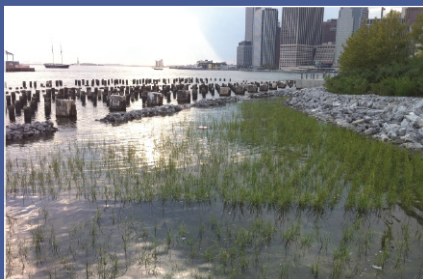
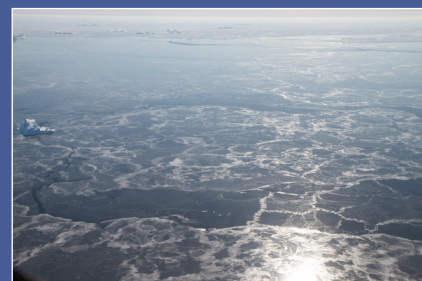


# Climate Change Adaptation in United States Federal Natural Resource Science and Management Agencies: A Synthesis

Jessica E. Halofsky, David L. Peterson, and Kailey W. Marcinkowski

April 2015

Report organized under the auspices of the Adaptation Science Interagency Working Group, Interagency Land Management Adaptation Group, and sponsored by the U.S. Department of Agriculture Forest Service.



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Jessica E. Halofsky\*, David L. Peterson+, and Kailey W. Marcinkowski\*

*\*University of Washington, +U.S. Department of Agriculture Forest Service*

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*Cover images: top left, USDA Natural Resources Conservation Service; bottom left, Department of City Planning, New York City; center, photo by Patrick Gonzales; top right, NASA; bottom right, photo by May-Le Ng.*

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## About the U.S. Global Change Research Program

The U.S. Global Change Research Program (USGCRP), under the White House Office of Science and Technology Policy, coordinates and integrates research efforts on climate change and its societal impacts across 13 federal agencies. Beginning as a Presidential initiative in 1989, USGCRP was later codified by Congress in the Global Change Research Act of 1990 (GCRA 1990). Since then, USGCRP has been assisting the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change through interagency partnerships, working groups, and collaborations with experts.

## About the USGCRP Adaptation Science Interagency Working Group

The mission of USGCRP's<sup>1</sup> Adaptation Science Interagency Working Group (ASIWG)<sup>2</sup> is to ensure that Federal science effectively informs adaptation decisions at a range of scales, in diverse sectors. The ASIWG is responsible for effective implementation of USGCRP's shared interagency priorities, investments, and activities related to science in support of adaptation within the broader context of the USGCRP Inform Decisions Strategic Goal. Several critical roles of the ASIWG include: (1) conducting, translating, and facilitating the development of research for and of climate change adaptation; and (2) providing interagency coordination, management, and oversight of the USGCRP adaptation science portfolio. Through these roles, the ASIWG provides scientific support to agencies in the adaptation planning process outlined in *Executive Order 13653: Preparing the United States for the Impacts of Climate Change*<sup>3</sup> and *EO 13693: Planning for Federal Sustainability in the Next Decade*<sup>4</sup>.

## About the Interagency Land Management Adaptation Group

The Interagency Land Management Adaptation Group (ILMAG) is an informal collaborative effort of federal land management and science agencies that has been organized to integrate adaptation to climate change and related stressors into land management activities; develop shared capacity for training, monitoring, and assessments; improve science/management coordination; and build inclusive landscape scale adaptation strategies. ILMAG offers a unique opportunity as a forum for interagency discussion and collaboration on terrestrial land management in an era of rapid, large scale changes. Representatives in ILMAG are generally those individuals who are responsible for climate change adaptation and/or land management strategy and planning programs within their agencies. This partnership is open to federal

<sup>1</sup> U.S. Global Change Research Program. *About*. See <http://globalchange.gov/about>

<sup>2</sup> U.S. Global Change Research Program. *Interagency Working Groups*. See <http://www.globalchange.gov/about/iwgs>

<sup>3</sup> White House. *Executive Order 13653: Preparing the United States for the Impacts of Climate Change*. Federal Register Vol. 78, No. 215. November 2013. See <http://www.gpo.gov/fdsys/pkg/FR-2013-11-06/pdf/2013-26785.pdf>

<sup>4</sup> White House. *Executive Order 13693: Planning for Federal Sustainability in the Next Decade*. Federal Register Vol. 80, No. 57. March 2015. See <http://www.gpo.gov/fdsys/pkg/FR-2015-03-25/pdf/2015-07016.pdf>

agencies to promote coordination and collaboration. The scope of interest and action is land management and landscape scale conservation. While ILMAG is not an official working group within the US-GCRP, ASIWG is represented as a member of the group for collaboration and coordination purposes.

## Acknowledgements

*This report is a product of the ASIWG, prepared in collaboration between Jessica E. Halofsky<sup>5</sup>, David L. Peterson<sup>6</sup>, and Kailey W. Marcinkowski<sup>7</sup>, edited by Emily Seyller<sup>8</sup>.* Development of this report was funded by David Cleaves at the USDA Forest Service Climate Change Advisor's Office. We would like to thank the many individuals who provided input to and/or reviewed the report, including Jeffrey Arnold (USACE), Dan Bader (NASA), Nancy Beller-Simms (NOAA), Gustavo Bisbal (USGS), Karen Blakney (BLM), Peter Boice (DoD), Levi Brekke (Bureau of Reclamation), Donna Brewer (FWS), Joshua Brown (NOAA), Sarah Close (NOAA), Marlene Cole (EPA), David Considine (NASA), Thomas Cuddy (CEQ), Alison Dalsimer (Booz Allen Hamilton), Cathryn Dowd (USDA Forest Service), Louisa Evers (BLM), Christopher Farley (USDA Forest Service), Kate Freund (FWS), Kim Gotwals (Leidos), Sean Hart (BIA), Leonard Hirsch (Smithsonian Institution), Cat Hawkins Hoffman (NPS), Radley Horton (NASA), Christina Hudson (Leidos), Randy Johnson (USDA Forest Service), Christine Lee (NASA), TyAnn Lee (NOAA), Allison Leidner (NASA), Christine Mataya (Booz Allen Hamilton), Robin O'Malley (USGS), Adam Parris (NOAA), Kim Penn (NOAA), Joel Scheraga (EPA), Nancy Searby (NASA), Emily Seyller (USGCRP), Pamela Stevens (NSF), Ben Thatcher (FWS), Kim Toufectis (NASA), Woody Turner (NASA), Ming-Ying Wei (NASA), and Elizabeth Yoseph (Booz Allen Hamilton). Maps were created by Robert Norheim.

<sup>5</sup> University of Washington, School of Environmental and Forest Sciences, Seattle, Washington.

<sup>6</sup> U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Seattle, Washington.

<sