. and W. V. Tangborn. "The effects of glaciers on streamflow variations." *Water Resources Research*, 21. 1985. p. 579–586.

high-elevation streams intermittent. Finally, away from streams and lakes, decreased precipitation and more frequent or intense droughts may result in land degradation.

STATEMENT OF OPTIONS

The specific effects of climate change on water availability at particular locations cannot be accurately simulated without additional research. For example, additional research will be necessary to provide inputs to reservoir simulation models that reflect future climate conditions. Uncertainties include (1) whether the timing of runoff events will change, (2) whether the intensity of precipitation events will change, and (3) whether these changes will be large enough to affect ecosystems and the operation of infrastructure. We considered a number of options, but some would require very large expenditures, would require completion of site-specific engineering studies, or are only indirectly under DOI control. For example, at severely impacted locations, the development of new sources of water may be considered in the future (e.g., new dams and desalination plants). DOI may also strengthen existing programs to encourage water users that are supplied by DOI facilities to reduce their demand for water. Full analysis of these options is needed before they can be implemented at any location, and this was beyond the available time and scope of this report.

The first adaptation option listed below is a vulnerability assessment that addresses this need for site-specific information and should be implemented before site-specific options, such as Options 3, 4, and 5, are selected.

Option 1: Assess Vulnerabilities: Water Availability. Identify locations most vulnerable to experiencing water shortages due to climate change in order to prioritize future work.

Option 2: Establish Climate Change Water Forums to Enhance Regional Coordination. Enhance coordination of water planning activities by establishing water forums to find efficient solutions to manage the water-related impacts of climate change.

Option 3: Enhance Monitoring. Expand monitoring of water demand and streamflow, snowpack, glaciers, and ecosystem health at vulnerable locations to detect changes and improve understanding of hydrologic and ecosystem processes under climate change. Locations identified as vulnerable in Option 1 should be prioritized for enhanced monitoring.

Option 4: Reevaluate Reservoir Operating Strategies and Long-Term Planning. Update reservoir operating strategies and long-term planning to reflect predicted streamflow under climate change. Locations identified as vulnerable in Option 1 should be prioritized for these studies.

Option 5: Update Drought Plans for DOI Lands. Update or develop drought emergency plans that reflect climate change predictions and implement long-term conservation measures at vulnerable locations.

Option 6: Incorporate Water Availability Changes into Land- and Habitat-Management Activities. Develop tools for managing aquatic and riparian habitat in the context of climate change and changes to water availability.

Table 2-A provides a tabular look at the analyzed criteria for these options.

ANALYSIS OF OPTIONS

Option 1: Assess Vulnerabilities: Water Availability. A first step towards addressing climate change impacts on water resources is to conduct a vulnerability assessment of DOI-managed facilities (i.e., reservoirs, water supply systems, recreational facilities) and DOI resources dependent on water (DOI lands with significant riparian or instream components), and waters for native peoples. This assessment should address vulnerabilities of human societies as well as ecological vulnerabilities to water shortages. This analysis would allow DOI to identify the resources most vulnerable to detrimental effects from climate change as well as the most appropriate adaptation options for those locations. An initial vulnerability assessment done at a screening level could be completed quickly using existing information. By identifying the most at-risk resources and facilities, this option would allow DOI to focus its limited resources in an effective manner. Components of the vulnerability assessment include the following:

- Inventory water resources facilities and water-dependent resources. These include DOI-managed reservoirs; water supply systems for DOI facilities or tribes; DOI lands with significant water resources; livestock/wildlife watering systems on public lands; and water supplies needed for conservation purposes, such as waterfowl and endangered species that are under DOI stewardship.
- Define vulnerability criteria. Factors to consider include the likely climate impact, the current level of stress, the presence of endangered species, the existence of higher or lower priority water rights, human recreation and subsistence uses of the water source, and plants and animals that depend upon the water source.
- Use the criteria to identify vulnerable locations.
- Analyze the options for these vulnerable locations to identify applicable adaptation options. Based on the specific site characteristics, some options may be more appropriate than others. It may be necessary to first prioritize vulnerable locations.

This option could be implemented nationwide and coordinated with native peoples. The vulnerability assessment could be started as a screening-level analysis, and the analysis of the options could be continued as more detailed information is acquired for priority vulnerable locations. A complete options analysis would require improved data and models to enhance local and regional climate change predictions.

Table 2-A: Water Availability Options

Options	Timescale to Implement	Degree of DOI Control	Scale of Impact	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Low–High, Indirect, or Brief Description	Brief Description	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Option 1: Assess Vulnerabilities: Water Availability	Short	High	Large	N/A	N/A	Recreation, Economy
Option 2: Establish Climate Change Water Forums to Enhance Regional Coordination	Short to start, but continuing	High, although it requires partnerships	Potentially Large	N/A	States, Local governments, Tribes, Irrigation districts	Recreation, Economy
Option 3: Enhance Monitoring	Short to start, but continuing	High	Small–Large, depending on scale of implementation	Water data can be used for other purposes	Universities, States	Recreation, Economy
Option 4: Reevaluate Reservoir Operating Strategies and Long-Term Planning	Short to start, but continuing	High	Small–Large, depending on scale of implementation	May benefit other flood control or water supply agencies	US ACOE, TVA	Recreation, Economy
Option 5: Update Drought Plans for DOI Lands	Short to start, but continuing	High	Small–Medium	N/A	Local Water Agencies	Recreation, Economy
Option 6: Incorporate Water Availability Changes into Land and Habitat Management Activities	Short to start, but continuing	High	Small–Large, depending on scale of implementation	May improve overall ecosystem health	N/A	Recreation, Economy

Option 2: Establish Climate Change Water Forums to Enhance Regional Coordination. By disseminating information more efficiently, identifying system-wide efficiencies, and helping to find the most economically efficient uses of water, greater coordination and cooperation in regional water planning in response to climate change could benefit water managers. Water resource planning activities are typically complex and take place over long time horizons. While the Federal government has a major role in water management, native peoples and tribes through their role as domestic nations and ownership of water rights; State governments, through State laws, State-governed water rights, and State allocation systems; local agencies; and the public also play important roles in developing water management strategies. Consequently, future impacts on water resources from climate change warrant a collaborative planning approach.

Building upon existing forums, regional water forums with Federal, State, tribal, and local involvement could be formed specifically to address and develop adaptive response strategies to climate change in water management. The forums would seek to provide accurate, non-biased, current technical information on climate change to water managers. They would work toward collaborative solutions to water issues that arise from climate change by facilitating increased flexibility in water systems and the relaxation of institutional constraints and by seeking other water management alternatives for dealing with climate change impacts. Because impacts to western water resources from climate change are likely, this program could be piloted in western river basins.

The DOI Water 2025 program seeks to prevent future water crises. However, while it also promotes collaboration, Water 2025 does not currently consider climate change. Operational working groups have been formed to discuss implementation of operating strategies at reservoirs. However, these groups do not focus on long-term planning, and climate change impacts are not included in their mission. The proposed climate change water forums would create a proactive process for addressing the specific impacts of climate change and develop methods for incorporating climate change impacts into water resources planning and management.

As part of this effort, a technical workgroup could also be initiated to develop guidelines for water resources practice in systems impacted by climate change. This workgroup would suggest steps needed to develop a set of appropriately scaled climate change scenarios for water managers, and would also suggest the types of analyses that should be considered as standard practice for climate change studies.

A second technical workgroup focused on ecosystem issues could also be initiated. This workgroup would provide regional resource managers and scientists with an opportunity to share information, identify ecosystem resources and processes that may be most susceptible to climate change, develop plausible scenarios of future climates and ecosystem response, and develop management plans accordingly. In particular, the effects of dust-storm events and their effect on water availability in general and on ecosystems in particular could be addressed.

There are also opportunities to participate in and build upon other federal programs. For example, in 2006, the National Oceanic and Atmospheric Administration was authorized to develop the National Integrated Drought Information System (NIDIS). It is envisioned that NIDIS will provide water users across the board – farmers, ranchers, utilities, tribes, land managers, business owners, recreationalists, wildlife managers, and decision-makers at all levels of government. This should provide them with the ability to assess their drought risk in real time and before the onset of drought, so that they can make informed decisions that may mitigate a drought’s impacts. While NIDIS is primarily focused on drought, it is becoming clear that NIDIS will consider climate change in developing future tools and strategies for drought.

NIDIS seeks partnerships amongst government agencies and water users in order to develop relevant information and tools for decision makers, DOI already participates in NIDIS. Rather than establishing a new forum as proposed earlier in Option 2, DOI could alternatively choose to work through NIDIS to achieve these goals. NIDIS is focused mainly on monitoring and forecasting drought, and there may still be a need to establish regional forums to discuss and develop collaborative strategies for addressing the impacts of drought and climate change. The Western Governors’ Association has been active with NIDIS and in seeking integrated drought policy, and would be a potential partner for such an effort.

Option 3: Enhance Water Monitoring. An expanded monitoring program informed by the vulnerability assessment in Option 1 could help DOI to refine predictions of climate-related changes to water availability. Monitoring could also refine DOI’s understanding of what locations are vulnerable to climate change and provide early warning when thresholds requiring action are being reached.

The DOI bureaus already have established monitoring networks, but individual stations are at constant risk of termination due to budget constraints. A good example is the USGS streamgauge network. The USGS currently operates about 7,500 streamgages nationwide. Between 2000 and 2006, 661 gages were discontinued, primarily due to lack of funding. Long-term funding for these networks would ensure that long-term monitoring sites are not discontinued. The sufficiency of the existing monitoring program at climate-sensitive locations could be evaluated. As needed, discontinued monitoring sites could be reinstated or additional monitoring could be established in climate sensitive areas. With an expanded monitoring network, scientists can better answer questions of importance to land and water managers. For example, monitoring data can be used to help understand what affects water availability (e.g., dust deposition) and what causes changes to natural sources of water on their lands (e.g., small streams or springs). Such information can help land managers effectively manage for water-supply changes, an integral part of adaptive management.

Option 4: Reevaluate Reservoir Operating Strategies and Long-Term Planning. Operating strategies and long-term planning for DOI reservoirs and other water resources facilities have been developed based upon the historical streamflow record. They are, therefore, based on the assumption that the climate is not changing. This assumption

needs to be reevaluated in light of climate change. To the extent that altered timing or volume of runoff affects management strategies and planning scenarios for reservoirs, these will need to be reexamined. For example, snowmelt runoff in the mountainous headwaters of western rivers is expected to come earlier in the spring under a warmer climate. This will change the timing of seasonal peak streamflow, which will have implications for reservoir management for flood control. An overall decrease in precipitation and runoff may also warrant adjustments to reservoir operations. Many reservoirs are operated to serve multiple purposes, including recreation, flood control, water storage, and mitigation of downstream environmental impacts. Engineering and planning studies can be used to reevaluate, and adapt as appropriate, the operating strategies used to meet these objectives in light of climate change predictions.

To the degree that changes in operating strategies are able to make the most efficient use of available water, damaging effects on downstream ecosystems or on water supply needs can be minimized. Modifying flood control operations, as well as short-term and mid-term operations, may save lives, optimize reservoir storage, enhance the environment, and directly affect everyone who uses the system. Scenarios showing likely reservoir levels could also be used to identify and plan for needed changes in economic uses such as recreational facilities.

The effort to update operating strategies and long-term planning studies could be initiated at a limited number of high-priority locations before being expanded to all DOI water facilities. A technical workgroup could be created to establish standards of practice and to develop a program to acquire or develop suitably scaled climate scenarios. This technical workgroup could also suggest experimental designs.

DOI has a long history of engineering and planning studies of this nature. The success of these studies, however, is dependent on appropriate streamflow scenarios that are scaled to the watershed(s) of interest. Additional climate predictions on a local scale are needed to develop these streamflow scenarios, and the confidence levels of these scenarios need to be determined to facilitate planning.

Option 5: Update Drought Plans for DOI Lands. Drought and water conservation planning is needed to specifically identify potential water shortages and adaptation measures for DOI facilities in DOI lands as well as for native peoples. Water conservation programs could be implemented or strengthened at DOI lands that have been identified as vulnerable to decreased water availability due to climate change. Drought plans to deal with severe conditions could be written or updated. Such a plan may identify triggers for enhanced conservation measures or other management actions and should incorporate new climate change scenarios.

This action is consistent with, and adds a climate change dimension to, the Drought Policy Act of 1998.⁹ The effects of climate change on water scarcity on DOI facilities and tribal water supplies are expected to vary greatly. The vulnerability assessment

⁹ Public Law 105–199

(Option 1) could be used to identify resources most at risk of experiencing water scarcity problems. Focusing drought planning and water conservation activities on vulnerable resources could help DOI alleviate impacts of water scarcity at its facilities and for tribal water supplies.

Drought conservation activities could be highlighted at visitor centers, helping DOI to educate visitors and lead by example.

Option 6: Incorporate Water Availability Changes into Land- and Habitat-Management Activities. Changes in water availability need to be incorporated into land use and broad ecosystem plans, habitat conservation plans, county-level open space plans, and State wildlife plans. Indian water and related plans for land resources management at the local level could also be updated to reflect climate change considerations. DOI could develop tools to support local-level habitat management, restoration planning, and implementation, providing managers with methods to manage the loss or degradation of wetlands and riparian systems, the decrease of instream flows, and the impacts of drought on lands away from streams.

Potential toolbox options include

- removing other impediments that cause stress to aquatic ecosystems, such as non-native competitors and pests;
- removing barriers to migration (e.g., removing barriers to the migration of coldwater fish to higher, colder waters, which may include construction of passageways, removal of non-native species—if they pose impediments—and dam removal);
- restoring flood plains, riparian buffers, and wetlands (Riparian buffers, in particular, can offer shade—cooling effect—and some filtering of contaminants.);
- purchasing land or water rights to protect habitat that provides adequate water;
- moving species to alternate habitats after thorough evaluation of the practicality, feasibility, and potential for causing ecological harm;
- modifying off-road vehicle use, grazing, or other high-impact activities on public lands to compensate for impacts of climate change and dust formation through land disturbance and vegetation damage; and
- providing alternative water sources for wildlife and grazing animals on lands subject to loss of natural water sources (e.g., springs and streams that may become intermittent).

Implementing this plan nationwide could have a large effect on aquatic resources and lands impacted by climate change. Effective management can help ecosystems become more resilient to all types of stresses, not just climate change. Enhanced ecosystems will improve recreational opportunities. Partnerships with other interested groups to implement this option are possible.

Water Quality

STATEMENT OF ISSUE

Water quality in reservoirs, lakes, and rivers will likely change as atmospheric heat is transferred to these bodies of water. Higher water temperature, by itself, can affect habitat suitability and the chemical properties of water. In addition, decreases in the volume of water, whether due to reduced precipitation or increased evapotranspiration, can increase the concentration of dissolved solids and chemical contaminants in rivers and lakes. Any increase in high-intensity storms may also wash from the land and transport more contaminants to bodies of water or cause more treatment plants to overflow.

DESCRIPTION OF ISSUE

Chemical properties of water, such as the concentration of oxygen dissolved in the water, are influenced by water temperature. The transfer of increased atmospheric heat to reservoirs and lakes may reduce dissolved oxygen concentrations. Increased water temperatures in reservoirs and lakes will also increase the potential for algal blooms, which can further reduce oxygen levels.

Increased evaporation rates from lakes and reservoirs and reduced instream flows, coupled with the corresponding reduction in the volume of water, may result in higher concentrations of contaminants and dissolved solids in bodies of water. Contaminants can include sediment, nutrients, chemical pollutants, pesticides, and heavy metals. At the same time, non-point source pollution (i.e., runoff from agriculture fields and roads) may increase with increases in high-runoff events in some areas. The existing sewer and storm drain systems may not be properly sized to handle higher rates of runoff related to possible higher intensity storms, resulting in more frequent or higher volume sewage overflows into streams. As a consequence, factories and industrial areas may accidentally release contaminants and hazardous materials into surrounding waters as the storm drainage systems of these facilities become overwhelmed.

Decreased water quality has the potential to have many impacts. Impacts on aquatic life may arise from increased water temperatures, lower dissolved oxygen concentrations, higher concentrations of sediments and pollutants, or a combination of these factors. Human recreation in affected bodies of water may need to be limited if water quality conditions are sufficiently degraded. Livestock grazing, aquatic ecosystems in DOI lands, and water delivered for water supply or irrigation may also be affected by degraded water quality.

In areas with melting ice and permafrost, previously frozen ground may become more susceptible to erosion, resulting in more sedimentation problems in streams and estuaries. Increased siltation in streams may smother fish eggs, while increased sediment in estuaries may affect phytoplankton. Chemicals and heavy metals can also be released from melting permafrost. While the human health aspects of such potential increases in contaminant concentrations are discussed in the section, "Impacts on Native Peoples," the

Subcommittee did not identify other adaptation options for these water quality problems and the topic may warrant further consideration by other experts in this field.

STATEMENT OF OPTIONS

The specific effects of climate change on a body of water depend on the nature of the climate change impacts. Since these impacts can vary from location to location, as in the “Water Availability” section, a vulnerability assessment is the first option listed for this issue. This would allow DOI to prioritize locations needing action to protect water quality affected by climate change.

Option 1: Assess Vulnerabilities: Water Quality Degradation. Identify DOI resources that are most vulnerable to water quality degradation due to climate change in order to prioritize limited resources.

Option 2: Enhance Water Quality Monitoring. Enhance water quality monitoring to detect changes to water quality due to climate change and to identify solutions tailored to the identified problems. Monitoring can be focused at locations identified in the vulnerability assessment.

Option 3: Implement Non-point Source Pollution Controls. Implement measures to control non-point source pollution to minimize water quality degradation due to climate change’s effects on hydrology. Implementation of controls could be prioritized for locations identified in the vulnerability assessment.

Option 4: Incorporate Water Quality Impacts into Habitat Management Activities. Integrate climate change impacts on water quality into management activities.

Table 3-A provides a tabular look at the analyzed criteria for these options.

ANALYSIS OF OPTIONS

Option 1: Assess Vulnerabilities: Water Quality Degradation. Option 1 of the “Water Availability” section describes a vulnerability assessment in which water-quality considerations could be included.

Option 2: Enhance Water Quality Monitoring. Option 2 of the “Water Availability” section provides a discussion of the benefits and requirements of an enhanced water monitoring program. This program could include water quality monitoring.

Option 3: Implement Non-Point Source Pollution Controls. Non-point source pollution originates from contaminants distributed on the land surface (e.g., pesticides on fields or chemicals on parking lots) that are washed off and transported to streams during runoff events. Climate change may increase high-intensity storms and thereby increase the transportation of contaminants. Enhancing controls of non-point source pollution could help to reduce the pollutant load. Climate change may also increase pollutant

Table 3-A: Water Quality Options

Options	Timescale to Implement	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Option 1: Assess Vulnerabilities: Water Quality Degradation	Short	Low	Large	Low	N/A	N/A	Recreation, Economy, Subsistence
Option 2: Enhance Water Quality Monitoring	Short to start, but continuing	Low–High	Small–Large, depending on scale of implementation	Low–High, depending on scale of implementation	Data can be used for other purposes	Universities, States	Recreation, Economy, Subsistence
Option 3: Implement Non-Point Source Pollution Controls	Short to start, but continuing	Low–High	Small–Large, depending on scale of implementation	Low–High, depending on scale of implementation	General benefit to ecosystem	States, Local governments, Tribes, Irrigation districts, Watershed associations	Recreation, Economy, Subsistence
Option 4: Incorporate Water Quality Impacts into Habitat Management Activities	Short to start, but continuing	High	Small–Large, depending on scale of implementation	Low as policy, High for implementation	May improve overall ecosystem health	N/A	Recreation, Economy

concentrations by reducing the water available for dilution. Reducing the pollutant load through non-point source controls could also reduce this impact.

Storm Water Pollution Prevention Plans and Best Management Practices are routinely used to control non-point sources of pollution. Water quality standards are set by the Environmental Protection Agency (EPA) through the Clean Water Act. Pollutants that affect aquatic habitat include sediment and chemical contaminants. Implementing non-point source controls, following guidelines already in place by the EPA, can help to protect DOI resources from increased water quality degradation. Among the suite of non-point source pollution control measures is restoration of riparian habitat and establishment of riparian buffers. This may be an especially attractive option for adapting to climate change because riparian vegetation can filter some contaminants and provide the cooling effects of shade, while also positively affecting flora and fauna in the area. Other possible control measures include erosion control, agricultural best management practices, wetlands creation, and detention pond construction.

DOI has extensive land holdings, some of which may be non-point sources of pollution to bodies of water. DOI could identify these areas and implement non-point source pollution control measures in locations where its lands are contributing to water quality problems. DOI may also partner with others to implement non-point source pollution control measures on lands not owned by DOI but upstream of critical DOI resources.

Option 4: Incorporate Water Quality Impacts into Habitat Management Activities.

Incorporate climate change impacts on water quality into aquatic and riparian habitat management plans, including broad ecosystem plans, habitat conservation plans, county-level open space plans, and State wildlife plans. DOI could develop a toolbox for developing and implementing landscape-level habitat management and restoration plans that help reduce or mitigate water quality problems caused by climate change.

Many of the tools described in the “Water Availability” section could also be used to address issues of water quality. The toolbox found there could be expanded to include the following additional water-quality tools:

- increasing the size of protected areas through conservation easements or acquisition of inholdings (private land within the boundaries of a Federal preserve) and adjacent land parcels;
- developing early detection and rapid response systems for events affecting water quality such as upstream contaminant spills; and
- minimizing hill slope erosion to prevent transportation of sediment to streams (e.g., through fire management and maintaining vegetated groundcover and pervious surfaces).

Increased Flood Risk

STATEMENT OF ISSUE

More intense rainstorms, earlier melting of seasonal snowpack, and more events of rain or snow are expected consequences of climate change and may create more frequent and severe flooding associated with lakes and rivers. Similarly, glacial outburst floods (sudden releases of water stored within or at the base of glaciers) may also occur more often. Floods can adversely affect local populations of plant and animal species, especially threatened or endangered species that may be concentrated in a particular area. The “Species Migration and Habitat Change” and “Threatened and Endangered Species” sections present more information on this aspect of the flood issue. Here, however, the Subcommittee focuses on visitors to DOI lands and the protection of assets that DOI owns or for which it has management responsibility, such as historically significant sites and facilities.

DESCRIPTION OF ISSUE

DOI protects and maintains many of our Nation’s most culturally and historically significant sites, some of which are located in areas that may become more vulnerable to flooding due to climate change. In addition, bureaus within DOI manage parks, refuges, and other non-urban areas where visitor centers, administrative offices, research facilities, and other structures are vulnerable to significant and costly damage from flooding. DOI land managers are aware of the need to avoid constructing facilities in the flood plain, but in many instances, the flood plain maps and historical rainfall and streamflow data upon which they rely may be outdated because they do not consider the impacts of climate change on future flood events. Bridge and culvert design also depends on expected flood frequencies and these will need to reflect future climate conditions.

In addition to flooding from rivers and lakes, glacial outburst floods pose a threat in the western alpine mountain regions and in Alaska. At peak discharge, these glacial outbursts often match streamflow rates experienced in the worst of floods. For example, at Mount Rainier National Park there have been at least three dozen glacial outburst floods during the past century. Bridges, roads, and park facilities have been damaged or destroyed on at least 10 occasions. Floods originating from glaciers on DOI lands may also pose a hazard to people and property outside the boundaries of the DOI lands.

Warmer temperatures associated with climate change are expected to cause glacial lakes to grow in size and number, potentially exacerbating glacial outburst floods. DOI could take action to reduce risks to life and property in and outside Mount Rainier National Park and at other DOI sites where the potential for glacier outburst flooding and other flood events exists.

STATEMENT OF OPTIONS

Option 1: Assess Vulnerabilities: Flood Risk. Identify resources that are most vulnerable to floods under climate change conditions.

Option 2: Update Flood Frequency Estimates and Flood Plain Maps. Update flood frequency estimates and flood plain maps to reflect climate change conditions.

Option 3: Enhance Emergency Preparedness. Enhance monitoring and implement emergency plans at vulnerable locations.

Table 4-A provides a tabular look at the analyzed criteria for these options.

ANALYSIS OF OPTIONS

Option 1: Assess Vulnerabilities: Flood Risk. An assessment of the risks associated with flooding could be conducted to prioritize locations where the flood frequency estimates, flood plain maps, and emergency plans need to be updated (as suggested under Options 2 and 3). The initial vulnerability assessment could be completed quickly based on currently available information. DOI could identify vulnerable locations by inventorying resources, defining vulnerability criteria, and then using those criteria to identify vulnerabilities and analyze options. See Option 1 of the “Water Availability” section for a more detailed description of these steps.

More detailed analysis of the risks of flood events may be conducted after the initial vulnerability assessment. Additional research and modeling of snowmelt and precipitation-based floods in the context of climate change may be needed. Further, additional research into the dynamics of glaciers may be needed to better understand the risks of glacial outburst floods.

Table 4-A: Increased Flood Risk Options

Options	Timescale to Implement	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Option 1: Assess Vulnerabilities: Flood Risk	Short	High	Large	Low–Medium	N/A	N/A	Recreation, Economy
Option 2: Update Flood Frequency Estimates and Flood Plain Maps	Short	Direct	Large	Low–Medium	N/A	N/A	Primarily Economy
Option 3: Enhance Emergency Preparedness	Short	Direct	Local	Low–Medium	N/A	N/A	Safety

Because of their national importance, DOI might wish to begin reevaluation of the flood risk to historic sites soon. It must be noted that the cost of ensuring safety at some sites could be substantial.

Option 2: Update Flood Frequency Estimates and Flood Plain Maps. Flood plain maps are developed according to guidelines specified by the Federal Emergency Management Agency (FEMA) and its partners, which include DOI bureaus. These maps and the flood frequencies upon which they are based have been developed using the historical hydrologic record. Under future climate conditions, the actual risk of floods may increase in some locations due to changes in precipitation and snowmelt. In areas downstream from glaciers, climate change may significantly increase the risk of glacial outburst floods. Consequently, flood plain maps and flood estimates should be revised using the latest climate change data and modeling techniques and would require periodic updates as climate changes and our knowledge of the actual impacts of climate change evolves. Standard methods of incorporating the potential effects of climate change into flood plain maps have not been established. Consequently, creation of official floodplain maps would require cooperation with FEMA and other interested parties to create these standards.

Updated flood information would allow land managers to incorporate new climate information into the DOI's design and construction policies. Also, based on the new information, managers could consider whether existing facilities should be afforded additional flood protection or be relocated. Updated flood information could also be used by reservoir managers to reevaluate flood storage, as discussed under Option 4 of the "Water Availability" section.

Implementation of this option would be costly and time consuming. As such, this option should be taken first at the most vulnerable locations identified in the vulnerability assessment (Option 1).

Option 3: Enhance Emergency Preparedness. In addition to the DOI-wide emergency response option discussed under DOI-Wide Option 7, the Subcommittee believes that emergency plans should be developed or updated at vulnerable locations identified in the vulnerability assessment (Option 1). Many plans would likely include public education about the nature of the potential floods. Early warning systems and emergency evacuation plans could be developed and implemented, as appropriate. This may include additional monitoring of streamflow in high-risk areas, or of glaciers themselves. Warning systems and evacuation plans should be tested periodically.

Implementation of this option could begin quickly as hazard assessments may already have been done in some locations. Costs associated with developing and implementing plans is expected to be low.

Coastal Impacts Associated with Sea-Level Rise

STATEMENT OF ISSUE

Expected sea-level rise, combined with storm surge effects will have a profound effect on DOI coastal systems, with the most dramatic effects being wetland loss, loss in the productivity of our estuaries, changes in our barrier islands, and increased vulnerability to coastal erosion and flooding. The possible increase in the intensity of coastal storms would increase this vulnerability along the Gulf and South Atlantic coastal margins. Independently or combined, sea-level rise and more intense storms foreshadow extensive changes. These effects are expected to lead to the threatening or loss of coastal DOI natural communities, cultural resources, coastal tribal lands, the coast and economies of the Pacific and Caribbean Islands and our coastal infrastructure, as well as the disruption of energy production and visitor and recreational use.

DESCRIPTION OF ISSUE

According to the IPCC, the global sea level is expected to rise between 0.19 and 0.59 meters (7 and 23 inches) by the end of the century.¹⁰ Coastal and marine systems are already feeling the effect of recent, more gradual sea-level rise [e.g., 0.28 meters (11 inches) since 1931 as measured in the New York harbor region], which is contributing to the loss of fragile coastal wetlands, changes in our barrier island systems, and increases in coastal erosion and flooding.

DOI manages 75 coastal national park units, 162 coastal wildlife refuges, one coastal monument, and over 35,000 miles of our Nation's shoreline—more miles than any other agency or entity. The NPS alone estimates 76 million visitors use its coastal parks each year. Sea-level rise will also have effects on native peoples, including Caribbean and Pacific Islanders, by threatening infrastructure, inundating cultural sites, and modifying habitats of fish and wildlife on which these cultures depend.

Reductions in the biological diversity of estuaries and other coastal habitats will affect all coastal areas of the United States, including parks, refuges, and coastal tribal lands. Sea-level rise will have several negative effects on these fragile systems, including changes in salinity throughout the estuaries, altered flushing rates, changes to the natural hydrology of the estuary, and wetland loss. For example, at the Jamaica Bay Estuary (located in the Gateway National Recreation Area in New York and New Jersey), park scientists have recorded 44 acres of wetland loss over the past 3 years alone. Further, increases in sea level and past storm activity are threatening the East and West Potomac Park Seawall in Washington, DC. This condition is expected to worsen as sea level rises and if increased storms intensity materializes as a consequence of climate change.

¹⁰ IPCC. *Climate Change 2007: Impacts, Adaptation and Vulnerability—Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. M.L. Parry et al., Eds., Cambridge University Press, Cambridge. p. 323.

Coastal wetlands (i.e., those areas along the coast that are inundated by water during high tide and exposed to the air during low tide) are a particularly vulnerable component of estuaries. As the sea level rises, some coastal wetlands are being “drowned in place,” because constant submersion does not allow for the below-water/above-water cycle (associated with tidal changes) that is necessary for wetland development. Without this wet/dry cycle the characteristic plants and animals that inhabit the areas die off. While some wetlands naturally maintain suitable bottom elevation through deposition of sands and sediments, many others do not. Coastal wetlands are critical to the health of marine wetland-dependent species, including numerous endangered species. For example, the loss of intertidal breeding areas has a negative effect on breeding populations of horseshoe crabs. As a consequence of this, species such as the redknot, a biological indicator bird species, that depend on the horseshoe crabs will also decline. Coastal wetlands also serve as strong defenses against coastal flooding and damage associated with coastal storms. As learned from Hurricane Katrina, loss of these defenses will jeopardize our Nation’s infrastructure.

Large portions of our coast are protected by a barrier island system, which helps buffer the intensity of devastating storms. Healthy coastal shorelines also protect public infrastructure and private property from coastal storms. Many of the barrier islands and sections of mainland shoreline are part of the DOI system of parks and refuges. Barrier islands and shorelines also provide valuable habitat for rare, threatened, or endangered species. The resiliency and effectiveness of barrier islands and mainland shoreline in standing up to coastal storms is compromised by coastal development, hardening shorelines, and alterations in natural shoreline sediment processes—all hamper the natural ability of barrier islands to naturally “rollover” (i.e., reshape and rebuild themselves) and respond to storm events.

The DOI coastal lands and waters contain a number of ecological systems—coral reefs, kelp beds, eel grass beds, etc.—that are particularly sensitive to stressors associated with climate change. These ecological systems contribute to the overall health of the near-shore ocean environment. DOI managers need a better understanding of the health of these resources and the effects that sea-level rise, storms, and other factors are having on the health and productivity of these systems.

With predictions of sea-level rise and increased storm intensity, submerged natural and cultural resources (e.g., shipwrecks and lighthouse foundations) administered by DOI will be at increased risk. Because ocean boundaries are not staked with survey markers and fences like terrestrial boundaries, conflicts can arise about responsibilities and authorities for protecting these resources. Land managers need better knowledge of DOI’s legal underwater boundaries, authority, and jurisdiction to protect these resources in advance of storm events and to recover those exposed during storms or by other factors.

Many of the following options focus on restoration of disturbed landscapes. The bureaus focus on restoration as the preferred alternative in their attempts to improve habitat and natural conditions, as well as the biological and physical components of systems, as this

strengthens their ability to withstand new threats potentially posed by climate change. As an example, the NPS directs the restoration of natural systems: “The Service will use the best available technology, within available resources, to restore the biological and physical components of these systems, accelerating both their recovery and the recovery of landscape and biological community structure and function”.¹¹

STATEMENT OF OPTIONS

Option 1: Assess Vulnerabilities: Coastal Impacts. Identify coastal locations most vulnerable to sea-level rise due to climate change in order to prioritize future stabilization and restoration projects.

Option 2: Restore the Natural Hydrology and Ecological Function of Estuaries. Restore the natural health and biological diversity of estuaries threatened by sea-level rise.

Option 3: Protect and Restore Coastal Wetlands, Shorelines, and Barrier Islands. Update management plans for coastal parks and refuges to consider climate change impacts on wetlands, shorelines, and barrier islands and include actions to maintain their resiliency.

Option 4: Develop an Interagency Agreement with the U.S. Army Corps of Engineers for Coastal Restoration. Develop an interagency agreement to facilitate cooperation in restoring DOI coastal shorelines to enhance their health so that they are better able to deal with the effects of climate change.

Option 5: Protect and Restore Sensitive Marine Ecosystems. Develop programs and apply restoration techniques to help protect and restore sensitive marine ecosystems, such as corals, threatened by the effects of climate change.

Option 6: Engage the Office of the Solicitor to Review Marine Boundaries, Jurisdictions, and Authorities for Coastal Parks, Refuges, and other DOI Holdings. Conduct a comprehensive boundary, jurisdiction, and legal authority’s review of all waters within the administrative management of DOI to give managers the tools to help protect these resources.

Table 5-A provides a tabular look at the analyzed criteria for these options.

¹¹ Section 4.1.5. “2006 Management Policies.” National Park Service.

Table 5-A: Coastal Impacts Associated with Sea-Level Rise Options

Options	Timescale to Implement	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M– \$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Option 1: Assess Vulnerabilities: Coastal Impacts							
Sub-options:							
Inventory and Assess Vulnerabilities of Coastal Wetlands	Short	High	Medium	Low		States	
Inventory infrastructure features and stability of coastal barriers under DOI control	Short	High	N/A	Low	N/A	N/A	(Ultimately) Recreation, Flood Control/ Economy
Assess vulnerability of cultural and historical sites on DOI coastlands; if appropriate, move important heritage features to more secure sites	Short	High	Low–High	Low–High, depending on site	Cultural	N/A	Tourism, Culture
Inventory existing threatened infrastructures along the Beaufort and Bering Seas and continue monitoring erosion rates at sensitive DOI sites	Short	High	High	Low	Subsistence	Insular governments, Local communities	Subsistence
Create a catalog of DOI coastlands in need of sediments	Short	High	N/A	Low	May affect the future of coastal landforms and all that they protect	Corps of Engineers	N/A
Review locations for adopting protected marine reserves	Short	Medium	High	Low	Protection for marine mammals	NOAA	Recreation, Economy
Option 2: Restore the Natural Hydrology and Ecological Function of Estuaries							
Sub-options:							
Restore natural water movement and freshwater inflows to estuaries	Medium–Long	High	High	Medium–High	Threatened and Endangered species	State of LA, US ACOE	Recreation, Economy
Backfill/plug manmade canals and other water-diversion projects (e.g., levees, mosquito ditches) to prevent salt water intrusion	Short–Medium	High	High	Low	T&E species, Maintaining salinity	State of LA, US ACOE	Recreation, Economy
Establish a network of groundwater monitoring wells and tidal gauges on DOI coastal units	Short	High	High	Medium	Benefits to coast/island communities	Local governments	N/A

Options	Timescale to Implement	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
Option 3: Protect and Restore Coastal Wetlands, Shorelines, and Barrier Islands							
Sub-options:							
Develop education program about the importance of maintaining coastal wetlands and barrier islands in a changing climate	Short	High	High	Low	Community involvement	NOAA, Sea Grant	N/A
Support 3 demonstration projects in Louisiana (Mandalay NWR), San Francisco (NWR) and New York (Gateway National Recreation Area) (PILOT)	Medium	High	Medium	Medium	T&E species, Salinity and wave buffer	States of LA, CA, NY	Recreation, Economy, Subsistence, Culture
Create a policy regarding infrastructure on DOI-managed barrier islands that limits construction to essential, sustainable, and removable (in advance of storm events) structures	Short	High	Medium	Could save taxpayer \$)	N/A	N/A	N/A
Develop a comprehensive plan to remove those structures/features that limit barrier islands from naturally replenishing themselves, rolling over, reshaping and/or reforming	Short	High	High	Medium	N/A	N/A	N/A
Develop predictive models, scaled down to the park, refuge, village, reservation or other site level	High	High	Medium	Medium	T&E species	States, Corps of Engineers, Tribes	Recreation, Economy, Flood control
Option 4: Develop an Interagency Agreement with the U.S. Army Corp of Engineers for Coastal Restoration							
Coordinate planning between the US ACOE and DOI on projects to provide beneficial fill for DOI restoration projects	Medium	High	Medium–Large	Low–Medium	N/A	US ACOE, States	Recreation, Economy
Option 5: Protect and Restore Sensitive Marine Ecosystems							
Sub-options:							
Restrict marine transportation in sensitive marine ecosystems	Short	High	Medium	Low	Reduced spill potential	NOAA, USCG	Recreation, Economy
Restore coral reefs and sea grass beds	Long	High	High	Medium	T&E species	States	Recreation, Economy
Evaluate the development of a "Rigs to Reefs" program	Medium	High	Medium	Low	T&E species	States	Recreation, Economy
Option 6: Engage the Office of the Solicitor to Review Marine Boundaries, Jurisdictions, and Authorities for Coastal Parks, Refuges, and Other DOI Holdings							
Develop a DOI Solicitor's evaluation of marine boundaries, jurisdiction, and authorities for each DOI area	Medium	High	High	Low	T&E species	States	Recreation, Economy, Culture

ANALYSIS OF OPTIONS:

Option 1: Assess Vulnerabilities: Coastal Impacts. Conducting an assessment of DOI locations along the coast (e.g., wetlands, barrier islands, shorelines, and marine ecosystems) and of infrastructure most vulnerable to sea-level rise due to climate change would help to prioritize future research, monitoring, and possible restoration projects.

DOI coastal areas contain a number of ecological systems that are particularly sensitive to stressors associated with climate change. An inventory and vulnerability assessment of these areas could be conducted to determine their sensitivities to the impacts of climate change. This option could involve the following activities:

- assessing coastal wetlands to help prioritize research, monitoring, and possible restoration needs and to help prioritize possible wetlands restoration projects;
- cataloging the infrastructure features and shorelines of each barrier island under the administrative control of DOI to characterize each island in terms of its ability to help protect nearshore bays, shorelines, and other features; and
- cataloging DOI coastlands in need of sediments to restore them and assessing their status relative to sediment inputs, sea-level rise, subsidence, and other factors that determine their ability to keep pace with sea-level rise.

This information could help DOI pursue activities to restore DOI-managed coastal habitats, if appropriate.

The degradation of the shoreline along the coast, combined with increased threats from sea-level rise and storm activity, threatens DOI-administered infrastructure, particularly along the coast of Alaska. Assessing cultural and historical sites on DOI-administered lands along our coast could determine those that are most vulnerable to climate change. If deemed appropriate, DOI could move important features to more secure sites.

Consultation with State historic preservation offices and with tribes would be required. DOI could also benefit from an inventory of all infrastructure features, the stability of coastal barriers under DOI control, and existing threatened infrastructures (e.g., those present along the Beaufort and Bering Seas). Monitoring efforts on erosion rates at sensitive DOI sites could be continued.

Option 2: Restore the Natural Hydrology and Ecological Function of Estuaries.

Estuaries serve as the nurseries of our oceans. Ensuring healthy estuaries promotes biological productivity. Sea-level rise associated with climate change will influence the salinity levels, the natural hydrology of the system, wetland loss, and biological productivity within our estuaries.

DOI could take a leadership role by developing and implementing estuary management plans for vulnerable estuaries that contain DOI resources. These comprehensive plans could consider the effects of climate change on estuary health and work to restore the potentially impacted estuaries.

DOI could restore natural water movement and freshwater inflows to coastal marshes and estuaries impacted by climate change. For example, depending on the vulnerability

assessment (Option 1), DOI could work with the State of Louisiana to restore the Mississippi River to the Mississippi River delta, or it could incorporate climate change and sea-level rise effects into the Comprehensive Everglades Restoration Plan.

Establishing a monitoring network would allow managers to detect local changes from sea-level rise and saltwater intrusion into DOI coastal habitats. Based on this monitoring, management could modify their plans to include proactive measures such as backfilling or plugging manmade canals or using other water diversion techniques like levees or mosquito ditches.

Option 3: Protect and Restore Coastal Wetlands, Shorelines, and Barrier Islands.

Coastal wetlands, shorelines, and barrier islands all provide protection from increased floods that may be associated with climate change. Additionally, they are critical to the ecological health of marine and coastal systems.

Management plans for coastal parks and refuges could be updated to consider climate change impacts on wetlands, shorelines, and barrier islands and to include specific actions to maintain their resiliency. Detailed plans for vulnerable wetlands, shorelines, or barrier islands may be appropriate. DOI could create a program that promotes the maintenance and sustainability of wetlands, shorelines, and barrier islands. Such a program would likely also include guidance on when it is no longer appropriate to replenish existing wetlands, shorelines, or barrier islands. Finally, DOI could develop an education program that explains the valuable features of naturally functioning wetlands, shorelines, and barrier islands. Enhanced public awareness may help to build support for DOI policies on these coastal features, where appropriate.

Vulnerable locations identified in the vulnerability assessment (Option 1) could be prioritized for restoration, protection, and development of management plans. Monitoring erosion at some of these locations may be appropriate if infrastructure failure would pose an imminent and substantial risk to public health, safety, or the environment.

Coastal Wetlands

Information about the processes controlling the reestablishment of coastal wetlands is incomplete. DOI has three major coastal wetland restoration demonstration projects in progress (i.e., Mandalay National Wildlife Refuge in Louisiana, San Francisco National Wildlife Refuge in California, and Gateway National Recreation Area in New York and New Jersey). These projects provide opportunities to learn about the physical and biological processes that control wetland restoration and to test restoration techniques. DOI could create a forum for discussing ongoing restoration projects, restoration techniques, and criteria that could be used to evaluate future restoration projects. Using knowledge learned from the demonstration projects, DOI could expand its wetland restoration program to include other high-priority wetlands.

DOI could encourage best management practices and alternatives to hardened shorelines (e.g., bulkheads, jetties, rocks, and other rip-rap used to protect shorelines from erosion) that create a barrier to natural wetland development as sea-level rises. DOI could create

criteria for formally reviewing existing and proposed hardened shoreline features for its lands.

Shorelines and Barrier Islands

Barrier islands absorb storm effects and, like shorelines, must be replenished (whether naturally or by man) in order to continue to provide storm protection. Developmental features (including hardened shorelines and other structures) that limit natural replenishment of barrier islands and shorelines, or that restrict barrier island movement and rollover, can be removed. If appropriate, their removal should be guided by reviews of existing infrastructure, the establishment of guidelines for the construction of any new infrastructure, and the use of sustainable designs for those facilities essential to visitor and/or administrative use of these areas. Where removing these features is impractical, DOI could explore alternatives such as sand by-pass systems (mechanical systems that pump sand around such features). Pilot projects are in use or underway at Assateague Island National Seashore and Sandy Hook (Gateway National Recreation Area) and might be evaluated for possible use in other locations.

Currently, there is little or no predictive modeling on the effects of climate change on our barrier island system. Developing predictive models that are scaled down to the level of individual parks and refuges could help planners and managers make sound decisions about visitor and recreational use and infrastructure planning.

Option 4: Develop an Interagency Agreement with the U.S. Army Corps of Engineers for Coastal Restoration. DOI often needs dredge material for wetland restoration, beach re-nourishment, and barrier island maintenance; and the U.S. Army Corps of Engineers controls the dredging of rivers and seabeds. Currently, there is no regular process in place to coordinate the transfer of this material from the Corps to DOI coastlands in need. An interagency agreement between DOI and the Corps could facilitate the distribution and use of dredge material for rehabilitation projects.

Option 5: Protect and Restore Sensitive Marine Ecosystems. Based on the vulnerability assessment (Option 1) and within areas under DOI jurisdiction, DOI could develop adaptation strategies to protect and restore these sensitive aquatic and marine habitats. Efforts would focus on reducing current stressors on marine ecosystems to increase their resilience to thermal stress and ocean acidification. For example, DOI could restrict marine transportation or establish marine protected areas in which damaging activities such as vessel anchoring, coral harvesting, and trawling are prohibited. Such areas might include those with coral reefs, sea grasses, or shallow live bottoms to protect critical ocean bed habitat.

DOI could also encourage the re-propagation of corals and eel grass to restore healthy communities. This action would require such steps as collecting coral and eel grass from live reefs or environments where they would not survive and transplanting them to degraded reefs. Additionally, DOI could explore how to create new communities, perhaps through modifications to existing programs such as its Rigs-to-Reefs program.

Option 6: Engage the Office of the Solicitor to Review Marine Boundaries, Jurisdictions, and Authorities for Coastal Parks, Refuges, and Other DOI holdings.

Marine boundaries for coastal parks, refuges, and other DOI holdings are frequently based on “firm” points of reference (e.g., a quarter mile from mean low water level) established in the enabling legislation. As sea levels rise and shorelines erode due to increased storm activity, these land-based reference points change, calling marine-based boundaries into question. Additionally, the marine jurisdictions and authorities of many parks, refuges, etc., are not clearly defined due to variations in States authorities, types of Federal jurisdiction, etc. Better knowledge of DOI’s legal underwater boundaries, authorities, and jurisdictions is needed to protect submerged natural and cultural resources. For example, as storms expose shipwrecks or other cultural resources, these same storms may alter the reference point that established the jurisdictional authority to protect and manage the resource. The DOI’s Office of the Solicitor could review and prepare opinions to clearly identify marine boundaries, jurisdictions, and authorities for each coastal park, refuge, and other DOI holding in light of altered coastal lines due to climate change.

Melting Permafrost and Sea Ice

STATEMENT OF ISSUE

The melting of the cryosphere—the frozen part of the Earth’s surface, including polar ice caps, mountain glaciers, sea ice, snow cover, lake and river ice, and permafrost—from climate change poses serious threats to human and natural communities and infrastructure located in or near these areas. Moreover, potential impacts on resource development activities could have significant adverse impacts not only on local economies but also on the U.S. economy as a whole.

DESCRIPTION OF ISSUE

Warming of the Arctic and other areas characterized by snow and ice will have significant effects on animal and plant life. For example, the loss of sea ice due to warmer temperatures may be reducing the platform that seals and walrus traditionally use to rest between searches for fish and mussels. In some Arctic regions, polar bears appear to be experiencing shorter feeding periods and decreased accessibility to the seals they hunt because of reductions in sea ice.

The effects of a melting cryosphere will also have substantial human implications that should be considered in DOI’s efforts to cope with climate change. For example, the “Impacts on Native Peoples” section describes how erosion related to the melting of the permafrost threatens a number of Alaskan communities, some of which will need to be fortified or relocated.

It is reported that sea ice off the Arctic coast of Alaska is thawing and retreating, having widespread effects on marine ecosystems, human settlements, and subsistence activities. Since the 1960s, sea ice over large areas of the Arctic Basin has thinned by 3 to 6 feet, losing about 40 percent of its total thickness. The retreat of sea ice allows larger storm

surges to develop, and coasts also made vulnerable by permafrost thawing, face increasing risk of inundation and erosion.

Permafrost is a critical component of the Arctic system. It has profound effects on hydrology, erosion, vegetation, and human activities. It limits movement of ground water and the rooting depth of plants. On slopes, it allows fluid-like movement of surface soil and deposits. Seasonal thawing over continuous permafrost creates a saturated surface layer in which pools of meltwater accumulate, a condition that is likely to create marsh and tundra ecosystems and peat formation. Thawing permafrost creates uneven surface topography that includes pits, troughs, mounds, and depressions. Forests and other ecosystems may be damaged by flooding in low-lying zones. Thawing of the permafrost can also contribute to erosion and increased sedimentation and siltation in rivers, posing additional environmental concerns.

This damage is particularly relevant to communities throughout Alaska, where more than 60 percent of the land is federally owned, much of it managed by DOI. On a national level, thawing of the permafrost may have serious long-term implications on the development and production of oil and gas in Alaska, for the operation of the Trans-Alaska Pipeline, and for the potential construction of a pipeline from Alaska to the continental United States to deliver natural gas. These energy supplies are essential to our Nation's economic stability and growth and energy security.

Climate change effects on the cryosphere will affect DOI facilities and operations as well as those of its contractors and regulated entities. Alaska contains, by area, 75 percent of U.S. national park lands and 90 percent of wildlife refuge lands. Tourism associated with the parks and refuges is a major component of the Alaskan economy.

If the new conditions that are expected to result from melting sea ice and permafrost come to fruition, DOI resource managers would need to take new measures to ensure the safety of the facilities and infrastructure they manage, as well as to ensure that contractors, concessionaires, lessees, and others who operate on DOI lands can do so safely and in an environmentally sound manner.

STATEMENT OF OPTIONS

Although the thawing of the permafrost and the melting of the sea ice each present unique problems and challenges, there are common actions that DOI could take to help minimize the adverse effects resulting from these climate-related phenomena.

Option 1: Assess Vulnerabilities: Melting Cryosphere. Assess DOI facilities for possible damage that could be caused by melting permafrost and sea ice.

Option 2: Modify Contracts, Leases, and other Legal Instruments to Reflect Effects of Melting Permafrost and Sea Ice. Ensure that contractors, lessees, and other entities conducting activities on Federal lands where permafrost is melting do so safely and in a way that recognizes and protects the changing ecosystem.

Table 6-A provides a tabular look at the analyzed criteria for these options.

Table 6-A: Melting Permafrost and Sea Ice Options

Options	Timescale to Implement	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Option 1: Assess Vulnerabilities: Melting Cryosphere	Short–Long	Direct	Confined primarily to Alaska	Medium–High	N/A	N/A	Safety, Economy
Option 2: Modifying Contracts, Leases, and Other Legal Instruments to Reflect Effects of Melting Permafrost and Sea Ice	Medium–Long	High	Confined primarily to Alaska	Medium–High	N/A	Concessionaires and Lessees	Economy

ANALYSIS OF OPTIONS

Option 1: Assess Vulnerabilities: Melting Cryosphere. DOI bureaus located in Alaska could assess all facilities and other assets under their jurisdiction to identify those that are vulnerable to damage from thawing permafrost or melting sea ice. DOI bureaus could then identify and take cost-effective actions as appropriate. The bureaus could incorporate the effects of expected changes in the permafrost and sea ice conditions in all decisions on the design, construction, and location of future facilities and infrastructure. Management plans could be amended to include such actions.

Option 2: Modify Contracts, Leases, and other Legal Instruments to Reflect Effects of Melting Permafrost and Sea Ice. The bureaus could ensure, through regulations or contract terms, that entities operating on DOI lands (e.g., pipelines, timber companies, park concessionaires, and oil and gas lessees) use the most appropriate technology to protect the environment and ensure the safety and durability of their facilities and operations in light of current and expected conditions related to melting permafrost and sea ice.

Implementing both Option 1 and Option 2 would generally be confined to the State of Alaska and would help protect and preserve life, property, and the Alaskan environment. However, some other States with high-altitude lands will also be affected, and this option would apply to them too. Although most of the benefits would be local, national economic benefits would build as proposed responses continue critical energy production and transportation activities. Implementation of these options could begin right away.

Impacts on Native Peoples

STATEMENT OF ISSUE

Many American Indian and Alaska Native groups are highly vulnerable to the effects of climate change. The Secretary of the Interior exercises fiduciary responsibility for the lands and resources of Indian country and supports American Indians through funding of programs in such areas as education, housing, and law enforcement. The Secretary is also a partner with tribes and Alaska Native corporations in land management. For these reasons, the potential effects of climate change on American Indians and Alaska Natives are highly relevant to DOI's strategic mission areas of resource management, resource use, recreation, and serving communities.

In addition to responsibilities in the contiguous 48 states and Alaska, DOI bureaus manage lands and resources on the State of Hawaii and on other Pacific and Caribbean islands. The Secretary has certain administrative responsibilities regarding these U.S. insular territories. Climate change is likely to significantly affect these locations. Such effects are also relevant to DOI's mission.

DESCRIPTION OF ISSUE EFFECTS

Geography and modes of life make many American Indians and Alaska Natives particularly vulnerable to the effects of climate change. According to the IPCC, this vulnerability can be analyzed in terms of three sets of factors: *exposure* to the forces of climate change, *sensitivity* to their effects, and lack of *adaptive capacity* to respond.¹² Many native groups are located in areas particularly exposed to changing environmental conditions, such as the Arctic or the arid Southwest. A reliance on subsistence foods through hunting, fishing, gathering, and horticulture increases their sensitivity to climate-induced ecosystem change. In addition, the capacity to adapt to the forces of climate change is often limited by lack of adequate infrastructure (e.g., for water storage), capital (e.g., to facilitate economic diversification or to fund hardening of exposed structures), or technical knowledge (e.g., engineering expertise in alternative energy technologies).

The place that both subsistence resources and specific landscapes have in the lives of native peoples, including American Indians and Alaska Natives, makes it difficult to assign an economic value to the effects of climate change, and thus to realistically assess the costs and benefits of any adaptation strategy. Moreover, the subsistence activities put at risk by climate change affect far more than the economy; rather, for native peoples, hunting, fishing, gathering, and horticulture typically shape the patterns of social life, the processes of cultural transmission, and the ritual expression of spirituality.

Contiguous United States

The U.S. government, through DOI, exercises trust responsibilities for more than 300 American Indian tribes in the contiguous 48 States. Treaties, Federal statutes, and case law have created a complex web of resource rights and preferences, such as opportunities for hunting, fishing, and gathering, both on and off reservations, as well as rights to water for the productive use of reservation lands. Yet all these resources are potentially put in jeopardy by climate change.

The implications of climate change for tribes of the contiguous 48 States are difficult to characterize in general. Existing environmental conditions and the anticipated regional effects of climate change are diverse. The environmental dependencies of tribes across the contiguous 48 States are equally varied.

In many areas, climate change will affect American Indians in much the same way that it affects non-Indians, and quite differently from the way it affects American Indians in another region. Indian ranchers in Arizona, for example, will be challenged by the reduced availability of water much as non-Indian ranchers. Many of the conditions exacerbated by climate change reflect a zero-sum game (in which any gain by any one party must result in a corresponding loss by others), with diverse groups of users competing for an ever-scarcer resource, whether groundwater, fish runs, or forage for grazing. For this reason, management solutions will often require improved coordination

¹² IPCC. "Vulnerability." Annex B: Glossary. *Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. James J. McCarthy *et al.*, eds. Cambridge: Cambridge University Press.

among competing resource users, Indian and non-Indian, rather than actions that address the challenges facing a single group.

Social impacts of climate change in Indian country may be significant in the same geographic region. The ritual and spiritual significance of water for many Indian tribes of the Southwest, for example, suggests that water scarcity is likely to create an additional set of social consequences when compared with non-Indians. Nonetheless, in this context the opportunities for action by DOI are defined largely by the fundamental physical and biological effects of climate change. Three sets of projected climate change impacts are particularly relevant:¹³

1. Decreased availability of water. Water for Tribes of the southwestern United States is particularly at risk from the effects of rising temperatures, altered precipitation patterns, reduced groundwater recharge, and declining streamflows. This is a critical issue for many western and southwestern tribes. The right to water to ensure the beneficial use of reservation lands has long been recognized by the Federal courts as an implied right reserved by tribes in the course of treaty-making.¹⁴ This is an area in which the Federal government has very significant trust responsibilities. See the issues and options in the section “Water Availability.”
2. Vulnerability of culturally significant species. Climate change is likely to further jeopardize the viability of many plant and animal species that have specific economic or ritual importance for native peoples. For example, the anadromous fisheries of the Columbia River system (including chinook, coho, sockeye, and steelhead fisheries), which have great importance for tribes of the Pacific Northwest, are expected to be further damaged by climate change. See the issues and options in the section “Threatened and Endangered Species.”
3. Flooding. Rising sea levels in many coastal regions put tribal lands and cultural resources at risk of flooding. For example, this would include threats of inundation to Seminole and Miccosukee reservations in Florida.¹⁵ See the issues and options in the section “Coastal Impacts Associated with Sea-Level Rise.”

STATEMENT OF OPTIONS

Option 1: Assess Vulnerabilities: Impacts on Native Peoples. Collaborate with tribal organizations on a vulnerability assessment and action plan to conserve critical tribal resources.

¹³ Hanna, Jonathan M. “Native Communities and Climate Change: Protecting Tribal Resources as Part of National Climate Policy.” Natural Resources Law Center, University of Colorado Law School, Boulder. 2007. Available online: <http://www.colorado.edu/law/centers/nrlc/publications/ClimateChangeReport-FINAL%209.16.07.pdf> (Accessed Sept. 19, 2007).

¹⁴ *Winters v. United States*, 207 U.S. 564 (1908).

¹⁵ Hanna, Jonathan M. “Native Communities and Climate Change.” 2007. p. 26.

Table 7-A provides a tabular look at the analyzed criteria for this option.

Table 7-A: Impacts on Native Peoples, Contiguous 48 States, Options

Options	Timescale to Implement	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
CONTIGUOUS 48 STATES							
Option 1: Assess Vulnerabilities: Impacts on Native Peoples	Medium–Long	Moderate, multiple partners	Large	Medium	Preserves way of life	NCAI, National Tribal Environmental Council	Subsistence, Economy

ANALYSIS OF OPTIONS

Option 1: Assess Vulnerabilities: Impacts on Native Peoples. In partnership with tribes, DOI could undertake an assessment of climate change impacts on critical tribal resources in the contiguous 48 States. In the first stage of this effort, DOI would consult and collaborate with tribal government to define the assessment's aims, scope, and methods. In addition to tribal governments, potential partners include the National Tribal Environmental Council and the National Congress of American Indians. Sustained collaboration with tribes is essential to this effort, both because of DOI's trust obligations and because scientific information can be supplemented by traditional knowledge of environmental and social conditions for an effective assessment of the effects of climate change.

The intended products would include a vulnerability assessment for key resources and an action plan for conserving those key resources in greatest jeopardy from the effects of climate change. Coordination with other Federal agencies should be maintained throughout the effort to avoid duplicating existing studies and other on-going initiatives. A number of different assessment methods, including vulnerability analysis, have been refined for the purpose of climate change research.¹⁶ It may be useful for DOI to issue guidance to its bureaus regarding the most appropriate methods and approaches for assessing the human impacts of climate change.

Alaska

In contrast to the contiguous 48 States, the likely effects of climate change on the over 200 federally recognized Alaskan tribes are more consistent across the State. Three sets of effects have particular importance: (1) disruption of subsistence activities; (2) damage to housing and other infrastructure, especially in coastal communities; and (3) increased exposure to pollutants.

Some of the expected manifestations of climate change in Alaska include atmospheric warming, reduction in the extent of sea ice, thawing of permafrost, glacial melting, altered streamflows, increased sediment infilling of fish spawning beds, and northward expansion of coniferous boreal forest, displacing tundra. In combination, these changes are expected to create major shifts in the physical and biotic conditions that provide the basis not only for subsistence economies, but also for much of the activity in the formal economy upon which many Alaska Natives (as well as non-natives) depend, including commercial fishing, forestry, oil and gas development, and tourism. Some of the anticipated consequences of these changes include reduced abundance and biodiversity of

¹⁶ Eakin, Hallie, and Luers, Amy Lynd. "Assessing the Vulnerability of Social-Environmental Systems." *Annual Review of Environment and Resources*, 31. 2006. p. 365–94.

Carter, T. R., *et al.* "New Assessment Methods and the Characterization of Future Conditions." *Climate Change 2007: Impacts, Adaptation and Vulnerability—Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M. L. Parry *et al.*, eds., Cambridge University Press, Cambridge, UK, 2007. p. 133–171.

freshwater fish; declining populations of polar bear, walrus, seal, and cetaceans; and impacts to caribou habitat, population, and migration patterns.¹⁷

Some of the potential social and economic impacts of these ecological changes include reduced nutrition and associated health impacts; disruption of rural community-level social relationships based on exchange of subsistence foods; reduced sense of well being; disruption of cultural transmission through reduced participation in subsistence practices; increased cost and risk entailed in subsistence hunting and fishing; and greater reliance on wage labor and transfer payments.

Retreat of sea ice allows larger storm surges to develop, increasing the risk of inundation and increasing erosion on coasts that are also made vulnerable by permafrost thawing. One effect of these combined forces is to undermine homes and other structures located in vulnerable settings. A 2003 study by the Government Accountability Office (GAO) found that flooding and erosion affect over 180 Alaska Native villages. For a number of threatened villages, relocation is the only realistic option. The estimated cost of relocating Kivalina, a coastal village of under 400 people, ranges from \$100 to \$400 million.¹⁸ Many of the villages examined in the GAO report, as well as other rural Alaska communities facing relocation, cannot qualify for existing Federal assistance programs.

Climate change is likely to affect both wind patterns and ocean currents in ways that increase the transport of heavy metals and persistent organic pollutants to the Arctic. A significant amount of these pollutants is now bound up in ice and permafrost. As these melt, human exposure to heavy metals (including mercury and lead), persistent organic pollutants, and naturally occurring radionuclides, will increase.¹⁹ Heavy metals and persistent organic pollutants pose the greatest health risks. Exposure of populations to heavy metals can adversely affect children's mental development; and exposure to persistent organic pollutants can reduce resistance to infections and alter children's growth and sexual development.

¹⁷ Anisimov, O.A., *et al.* "Polar regions (Arctic and Antarctic)." *Climate Change 2007: Impacts, Adaptation and Vulnerability—Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. M.L. Parry *et al.*, Eds., Cambridge University Press, Cambridge. 2007. p. 666.

Juday, Glenn P., *et al.* "Forests, Land Management, and Agriculture." *Arctic Climate Impact Assessment*. New York: Cambridge University Press. 2005. p. 851.

Nuttall, Mark *et al.* "Hunting, Herding, Fishing, and Gathering: Indigenous Peoples and Renewable Resource Use in the Arctic." *Arctic Climate Impact Assessment*. 2005. p. 656–57, 680–85

Wrona, Frederick J. *et al.* "Freshwater Ecosystems and Fisheries." *Arctic Climate Impact Assessment*. 2005. p. 434.

¹⁸ Government Accountability Office. "Alaska Native Villages: Most Are Affected by Flooding and Erosion, but Few Qualify for Federal Assistance." Report GAO-04-142. 2003. p. 2.

¹⁹ AMAP (Arctic Monitoring and Assessment Programme). "Arctic Pollution 2002." Oslo, Norway. 2002. p. 97–111. Available online: <http://amap.no/> (Accessed Sept. 17, 2007).

STATEMENT OF OPTIONS

Option 1: Assess Vulnerabilities: Alaska Subsistence Systems. Prepare a vulnerability assessment of subsistence systems in Alaska, in collaboration with the State of Alaska, Alaska Native representatives, rural communities, and other appropriate organizations and governmental agencies.

Option 2: Support Interagency Activities to Address Damage to Housing and Other Infrastructure. Support interagency activities addressing threatened infrastructure.

Option 3: Disseminate Information Regarding Pollutants. Disseminate information on anticipated climate change impacts affecting public health, as appropriate.

Table 8-A provides a tabular look at the analyzed criteria for these options.

ANALYSIS OF OPTIONS

Option 1: Assess Vulnerabilities: Alaska Subsistence Systems. In partnership with the State of Alaska, Alaska Native representatives, rural communities, other appropriate organizations and governmental agencies, and other Federal agencies, DOI could participate in and perhaps coordinate a comprehensive interagency vulnerability assessment regarding the effects of climate change on rural subsistence systems. Because of the multifaceted nature of climate change, the task of identifying likely human impacts poses a significant analytic challenge. Sustained collaboration with tribes and rural communities is fundamental to such an assessment. Such collaboration is also needed because scientific information must be supplemented by traditional knowledge of environmental and social conditions for an effective assessment of Alaskan subsistence systems.²⁰

Option 2: Support Interagency Activities to Address Damage to Housing and Other Infrastructure. DOI, through its bureaus in Alaska, could take a leadership role in developing and disseminating information on anticipated changes in permafrost and sea ice conditions. Consistent with DOI's legislative mandates and authorities, the bureaus could work with the Denali Commission, the U.S. Army Corps of Engineers, the State of Alaska, tribal organizations, and Alaska Native corporations to address these and other hazards posed to infrastructure as a result of climate change.

²⁰ Austin, Diane *et al.* Building Partnerships with Native Americans in Climate-Related Research and Outreach. CLIMAS Report Series CL2-00. University of Arizona, Tucson. 2000. Available online: <http://www.ispe.arizona.edu/climas/pubs/CL2-00.pdf> (accessed Sept 17, 2007).
Huntington, Henry *et al.* "The Changing Arctic: Indigenous Perspectives." *Arctic Climate Impact Assessment*. New York: Cambridge University Press. 2005. p. 61–98.

Table 8-A: Impacts on Native Peoples, Alaska, Options

Options	Timescale to Implement	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
ALASKA							
Option 1: Assess Vulnerabilities: Alaska Subsistence Systems	Medium	Moderate, multiple partners	N/A	Medium	N/A	State of AK, Federal Subsistence Board, Alaskan Native tribes	Subsistence
Option 2: Support Interagency Activities to Address Damage to Housing and Other Infrastructure	Medium	Low	Low	Low	N/A	Denali Commission, US Army Corps of Engineers	Economy, Culture
Option 3: Disseminate Information Regarding Pollutants	Medium	Low	N/A	Low	N/A	Indian Health Service, EPA	Subsistence, Economy, Culture

The Denali Commission is an innovative Federal-State partnership designed to provide critical utilities, infrastructure, and economic support throughout Alaska. In a response to the 2003 GAO report, now Deputy Secretary Lynn Scarlett indicated that DOI planned to assist the Denali Commission in addressing these issues. Some work by DOI agencies has already been done. In 2004, the FWS completed a land exchange in response to erosion at the village Newtok, while both the FWS and NPS are working with several other Alaska Native villages on land exchanges and other actions to respond to these hazards.

Option 3: Disseminate Information Regarding Pollutants. DOI, through its bureaus in Alaska, could partner in developing and disseminating information on anticipated effects of climate change likely to affect the transport and human ingestion of heavy metals, persistent organic pollutants, and radionuclides. Consistent with DOI's legislative mandates and responsibilities, the bureaus could work with the State of Alaska, tribes, Alaska Native corporations, the EPA, and other appropriate agencies to ensure that the potential for increased exposure to such pollutants is considered in the design of public health programs and other responses.

United States (50 States and Insular Territories)

In addition to responsibilities in the contiguous 48 States and Alaska, DOI bureaus manage lands and resources in Hawaii, American Samoa, Guam, and other islands in the Pacific, and in Puerto Rico and the U.S. Virgin Islands in the Caribbean. The Secretary of the Interior also has administrative responsibility for coordinating Federal policy in the territories of the U.S. Virgin Islands, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands.²¹ On most of these islands, native peoples compose a significant proportion of the population.

Small islands are particularly vulnerable to the effects of climate change, in part because settlements and infrastructure are predominantly located on or near coastlines. Sea-level rise is likely to increase storm surge, erosion, and inundation, resulting in significant damage to buildings and infrastructure. Sea-level rise, extreme events, and a projected decline in water availability on many islands are likely to adversely affect both commercial and subsistence agriculture. For many of these islands, a narrow resource base and a relatively large population density also contribute to this vulnerability.²² For native peoples of the United States, including its Pacific and Caribbean island territories, environmental observations and resource strategies are usually expressed in localized and culturally salient terms, rather than in the more abstract and universal language of the environmental sciences.²³ Such traditional ecological knowledge is particularly relevant here because it is often more likely than scientific observations to

²¹ For more information, see the DOI Office of Insular Affairs Web site, http://www.doi.gov/oia/Firstpginfo/oia_responsibilities.html.

²² Mimura, N., *et al.* "Small Islands." *Climate Change 2007: Impacts, Adaptation and Vulnerability—Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, *et al.*, Eds., Cambridge University Press, Cambridge, UK. 2007. p. 689–91.

²³ Berkes, Fikret *et al.* "Rediscovery of Traditional Ecological Knowledge as Adaptive Management." *Ecological Applications*, 10 (5). 2000. p. 1251–1262.

capture both subtle environmental changes at a local scale and their implications for native social systems and ways of life. Juxtaposing environmental science and traditional ecological knowledge could significantly improve our understanding of how climate change is affecting native peoples.

STATEMENT OF OPTIONS

Option 1: Create a Geospatial Local Knowledge Database to Assess Climate Change Impacts on Areas Associated with Native Peoples. Work with tribal governments and other native organizations to develop a geographic information system documenting local impacts of climate change.

Table 9-A provides a tabular look at the analyzed criteria for this option.

ANALYSIS OF OPTIONS

Option 1: Create a Geospatial Local Knowledge Database to Assess Climate Change Impacts on Areas Associated with Native Peoples. In close coordination with tribal governments and other native organizations, DOI could develop an internet-accessible geographic information system to integrate traditional ecological knowledge and scientific information bearing on the effects of climate change on areas associated with native peoples of the United States.

This system would be used to document localized impacts of climate change that have affected economic and social practices and values, and to compare these observations with environmental data and trends derived from scientific research. Traditional ecological knowledge would be a major component of the system, complementing western-based scientific data. The juxtaposition of local and scientific knowledge organized in a geospatial framework would increase the ability of tribal organizations to anticipate and adapt to climate change. The system would also significantly improve DOI's ability to characterize climate change impacts on native peoples across the 50 States and island territories, providing a better understanding of the big picture and increasing DOI's ability to respond systematically to this challenge.

This proposal responds to requests from American Indian and Alaska Native organizations at a July 2007 symposium on climate change impacts. The USGS could serve as the lead DOI bureau for this project, building on current USGS participation on the NativeView Tribal College Board. The project could be initiated inexpensively. An additional benefit of this option would be the opportunity to enhance native students' knowledge of geospatial and computer technologies.

Table 9-A: Impacts on Native Peoples, United States (50 States and Insular Territories), Options

Options	Timescale to Implement	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
UNITED STATES (50 States and Insular Territories)							
Option 1: Create a Geospatial Local Knowledge Database to Assess Climate Change Impacts on Areas Associated with Native Peoples	Short–Medium	Moderate, multiple partners	Large	Low	Tribal scientific and technical training	NativeView, Tribal College Board	Subsistence, Economy, Culture

Outbreaks of Pests, Invasive Species, and Diseases

STATEMENT OF ISSUE

Climate changes may contribute to pest outbreaks and increases in invasive species populations, potentially simplifying or homogenizing ecosystems. Climate change may also lead to increases in endemic and exotic diseases among plant and animal species on DOI lands.

DESCRIPTION OF ISSUE

The “Fourth Assessment Report” of the IPCC concluded that climate change and variability will impact food, fiber, and forests around the world due to the effects on plant growth and yield because of elevated carbon dioxide, higher temperatures, altered precipitation and transpiration regimes, increased frequency of extreme events, and modified weed, pest, and pathogen pressure. Warmer temperatures have already enhanced the opportunities for insects to spread across the landscape. Climate change can shift the current boundaries of insects and pathogens and modify tree physiology and the ways trees defend themselves. Increased climate extremes may promote pest outbreaks and plant disease.

At northern latitudes and in alpine regions, frosts and generally low temperatures appear to limit insect outbreaks. Outbreaks currently held back from northern ranges could become more frequent. If the climate warms and this area of transition becomes exposed to more droughts, insect outbreaks may become a major factor at higher latitudes.²⁴ For example, whitebark pine is found in a narrow belt at the timberline above other conifer species that require warmer temperatures. These trees are now susceptible to attack by mountain pine beetles, the expansion of which used to be limited due to cold weather. However, the expansion now may move into the north and east parts of the United States.²⁵

Insect and pest epidemics greatly increase the risk to natural resources and socioeconomic infrastructures and may exacerbate the risk of other types of disturbances such as wildland fires and floods. Without acting to enhance the resiliency of ecosystems today, without thoughtful preparation and planning, and without early intervention through surveillance and detection systems insect and pest epidemics may become increasingly difficult to manage.

Outbreaks of diseases and the movement of disease vectors (organisms that spread disease from one host to another, such as ticks and mosquitoes) may occur as

²⁴ IPCC. *Climate Change 2007: Impacts, Adaptation and Vulnerability—Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. M.L. Parry *et al.*, Eds., Cambridge University Press, Cambridge. 2007. p. 228.

²⁵ “Bark Beetles Hammer Forests throughout the West, Headed Eastward.” *Refuge Notebook*. Kenai National Wildlife Refuge, U.S. Fish and Wildlife Service—Alaska. Available online: <http://kenai.fws.gov/overview/notebook/2005/nov/25nov2005.htm>. (Accessed Jan. 18, 2008).

temperatures increase. Disease vectors will generally become more concentrated around existing water sources, and wildlife, humans, and vectors will come into increasing overall contact because of concentrated water sources. One example of a projected change in disease is bluetongue, a viral disease transmitted by biting insects that affects primarily sheep, but also cattle, goat, and deer.²⁶ Models project that it may spread from the tropics and become more prevalent in the mid-latitudes.²⁷

Native species are sometimes less able to compete with exotic species as climate changes, particularly if they are at the edge of their natural range. As native species die, both exotic and U.S. invasive species will take over the empty niches if they are better able to survive in the new climate. Competition and predation from non-native species poses risks to approximately 50 percent of threatened and endangered species.²⁸ This is a critical concern to DOI because the conversion of native plant communities to exotics reduces the productivity and diversity of DOI lands and the natural and commodity uses available.

Once invasive species cross a threshold to dominance, costs to restore native species become prohibitively expensive. Invasive species can increase the susceptibility to wildland fires and reduce the productivity of desirable species, including those wanted for livestock grazing on DOI lands. For example, the increase in wildland fires in the Great Basin and Colorado Plateau is closely tied to cheatgrass, an exotic annual grass. Researchers have recently demonstrated that increased carbon dioxide in the atmosphere has already made cheatgrass more competitive.²⁹ As the production of biomass increases and the decomposition of cheatgrass decreases, fuel loads will continue to grow. Therefore, increased cheatgrass and other invasive species will raise the chance for wildland fire, and following the fire raises the chances of dust storms that will deposit nutrient-rich soils in waters and on snowpack.

Invasive species may also put native fish species at risk of large decreases and, in some cases, extinction. Furthermore, wildlife habitat may be compromised or lost. Tourism and recreational opportunities on DOI lands may be affected. Historic landscapes could become more costly to maintain (if it is even possible to continue to maintain them). For instance, the increased damage by barnacles and other parasites (expected to increase in number due to climate change) on cultural resources and DOI infrastructure may require additional management resources.

²⁶ Bluetongue Factsheet. USDA–APHIS. June 2003. Available online: http://www.aphis.usda.gov/lpa/pubs/fsheet_faq_notice/fs_ahbluetongue.pdf (Accessed Jan. 18, 2008.)

²⁷ IPCC. “Food, Fibre and Forest Products.” *Climate Change 2007: Impacts, Adaptation and Vulnerability—Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. M.L. Parry et al., Eds., Cambridge University Press, Cambridge. 2007. p. 283

²⁸ “Invasive Species Program.” FWS. <http://www.fws.gov/invasives>.

²⁹ LH. Ziska, JB. Reeves III, and B. Blank. “The impact of recent increases in atmospheric CO₂ on biomass production and vegetative retention of Cheatgrass (*Bromus tectorum*): implications for fire disturbance.” *Global Change Biology*, 11 (8). 2005. p. 1325–1332.

STATEMENT OF OPTIONS

Option 1: Accelerate Development of Control Measures for Invasive Species.

Accelerate research on, and the application of techniques for, controlling invasive species whose ability to compete will be enhanced by climate change, including biological options for selected invasive species and pest control for affected native species.

Option 2: Restrict Entry of New Invasive Species. Strengthen existing means to further reduce entry of exotic species whose ability to compete will be enhanced by climate change.

Option 3: Develop Predictive Models of Climate Change Effects on Invasive Species to Monitor and Treat Expansions. Develop predictive models of climate change effects on invasive species (both native and exotic) to monitor and treat expansions and to develop appropriate management targets.

Option 4: Manage Habitat to Ensure Establishment of Desirable Native Species. Evaluate the feasibility of introducing or reintroducing U.S. native species in target ecosystems.

Table 10-A provides a tabular look at the analyzed criteria for these options.

ANALYSIS OF OPTIONS

Option 1: Accelerate Development of Control Measures for Invasive Species. DOI could accelerate research on control techniques, including biological options for selected invasive species and pest control for affected native species. For selected invasive species, DOI could also accelerate the application of biological controls whose effectiveness may be affected by climate change. Controlling invasive species is one of DOI's most significant land management challenges. Enhanced research and development, as well as testing programs, could help determine which areas need more aggressive control programs, including those that have been subject to climate-induced drought.

Currently, DOI requires bureaus and offices to incorporate Integrated Pest Management into their pest management activities.³⁰ To combat predicted pest outbreaks, DOI could direct the bureaus to consider climate change and improve the effectiveness of their pest, disease, and weed management practices. Improvements could be made by expanding the use of integrated pest and pathogen management, maintaining or improving quarantine capabilities, and pursuing sentinel monitoring programs and the surveillance of pests, diseases, and other factors directly affected by climate change. Research on control techniques could lead to best practices being shared and used across DOI to both attack the problems caused by invasive species and help affected native species on DOI lands.

³⁰ DOI Departmental Manual, Pesticide Use Policy, 517 DM 1.

Table 10-A: Outbreaks of Pests, Invasive Species, and Diseases Options

Options	Timescale to Implement	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Option 1: Accelerate Development of Control Measures for Invasive Species							
Sub-options:							
Accelerate research on biological controls of selected invasive species and pest control for native species	Short	Indirect, generally managed by USDA	Small	Medium	N/A	N/A	Recreation, Economy, Subsistence,
Accelerate applications of biological controls of selected invasive species	Short–Long	High	Large	High	N/A	States, Private landowners	Recreation, Economy
Institute a more aggressive invasive species control program	Long	Moderate	Regional	High	Protection against future threats	Public, Other government agencies, Neighbors	None
Option 2: Restrict Entry of New Invasive Species	Short–Long	Moderate	Large	Medium	N/A	States, NOAA, USDA, Private industry	Recreation, Economy, Culture
Option 3: Develop Predictive Models of Climate Change Effects on Invasive Species to Monitor and Treat Expansions							
Sub-options:							
Model expected invasive species expansion with appropriate climate change data	Short–Medium	High	Large as models apply to all land ownerships	Low	N/A	Other academic and Federal research entities	Recreation, Economy

Options		Timescale to Implement	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Implement long-term monitoring in areas predicted for invasive expansion. Accelerate control and monitoring efforts in expansion areas	Long	Moderate	Moderate as expansion may occur off DOI lands	High	Monitoring would provide other info	Other State and non-DOI Federal agencies, Tribes	Recreation, Economy, Subsistence
	Replace historical plant community reference conditions (targets) with more realistic ones given climate change scenarios	Medium	Low	Moderate	Low	N/A	Other scientists	None
	Establish a more flexible policy for species management	Short	High	DOI-wide	Low	N/A	Public, Other government agencies	None
Option 4: Manage Habitat to Ensure Establishment of Desirable Native Species								
Sub-options:								
	Implement restoration treatments in priority ecosystems to increase resistance to invasive species threats due to climate change	Medium–Long	Moderate	Moderate as restoration expense will limit acres restored	Medium–High	Improved wildlife habitat, Livestock forage, etc.	Numerous (e.g., NGO's, Citizen groups)	Recreation, Economy, Subsistence,
	Develop additional supplies of native species adapted to lands affected by climate change	Medium	Moderate	Moderate	Medium	Improved wildlife habitat, Livestock forage, etc.	NGO's, Citizen groups	Recreation, Economy
	Evaluate the utility of using desirable non-native species to compete with target invasive species as a placeholder until natives can be established	Short	High	Large	Low	N/A	Academic/ Research entities	Recreation, Economy
	Establish a new native plants center	Medium	High	Large	Medium	Improved wildlife habitat, Livestock forage, etc.	States, Private industry, Other government agencies	Recreation, Economy

Option 2: Restrict Entry of New Invasive Species. DOI could form a taskforce with the USDA and National Oceanic and Atmospheric Administration (NOAA) to discuss strengthening regulations to reduce entry of exotic species. A warming climate and increasing seawater temperature may increase the likelihood of aquatic exotic species entering the United States and becoming established, putting native species at risk. Currently, DOI works with Federal and State agencies and private groups to implement national, regional, and local-level exotic or invasive species management activities and to share information and new techniques for fighting exotic or invasive species. DOI could supplement its existing policies by directing the bureaus to use various techniques of prevention, early detection, rapid response, and control and management as key components of their management plans to deal with new invasive species that may result from the impacts of climate change.

To limit the entry of invasive species via ports, DOI could strengthen its relationship with the U.S. Coast Guard for implementing prevention options (e.g., shore-based treatments on vessels, treating vessels on board, and ballast water exchange). The Secretary could also direct bureaus to use the Hazard Analysis and Critical Control Points (a systematic, preventative approach to hazards) to limit the spread and introduction of invasive species. In this approach, planning focuses attention on critical points of control where invasive species can be removed. Documenting the risks and the methods used to remove invasive species gives managers a strategic method to make consistent decisions based on the identified risks. Planning builds a logical framework of information in which managers can weigh the risks for species spread against the management benefits. Using this planning approach could help to strengthen DOI's existing guidelines.

Option 3: Develop Predictive Models of Climate Change Effects on Invasive Species to Monitor And Treat Expansions. Using current research on invasive species and climate change, scientists could develop predictive models to determine where they expect invasive species to expand. Based on this research, DOI could implement long-term monitoring in areas where (1) invasive species are predicted to expand, or (2) treatments have been implemented. DOI could also factor this information into planning and budgetary decisions. Modeling efforts could also help address outbreaks of pests and diseases.

Unfortunately, modeling of climate change impacts on insect and pathogen outbreaks remains extremely limited. DOI land and water managers would benefit from improved modeling approaches that link the effects of ozone, climate change, and the availability of nutrients and water on individual plants and ecosystems at large. Most assessment studies do not explicitly consider the combined effects of elevated carbon dioxide and climate change in either pest-plant dynamics or impacts on livestock health. DOI could conduct research to create effective models of the combined effects of elevated carbon dioxide and climate change on pests, weeds, and diseases.

DOI could use the modeling results to develop appropriate management targets relative to climate change. For example, DOI could replace historical plant community reference conditions (targets) with those expected in the climate-change scenario. Planning

documents would need to incorporate new vegetation management targets appropriate to a changing climate environment. To help develop these targets, DOI could establish a more flexible policy for species management. Native species that are more tolerant of heat or drought could be considered in new areas. In the long run, establishing self-sustained targets with minimal human intervention may be the most effective way to use this approach.

Option 4: Manage Habitat to Encourage Establishment of Desirable Native Species.

DOI could encourage the establishment of desirable species to avoid the invasion of exotic species. To accomplish this, DOI could implement restoration treatments in priority ecosystems to make the ecosystem more resistant to invasive species threats due to climate change. DOI could also develop additional supplies of native species that would be adapted to lands affected by climate change. With climate change forcing some native species to migrate to other areas, DOI may need to determine what U.S. natives from other areas may need to be relocated to avoid the establishment of invasive species in some areas. DOI could evaluate the effectiveness of using desirable non-native species as a placeholder, competing against target invasive species, until natives can be established. DOI could allow the planting of different species (i.e., non-native) that are more adaptable to the types of environments resulting from climate change. Maintaining native plant communities or restoring functional ones could also help to promote natural water conservation in arid regions.

DOI could address the wildland fire–cheatgrass cycle and associated loss of native shrublands in two ways: (1) maintain functioning shrublands by reducing wildland fire impacts in these important shrub- and/or tree-dominated plant communities; and (2) restore degraded cheatgrass communities to functional, desired plant communities, preferably with native species.

As DOI lands and the vegetation on them are stressed by elements of climate change and directly impacted by disturbance events (e.g., hurricanes, floods, and wildfires), restoration and rehabilitation may be needed on a far greater scale than now. DOI could establish a new Native Plants Center with representation from all DOI bureaus and the mission of restoring and rehabilitating areas affected by climate change. The center's actions could include increasing DOI's native seed storage capacity; collaborating with the U.S. Department of Agriculture to develop guidelines for transferring the seeds of native species through common garden studies; overseeing the development of seed technology and cultural practices for producing agricultural crops of native seed; ensuring collaboration with seed regulatory agencies and the private seed industry to improve native seed supplies; examining the interactions of native species and exotic invasive plants in order to formulate prescriptions for seeding; and finally, developing application strategies and technologies to improve the establishment of native seedlings in restoration projects.

Species Migration and Habitat Change

STATEMENT OF ISSUE

Climate change causes species and natural communities to shift in latitude and/or elevation (primarily northward or upward) across the landscape, perhaps away from DOI-managed lands.

DESCRIPTION OF ISSUE

Plants and animals only reproduce, grow, and survive within specific ranges of climate and environmental conditions. When conditions change beyond their tolerance, both plant and animal species may respond by shifting range boundaries or changing the density of individuals within their ranges.³¹ Predicted climate changes will make the current ranges inhospitable for many resident species on DOI lands. Following suitable habitat conditions, these species will generally attempt to migrate northward or upward.

This “species migration” is not the short-term seasonal migration that waterfowl perform each year, but long-term shifting of entire species or local communities to new home ranges. These natural communities will not be replaced suddenly. Individual species will migrate to new areas or die off, placing stress on other species in the community that depend on them for food or habitat. Species losses will eventually cascade through many natural communities and landscapes. Other species will invade empty niches left behind, bringing with them changes to the historical landscape and the ecological services and benefits to which people are accustomed.

A wide variety of natural and man-made barriers can prohibit the natural migration of plants and animals to suitable new locations. Highways, urban areas, rivers, agricultural lands, pipelines, dams, unseasonably low river flows, habitat fragmentation, and lack of connectivity between water sources are just a few obstacles to migration. Even highly mobile species may face serious obstacles to successful migration if their food and habitat requirements cannot cross barriers or do not exist in new areas.

Migratory waterfowl, neotropical birds, anadromous fish (those that migrate from saltwater to freshwater to spawn), and some insects such as Monarch butterflies, offer unique challenges. These species travel great distances during their life cycle, generally from wintering to breeding habitats. Loss of any portion of essential habitat along their migration routes may cause serious population declines. For example, much of the Prairie Pothole wetlands in the upper Midwest is predicted to dry due to climate change. This drying would eliminate critical breeding grounds for ducks and geese along the central flyway.

³¹ IPCC. *Climate Change 2007: Impacts, Adaptation and Vulnerability—Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. M.L. Parry *et al.*, Eds., Cambridge University Press, Cambridge. 2007. Section 1.3.5.

Anadromous fish are of particular concern to DOI because they provide significant ecological, economic, and cultural values to native peoples, rural Alaskans, and American society as a whole. Many salmon species are already suffering serious declines due to past and present human-induced habitat modifications and other stresses that are not yet well understood. Climate changes are expected to cause additional stresses, possibly pushing some populations to the brink of collapse. Actions could be taken to increase our understanding of fish responses to changing climate conditions and to reduce other stressors to fish populations.

STATEMENT OF OPTIONS

Option 1: Assess Vulnerabilities: Species Migration. Conduct a screening level vulnerability assessment of ecosystem shifts in relation to DOI lands.

Option 2: Encourage Regional Inventory and Monitoring Partnerships. Develop regional partnerships to build on existing biodiversity monitoring programs to inform regional-scale decisions for species on DOI lands.

Option 3: Identify and Highlight Species Migration Case Studies. Use selected case studies to educate and inform resource managers on successful species migration and relocation projects.

Option 4: Develop Predictive Models for Species Response. Develop planning models to predict species response.

Option 5: Promote Regional Partnerships for Species Migration and Relocation. Promote regional partnerships to enhance the success of species migration and relocation in response to climate change. This option is more fully described under DOI-Wide Option 6, “Develop an Interior Climate Adaptation Partners (ICAP) Program.”

Table 11-A provides a tabular look at the analyzed criteria for these options.

ANALYSIS OF OPTIONS

Option 1: Assess Vulnerabilities: Species Migration. DOI could conduct a vulnerability assessment of ecosystem shifts in relation to DOI lands. The first phase of the assessment could begin by using regional-scale models of climate change predictions and ecosystem responses to create a series of regional maps that overlay expected ecosystem shifts onto DOI lands. These initial maps could then be used to focus national DOI resources on climate change species migration hot-spots. The initial assessment would be regional aimed at completing all regions within a short timeframe.

Table 11-A: Species Migration and Habitat Change Options

Options	Timescale to Implement	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Option 1: Assess Vulnerabilities: Species Migration	Short	High	Local–National	Low–Medium	Strategic planning	Science agencies, (e.g., NOAA, National Weather Service)	Minimal direct impact
Option 2: Encourage Regional Inventory and Monitoring Partnerships	Medium	Medium–High	Regional	Low–Medium	Many, including cost benefit	USDA, EPA, Universities	Recreation, Economy, Culture
Option 3: Identify and Highlight Species Migration Case Studies	Short	High	Local–National	Low–Medium	Improve technology transfer and education, increase effectiveness	Educates, Improves partner successes	Recreation, Economy, Esthetics
Option 4: Develop Predictive Models for Species Response	Short–Medium	High	Local–National	Low–Medium	Leadership in field of ecosystem response to climate change	Universities, NOAA, International science community	Indirect
Option 5: Promote Regional Partnerships for Species Migration and Relocation	Short–Long	High	Local–National	Low–Medium	Improved cooperation between DOI field units and their neighbors	Other Federal and State agencies, Canada and Mexico, Private and business landowners, Nonprofits	Indirect

A second phase of the vulnerability assessment would focus on the species migration hotspots identified in the initial assessment. At this scale, the assessment would focus on identifying individual species and their specific habitats that are expected to either migrate away from protection of DOI lands or be locally extirpated due to climate change. These species will need specific intervention either to protect species health, or to ensure continuance of the services (ecosystem, economic, or cultural) they provide. The cost of a second-level vulnerability assessment would be medium and the timeframe would be medium to long, depending on the availability of resources and the findings of the initial regional assessments. There would be ample opportunity for partnerships with other agencies and with existing partnerships as data are developed and compared.

Option 2: Encourage Regional Inventory and Monitoring Partnerships. DOI could develop regional partnerships to build on existing biodiversity monitoring programs. For example, these could build upon existing partnerships between DOI and sister Federal agencies, such as the EPA and USDA, and other partnerships such as the National Biological Information Infrastructure and NatureServe.

As discussed in DOI-Wide Option 1, adaptive management provides a framework for decision making in the face of uncertainty about human and ecological responses to climate change. This framework includes an iterative decision-making process that involves an initial assessment of conditions, a decision, and monitoring for results. As information is received through the monitoring process, understanding and management decisions are updated by what is learned. Therefore, inventory and monitoring information is necessary for both the initial assessment, and for the iterative management decisions inherent in adaptive management.

Few DOI land management units have complete biological inventories of species. Additionally, DOI has no cohesive, systematic program for monitoring change over time in the distribution of species and communities. Inventories will be critical to assessing climate change impacts and to developing management responses to those impacts. During the time that DOI conducts the initial regional-scale vulnerability assessments mentioned in Option 1, managers of DOI lands can begin evaluating existing resource inventories on their individual operating units to identify resource risks, and data gaps. Our lands do not exist in a vacuum. Rather, they exist in a matrix with other Federal, State, private, non-profit, and corporate neighbors. DOI resource managers can begin developing partnerships at various organizational levels for filling ecological data gaps and for monitoring ecological trends that would help guide our adaptive management strategies into the future.

At the national level, DOI could explore strategic partnerships with one or more well-established national programs to identify current biological resources and assess changes in response to climate change. Joining in one or several of these programs would provide a more complete picture of the biological resources on and adjacent to DOI lands allowing DOI land managers to see their resources and make management decisions in the context of the larger landscape. Examples include the following programs:

- The USDA supports two national programs that inventory and monitor terrestrial resources at national and regional scales, and at local scales for large administrative units. The USDA Forest Inventory and Analysis program, operating in 47 States, focuses on keeping a current and comprehensive inventory and analysis of the conditions associated with the Nation’s forest and rangelands. Another national assessment, the National Resource Inventory, conducted by the USDA Natural Resource Conservation Service, is a decades old longitudinal survey of soil, water, and related environmental resources designed to assess conditions and trends every 5 years on non-Federal lands.
- The EPA supports the Environmental Monitoring and Assessment Program (EMAP), a research program aimed at developing the scientific understanding needed to take environmental monitoring data from multiple spatial and temporal scales and translate it into assessments of ecological condition and forecasts of future risks to the sustainability of our natural resources. EMAP, in turn, supports the National Environmental Monitoring Initiative, a program that integrates and coordinates environmental monitoring and related research through government and private-sector collaboration.

Managers at regional and local scales could develop other partnerships to deal with more local issues and to begin developing local and regional strategies for meeting the challenges climate change poses to their resources. These would compliment the activities of the national programs previously discussed. By enabling DOI to monitor for changes using the same data and parameters as these other organizations, collaboration on monitoring would promote adaptation partnerships. The direct cost to DOI would likely be in the low-to-medium range and the savings could be substantial as compared to setting up completely new and independent DOI monitoring programs.

Option 3: Identify and Highlight Species Migration Case Studies. Selected case studies could be used to educate and inform resource managers on successful species migration and relocation projects. Case studies would be posted on the DOI Web site. This option is more fully described under DOI-Wide Option 6: “Develop an Interior Climate Adaptation Partners (ICAP) Program.”

Option 4: Develop Predictive Models for Species Response. In an uncertain climate future, models will be important tools for predicting how plants and animals are expected to respond to climate changes and for adapting and revising management plans accordingly. These models would allow managers to analyze scenarios that incorporate local and regional temperature, rainfall, and streamflow, as well as selected management actions, and to predict responses of plant and animal communities. The *DOI Adaptive Management Technical Guide* addresses the need for models. While vulnerability assessments would help prioritize the species for taking next steps, it may be reasonable to begin developing models for anadromous fish now. Science shows that many populations are already at serious risk, and the models that DOI develops would be widely applicable along coastal ecosystems. The costs of developing models will be scalable according to the timeline desired by DOI leadership. Annual costs would likely

be in the low-to-medium range. There are opportunities for partnerships with university researchers and with NOAA on the broad range of issues that require model development. Such models would have high education and demonstration values for resource managers around the world.

Option 5: Promote Regional Partnerships for Species Migration and Relocation.

DOI could promote regional partnerships to enhance the success of species migration and relocation in response to climate change. This option is more fully described under DOI-Wide Option 6: “Develop an Interior Climate Adaptation Partners (ICAP) Program.” In particular, DOI’s success in both its Healthy Lands Initiative and its Cooperative Conservation Initiative could serve as examples.

Threatened and Endangered Species

STATEMENT OF ISSUE

The loss of habitat resulting from climate change may increase the number of species classified as threatened or endangered as well as the potential for extinction of species already designated as threatened or endangered.

DESCRIPTION OF ISSUE

Climate change impacts habitat primarily through increased temperature, changes in precipitation patterns, and sea-level rise. The effects of climate change can vary depending on the particular ecosystem. For example, arid areas can be subject to unusual droughts or floods, coastal wetlands can experience excessive flooding, and cryosphere areas can melt. As environmental conditions shift within a habitat, certain species within that area may be unable to adapt to the changing environment. This inability to adapt can lead to species localized extirpation or extinction of the species.

Historically, plants and animals have adapted to environmental change through genetic evolution or relocation. However, climate change appears to have affected the timing and rate of environmental change. In the future, plant and animal evolution may not be able to keep pace with this accelerated environmental change, leaving relocation as their only alternative. Yet, some species will likely encounter regional and geographical barriers that will prevent them from migrating to other areas. These barriers could be natural or human induced. For example, climate change will likely increase the isolation of mountain peaks, known as “sky islands.” Species native to these tundra regions (e.g., marmots, pika, white-tailed ptarmigan, and rosy finches) could be trapped on these “islands” and unable to escape to colder climates or to adapt fast enough to the warmer environment generated through climate change. Another example is coastal nesting grounds for species such as the sea turtle. As sea-levels rise, nesting areas will have to move further inland but may run into man-made barriers like seawalls. If these species are unable to evolve or migrate, they could face extinction.

Increases in endangered or extinct species will have physical, social, and economic impacts on DOI lands and resources. For example, the loss of sea ice will diminish the polar bear, walrus, and seal populations, which will impact the hunting of these species by indigenous peoples for subsistence and food resources and affect their traditional customs and uses. Habitat loss will also affect recreational activities on DOI lands, such as hunting and fishing, leading to social and economic impacts. Increases in sea-surface temperatures greater than 1°C (1.8°F) during the summer could result in loss of symbiotic algae and more frequent coral bleaching events,³² ultimately impacting commercial fisheries and tourism. Should certain species, such as the sage grouse, be elevated to an endangered status, additional obstacles and hurdles to mineral and energy leasing within some regions would be created.

STATEMENT OF OPTIONS

The threatened and endangered species issue is not a new concern. Under the Endangered Species Act of 1973, the FWS oversees the management of most terrestrial and freshwater threatened and endangered species. Because the primary effect of climate change on endangered species is exacerbation of the issue(s), many of the options raised by the working groups are already in place within the agency. Accordingly, this report does not address these practices, but instead focuses on new options posed specifically in response to the effects of climate change.³³

Option 1: Assess Vulnerabilities: Threatened and Endangered Species. Identify, design, and request local studies and/or overlay modeling that rank and prioritize habitats and species that are most vulnerable to climate change.

Option 2: Use Climate Change Data when Classifying Endangered Species. Use scientific climate change data when determining whether a species should be listed as threatened or endangered when completing 5-Year Reviews of all species currently listed as threatened or endangered and when reviewing all Threatened and Endangered Species Recovery Plans.

Option 3: Reduce Stressors. As noted in DOI-wide theme 11, reduce current or predicted stressors on threatened and endangered species and their habitats in order to enhance species resiliency and ability to adapt to climate change.

Option 4: Develop Regional Planning and Cooperative Conservation Partnerships. Develop regional plans and cooperative conservation partnerships necessary to maintain critical threatened and endangered species affected by climate change.

Table 12-A provides a tabular look at the analyzed criteria for these options.

³² A Report Accepted by Working Group II of the Intergovernmental Panel on Climate Change, Table TS.8, p. 74.

³³ For more information on the practices and programs already in place, see the FWS Web site at <http://www.fws.gov/endangered/>.

Table 12-A: Threatened and Endangered Species Options

Options	Timescale to Implement	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Option 1: Assess Vulnerabilities: Threatened and Endangered Species	Short	High	Large, depending on number of studies	Low	Strategic planning	Science agencies	None
Option 2: Use Climate Change Data when Classifying Endangered Species							
Sub-options:							
Develop FWS guidelines	Short	High	National	Low	N/A	None	Economy
Incorporate Guidelines into 5-Year Reviews and Recovery Plans	Medium	High	National	Low	N/A	None	Recreation, Economy, Culture
Option 3: Reduce Stressors	Medium–Long	High, although it may require partnerships	National	Medium–High	N/A	Federal, State, Local governments, Tribes, Adjacent landowners	Recreation, Economy
Option 4: Develop Regional Planning and Cooperative Conservation Partnerships							
Sub-options:							
Create Workshops to Share Information	Short–Long	High	Low	Low	Leadership	Federal, Tribal, State, and Local agencies; Regional resource managers; Climate experts; Environmental organizations; Neighboring landowners	Economy
Maintain Species in Artificial Setting	Long	High	High	Medium–High	N/A	Conservation partnerships with private entities (e.g., zoos, captive breeding groups, gene banking facilities)	Culture, Recreation, Economy

ANALYSIS OF OPTIONS

Option 1: Assess Vulnerabilities: Threatened and Endangered Species.

The FWS and other interested partners could identify, design, and request specific studies and/or overlay modeling that rank and prioritize those habitats and species most vulnerable to climate change.

DOI has extensive policies and procedures in place to identify and address endangered species. FWS field offices work cooperatively with other Federal, tribal, State, and local agencies, private citizens, and conservation organizations to identify potential candidate species through its candidate assessment program. They use a variety of scientific data to rank and evaluate species status and make biologically sound determinations of what species are at-risk. However, a large portion of the data is generated from historical data and does not account for future environmental behavior, including that due to climate change.

The FWS and its partners could consider whether additional scientific research that incorporates climate change predictions is needed, and if so, what the scope of that research should be. The research could identify which habitats and species will likely be elevated to an endangered status due to the effects of climate change, including conditions or events that are exacerbated by climate change. The necessary studies will differ depending upon the habitat under review. To ensure that effective scientific information is acquired for each local area, FWS field office managers may be the appropriate personnel to drive the scoping of the studies.

By pinpointing the species likely to be elevated to a threatened or endangered status due to climate change, DOI managers could assess the scope and scale of actions needed and take proactive measures to protect critical species.

Option 2: Use Climate Change Data when Classifying Endangered Species. The FWS could add the use of scientific data on climate change to its usual considerations when determining whether a species should be listed as threatened or endangered, when designating critical habitat, when completing 5-Year Reviews of all species currently listed as threatened or endangered, and when reviewing or revising all Threatened and Endangered Species Recovery Plans.

To help personnel use these data properly, the FWS could develop a guide for using available climate change data. Accordingly, the FWS could provide guidance on how scientific data regarding climate change should be used in determining the status of species under the Endangered Species Act. Once the guide is in place, the FWS can use it for future assessments and during the 5-Year Reviews of currently listed species and reviews of the Recovery Plans for those species.

Recently, climate change predictions have become a factor raised in questioning whether a species should be listed (e.g., polar bears). How the FWS handles these data when identifying threatened or endangered species may have management and legal

implications. Without clearly defined and established guidelines, personnel may be inconsistent in how they use the data to assess a species. This inconsistency could result in inaccurate classifications, which would increase and perhaps unduly burden the bureau's management responsibilities. In addition, it could open the door to unnecessary litigation if environmental groups and other interested parties believe that the FWS is ignoring or misapplying the science.

Option 3: Reduce Stressors. As noted in Common Theme 10, "Species Inventory and Monitoring," where research or modeling indicates, the DOI could reduce current or predicted stressors on threatened and endangered species and their habitats in order to enhance the resiliency and ability of species to adapt to climate change.

In order to increase resilience to climate change, the DOI could remove or modify impediments that cause stress to species, especially barriers to migration, non-native competitors and pests, and pollutants. This option depends largely on scientific predictions and could be implemented in a variety of ways. For example, actions could involve identifying adjacent land owners and acquiring land, developing conservation easements, or using other approaches to secure essential habitats where DOI holdings are not sufficiently large enough to maintain viable populations. Alternatively, the land management agencies could modify management plans and programs by restricting licensing and permitting allowances or limiting the number of visitors allowed during any given time. Water rights for refuges and other protected lands could be secured. As a last resort, species could be moved to alternate habitats after thorough evaluation of the practicality, feasibility, and potential for causing ecological harm.

Option 4: Regional Planning and Cooperative Conservation Partnerships. DOI managers could develop and assess regional planning and cooperative conservation partnerships that are critical to maintaining some threatened and endangered species, specifically recognizing the role of climate change.

The DOI could bring Federal, tribal, State, and local agencies; regional resource managers; climate change experts; environmental organizations; neighboring landowners; and other interested parties together in a series of workshops to share information and help identify ecosystem resources and processes that may be most susceptible to climate change. Through these workshops, the team could develop plausible scenarios of future climates and ecosystems, including those with low probability of occurrence but high environmental cost, and develop management plans accordingly.

The extinction of some species may be inevitable and unavoidable in the face of climate change. Where actions are not available to sufficiently protect natural habitat, the DOI could assess the trade-off of losing a species versus the societal benefits of maintaining a species in artificial settings, such as through zoos, captive breeding facilities, or gene banking. Regional planning should include the consideration of conservation partnerships with private entities to preserve critical species.

Wildland Fires

STATEMENT OF ISSUE

As temperatures rise, the duration, frequency, intensity, and extent of wildland fires increase. Conditions contributing to the incidence of wildland fires, such as prolonged droughts and shifts of fire-prone invasive species into new areas, are expected to increase as a result of climate change.

DESCRIPTION OF ISSUE

In analyzing the geographic location, seasonal timing, and regional climatology of 1,166 recorded wildland fires in the western United States that were roughly 1,000 acres or larger, researchers found that from 1970 to 2003 the length of the active wildland fire season in the western United States increased by 78 days and that the average burn duration of large fires increased from 7.5 to 37.1 days.³⁴ Based on comparisons with climatic indices that use daily weather records to estimate land surface dryness, the researchers attributed this increase in wildland fire activity to an increase in spring and summer temperatures by $\sim 0.9^{\circ}\text{C}$ (1.62°F) and a 1-to-4-week earlier melting of mountain snowpacks.

The hydrology of the western United States is dominated by snow. In fact, 75 percent of annual streamflow comes from snowpack. Snowpacks keep the fire danger low in these areas until the spring melt period ends. Once snowmelt is complete, these areas can become combustible within one month because of low humidity and sparse summer rainfall. Land dryness and hot, dry, windy weather are the necessary and increasingly common ingredients for wildland fire activity for most of the summer. Climate change models are predicting that these conditions may increase in the future. Further, disturbed lands, whether due to fire or other factors (e.g., off-road vehicles, cattle, or seismic crew use), increase the likelihood of dust storms and the negative health, water, and wildlife effects that accompany them.

When wildland fires burn, they endanger life and property; they destroy critical vegetation and wildlife habitats, key watersheds, and recreation areas. In the 2007 fire season, Alaska experienced the biggest tundra fire ever recorded on the North Slope. The consequences of this wildland fire on the permafrost, hydrology, caribou forage, and associated subsistence activities are not yet fully understood. Furthermore, in 2006 in the United States, nearly 10 million acres burned due to massive wildland fires, at a cost of over \$2 billion to fight.³⁵

³⁴ A.L. Westerling, H.G. Hidalgo, D.R. Cayan, T.W. Swetnam. "Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity." *Science*. 313 (5789). Aug. 18, 2006., p. 940–943.

³⁵ "Fire Information—Wildland Fire Statistics: Wildland Fire Season 2006." National Interagency Fire Center. http://www.nifc.gov/fire_info/fire_summaries/summary_2006.htm. (Accessed January 18, 2008.)

STATEMENT OF OPTIONS

The utilization of biomass as an option to address the issue of wildland fires was suggested by the subcommittee but was deemed a mitigation opportunity rather than an adaptation issue. See the discussion on Biomass in the “Development of Renewable Energy on DOI lands” section, in the Mitigation section of the report.

Option 1: Accelerate and Enhance the Hazardous Fuel Reduction Program.

Accelerate, expand, and enhance DOI’s current Hazardous Fuel Reduction policies, recognizing the additional impacts due to climate change.

Option 2: Improve Smoke-Management Practices. Engage in better smoke-management practices in DOI to reduce climate change effects.

Table 13-A provides a tabular look at the analyzed criteria for these options.

ANALYSIS OF OPTIONS

Option 1: Accelerate and Enhance the Hazardous Fuel Reduction Program. DOI could help reduce the adverse impacts of climate change on DOI lands by pursuing a more aggressive and efficient Hazardous Fuel Reduction program. DOI could conduct more research to determine the areas that need programs in hazardous fuel reduction. A more aggressive program could also benefit DOI by lowering the rising costs of its wildland fire suppression efforts. Each year, DOI manages the vegetation on millions of acres of land to make them more resistant to wildland fires. A critical way for treatments to be successful and improve the ability of DOI lands to withstand the stresses associated with climate change would be to encourage the application of treatments across all land jurisdictions—crossing Federal, State, tribal, and county boundaries.

DOI could prepare for extreme fire events by restoring ecosystems and reducing uncharacteristic fuel levels by expanding various DOI programs, including prescribed burns, biological and chemical controls, and restoration of native plant communities on DOI lands. Research shows that future climate change may suggest using prescribed fire outside of traditional burn seasons as climate change makes some areas more accessible in winter. This may allow for more acres to be burned under less extreme fire weather conditions than wildland fires that might occur in the future under extreme heat or drought conditions.

There is an extensive body of applied social science research on public acceptance of resource management practices, such as prescribed fires, which could be used in designing fuels treatment programs. Community acceptance to the use of fire reflects environmental values, recreation and public health concerns, assessment of both risk and the potential consequences of inaction, and the level of trust felt toward land managers. This body of knowledge should serve DOI well as it works to adapt to climate changes.

Table 13-A: Wildland Fires Options

Options	Timescale to Implement	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Option 1: Accelerate and Enhance Hazardous Fuel Reduction Program	Short	Moderate	Large	High	Increased protection to life and property	USDA, States, Tribes, Counties	Recreation, Economy, Society, Culture
Option 2: Improve Smoke Management Practices	Short	High	Large	High	Fewer emissions, Improved public health/air quality	USDA, EPA, States, Tribes, Counties	Economy, Recreation, Health

Factoring in the connection between invasive species and wildfires is critical as DOI manages its programs to reduce hazardous fuel. For some exotic species, such as cheatgrass in the Great Basin, their ability to compete is enhanced by increases of carbon dioxide in the atmosphere. Fuel loads on DOI lands will continue to increase as a result of increased biomass production and reduced decomposition of cheatgrass in the future. Implementing programs to reduce fuel in this area and across DOI lands can help to alleviate the fuel load and limit the ingredients that often lead to catastrophic wildland fires.

In many cases the limiting factor on efforts to reduce fuels is the inability to offset project costs. When feasible, fuels reduction programs should be linked to community development opportunities by enhancing local capacity to use small-diameter trees, biomass, or other wood products. This requires a careful match of resources, products, markets, and the economic capabilities of communities adjacent to Federal lands. Once hazardous fuels are removed, an additional climate benefit arises since remaining trees and seedlings become healthier and more vibrant, enabling them to absorb more carbon dioxide. Beyond this, the woody debris removed from lands could be used for wood products or biomass fuel/energy production.

Option 2: Improve Smoke-Management Practices. Smoke management practices can also affect the amount of greenhouse gas emissions because wildland and prescribed fires convert the carbon in the biomass into carbon dioxide. They also release methane, nitrous and other nitrogen oxides, carbon monoxide, volatile organic compounds, and particulate matter (including soot). From the point of view of only greenhouse gas emissions, the net amount of biomass burned should be minimized. Thus, to the extent that fire management (including prescribed burns) reduces the extent of wildfire, reducing the amount of biomass burned would reduce net greenhouse gas emissions. This should be factored into fire management and control activities without losing sight of the primary goals of such activities, namely, minimizing net threats to public health and safety and adverse ecological consequences. Consequently, flexibility in smoke management rules is paramount. Furthermore, the Department could control fire-promoting and highly flammable non-native plant species by planning for the expected increased spread and persistence of these species in some geographic areas (due not only to increased temperatures but also to increased carbon dioxide levels) and by appropriately applying prescribed fire or mechanized treatments at the landscape level.

MITIGATION OPPORTUNITIES AND OPTIONS

OPPORTUNITIES AND OPTIONS

Using the IPCC's strict definition of mitigation, the Subcommittee identified and catalogued mitigation measures that are likely to produce the most benefits, are the most practical, and coincide with the DOI's current mission and goals. Nine mitigation issues were originally identified to the Climate Change Task Force Steering Committee. Six issues with associated options were subsequently developed for this report. These issues were prioritized based on legal mandates, feasibility, scale of impact, and co-benefits. This is not a comprehensive list of mitigation issues and options but a list of those that seem to us as the most viable for DOI. Many of the mitigation strategies presented here have benefits in addition to the reduction of greenhouse gas emissions, such as habitat restoration, energy security, and leading by example.

Terrestrial Carbon Sequestration

STATEMENT OF OPPORTUNITY

Terrestrial carbon sequestration is the process through which carbon dioxide (CO₂) from the atmosphere is absorbed by trees, plants, and crops through photosynthesis and stored as carbon in biomass (i.e., tree trunks, branches, foliage, and roots) and soils.³⁶

Enhancing the natural processes that remove CO₂ from the atmosphere is thought to be one of the most cost-effective means of reducing atmospheric levels of CO₂, and deforestation abatement and forestation efforts are already under way. Research and development in this program area seeks to increase the rate of sequestration while considering all the ecological, social, and economic implications. According to the Department of Energy (DOE), "There are two fundamental approaches to sequestering carbon in terrestrial ecosystems: (1) protection of ecosystems that store carbon so that carbon stores can be maintained or increased; and (2) manipulation of ecosystems to increase terrestrial carbon sequestration beyond current conditions."³⁷

DOI is poised to play a key role in reducing the amount of CO₂ in our atmosphere through terrestrial carbon sequestration. There is an opportunity to reduce DOI's carbon footprint through specific mitigation actions, such as minimizing or offsetting residual carbon emissions through a comprehensive terrestrial carbon sequestration program, and

³⁶ EPA. "Sequestration." Web site <http://www.epa.gov/sequestration.html>.

³⁷ DOE. "Terrestrial Sequestration Research." Web site <http://fossil.energy.gov/programs/sequestration/terrestrial/>. (Accessed Jan. 18, 2008.)

to partner with outside entities to reduce their carbon output while restoring high-priority wildlife habitat across the country.

DESCRIPTION OF OPPORTUNITY

Strategic restoration of previously altered ecosystems (e.g., by planting native vegetation) to capture carbon is a key part of the overall suite of solutions emerging to address the increase in CO₂ concentrations in the atmosphere. It provides DOI with a creative way to engage non-traditional partners in strategic conservation actions that will conserve important resource values while reducing the overall amount of CO₂ in the atmosphere.

DOI's use of adaptive management is crucial to the ultimate success of this option. Indeed, as DOI understands more about rising sea levels, drought conditions, increased frequency and intensity of storms, and excessive wet periods, DOI can better understand what habitats will be essential. DOI lands provide anchors of biodiversity across North America. Strategic habitat conservation efforts, including restoration of key tracts on and off DOI lands, may significantly improve the chance for wildlife to adapt to changing climates. For example, 7 years ago, the FWS began an innovative carbon sequestration program to bolster its land conservation efforts to benefit waterfowl, wildlife, and forest-breeding birds. FWS leadership in the Lower Mississippi Valley began working with utility companies and two land trusts interested in "banking" carbon credits in the context of the growing evidence of climate change. Early in the program, the companies simply restored lands that the FWS already owned. More recently, energy companies have purchased high-value lands, restored them based on the needs of priority species, donated the restored lands to the FWS, and provided limited funds to support operations and maintenance, but reserved the carbon credits to report for themselves. Working with its partners, the FWS added 40,000 acres to its refuge system, restored a total of 80,000 acres to native habitats, planted more than 22 million trees, and triggered the sequestration of an average of 330,000 tons of carbon annually over 99 years. DOI has a significant opportunity to expand this program on and off Federal land over the next 5 years.

The process of mineral extraction drastically alters our landscape and denudes established forests, reducing the land's ability to naturally sequester carbon. Coal mining is the most prevalent form of mineral extraction in our country. It is the OSM's charge to balance the Nation's need for continued domestic coal production while protecting the environment. Currently, over 4.4 million acres of land are being impacted by coal mining with about 62 percent (2.7 million acres) located in the eastern United States. It has been reported that, if only 50 percent of the coal-mined land in the eastern United States is reforested (rather than vegetated into grasslands), the resulting increase in sequestered carbon would potentially be 330,000 tons of CO₂ per year.³⁸

³⁸ Zipper C.E, *et al.* "Carbon Accumulation Potentials Of Post-SMCRA Coalmined Lands, 30 Years of SMCRA and Beyond, June 2-7, 2007." Gillette WY R.I. Barnhisel ed. American Society of Mining and Reclamation. 2007.

STATEMENT OF OPTIONS

Option 1: Develop a Terrestrial Carbon Sequestration Policy. Develop a DOI-wide policy statement directing each bureau to create and implement a terrestrial carbon sequestration program aimed at reducing CO₂ in the atmosphere while restoring native plant communities.

Option 2: Conduct a Comprehensive Terrestrial Carbon Assessment. Determine DOI's comprehensive carbon footprint by assessing each bureau's terrestrial carbon sequestration assets and carbon emissions inventory with the goal of being the first Federal agency to become carbon neutral in its practices.

Option 3: Create Habitat Restoration Partnerships. Use statutory authorities, existing policies and regulations, programs, and expertise to work with private landowners and CO₂ emitters to restore significant habitat, while helping to offset CO₂ emissions.

Table 14-M provides a tabular look at the analyzed criteria for these options.

ANALYSIS OF OPTIONS

Option 1: Terrestrial Carbon Sequestration Policy. A broader DOI-wide policy is needed to expand activities under a Terrestrial Carbon Sequestration program across the DOI bureaus. Up to now, many carbon sequestration conservation projects have involved the afforestation of bottomland hardwoods (i.e., restoration of low-lying lands near a river back into hardwood forest ecosystems). DOI could encourage the restoration of other native habitats, such as tall grass prairie, sagebrush steppe, pocosin wetlands, longleaf pine, sub-tropical dry forests, and tidal wetlands. Targeted research could focus on the contribution these habitats would have on sequestration rates. Investing in habitats with high yields of carbon sequestration should be encouraged.

A DOI-wide policy statement on carbon sequestration would set a consistent course for all bureaus to follow, giving stakeholders—including energy companies, conservation organizations, and land trusts—more options for creating partnerships for restoring native plant communities and reducing the amount of CO₂ in the atmosphere. The impact of a consistent, DOI-wide program aimed at habitat restoration that bolsters the capability of existing operations to respond to emerging climate change impacts would be significant.

In 2003, a departmental policy on terrestrial carbon sequestration was drafted with no further action. This draft policy could serve as a foundation upon which individual bureaus develop terrestrial carbon sequestration strategies appropriate to their mission and resource base. The OSM Appalachia Region Reforestation Initiative and FWS Terrestrial Carbon Sequestration Initiative could serve as models for bureau-specific strategy development.

Table 14-M: Terrestrial Carbon Sequestration Options

Options	Timescale to Implement	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Option 1: Develop a Terrestrial Carbon Sequestration Policy	Short	High	Significant	Low	Promotes partnerships within DOI	N/A	N/A
Option 2: Conduct a Comprehensive Terrestrial Carbon Assessment	Short–Medium		Unknown but potentially significant	Medium–High	N/A	N/A	N/A
Option 3: Create Habitat Restoration Partnerships	Short–Long, depending on programs	High, Indirect	Unknown but potentially significant	N/A	Bolsters partnership with traditional and non-traditional stakeholders and expands ability to restore native wildlife habitat and address climate change impacts to wildlife	DOI Land Management Bureaus, USDA, Energy companies, Conservation groups, State agencies, NGO's	Recreation (e.g., Hunting, Fishing), Economy

Alternatively, each bureau could adopt its own policy statement including an outline of projects it would like to pursue. The challenge with this approach is that the policy statements may not be coordinated or consistent.

Option 2: Conduct a Comprehensive Terrestrial Carbon Assessment. DOI has responsibility for the management of existing soil and vegetation carbon stores, but in most cases, carbon is managed as a byproduct of the management of other resources or processes, such as water, habitat, or fire. Understanding these processes and monitoring the effects of management activities could substantially increase DOI's capacity to sequester carbon in terrestrial systems.

DOI could determine its comprehensive carbon footprint by creating an overall DOI carbon inventory and assessing each bureau's terrestrial carbon sequestration assets and CO₂ emissions. To accomplish this, resource managers would need information, guidance, and models to help them to quantitatively assess how their management activities affect the rate and fate of carbon stores in the various ecosystems they manage and to reduce the sources of emissions. However, DOI should not include in its inventory emissions due to the use of fossil fuels extracted from DOI lands.

To implement this option, the methodology for a consistent carbon assessment and monitoring (including carbon assets and emissions) must be determined. A focus on highly sensitive systems, such as Arctic peatlands, that are vulnerable to fire and drying is needed to quantify highly threatened carbon stores. There are many tools available for assessing greenhouse gas emissions. The NPS, through a partnership with the EPA, developed the Climate Friendly Parks program to help national parks conduct emission inventories, develop action plans, and communicate about climate change. The Climate Friendly Parks assessment tool considers energy, transportation, waste, and forest management and other emissions sources, but does not take into account available carbon sinks on DOI lands. The accuracy of the assessment depends on the collection of accurate terrestrial sequestration and greenhouse gas emissions data.

Establishing a baseline carbon metric will help bureaus determine where to best focus their limited resources to reduce greenhouse gas emissions. Taking a leadership role in offsetting DOI's carbon footprint offers value from both programmatic and public relations points-of-view. Providing land managers with specific guidance on available tools would be essential. DOI is well positioned to be the first major agency to become carbon neutral. Innovative tools such as renewable energy certificates also known as green certificates, green tags, or tradable renewable certificates could be explored as a means of affecting the DOI footprint. The Conservation Fund's Go ZeroSM program among individuals and businesses is another example of an innovative way to reduce or offset DOI's carbon footprint. The fund and its Go ZeroSM program are planting trees on national wildlife refuges through this program and a partnership with the FWS.

Option 3: Create Habitat Restoration Partnerships. DOI could use its statutory authorities, existing policies and regulations, programs, and expertise to work with private landowners and CO₂ emitters to restore significant habitat—while helping to offset CO₂ emissions. An important component of the option is to understand where to best establish habitat linkages. A plant and wildlife habitat gap analysis could be used to strategically determine where important plant and wildlife habitat linkages (i.e., wildlife and ecosystem corridors) are needed across the landscape. The results would guide private lands programs and broaden the impact of a comprehensive carbon program to restore native wildlife habitat. (Refer to DOI-Wide Option 6, “Develop Interior Climate Adaptation Partners (ICAP) Program,” and Adaptation section “Species Migration and Habitat Change” Option 5, “Regional Partnerships for Species Migration and Relocation,” for habitat gap analysis.)

DOI’s land base provides anchors of biodiversity that could serve as a foundation for our conservation efforts. Linking these lands together as corridors will require public/private partnerships aimed at cooperatively working with private landowners. Strategic habitat conservation through a well conceived terrestrial carbon sequestration program may accomplish a number of public policy goals, including offsetting CO₂ emissions and conserving nationally important natural resources. For example, restoring native sagebrush-steppe plant communities in the Great Basin of the Intermountain West, where as much as 17 million acres are estimated to be dominated by the highly flammable invasive species, cheatgrass, would change these areas from their current status as a carbon source to their natural role as carbon sinks once again.³⁹

DOI could establish collaborative effort with the USDA Forest Service Farm Service, USDA Agency and Natural Resources Conservation Service and with non-governmental organizations to look for ways to provide incentives to private landowners as part of a broad terrestrial carbon sequestration program. Options include using existing wetlands, grasslands, and conservation reserve programs.

This mitigation option would bolster partnerships with traditional and non-traditional stakeholders and expand DOI’s ability to restore habitat and address climate change impacts. Land trusts, energy companies, and other conservation organizations that support these goals recognize that partnership provides DOI bureaus with another tool to conserve and restore important habitats and provides companies with carbon emission credits. Depending upon future legislative actions and market trends, carbon emission credits may play an increasingly significant role. In 2001 and June 2007, the DOI Office of the Solicitor approved the partnership agreements used by the FWS and the energy companies it is working with in its carbon sequestration program. Under the Energy Policy Act of 1992, the Department of Energy completed work on voluntary reporting guidelines under which organizations can voluntarily report work to sequester and/or reduce CO₂ emissions.⁴⁰

³⁹ Bradley, B., R.A. Houghton, J. Mustard, and S.P. Hamburg. “Invasive grass reduces aboveground carbon stocks in shrublands of the Western U.S.” *Global Change Biology*, 12. 2006. p. 1815–1822.

⁴⁰ “Section 1605B.” Energy Policy Act of 1992.

Geologic Carbon Sequestration under Federal Lands

STATEMENT OF OPPORTUNITY

Geologic carbon sequestration is the isolation and/or removal of CO₂ from industrial processes and its long-term storage underground to reduce or prevent increasing levels of CO₂ in the atmosphere. There is potential for significant emission reductions in the United States if this can be implemented on a large, commercial scale. The Department of Energy continues to conduct research and develop technologies to support carbon sequestration.

DOI owns or has a material interest in over 500 million acres of land in the United States. Beneath these Federal lands there is the potential to geologically sequester CO₂ in oil and gas reservoirs, deep saline reservoirs, and unmineable coal seams.

DESCRIPTION OF OPPORTUNITY

According to the IPCC report, “emissions of carbon dioxide due to fossil fuel burning are virtually certain to be the dominant influence on the trends in atmospheric CO₂ concentration during the 21st century.”⁴¹ A potential option to reduce this impact involves geological sequestration, or removing carbon dioxide that would otherwise be emitted into the atmosphere and pumping it into cavities underground, where appropriate.

STATEMENT OF OPTIONS

Option 1: Inventory Geologic Sequestration of DOI Lands. The Secretary could direct the USGS to inventory and characterize lands managed by the DOI bureaus for possible geological carbon sequestration.

Option 2: Research Geologic Sequestration. Establish a partnership between the USGS and the Department of Energy to conduct additional research on the benefits and risks of geologic sequestration on Federal lands, including evaluating the retention rates and long-term fate of CO₂ in underground repositories, better understanding saline and mineral formations potentially suitable for underground storage, and better understanding the potential environmental and human effects of such storage.

Table 15-M provides a tabular look at the analyzed criteria for these options.

⁴¹ IPCC. “Introduction.” *Special Report on Carbon Dioxide Capture and Storage*. p. 53

Table 15-M: Geologic Carbon Sequestration under Federal Lands Options

Options	Timescale to Implement	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Option 1: Inventory Geologic Sequestration of DOI Lands	Short	High	Unknown but potentially significant	Medium	Possible more efficient extraction of natural gas and other fuels	Other DOI bureaus	Economy
Option 2: Research Geologic Sequestration	Medium	Medium	Unknown but potentially significant	Medium	Possible more efficient extraction of natural gas and other fuels	DOE	Economy

ANALYSIS OF OPTIONS

Option 1: Inventory Geologic Sequestration of DOI Lands. DOI could gain an improved understanding of the geologic carbon sequestration potential under its lands. Depending on the information that is gathered about the feasibility of this type of sequestration, this inventory could become a vital tool in identifying sequestration sites that could help the United States reduce the level of CO₂ in the atmosphere. Recently introduced legislation includes provisions related to geological sequestration and its associated research. Fiscal and time constraints would need to be evaluated.

Option 2: Research Geologic Sequestration. Although demonstrated to be technologically feasible, there are still significant economic costs (e.g., transportation and other energy costs) and environmental unknowns (e.g., permanence of storage and potential leakage, direct and indirect impacts to potable aquifers, and potential effects on biological communities associated with deep saline solutions) associated with geologic sequestration. Depending on the information that is gathered about the commercial feasibility of this type of sequestration, geologic sequestration could become a vital tool that helps this country reduce the level of CO₂ in the atmosphere.

Environmental concerns (e.g., hydrologic, seismic, and ecological), however, must be addressed before geological carbon sequestration can be undertaken at a commercial scale. The USGS has considerable expertise for addressing such issues as does the Department of Energy.

DOI could leverage its resources by partnering with the Department of Energy and gain a much more complete understanding of the attributes and risks associated with underground carbon storage on DOI lands. Fiscal and time constraints would need to be evaluated.

Development of Renewable Energy on DOI Lands

STATEMENT OF OPPORTUNITY

Renewable energy directly offsets fossil fuel-based energy. DOI has the unique opportunity to develop renewable energy on its lands.

DESCRIPTION OF OPPORTUNITY

DOI manages over 500 million acres of land onshore and 1.76 billion acres of the Outer Continental Shelf. Some of these areas could provide renewable energy opportunities, except as excluded under the Energy Policy Act of 2005. Some of these lands fall within the urban interface or are within close proximity to highly dense populations. Some DOI-managed lands also have renewable resources, such as geothermal resources, on them. By providing access for renewable energy development, the DOI could play a major role in increasing the use of these climate-friendly renewable energy sources.

The use of renewable energy and its required developmental impacts create much lower amounts of greenhouse gas emissions than use of traditional fossil fuels. Increasing the use of renewable energy can significantly reduce greenhouse gas emissions.

DOI's Renewable Energy Program portfolio is built around geothermal, wind, solar, tidal, hydropower, and biomass resources. Some of the biomass resources on these lands would offset the need to import equivalent amounts of energy from foreign sources. Following is a closer look at these renewable energy resources.

Wind and Solar

DOI programs authorize rights-of-ways for using public lands as wind and solar energy production sites, except as excluded by the Energy Policy Act of 2005. The BLM and MMS anticipate an increasing interest in the use of public lands for renewable energy development, due to recently enacted laws in some States requiring energy companies to provide a portion of their products from renewable energy sources.

The current total generation capacity of wind energy projects installed on public land is approximately 500 megawatts. Another almost 600 megawatts of wind energy projects have been proposed or recently approved by the BLM. An additional two separate solar energy project proposals were submitted to the BLM in California, with an estimated 800 megawatts of combined power. The BLM will also continue conducting studies necessary to evaluate and process the increasing number of applications for rights-of-way for the siting of wind and solar energy projects and applications for rights-of-way for electric transmission lines from these projects. The MMS is developing a Federal Program to facilitate and manage renewable energy and alternative use projects on offshore Federal lands.

Geothermal

DOI programs manage the exploration, development, and oversight of geothermal resources on public lands. The BLM is responsible for leasing Federal geothermal resources, and then issuing permits and licenses for post-lease development for both electrical and direct-use heat applications. This must be done while ensuring compliance with lease terms and the National Environmental Protection Act and the protection of other resources. The BLM manages 354 geothermal leases, with 69 leases in producing status at the end of 2006. The installed capacity of these geothermal leases is 1,275 megawatts. These leases generate over 4,600 gigawatt-hours of electrical power per year and provide alternative heat sources for commercial endeavors. Geothermal operations generate more than \$12 million in Federal revenues each year.

Hydropower Re-licensing

The Federal Power Act of 1920 authorizes the Federal Energy Regulatory Commission to permit the use of Federal lands by private entities to develop hydropower facilities. Although there are some large projects on Federal lands, generation from most of these facilities is small. These existing facilities, many of which were licensed in the 1940s and 1950s, are located on public lands and are reserved for this use only. A large number of these facilities are nearing the end of their license terms, and the BLM, through

participation in the commission's re-licensing process, is providing input into the license review and approval process, and identifying applicable terms and conditions necessary to protect or enhance specific resource values. The generation capacity of these hydropower facilities is approximately 30,000 megawatts.

Ocean (Tidal, Wave, and Current)

Ocean energy consists of mechanical energy produced by waves and currents and thermal energy produced by the sun. Various technologies are being developed that will capture wave, current, and thermal energy to generate electricity.

The Energy Policy Act of 2005 gave the MMS management authority over Federal offshore renewable energy and alternative uses of America's offshore public lands. The MMS is presently preparing regulations to implement this new renewable energy program.

Biomass

Biomass consists of plant matter, such as trees, grasses, agricultural crops, or other biological material. It can be used as a solid fuel or can be converted into liquid or gaseous forms for the production of electric power, heat, chemicals, or fuels. Forest products, such as lumber and paper, sequester carbon during the life of the wood product, often several hundred years. Biomass used for biopower or biofuels reduces the demand for fossil fuels and can result in lower or no net gain in carbon emissions. Removing these products prior to wildland fire or prescribed burning reduces smoke and greenhouse gas emissions. Compared to unmanaged forests and woodlands, active forest management can serve to reduce emissions and also sequester carbon.

DOI manages over 120 million acres of forests and woodlands. Commercial timber management occurs primarily on tribal lands managed by the BIA or tribal governments and Public Domain Lands and Oregon and California Grant Lands managed by the BLM. The FWS and the NPS also actively manage lands for wildlife habitat and scenic values. They sometimes produce woody biomass by-products.

Forest management goals of the DOI include maintaining and restoring the health of public and tribal forests and woodlands and providing forest products for economic opportunities. Since 2004, the DOI has funded 16 tribal biomass project projects for a total of \$2.1 million in renewable energy development grants and programs in support of tribal enterprises. In 2008, the BLM will fund biomass project work to contribute to biomass energy supply. The BLM's Biomass Program continues to focus on the utilization of biomass, through both on-the-ground projects and assistance to community groups, to attract and develop industry infrastructure. In 2006, the BLM approved funding on public lands for five biomass projects in five States totaling \$290,000. For example, in Royal Gorge, CO, the Aquila Power Plant is mixing about 10 percent biomass with coal to reduce emissions and is producing approximately 2 megawatts of green energy annually. In 2007, the BLM approved funding for 19 biomass projects in 10 States totaling \$757,000. To promote reduction of greenhouse gas emissions, priority

should be placed on those projects that provide an overall net reduction of greenhouse gas emissions.

Expanding the biomass utilization program on DOI lands could produce an additional annual capacity of approximately 51 megawatts of woody biomass. There may be legal constraints regarding long-term fuel supply commitments on DOI lands that may hinder significant progress in biomass utilization. These problems are mostly on BLM lands, as renewable energy development and biomass supplies on tribal lands are primarily within the scope of responsibility of tribal governments.

STATEMENT OF OPTION AND ANALYSIS

Option 1: Develop a Renewable Energy Coordination Policy. The Secretary could request the heads of the land-managing bureaus to identify a point-of-contact to serve as the Bureau Renewable Resources Ombudsman. Under the guidance of DOI's existing Renewable Energy Ombudsman, a working group could be formed to develop DOI's direction and policy to encourage coordination and cooperation in authorizing use for developing renewable energy.

A Policy Statement from the Secretary could set the course for all bureaus to follow and allow for a consistent approach to renewable resource development. The Energy Policy Act of 2005 addresses geothermal, energy rights-of-way, and other renewable energy improvements and access. Significant revenues would be generated through royalties and use authorization fees.

Expanding access to develop renewable energy on DOI lands would result in a reduction of greenhouse gas emissions and support domestic energy producers in meeting State renewable energy standards. An additional duty of the ombudsman would include tracking the numbers and types of projects at various levels of development and the energy they produce.

Table 16-M provides a tabular look at the analyzed criteria for this option.

Table 16-M: Development of Renewable Energy on DOI Lands Options

Options	Timescale to Implement	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Option 1: Develop a Renewable Energy Coordination Policy	Short	High	Unknown but potentially significant	Low	Significant revenues generated on royalties and use authorization fees, Reduced dependency on foreign oil	Forest Service	Economy

Fleet Management

STATEMENT OF OPPORTUNITY

Motor vehicle emissions from DOI's vehicle fleet contribute to greenhouse gas emissions. Reducing the number of vehicles in the fleet, acquiring more fuel efficient vehicles, improving vehicle efficiency, and using alternative fuels could significantly reduce these emissions.

DESCRIPTION OF OPPORTUNITY

DOI's fleet management program consists of the acquisition, management, use, and disposal of the DOI fleet, which includes motor vehicles for both on-road and licensed off-road purposes. DOI's fleet consists of 36,000 motor vehicles and consumes over 20 million gallons of petroleum, emitting greenhouse gases. Decreasing greenhouse gas emissions will reduce DOI's impact on the environment and allow DOI to lead other Federal agencies by example. DOI has the opportunity to save on fuel costs by acquiring more fuel efficient vehicles as fleet vehicles are ready to be replaced.

DOI strives to be a leader in the reduction of greenhouse gas emissions that are harmful to the environment. The Energy Policy Acts of 1992 and 2005 and Executive Order 13423, "Strengthening Federal Environmental, Energy, and Transportation Management," established transportation management requirements for Federal agencies. These requirements include decreasing consumption of petroleum products, increasing the use of alternative fuels consumed, and acquiring alternative fuel vehicles. DOI bureaus strive to reduce miles traveled, improve vehicle efficiency, decrease petroleum use, and increase the use of alternative fuels to reduce emissions.

DOI fleet managers in the field have many unfunded and under-funded projects that would benefit from increased funding to support their greenhouse gas emission reduction and conservation efforts.

STATEMENT OF OPTIONS

Option 1: Engage Department of Energy and General Services Administration Leadership. Engage leadership in the Department of Energy and the General Services Administration to address the additional charges associated with purchasing and/or leasing hybrid vehicles. In addition, seek assistance in making the most fuel efficient vehicles readily available and establishing timely, cost-effective methods for acquiring emerging alternative fuel technologies to help promote their use.

Option 2: Expedite Acquisition of Alternative and High Fuel Efficiency Vehicles. Expedite the replacement of conventionally fueled (i.e., gasoline or diesel) and older, less fuel-efficient, light-duty sedans and pick-up trucks with alternative fuel, hybrid, and higher fuel efficiency vehicles.

Option 3: Expand DOI Alternative Fuel Infrastructure. Expand the installation of alternative fuel tanks at DOI refueling locations. Acquire and provide biodiesel at DOI facilities with existing diesel refueling infrastructure.

Table 17-M provides a tabular look at the analyzed criteria for these options.

ANALYSIS OF OPTIONS

Option 1: Engage Department of Energy and General Services Administration Leadership. DOI has been unable to secure delivery of high fuel efficiency vehicles and emerging alternative fuel technologies. DOI pays an additional \$6,000–\$10,000 per hybrid vehicle to purchase or lease hybrid vehicles from GSA. Because GSA passes the additional manufacturer’s costs associated with high fuel efficiency vehicles onto the agencies, these price challenges limit DOI’s opportunity to modernize our fleet and limit CO₂ emissions. DOI leadership could engage senior Department of Energy and General Services Administration officials on this issue to enhance availability to take advantage of the opportunities provided by modern vehicle technology.

By making vehicles that are less greenhouse-gas-intensive readily available for land managers to use, this option would have positive impacts within DOI and improve general public perceptions. It would have positive economic impacts through DOI’s demonstration and promotion of emerging alternative fuel technologies. This option could result in savings of approximately \$6000–\$10,000 per hybrid vehicle if these surcharges are waived or reduced through the use of the Federal government’s purchasing power. Without such a price reduction, the estimated incremental costs associated with acquiring high fuel efficiency and alternative fuel vehicles to bureaus and offices are \$2 million annually.

Option 2: Expedite Alternative and High Fuel Efficiency Vehicle Acquisition. The average age of a DOI-owned vehicle, including sedans, vans, SUVs, light-duty and medium-duty trucks, is 8.5 years. The average age of light-duty trucks within the DOI-owned fleet is approximately 10 years.⁴² As older, less fuel efficient vehicles qualify for replacement, moving to alternative fuel, hybrid, and high fuel efficiency vehicles would advance DOI’s efforts to meet Energy Policy Act of 2005 and Executive Order 13423 conservation goals, as well as reduce greenhouse gas emissions. While resolving the additional cost of hybrid vehicles (Option 1) would relieve part of the cost of replacing DOI’s fleet, some additional funding would still be required to supplement DOI’s acquisition of more fuel efficient vehicles, decrease the use of petroleum-based products, and increase the use of alternative fuels. Disposal of hybrid vehicle batteries may incur additional costs for purchased vehicles in the future.

⁴² FY 2007, OMB A-11 Fleet Report

Table 17-M: Fleet Management Options

Options	Timescale to Implement	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Option 1: Engage Department of Energy and General Services Administration Leadership	Short	High for meeting, Low for GSA decision	Low	Low, potential savings for Bureaus	Reduce dependency on foreign oil, Accelerated DOI progress in meeting EPAAct05 and EO goals	GSA, DOE	None
Option 2: Expedite Acquisition of Alternative and High Fuel Efficiency Vehicles	Medium with funding	High with supplemental funding	Low	Medium, incremental \$2M increase annually	Reduce dependency on foreign oil, Accelerated DOI progress in meeting EPAAct05 and EO goals	DOE	
Option 3: Expand DOI Alternative Fuel Infrastructure	Medium with funding	High with supplemental funding	Low	Medium, incremental \$2M increase annually	Reduce dependency on foreign oil, Increased alternative fuel consumption, Energy security, Meeting EPAAct05 and EO goals	DOE, Other Federal agencies	Possible Economy

Expanding and expediting the acquisition of high fuel efficiency and alternative fuel vehicles would positively influence DOI's internal efforts to reduce greenhouse gas emissions. This initiative would greatly facilitate the land managers' efforts to implement greenhouse gas mitigation strategies, as well as demonstrate DOI's commitment to reducing greenhouse gas emissions.

Option 3: Expand DOI Alternative Fuel Infrastructure. Using alternative fuels such as ethanol and biodiesel will reduce vehicle-produced greenhouse gas emissions. Currently, alternative fuel infrastructure (i.e., refueling stations) is lacking throughout the Federal government and commercial industry, especially in areas accessible by DOI vehicles. This negatively impacts DOI's ability to use alternative fuels. To increase DOI's alternative fuel consumption and reduce the amount of greenhouse gas emissions produced, DOI could identify strategic DOI locations that have the capability for self-contained refueling stations and install alternative fuel tanks. Additional funding to bureaus would be required. An estimated \$2 million annually would be required to install and construct alternative fuel tanks at existing DOI refueling stations.

Alternative fuel tanks at DOI refueling stations would increase DOI's ability to use alternative fuels. By making these tanks available to other Federal agencies, DOI could lead by example and increase the positive impacts. This initiative would also greatly facilitate the efforts of land managers to implement greenhouse gas mitigation strategies and demonstrate DOI's commitment to reducing greenhouse gas emissions. As the demand for alternative fuels increases, economic development of commercial alternative fuel refueling stations will increase, potentially reducing the need for some future DOI refueling stations.

Facility Operations

STATEMENT OF OPPORTUNITY

Because facility operations contribute to CO₂ emissions primarily through the consumption of energy produced by the combustion of fossil fuels, improving the efficiency of DOI facilities will reduce the associated emissions.

DESCRIPTION OF OPPORTUNITY

The effects of climate change, such as warmer temperatures and extended visitor seasons, will increase the consumption of fossil fuels to cool and operate DOI facilities. Facility CO₂ emissions can be reduced by energy conservation and incorporating green building practices. The amount of CO₂ emissions produced by a facility depends on the fuel mix, weather, price and consumption of energy, and availability of non-fossil fuel alternatives.

DOI owns and operates approximately 46,000 buildings nationwide.⁴³ These buildings include visitor centers, schools, dormitories, office and maintenance buildings, comfort stations, laboratories, housing, detention centers, and warehouses. The vast majority of these buildings is geographically dispersed and are less than 10,000 square feet.

The primary type of fuel consumed at DOI facilities is purchased electricity used for lighting, heating, cooling, and operating equipment and computers. Nearly 50 percent of the electricity generated in the United States is produced by coal-fired power plants, which are a major contributor of CO₂ emissions.⁴⁴ “The actual implications for CO₂ emissions depend on the carbon content of the energy sources used to provide the heating and cooling services.”⁴⁵ Using renewable energy sources, such as solar and wind, can significantly reduce emissions.

The Energy Policy Act of 2005, Public Law 109-58, and Executive Order 13423, set forth aggressive energy reduction and renewable energy consumption goals for Federal facilities. Secretary Kempthorne issued a memorandum on April 4, 2007, directing DOI to lead by example on the implementation of the Executive Order requirements.

The U.S. Green Buildings Council Leadership in Energy and Environmental Design (LEED) established criteria to measure and document building performance. As required by the Executive Order, the incorporation of LEED or equivalent criteria within DOI build designs will be required through the DOI Sustainable Building Implementation Plan, now in draft. This requirement will result in additional construction costs but should be recouped over the building’s life through more efficient building operations. Employing sustainable design and operating principles, improving energy efficiency and increasing renewable energy consumption at DOI’s new and existing facilities will lower DOI’s CO₂ emissions and reduce fuel and electricity consumption.

STATEMENT OF OPTIONS

Option 1: Expedite Use of Energy Efficiency Technologies. Expedite the implementation of energy efficiency technologies at DOI facilities.

Option 2: Expand Use of Renewable Energy. Expand the implementation of renewable energy technologies and increase the use of renewable energy at DOI facilities.

⁴³ The Federal Real Property Council. “FY 2006 Federal Real Property Report: An Overview of the U.S. Federal Government’s Real Property Assets.” July 2007.
http://www.gsa.gov/gsa/cm_attachments/GSA_DOCUMENT/FRPCFY06SummaryReportFRPP_R2-i13-v_0Z5RDZ-i34K-pR.pdf

⁴⁴ Energy Information Administration. “Annual Electric Generator Report.” 2005.

⁴⁵ “Inter-relationship Between Adaptation and Mitigation.” *Climate Change 2007: Impacts, Adaptation and Vulnerability—Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. M.L. Parry *et al.*, Eds., Cambridge University Press, Cambridge. 2007. p. 760.

Option 3: Update Existing Policies. Update existing policies to incorporate opportunities to reduce greenhouse gas emissions due to the operation of equipment, vessels, and other fossil-fuel consuming equipment.

Option 4: Explore use of Energy Savings Performance Contracts. Expand the use of ESPCs, contracting vehicles that allow federal agencies to install energy saving technology without up-front capital costs.

Table 18-M provides a tabular look at the analyzed criteria for these options.

ANALYSIS OF OPTIONS

Option 1: Expedite Use of Energy Efficiency Technologies. Expediting the implementation of energy efficiency projects would reduce CO₂ emissions by facilities and keep DOI moving forward to meet the aggressive goals of the Energy Policy Act of 2005 and the Executive Order 13423. These goals include reducing building energy and water consumption, installing advanced electric metering systems, and implementing sustainable principles for our existing building inventory. Many of the energy efficiency improvements could be implemented quickly given the proper resources and could provide a return on investment in 3 to 5 years.

According to the IPCC, improving energy efficiency and switching fuels are some of the most frequently applied policy measures that result in mitigation of greenhouse gas emissions.⁴⁶ “It is often more cost-effective to invest in end-use energy efficiency improvements than in increasing energy supply to satisfy demand for energy services.”⁴⁷

Expediting these projects would require additional bureau funding specific to facility energy management, estimated at \$5 million annually, to be distributed among the bureaus. Bureaus currently use limited operations and maintenance and deferred maintenance funding to implement small energy projects. Without dedicated energy management funding, it will be difficult for the bureaus and DOI to meet the out-year energy and CO₂ reduction goals.

⁴⁶ IPCC. “Introduction.” *Climate Change 2007: Mitigation of Climate Change—Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. 2007. p. 106.

⁴⁷ IPCC. “Summary for Policymakers.” *Climate Change 2007: Mitigation of Climate Change—Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. 2007. p. 18.

Table 18-M: Facility Operations Options

Options	Timescale to Implement	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Option 1: Expedite Use of Energy Efficiency Technologies	Short–Medium with funding	High	Low	Medium, additional funding of \$5M annually	Cost savings, Accelerated DOI progress in meeting EPO05 and EO goals	DOE, Utility companies	--
Option 2: Expand Use of Renewable Energy	Short–Medium with funding	High	Low	Medium, additional funding of \$2M annually	Diversified power supply, Accelerated progress in meeting EPO05 and EO renewable energy (RE) goals, Stimulated RE market to produce more RE and higher efficiency technologies, Promotion of grid independence at remote DOI facilities	DOE, Utility companies, BIA Education Component	Economy - stimulating the RE market to produce more RE and Higher efficiency technologies
Option 3: Update Existing Policies	Short–Medium with funding	High	Low	Low to update policy, Medium–High to implement	Same as above	--	--
Option 4: Explore use of Energy Savings Performance Contracts	Short	High	Low	Low/Medium	Cost savings	--	--

DOI is authorized to use alternative methods of project financing, such as Energy Saving Performance Contracts and Utility Energy Service Contracts. These financing methods are encouraged but have been implemented by the bureaus on a very limited basis. In the past, it has been difficult to attract the interest of energy service companies, primarily due to the relatively small building size, remote locations, energy usage, and limited potential energy savings to generate sufficient funds to pay off the energy improvements within the payback periods. In addition, many DOI facilities are served by small rural electric cooperatives that do not offer the additional services (e.g., energy audits and financing) often provided by the larger utility companies. DOI is currently working with the

Department of Energy's Federal Energy Management Program and the National Rural Utilities Cooperative Finance Corporation to foster education and participation in Utility Energy Service Contracts at DOI facilities.

These efforts would empower facility managers to reduce CO₂ emissions and allow DOI to showcase highly efficient facilities to the many visitors of DOI lands. Sustainable, energy efficient buildings provide comfortable, safe, and productive environments for employees and visitors.

Option 2: Expand Use of Renewable Energy. Expanding renewable energy resources at DOI facilities will directly offset CO₂ emissions, reduce dependence on fossil fuels, and stimulate the renewable energy market.

DOI facilities can increase the use of renewable energy sources by installing and using onsite renewable energy components, such as solar and small wind turbines, purchasing "green" energy from utility service providers, and purchasing renewable energy certificates.

Since many DOI facilities are small and geographically dispersed, onsite renewable energy components could provide the electricity needs of these facilities, especially remote facilities where onsite diesel- or gasoline-powered generators now provide the electrical service. Onsite renewable energy components respect the natural environment and eliminate CO₂ emissions. Furthermore, due to the many visitors our facilities receive, onsite renewable components demonstrate that DOI is making a difference in reducing CO₂ emissions. In addition, expanding the use of these technologies at BIA education facilities could provide an opportunity to educate American Indian children about renewable energy resources.

While the preferred method of expanding renewable energy consumption is through the installation of onsite components, the purchasing of green energy and renewable energy certificates is another feasible method of offsetting CO₂ emissions where onsite renewable energy components cannot be implemented. Purchasing green energy and renewable energy certificates would further stimulate growth in the renewable energy market.

Expanding renewable energy resources at our facilities would require additional bureau funding (estimated at \$2 million annually to be distributed among the bureaus). Bureaus currently utilize limited project and deferred maintenance funding to implement small renewable energy projects. While incorporating onsite renewable components in projects increases the initial cost of the project, it reduces the long-term electricity costs, especially as electricity rates increase. In addition, utility companies generally charge a premium for green energy, and green energy purchase options are not available through all utility service providers.

The costs of renewable energy certificates have increased over the past few years due to the increased demand and limited supply. The cost of renewable energy certificates is anticipated to go up as States begin to require utilities to increase the portion of electricity produced from renewable resources.

There are significant benefits (in addition to reducing CO₂ emissions) to expanding DOI's use of renewable energy. Using alternative energy sources helps to diversify the power supply, stimulate the renewable energy market to produce more renewable energy and higher efficiency technologies, and promote grid independence at remote DOI facilities.

Option 3: Update Existing Policies. DOI could update existing policies to incorporate opportunities to reduce CO₂ emissions from equipment that runs on fossil fuels. For example, many leaf blowers, edge trimmers, and outboard boat motors still use 2-stroke technology, which is fuel inefficient. Where technologically feasible and cost effective, facility managers could consider using technologies and equipment that reduce emissions.

Option 4: Explore use of Energy Savings Performance Contracts. Energy Savings Performance Contracts, which contract vehicles that allow Federal agencies to install energy saving technology without up-front capital costs, have been successfully piloted by the BLM to introduce energy saving technology in their Boise District and the National Interagency Fire Center offices. In the pilot, the BLM saved \$122,000 in its first year. The BLM plans to expand this practice bureau-wide. Other bureaus could explore whether Energy Savings Performance Contracts could work for them as well.

Education and Outreach

STATEMENT OF OPPORTUNITY

Climate change and the impacts of greenhouse gas emissions are complex issues. DOI could work to educate its many visitors and employees on both the impacts of climate change and the actions they can take to reduce their greenhouse gas emissions.

DESCRIPTION OF OPPORTUNITY

DOI has a unique opportunity to educate visitors and showcase both the positive and negative effects of climate change. Helping others to understand the issues and

benefits/costs of addressing greenhouse gas emissions would have far reaching impacts on climate change.

DOI lands are already showing consequences of climate change. DOI bureaus have implemented projects to reduce greenhouse gas emissions, and these projects demonstrate DOI's commitment. However, if communication and education are not part of the project promotion, the importance of the change may go unnoticed and the opportunity to influence the public is lost. DOI, as a lead conservation agency, can showcase exhibits, research, and demonstrations of climate change adaptation and mitigation actions to the many visitors to DOI facilities.

By implementing an outreach program, DOI could teach employees and visitors how their actions and lifestyles contribute to climate change. Individual awareness and conservation actions (e.g., recycling; turning off lights; and walking, biking, using mass transit, or carpooling to get to work) can reduce energy consumption thus reducing greenhouse gas emissions well beyond our park borders and facilities.

STATEMENT OF OPTIONS

Option 1: Develop a Climate Change Education and Outreach Program. Develop an education and outreach program to increase employee and visitor awareness of climate change.

Option 2: Provide Incentives for Climate Change Conservation. Encourage public conservation by providing incentives, such as waived or reduced access fees to DOI lands for those who arrive on foot or via regional transportation, mass transit, bicycle, or alternative fuel vehicle.

Table 19-M provides a tabular look at the analyzed criteria for these options.

ANALYSIS OF OPTIONS

Option 1: Develop a Climate Change Education and Outreach Program. A DOI education and outreach program to increase employee and visitor awareness of climate change would help mitigate greenhouse gas emissions. Providing both a better understanding of the significance of making changes and information and tools on how to make changes would help others to reduce greenhouse gas emissions in their places of work, homes, and communities. The IPCC states, “changes in lifestyle and behavior patterns can contribute to climate change mitigation. Changes in occupant behavior, cultural patterns and consumer choice and use of technologies can result in considerable reduction in CO₂ emissions related to energy use in buildings.”⁴⁸

⁴⁸ IPCC. “Summary for Policymakers.” *Climate Change 2007: Mitigation of Climate Change—Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. 2007. p. 17.

Table 19-M: Education and Outreach Options

Options	Timescale to Implement	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Option 1: Develop a Climate Change Education and Outreach Program.	Short	High	Low direct impact Medium impact due to visitors	Low	Potential global impacts as visitors take back what they learned on DOI lands, Reduced dependency on foreign oil, meeting EPA Act 05 and EO goals	Visitors, Staff	Recreation, Visitation
Option 2: Provide Incentives for Climate Change Conservation.	Short–Medium	High	Low	Possible loss of revenue	Indirect co-benefits, Promotion of lifestyle changes	Area transit authorities	Recreation, Visitation

Executive Order 13423 requires that Federal agencies provide initial awareness training to employees and contractors regarding environmental, energy, and transportation management to ensure the objectives, goals, and benefits of the executive order are communicated. Educating employees and visitors and showcasing efforts demonstrates DOI's commitment to reducing greenhouse gas emissions. Through education and outreach, DOI is partnering with every visitor and employee.

DOI facilities need resources to develop displays, demonstrations, and park workshops for visitors on the subject of climate change and greenhouse gas reduction. While some parks have staff trained to develop such materials, many do not. A Climate Change Education and Outreach Initiative would assist DOI managers with manpower and resources to develop educational materials that highlight climate change issues in general and specifically highlight the adaptation and mitigation strategies that are being employed at each facility. In addition, partnerships among private entities and the parks, refuges, and lands may cultivate privately supported demonstration projects.

A Climate Change Education and Outreach Program could significantly influence DOI's more than 70,000 employees and the estimated 440 million visitors to DOI lands annually. See DOI-Wide Option 5, "Develop a DOI-Wide Climate Change Training Curriculum," in the Adaptation section of this report for an additional option for educating DOI employees and partners.

Option 2: Provide Incentives for Climate Change Conservation. Encourage people to conserve fuel and reduce emissions by providing incentives, such as waived or reduced access fees to DOI lands for those who arrive on foot, via regional transportation, mass transit, bicycle, or alternative fuel vehicle. Direct incentives could influence lifestyle changes. Waiving or reducing access or parking fees to DOI lands for climate friendly methods of transportation would have a positive impact on the general public. Partnerships could be formed with area transit authorities to promote use. The incentive may result in more visitors to DOI lands for recreation, and may have positive economic impacts through the development of more climate friendly forms of transit. There may be a loss of revenue to DOI due to the access fee waiver or reduction, but the losses may be offset by an increase in visitation, associated donations, and reduced need for parking spaces. Policy and legal issues would need to be fully evaluated by the DOI Office of the Solicitor.

APPENDIX A: SUBCOMMITTEE CONTRIBUTORS

Craig Axtell, Superintendent, Sequoia and Kings Canyon National Park

Craig Axtell has 32 years of experience in the management of National Parks. Assigned to five park units and two central offices over his career, Craig has land management experience in the Southeast, Upper Midwest, Central Rocky Mountains, the Desert Southwest, and most recently the Sierra Nevada. Craig has broad experience working in these various landscapes as a resources manager. B.S. Forest Science, M.S. Natural Resources Management.

Mohammad Baloch, Water Rights Engineer, Bureau of Indian Affairs

Mohammad S. Baloch is a Water Rights Specialist/Engineer in the Natural Resources Division, Bureau of Indian Affairs, in Washington, D.C. He is the Bureau's lead on developing a model tribal drought management plan. He has authored or co-authored several articles and reports (published and unpublished) in the field of Water Resources including Agricultural Drought, Water Resources Development and Management Plans, and Hydrologic studies (Stream Flow Characteristics). After working for state government and the Office of Surface Mining, Mr. Baloch joined the Bureau of Indian Affairs. In addition to Indian water rights litigation and negotiation, he has advised numerous Indian tribes on the development of water and related land resources management plans. He brings a total of 56 years experience in various aspects of water resources engineering to the task force, including years of overseas experience with irrigation systems and the effects of drought.

Jill Barron, Ecosystem Ecologist, Biological Sciences Discipline

Jill Barron has been conducting ecological research to support management of national parks since 1976, and has been conducting research on the effects of air pollution and climate on Rocky Mountain forests and high elevation lakes since 1981. As editor of the book "Rocky Mountain Futures," (2002, Island Press) she compiled evidence of the effects of human activities, including land, water, and natural resource use on past and present Rocky Mountain ecosystems, including natural processes and biodiversity, and presents scenarios of potential future environmental conditions. Barron is lead author of the CCSP SAP 4.4 chapter on Adaptation Options for National Parks to Climate Change. She obtained a BS in Botany and Geology from Cornell University, MS in Land Resources at UW-Madison, and a Ph.D. in Ecosystem Ecology at Colorado State University.

Doug Blatchford, River Operations Group Manager, Boulder Canyon Dam

As the River Operations Group Manager, in the Boulder Canyon Operations Office, in Reclamation's Lower Colorado Region, Douglas B. Blatchford, PE and staff manage operations of the Colorado River from Lee Ferry to the international boundary with Mexico. With more than 25 years experience in water resources, Mr. Blatchford brings both his experience and knowledge of the arid southwest, including the Colorado River watershed, to the DOI task force. This adds insight into impacts of climate change to water supply issues affecting stakeholders who depend on the Colorado River for their livelihood.

Todd Brindle, Superintendent, Big Thicket National Preserve

Todd Brindle is a 30-year veteran of the National Park Service. He has worked in 11 diverse park units from Florida to California, including national parks, monuments, recreation areas, and historic sites. He is currently Superintendent at Big Thicket National Preserve in Texas. Brindle earned a Bachelor's Degree in Political Science from the University of Florida in 1975.

Virginia Burkett, Chief Scientist, Global Change Research

Virginia Burkett is the USGS Chief Scientist for Global Change Research. Most of her research and publications deal with wetlands, coastal systems, and climate change. She was a lead author of the IPCC's Third (2001) and Fourth (2007) Assessment Reports and the U.S. National Assessment of climate change and its impacts (2001). Burkett formerly served as Director of the Louisiana Department of Wildlife and Fisheries and the Louisiana Coastal Zone Management Program. Her background in science and natural resource management has enabled her to focus on helping resource managers prepare for and adapt to climate change.

Mitch Ellis

Mitch Ellis has worked for the U.S. Fish and Wildlife Service for more than twenty years, with experience spanning eight National Wildlife Refuges and the Washington Office.

Mitch has a B.S. in wildlife ecology from the University of Arizona. He has managed federal wildlife refuges in Arizona, California, Texas, West Virginia, and Alabama.

Mitch brings significant experience to the team with regard to managing land in arid environments and dealing with challenging issues such as endangered species management and water allocation.

Terry Fulp, Area Manager, Boulder Canyon Operations Office

Terry Fulp is the Area Manager of the Bureau of Reclamation's Boulder Canyon Operations Office and oversees implementing the Secretary of the Interior's water master functions on the lower Colorado River (Lee's Ferry, Arizona to the Mexican border), including water delivery, accounting, and contracting. Fulp is actively involved in Colorado River operations and management issues and currently serves as Program Manager of the effort to develop additional operational guidelines that will address how Reclamation manages Lake Powell and Lake Mead, particularly during times of low reservoir conditions, thereby minimizing the effects of long-term drought on the Southwest.

Russell Galipeau, Superintendent, Channel Islands National Park

Russell Galipeau comes to the DOI task force on climate change with 26 years of experience as a natural and cultural resources manager for the National Park Service, and currently serves as the Superintendent of Channel Islands National Park. His assignments have spanned eco-regions of the U.S. This broad experience has given Russell perspective on the challenges of ecosystem management from the subtropics of Florida, the subarctic in Alaska, the Sierra Nevada in California, to the offshore islands within the Southern California Bight. These experiences bring insight into the landscape level of

climate change impacts and an understanding of the need for cross-jurisdictional and regional adaptations.

Susan Giannettino, Deputy State Director, BLM Idaho

Susan Giannettino has worked for the Forest Service and Bureau of Land Management in resource planning and management positions for nearly 30 years. She has lived and worked in seven of the western States providing broad exposure to the natural resource management issues associated with forests and rangelands. Her educational background (PhD in cultural anthropology from the University of Washington and MA in Instructional Technology from Boise State University) lead her to a focus on the human dimension of public land stewardship.

Sam Hamilton, Southeast Regional Director, FWS

Sam Hamilton, Southeast Regional Director, brings approximately 30 years of professional experience with the US Fish and Wildlife Service to the DOI task force on climate change. Over half his career was spent in ecological services field stations across the southeastern United States where he worked on threatened and endangered species issues, water resource projects and wildlife habitat restoration programs. He worked on fish and wildlife policies in the Service's Washington, DC headquarters and now serves as regional director for the Southeast region. He has brought hands-on experience in the area of landscape conservation and extensive work in the area of carbon sequestration.

Abraham E. Haspel, Assistant Deputy Secretary, Office of the Secretary

Abe serves as the Chair of the Subcommittee on Land and Water Management. He has worked on the issue of climate change since 1992. As a Deputy Assistant Secretary for Policy and International Affairs at the Department of Energy (DOE) and later as a DOE Deputy Assistant Secretary for Energy Efficiency and Renewable Energy, he played a central role in developing U.S. policy on climate change throughout the 1990s. In addition to attending all the international negotiating sessions sponsored by the United Nations, he also served as the Chair of the 23 nation Climate Technology Initiative from 1998 through 2000. After returning the DOI in 2002, Abe took on other management challenges at the Department but was asked to resume his participation in energy and climate change matters with the passage of the Energy Policy Act of 2005. As Chair of the Subcommittee on Land and Water Management, Abe brings 20 years of Senior Executive Service management experience and leadership to this task.

Helen Hankins, Field Manager, BLM

Helen Hankins brings more than thirty years experience as a public land resource manager in four states to the DOI task force on climate change. This broad experience has given Helen perspective on ecosystems from the Arctic and the Great Basin to the desert Southwest. This brings insight into landscape level of climate change impacts and an understanding of the need for cross-jurisdictional, regional adaptations to climate change.

Geoff Haskett, Assistant Director, NWRS

Geoffrey Haskett is the Assistant Director for the National Wildlife Refuge System with oversight on climate issues for the System such as sea level rise on coastal refuges, prairie pothole drying, southwest desertification and species and population range shifts. Haskett has 30 years of experience with the Department of the Interior mostly with the US Fish and Wildlife Service but some time with the Bureau of Land Management and the National Park Service as well. He has worked in Alaska, the arid southwest, the southeast and northwest regions of the Service as well as Washington DC. Mr. Haskett received a Masters in Public Administration from Portland State University in 1980 and the Secretary's Meritorious Service award in 2002.

Mary Heying, Engineer, Office of Acquisition and Property Management, OS

Mary Heying is a civil engineer within the Office of the Secretary, Office of Acquisition and Property Management with over twenty five years of experience working in design, construction, facility and program management. She is currently the Department's Energy Conservation Program Manager responsible for the incorporation of energy conservation measures and on-site renewable energy technologies at Department of the Interior facilities. She provides energy management policy and guidance to the Department's eight Bureaus. She holds a B.S. in Civil Engineering and is a registered professional engineer in the State of Maryland.

Emily Joseph, Program Analyst, Office of Environmental Policy and Compliance

Emily Joseph is currently a program analyst within the Office of Environmental Policy and Compliance working on environmental cleanup and liability issues. Emily recently completed a two-year leadership and development program in the Department rotating through six offices within the Office of the Secretary including the Office of Environmental Policy and Compliance, the Office of Wildland Fire Coordination, and the Office of International Affairs.

Kristin K'eit, Director of the Division of Environmental and Cultural Resources Management, BIA, Alaska Region

Kristin K'eit, an Alaska Native Tlingit Indian and Inupiaq Eskimo, is the Director of the Division of Environmental and Cultural Resources Management, Bureau of Indian Affairs, Alaska Region. Her experience with Alaska tribal environmental issues has broad overlap into the issues of climate change which impact Alaska Native traditional resources required for maintaining whole Native cultures: physical (including food, exercise, scientific data), spiritual, social, intellectual, and generational. Ms. K'eit's professional experience includes seven years as the BIA Alaska Regional Environmental Scientist, nearly two years as an Environmental Protection Specialist with Central Council of Tlingit & Haida Indian Tribes of Alaska, and leadership and membership in the Colorado School of Mines (CSM) Chapter of the American Indian Science and Engineering Society. Ms. K'eit received her Bachelor of Science degree from CSM in Chemical Engineering and Petroleum Refining.

Emily Kennedy, Program Analyst, Minerals Management Service

Emily Kennedy is a Presidential Management Fellow and a program analyst with MMS. Prior to entering public service, she attended the University of Houston Law Center concentrating on energy, environmental and natural resources issues. She also has four years of private industry experience as a chemical engineer with Motorola, Inc.

Julie Kiang, Hydrologist, Office of Surface Water, USGS

Julie Kiang is a hydrologist with the USGS. Among her duties is coordination of a climate change research program within the water discipline. Previously, she was a water manager for the D.C. metropolitan area, focusing on drought management and long term planning. She has also been a consultant to water suppliers in the western U.S. and conducted climate change research as part of her graduate work. She holds a B.S. in Civil and Environmental Engineering from Stanford University, an S.M. in Civil and Environmental Engineering from the Massachusetts Institute of Technology, and a Ph.D. in Hydrology and Water Resources from the Massachusetts Institute of Technology.

Tina Kreisher, Director of Communications, OS

Tina Kreisher is director of communications for the Department of the Interior and for Secretary Dirk Kempthorne. She also served as associate administrator for communications at the Environmental Protection Agency and communications director for the U.S. Senate Energy and Natural Resources Committee. These positions have given her a broad range of experience in natural resource issues, and knowledge of climate change from several perspectives.

Tania Larson, USGS

Tania Larson, a writer/editor with the USGS Office of Communications, is on a mission to translate science into everyday language. Her writing has been ranked in the top five by the Ragan Communications Awards, and projects she has edited have been honored with a USGS Shoemaker Communications Award, a National Association of Government Communicators Blue Pencil Award, and a top five ranking in the Ragan Communications Awards.

Roy Lowe, Project Leader, Oregon Coast NWR Complex

Roy W. Lowe has been involved in coastal and marine management issues for 26 of the past 30 years while employed with the U.S. Fish and Wildlife Service. He has worked on biological issues in estuarine, coastal and marine ecosystems in central and northern California and throughout the Oregon coast where in now manages six National Wildlife Refuges and two Wilderness Areas in a highly dynamic and changing environment. Roy obtained a Bachelor of Science degree in Wildlife Management from Humboldt State University in 1977.

Larry Maloney, Senior Policy Analyst, MMS

Larry Maloney recently retired after serving for over thirty years in the federal government. In his most recent position, Larry was a Senior Policy Analyst with the Minerals Management Service where he assisted with the development of regulations and policies associated with energy and resource management.

Len Meier, Chief, Program and Technology Support Branch, Mid Continent Region
Len Meier has been involved for the last 25 years in restoring lands and waters drastically disturbed by past mining activities in the Midwestern US, and ensuring that current mining is conducted in ways that protect people and the environment. Len has a BS in Agriculture and a MS in Biology with emphasis on conservation practices; provide strong academic background in the application of scientific methods to achieve ecological restoration and protection results. Len is currently a manager in the Mid-Continent Region of the DOI, Office of Surface Mining Reclamation and Enforcement.

Anne Morkill, Refuge Manager, Florida Keys NWR Complex
Anne Morkill has worked as a wildlife biologist and refuge manager for 18 years in Wyoming, Colorado, Alaska, and Florida. During her 14 year tenure with the Bureau of Land Management and U.S. Fish and Wildlife Service in Alaska, she was involved in various studies evaluating environmental changes and development impacts to coastal habitats and species. Ms. Morkill currently manages four national wildlife refuges in the Florida Keys that protect 21 threatened and endangered species and two globally imperiled habitats that may substantially disappear within 50 years under the IPCC's sea level rise scenarios, providing her with direct insight into the challenges that land managers face in adapting to climate change. Ms. Morkill received a B.S. Wildlife Biology from Colorado State University in 1986 and a M.S. Zoology from the University of Wyoming in 1990.

John Morton, Supervisory Biologist Kenai NWR
BS Wildlife Ecology (University of Wisconsin - Madison)
MS, PhD Wildlife Science (Virginia Polytechnic Institute & State University)
John Morton brings 20 years experience as a wildlife biologist with the U.S. Fish and Wildlife Service, including time with Arctic, Yukon Delta, Chesapeake Marshlands, Kenai, Chincoteague, and Guam National Wildlife Refuges. Most recently, Morton participated in the GAO workshop that evaluated how agencies were addressing the impacts of climate change on Federal lands, and he served on the steering committee for the USFWS Region 7 Climate Change Forum. He currently oversees research and monitoring of climate change impacts at Kenai National Wildlife Refuge.

Hans Neidig, Special Assistant, Office of Alaska Affairs, OS
Mr. Neidig is a lifelong Alaskan and avid outdoorsman. As a former Alaska legislative aide, Mr. Neidig worked predominately on Alaskan natural resource issues for 5 years. As Special Assistant to the Secretary of Interior for Alaska, Mr. Neidig advises the Secretary on all Alaska related matters as they pertain to the Department of the Interior. DOI manages over 50 percent of Alaska's lands. Mr. Neidig holds a Masters Degree in Public Management and resides in Anchorage, AK.

Michael Pellant, Coordinator, Great Basin Restoration Initiative
Mike Pellant is a rangeland ecologist with over 30 years of experience in dealing with the management and restoration of Intermountain rangelands. He has extensive management experience in dealing with droughts, wildfires, and invasive species and the actions required to mitigate their impacts. In 2007, Mike testified before both a House and

Senate subcommittee on climate change and drought impacts on Great Basin Rangelands. He is incorporating climate change into restoration strategies in the Intermountain area as the coordinator for BLM's Great Basin Restoration Initiative. Finally, Mike is the DOI representative for the United Nation's Convention to Combat Desertification and provides technical assistance to the State Department on human and climate impacts to the earth's ecosystems.

Tom Ryan, Lead Hydraulic Engineer, Glen Canyon Dam

BS Civil Engineering - University of Utah (1989)

BA Psychology - University of Michigan (1978)

Direct water operations at Glen Canyon Dam. Oversee the operation of Reclamation reservoirs in the Upper Colorado River Basin. Work with stakeholder groups and the public each year to develop the Annual Operating Plan for Colorado River Reservoirs. Oversee technical studies for implementation of new or revised operating criteria and/or guidelines for the operation of Colorado River reservoirs. Currently work on two major National Environmental Policy Act activities (“Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead EIS” and “Glen Canyon Dam Long-Term Experimental Plan EIS”).

From 1992-1995, was Reclamation’s lead in the Western Basins Climate Change Research Study, a collaborative study involving Reclamation and the USGS.

Reid Schuster, Chief of Staff to the Deputy Secretary, Office of the Secretary

Reid Schuster has been with the Department of the Interior for over six years. During his tenure at DOI he has worked on a number of issues ranging from DOI’s implementation of the Energy Policy Act of 2005 to the promotion of the importance of the outdoors to children’s development and well being.

Bodie Shaw, Deputy Director, BIA Branch of Wildland Fire Management

Bodie Shaw holds a Bachelor of Science in Forest Management and a Master of Science in Forest Resources from Oregon State University. He has testified before the Senate subcommittee on Forests and Public Land Management on tribal resource and environmental issues as well as briefed the House of Representatives, House Resource Committee members regarding tribal land management issues. Bodie was also a tribal forest manager and assistant professor at Oregon State University.

Tim Spisak, Chief, Fluid Minerals Division

Tim Spisak brings more than twenty three years experience as a public land and minerals resource manager in three states and the BLM Washington Office to the DOI task force on climate change. This broad experience has given Tim perspective on ecosystems in the Mid Continent area; oil, gas, geothermal, and helium development; and their relationship to the overall consumer market. This insight into minerals development and an understanding of the need for cross-jurisdictional, regional adaptations provides a balanced perspective when analyzing how the DOI-managed Lands must adjust to climate change. Tim has a BS degree in Petroleum and Natural Gas Engineering from Pennsylvania State University and a MBA from West Texas A&M University.

Mendel Stewart, Project Leader, San Francisco Bay NWR Complex

Mendel Stewart holds a Bachelor of Science from Western Kentucky University and a Master of Public Administration degree from the University of Memphis. His professional career with the U.S. Fish and Wildlife Service has focused primarily on management of the National Wildlife Refuge System in the southeast and California. He spent 5 years in Washington, DC developing policy related to both the Refuge System and wildlife conservation on private lands through Department of Agriculture conservation programs. Through this experience he brings over 23 years of land management knowledge to the analysis of potential impacts of climate change on wildlife populations and the future needs of management policies of Department of the Interior bureaus. Mendel is currently the manager of the San Francisco Bay National Wildlife Refuge Complex.

Kristen Strellec

Kristen Strellec brings ten years experience of public service to the DOI task force on climate change, including five years at the Environmental Protection Agency conducting economic impact analyses of water regulations and five years at the Minerals Management Service conducting socioeconomic impact analyses of offshore lease sales and oil and gas development in the Gulf of Mexico. This experience provides insight in areas of general policy analysis, cost-benefit analysis, regional economic impact analysis, and valuing changes in environmental quality. Kristen has a B.S. in Mineral Economics, a M.S. in Energy, Environmental, and Mineral Economics, and is A.B.D. on a PhD in Energy, Environmental, and Mineral Economics.

Barry Sullivan, General Superintendent, Gateway National Recreation Area (NJ/NY)

Barry Sullivan is currently the General Superintendent of Gateway National Recreation Area (NJ/NY) with a career of 31 years in the National Park Service having served as a park ranger and park manager at 7 different national park areas across our nation. Barry has a BA Degree in Biology and MS Degree in Environmental Science. He serves on the National Park Service's National Ocean Park Task Force and Chairs the Northeast Region's Ocean Park Task Force.

Peter Teensma, Senior Policy Advisor, Office of Wildland Fire Coordination, OS

Dr. Teensma advises departmental executives on applied fire ecology, fire effects, fuels and vegetation management, fuels hazard reduction and smoke management. He previously served as the Forestry and Fire Management Advisor to the Assistant Secretary, Land and Minerals Management (2003-2007), the BLM National Fire Ecologist (2000-2003), the BLM and USDA Forest Service Pacific Northwest Regional Fire Ecologist (1990-2000), and in various field level fire management positions (1983-1990). Dr. Teensma's doctoral dissertation was on the fire history and the factors that influence fire regimes in Douglas-fir forests of the Pacific Northwest.

Lois Uranowski, Chief, Ecological Services & Technology Transfer Branch, Division of Technical Support, Office of Surface Mining

Lois Uranowski is a branch chief within OSM's Technical Support Division with over 20 years experience working with the environmental impacts of coal mining. Her knowledge

of the mechanisms to capture fugitive methane from mineral extraction activities came into play under the mitigation chapter. Development and use of methane capturing techniques of fugitive methane from mineral extraction plays an important role in reducing GHG emissions by potentially as much as 4%. She holds a BS in Environmental Science, MS in Environmental Engineering and is a registered professional engineer.

Robert Winthrop, Senior Social Scientist, BLM

Since 2002 Rob Winthrop has served as Senior Social Scientist in the Bureau of Land Management's Division of Planning and Science Policy, in Washington, D.C. From 1982 until 2000 he directed Cultural Solutions, an Oregon-based consultancy providing impact assessment and conflict resolution in issues involving tribal cultural and resource rights in the western United States. Winthrop received a Ph.D. in cultural anthropology from the University of Minnesota in 1981, and a masters in international policy from the George Washington University in 2001, where he is a senior research associate in the Program on Culture in Global Affairs.

Andy Yuen, Project Leader, San Diego NWR Complex

Andrew Yuen has 24 years of experience working with endangered species recovery and National Wildlife Refuge management in Hawaii and California that would be directly affected by climate change. This background provides insight and experience relative to climate changes to wildlife and water resource management.

APPENDIX B: OPTIONS SUMMARY TABLE

* AS/BDs = Assistant Secretaries and Bureau Directors

** Under the Initiating Action Column, a “Memo” could be a “Secretarial Order.”

Appendix B Options Summary Table: DOI-Wide Options, Adaptation Options, and Mitigation Opportunities

Options	Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
DOI-Wide Options								
D1: Develop an Addendum to the Adaptive Management Technical Guide	Short	Memo instructing DOI Adaptive Management Working Group	High	National	Low	Facilitation of decision-making process	N/A	Recreation, Economy, Native peoples, Subsistence
D2: Issue a Secretarial Order Regarding Management of DOI Lands and Water in light of Climate Change	Short	Issue Secretarial Order to appropriate AS/BD	High	National	Low	Reduced legal challenges to changing land management plans	N/A	Recreation, Economy, Native peoples, Subsistence
D3: Define Key DOI Agency Terms in the Context of a Changing Climate	Short	Memo to Assistant Secretaries to form a DOI-wide taskforce or working group	High	Local–National	Low	Reduced legal challenges to changing land management plans	States, Tribes, Fish and wildlife organizations, Other Federal agencies	Recreation, Economy, Esthetics

Options	Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
D4: Streamline Process and Provide Additional Resources for Acquiring Local and Regional Data, Decision-Support Tools, and Models	Short	Memo to Bureau Directors forming taskforce group with USGS Lead	High	Local–National	Low	Better support to individual parks and refuges	N/A	Better data means better results for all parties
D5: Develop a DOI-Wide Climate Change Training Curriculum	Short	Memo to DOI University	High	Local–National	Low	N/A	Other Federal agencies	Education leads to more effective decisions affecting people
D6: Develop Interior Climate Adaptation Partners Program	Medium	Memo to appropriate AS/BDs	Medium–High	Local–National	Medium–High	Substantially increases regional partnerships	Numerous	Recreation, Economy, Esthetics
D7: Create Emergency Response All-Hazards Teams and Associated Natural/Cultural Response Teams	Short	Memo to Policy Management & Budget (PMB)	High	Local–National	Low	Public safety and resource protection	Other government agencies and emergency personnel	Enhanced safety, Recreation, Historic preservation, Economy
Adaptation Issue 1: Water Availability								
A1.1: Assess Vulnerabilities: Water Availability	Short	Memo to appropriate AS/BDs	High	Large	Low	N/A	N/A	Recreation, Economy

Options	Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
A1.2: Establish Climate Change Water Forums to Enhance Regional Coordination	Short to start, but continuing	Memo to appropriate AS/BDs	High, although it requires partnerships	Potentially Large	Low	N/A	States, Local governments, Tribes, Irrigation districts	Recreation, Economy
A1.3: Enhance Monitoring	Short to start, but continuing	Memo to appropriate AS/BDs	High	Small–Large, depending on scale of implementation	Low–High, depending on scale of implementation	Water data can be used for other purposes	Universities, States	Recreation, Economy
A1.4: Reevaluate Reservoir Operating Strategies and Long-Term Planning	Short to start, but continuing	Memo to Bureau of Reclamation	High	Small–Large, depending on scale of implementation	Low–High, depending on scale of implementation	May benefit other flood control or water supply agencies	USACE, TVA	Recreation, Economy
A1.5: Update Drought Plans for DOI Lands	Short to start, but continuing	Memo to appropriate AS/BDs	High	Small–Medium	Low–High, depending on scale of implementation	N/A	Local Water Agencies	Recreation, Economy
A1.6: Incorporate Water Availability Changes into Land and Habitat Management Activities	Short to start, but continuing	Memo to appropriate AS/BDs	High	Small–Large, depending on scale of implementation	Low as policy, High for implementation	May improve overall ecosystem health	N/A	Recreation, Economy
Adaptation Issue 2: Water Quality								
A2.1: Assess Vulnerabilities: Water Quality Degradation	Short	Memo to appropriate AS/BDs	Low	Large	Low	N/A	N/A	Recreation, Economy, Subsistence

Options	Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
A2.2: Enhance Water Quality Monitoring	Short to start, but continuing	Memo to appropriate AS/BDs	Low–High	Small–Large, depending on scale of implementation	Low–High, depending on scale of implementation	Data can be used for other purposes	Universities, States	Recreation, Economy, Subsistence
A2.3: Implement Non-Point Source Pollution Controls	Short to start, but continuing	Memo to appropriate AS/BDs	Low–High	Small–Large, depending on scale of implementation	Low–High, depending on scale of implementation	General benefit to ecosystem	States, Local governments, Tribes, Irrigation districts, Watershed associations	Recreation, Economy, Subsistence
A2.4: Incorporate Water Quality Impacts into Habitat Management Activities	Short to start, but continuing	Memo to appropriate AS/BDs	High	Small–Large, depending on scale of implementation	Low as policy, High for implementation	May improve overall ecosystem health	N/A	Recreation, Economy
Adaptation Issue 3: Increased Flood Risk								
A3.1: Assess Vulnerabilities: Flood Risk	Short	Memo to appropriate AS/BDs	High	Large	Low–Medium	N/A	N/A	Recreation, Economy
A3.2: Update Flood Frequency Estimates and Flood Plain Maps	Short	Memo to USGS	Direct	Large	Low–Medium	N/A	N/A	Primarily Economy
A3.3: Enhance Emergency Preparedness	Short	Memo to appropriate AS/BDs	Direct	Local	Low–Medium	N/A	N/A	Safety

Options	Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Adaptation Issue 4: Coastal Impacts Associated with Sea-level Rise								
A4.1: Assess Vulnerabilities: Coastal Impacts								
Sub-options:								
Inventory and Assess Vulnerabilities of Coastal Wetlands	Short	Memo to appropriate AS/BDs	High	Medium	Low	N/A	States	N/A
Inventory infrastructure features and stability of coastal barriers under DOI control	Short	Memo to appropriate AS/BDs	High	N/A	Low	N/A	N/A	(Ultimately) Recreation, Flood Control/ Economy
Assess vulnerability of cultural and historical sites on DOI coastlands; if appropriate, move important heritage features to more secure sites	Short	Memo to appropriate AS/BDs	High	Low–High	Low–High, depending on site	Cultural	N/A	Tourism, Culture
Inventory existing threatened infrastructures along the Beaufort and Bering Seas and continue monitoring erosion rates at sensitive DOI sites	Short	Memo to appropriate AS/BDs	High	High	Low	Subsistence	Insular governments, Local communities	Subsistence

Options	Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Create a catalog of DOI coastlands in need of sediments	Short	Memo to appropriate AS/BDs	High	N/A	Low	May affect the future of coastal landforms and all that they protect	Corps of Engineers	N/A
Review locations for adopting protected marine reserves	Short	Memo to appropriate AS/BDs	Medium	High	Low	Protection for marine mammals	NOAA	Recreation, Economy
A4.2: Restore the Natural Hydrology and Ecological Function of Estuaries								
Sub-options:								
Restore natural water movement and freshwater inflows to estuaries	Medium–Long	Memo to appropriate AS/BDs	High	High	Medium–High	Threatened and Endangered species	State of LA, USACE	Recreation, Economy
Backfill/plug manmade canals and other water-diversion projects (e.g., levees, mosquito ditches) to prevent salt water intrusion	Short–Medium	Memo to appropriate AS/BDs	High	High	Low	T&E species, Maintaining salinity	State of LA, USACE	Recreation, Economy
Establish a network of groundwater monitoring wells and tidal gauges on DOI coastal units	Short	Memo to appropriate AS/BDs	High	High	Medium	Benefits to coast/island communities	Local governments	N/A

Options	Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
A4.3: Protect and Restore Coastal Wetlands, Shorelines, and Barrier Islands								
Sub-options:								
Develop education program about the importance of maintaining coastal wetlands and barrier islands in a changing climate	Short	Memo to appropriate AS/BDs	High	High	Low	Community involvement	NOAA, Sea Grant	N/A
Support 3 demonstration projects in Louisiana (Mandalay NWR), San Francisco (NWR) and New York (Gateway National Recreation Area) (PILOT)	Medium	Memo to FWS and NPS	High	Medium	Medium	T&E species, Salinity and wave buffer	States of LA, CA, NY	Recreation, Economy, Subsistence, Culture
Create a policy regarding infrastructure on DOI-managed barrier islands that limits construction to essential, sustainable, and removable (in advance of storm events) structures	Short	Memo to appropriate AS/BDs	High	Medium	Could save taxpayer \$)	N/A	N/A	N/A

Options	Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Develop a comprehensive plan to remove those structures/features that limit barrier islands from naturally replenishing themselves, rolling over, reshaping and/or reforming	Short	Memo to appropriate AS/BDs	High	High	Medium	N/A	N/A	N/A
Develop predictive models, scaled down to the park, refuge, village, reservation or other site level	High	Memo to USGS	High	Medium	Medium	T&E species	States, Corps of Engineers, Tribes	Recreation, Economy, Flood control
A4.4: Develop an Interagency Agreement with the U.S. Army Corp of Engineers (USACE) for Coastal Restoration								
Coordinate planning between the USACE and DOI on projects to provide beneficial fill for DOI restoration projects	Medium	Memo to appropriate AS/BDs with PMB Lead	Medium	Medium–Large	Low–Medium	N/A	USACE, States	Recreation, Economy
A4.5: Protect and Restore Sensitive Marine Ecosystems								
Sub-options:								
Restrict marine transportation in sensitive marine ecosystems	Short	Memo to appropriate AS/BDs	High	Medium	Low	Reduced spill potential	NOAA, USCG	Recreation, Economy

Options	Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Restore coral reefs and sea grass beds	Long	Memo to appropriate AS/BDs	High	High	Medium	T&E species	States	Recreation, Economy
Evaluate the development of a "Rigs to Reefs" program	Medium	Memo to appropriate AS/BDs	High	Medium	Low	T&E species	States	Recreation, Economy
A4.6: Engage the Office of the Solicitor to Review Marine Boundaries, Jurisdictions, and Authorities for Coastal Parks, Refuges, and Other DOI Holdings								
Develop a DOI Solicitor's evaluation of marine boundaries, jurisdiction, and authorities for each DOI area	Medium	Memo to DOI Solicitor's Office	High	High	Low	T&E species	States	Recreation, Economy, Culture
Adaptation Issue 5: Melting Permafrost and Sea Ice								
A5.1: Assess Vulnerabilities: Melting Cryosphere	Short–Long	Memo to appropriate AS/BDs	Direct	Confined primarily to Alaska	Medium–High	N/A	N/A	Safety, Economy
A5.2: Modifying Contracts, Leases, and Other Legal Instruments to Reflect Effects of Melting Permafrost and Sea Ice	Medium–Long	Memo to appropriate AS/BDs	High	Confined primarily to Alaska	Medium–High	N/A	Concessionaires and Lessees	Economy

Options	Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Adaptation Issue 6: Impacts on Native Peoples								
Sub-Issue A: CONTIGUOUS 48 STATES								
A6.1.A: Assess Vulnerabilities: Impacts on Native Peoples	Medium–Long	Memo to appropriate AS/BDs	Medium, multiple partners	Large	Medium	Preserves way of life	NCAI, National Tribal Environmental Council	Subsistence, Economy
Sub-Issue B: ALASKA								
A6.1.B: Assess Vulnerabilities: Alaska Subsistence Systems	Medium	Memo to appropriate AS/BDs	Medium, multiple partners	N/A	Medium	N/A	State of AK, Federal Subsistence Board, Alaskan Native tribes	Subsistence
A6.2.B: Support Interagency Activities to Address Damage to Housing and Other Infrastructure	Medium	Memo to appropriate AS/BDs and Letter to appropriate Cabinet Agencies	Low	Low	Low	N/A	Denali Commission, US Army Corps of Engineers	Economy, Culture
A6.3.B: Disseminate Information Regarding Pollutants	Medium	Memo to appropriate AS/BDs	Low	N/A	Low	N/A	Indian Health Service, EPA	Subsistence, Economy, Culture

Options	Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Sub-Issue C: UNITED STATES (50 States and Insular Territories)								
A6.1.C: Create a Geospatial Local Knowledge Database to Assess Climate Change Impacts on Areas Associated with Native Peoples	Short–Medium	Memo to USGS and other appropriate AS/BDs	Moderate, multiple partners	Large	Low	Tribal scientific and technical training	NativeView, Tribal College Board	Subsistence, Economy, Culture
Adaptation Issue 7: Outbreaks of Pests, Invasive Species, and Diseases								
A7.1: Accelerate Development of Control Measures for Invasive Species								
Sub-options:								
Accelerate research on biological controls of selected invasive species and pest control for native species	Short	Memo to appropriate AS/BDs	Indirect, generally managed by USDA	Small	Medium	N/A	N/A	Recreation, Economy, Subsistence,
Accelerate applications of biological controls of selected invasive species	Short–Long	Memo to appropriate AS/BDs	High	Large	High	N/A	States, Private landowners	Recreation, Economy

Options		Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
		Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
	Institute a more aggressive invasive species control program	Long	Memo to appropriate AS/BDs or Secretarial Order	Medium	Regional	High	Protection against future threats	Public, Other government agencies, Neighbors	None
A7.2: Restrict Entry of New Invasive Species		Short–Long	Memo to BLM to lead formation of taskforce with NOAA, USDA and other appropriate DOI Bureaus	Medium	Large	Medium	N/A	States, NOAA, USDA, Private industry	Recreation, Economy, Culture
A7.3: Develop Predictive Models of Climate Change Effects on Invasive Species to Monitor and Treat Expansions									
Sub-options:									
	Model expected invasive species expansion with appropriate climate change data	Short–Medium	Memo to appropriate AS/BDs	High	Large as models apply to all land ownerships	Low	N/A	Other academic and Federal research entities	Recreation, Economy
	Implement long-term monitoring in areas predicted for invasive expansion. Accelerate control and monitoring efforts in expansion areas	Long	Memo to appropriate AS/BDs	Medium	Moderate as expansion may occur off DOI lands	High	Monitoring would provide other info	Other state and non-DOI federal agencies and tribes	recreation, economic, subsistence

Options	Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Replace historical plant community reference conditions (targets) with more realistic ones given climate change scenarios	Medium	Memo to appropriate AS/BDs	Low	Moderate	Low	N/A	Other scientists	None
Establish a more flexible policy for species management	Short	Memo to appropriate AS/BDs	DOI wide	Low	N/A	public, other government agencies	None	DOI wide
A7.4: Manage Habitat to Ensure Establishment of Desirable Native Species								
Sub-options:								
Implement restoration treatments in priority ecosystems to increase resistance to invasive species threats due to climate change	Medium–Long	Memo to appropriate AS/BDs	Moderate	Moderate as restoration expense will limit acres restored	Medium–High	Improved wildlife habitat, Livestock forage, etc.	Numerous (e.g., NGO's, Citizen groups)	Recreation, Economy, Subsistence,
Develop additional supplies of native species adapted to lands affected by climate change	Medium	Memo to appropriate AS/BDs	Moderate	Moderate	Medium	Improved wildlife habitat, Livestock forage, etc.	NGO's, Citizen groups	Recreation, Economy
Evaluate the utility of using desirable non-native species to compete with target invasive species as a placeholder until natives can be established	Short	Memo to appropriate AS/BDs	High	Large	Low	N/A	Academic/ Research entities	Recreation, Economy

Options	Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Establish a new native plants center	Medium	Memo to appropriate AS/BDs with FWS Lead	High	Large	Medium	Improved wildlife habitat, Livestock forage, etc.	States, Private industry, Other government agencies	Recreation, Economy
Adaptation Issue 8: Species Migration and Habitat Change								
A8.1: Assess Vulnerabilities: Species Migration	Short	Memo to appropriate AS/BDs	High	Local–National	Low–Medium	Strategic planning	Science agencies, (e.g., NOAA, National Weather Service)	Minimal direct impact
A8.2: Encourage Regional Inventory and Monitoring Partnerships	Medium	Memo to appropriate AS/BDs	Medium–High	Regional	Low–Medium	Many, including cost/benefit	USDA, EPA, Universities	Recreation, Economy, Culture
A8.3: Identify and Highlight Species Migration Case Studies	Short	Memo to appropriate AS/BDs	High	Local–National	Low–Medium	Improve technology transfer and education, increase effectiveness	Educates, Improves partner successes	Recreation, Economy, Esthetics
A8.4: Develop Predictive Models for Species Response	Short–Medium	Memo to appropriate AS/BDs	High	Local–National	Low–Medium	Leadership in field of ecosystem response to climate change	Universities, NOAA, International science community	Indirect

Options	Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
A8.5: Promote Regional Partnerships for Species Migration and Relocation	Short–Long	Memo to appropriate AS/BDs	High	Local–National	Low–Medium	Improved cooperation between DOI field units and their neighbors	Other Federal and State agencies, Canada and Mexico, Private and business landowners, Nonprofits	Indirect
Adaptation Issue 9: Threatened and Endangered Species								
A9.1: Assess Vulnerabilities: Threatened and Endangered Species	Short	Memo to appropriate AS/BDs	High	Large, depending on number of studies	Low	Strategic planning	Science agencies	None
A9.2: Use Climate Change Data when Classifying Endangered Species								
Sub-options:								
Develop FWS guidelines	Short	Memo to FWS	High	National	Low	N/A	None	Economy
Incorporate Guidelines into 5-Year Reviews and Recovery Plans	Medium	Memo to FWS	High	National	Low	N/A	None	Recreation, Economy, Culture
A9.3: Reduce Stressors	Medium–Long	Memo to appropriate AS/BDs	High, although it may require partnerships	National	Medium–High	N/A	Federal, State, Local governments, Tribes, Adjacent landowners	Recreation, Economy

Options	Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
A9.4: Develop Regional Planning and Cooperative Conservation Partnerships								
Sub-options:								
Create Workshops to Share Information	Short–Long	Memo to appropriate AS/BDs	High	Low	Low	Leadership	Federal, Tribal, State, and Local agencies; Regional resource managers; Climate experts; Environmental organizations; Neighboring landowners	Economy
Maintain Species in Artificial Setting	Long	Memo to appropriate AS/BDs	High	High	Medium–High	N/A	Conservation partnerships with private entities (e.g., zoos, captive breeding groups, gene banking facilities)	Culture, Recreation, Economy
Adaptation Issue 10: Wildland Fires								
A10.1: Accelerate and Enhance Hazardous Fuel Reduction Program	Short	Memo to appropriate AS/BDs noting role of NIFC	Medium	Large	High	Increased protection to life and property	NIFC, USDA, States, Tribes, Counties	Recreation, Economy, Society, Culture

Options	Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
A10.2: Improve Smoke Management Practices	Short	Memo to appropriate AS/BDs noting role of NIFC	High	Large	High	Fewer emissions, Improved public health/air quality	NIFC, USDA, EPA, States, Tribes, Counties	Economy, Recreation, Health
Mitigation Opportunity 1: Terrestrial Carbon Sequestration								
M1.1: Develop a Terrestrial Carbon Sequestration Policy	Short	Memo to Policy Management and Budget	High	Significant	Low	Promotes partnerships within DOI	N/A	N/A
M1.2: Conduct a Comprehensive Terrestrial Carbon Assessment	Short–Medium	Memo to appropriate AS/BDs with USGS Lead		Unknown but potentially significant	Medium–High	N/A	N/A	N/A
M1.3: Create Habitat Restoration Partnerships	Short–Long, depending on programs	Memo to appropriate AS/BDs	High, Indirect	Unknown but potentially significant	N/A	Bolsters partnership with traditional and non-traditional stakeholders and expands ability to restore native wildlife habitat and address climate change impacts to wildlife	DOI Land Management Bureaus, USDA, Energy companies, Conservation groups, State agencies, NGO's	Recreation (e.g., Hunting, Fishing), Economy

Options	Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Mitigation Opportunity 2: Geologic Carbon Sequestration under Federal Lands								
M2.1: Inventory Geologic Sequestration of DOI Lands	Short	Memo to USGS	High	Unknown but potentially significant	Medium	Possible more efficient extraction of natural gas and other fuels	Other DOI bureaus	Economy
M2.2: Research Geologic Sequestration	Medium	Memo to USGS to promote partnership with Department of Energy	Medium	Unknown but potentially significant	Medium	Possible more efficient extraction of natural gas and other fuels	DOE	Economy
Mitigation Opportunity 3: Development of Renewable Energy on DOI Lands								
M3.1: Develop a Renewable Energy Coordination Policy	Short	Memo to appropriate AS/BDs	High	Unknown but potentially significant	Low	Significant revenues generated on royalties and use authorization fees, Reduced dependency on foreign oil	Forest Service	Economy

Options	Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Mitigation Opportunity 4: Fleet Management								
M4.1: Engage Department of Energy and General Services Administration Leadership	Short	Memo to Policy Management and Budget	High for meeting, Low for GSA decision	Low	Low, potential savings for Bureaus	Reduce dependency on foreign oil, Accelerated DOI progress in meeting EPAct05 and EO goals	GSA, DOE	None
M4.2: Expedite Acquisition of Alternative and High Fuel Efficiency Vehicles	Medium with funding	Memo to appropriate AS/BDs with PMB Lead	High with suppl. funding	Low	Medium, incremental \$2M increase annually	Reduce dependency on foreign oil, Accelerated DOI progress in meeting EPAct05 and EO goals	DOE	N/A
M4.3: Expand DOI Alternative Fuel Infrastructure	Medium with funding	Memo to appropriate AS/BDs with PMB Lead	High with suppl. funding	Low	Medium, incremental \$2M increase annually	Reduce dependency on foreign oil, Increased alternative fuel consumption, Energy security, Meeting EPAct05 and EO goals	DOE, Other Federal agencies	Possible Economy

Options	Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
Mitigation Opportunity 5: Facility Operations								
M5.1: Expedite Use of Energy Efficiency Technologies	Short–Medium with funding	Memo to appropriate AS/BDs with PMB Lead	High	Low	Medium, additional funding of \$5M annually	Cost savings, Accelerated DOI progress in meeting EPO05 and EO goals	DOE, Utility Companies	N/A
M5.2: Expand Use of Renewable Energy	Short–Medium with funding	Memo to appropriate AS/BDs with PMB Lead	High	Low	Medium, additional funding of \$2M annually	Diversified power supply, Accelerated progress in meeting EPO05 and EO renewable energy (RE) goals, Stimulated RE market to produce more RE and higher efficiency technologies, Promotion of grid independence at remote DOI facilities	DOE, Utility Companies, BIA Education Component	Economy - stimulating the RE market to produce more RE and Higher efficiency technologies
M5.3: Update Existing Policies	Short–Medium with funding	Memo to appropriate AS/BDs with PMB Lead	High	Low	Low to update policy, Medium–High to implement	Same as above	N/A	N/A

Options	Timescale to Implement	Initiating Action	Degree of DOI Control	Scale of Impact	Cost	Ancillary Benefits	Partnerships	Human Dimension
	Short (1–2 yrs.), Medium (2–5 yrs.), Long (5+ yrs.)	Necessary Actions & Responsible Parties	Low–High, Indirect, or Brief Description	Brief Description	Low (< \$1M), Medium (\$1M–\$10M), High (\$10M+)	Brief Description	Potential Partners	Recreation, Economy, Subsistence, Culture, etc.
M5.4: Explore use of Energy Savings Performance Contracts	Short	FEMP	Medium	Low	Upfront High	Cost savings	N/A	N/A
Mitigation Opportunity 6: Education and Outreach Operations								
M6.1: Develop a Climate Change Education and Outreach Program	Short	Secretarial Order to promote program	High	Low direct impact, Medium impact due to visitors	Low	Potential global impacts as visitors take back what they learned on DOI lands, Reduced dependency on foreign oil, Meeting EPAct05 and EO goals	Visitors and Staff	Recreation/ Visitation
M6.2: Provide Incentives for Climate Change Conservation	Short–Medium	Memo to appropriate AS/BDs	High	Low	Possible loss of revenue	Indirect co-benefits, Promotion of lifestyle changes	Area transit authorities	Recreation/ Visitation

APPENDIX C: ACRONYMS AND ABBREVIATIONS

BLM – Bureau of Land Management
BIA – Bureau of Indian Affairs
BOR – Bureau of Reclamation
CO₂ – carbon dioxide
DOE – Department of Energy
DOI – Department of the Interior
EPA – U.S. Environmental Protection Agency
EPAct – Energy Policy Act
EMAP – Environmental Monitoring and Assessment Program
EO – Executive Order 13423
ESF – Emergency Support Function within the National Response Plan
FEMA – Federal Emergency Management Agency
FWS – U.S. Fish and Wildlife Service
GAO – Government Accountability Office
ICAP – proposed Interior Climate Adaptation Partners (ICAP) program
ICS – Incident Command System
IPCC – Intergovernmental Panel on Climate Change
LEED – U.S. Green Buildings Council Leadership in Energy and Environmental Design
NPS – National Park Service
NWR – National Wildlife Refuge
MMS – Minerals Management Service
NOAA – National Oceanic and Atmospheric Administration
OSM – Office of Surface Mining Reclamation and Enforcement
RE – Renewable Energy
US ACOE – U.S. Army Corps of Engineers
USDA – U.S. Department of Agricultural
USGS – U.S. Geological Survey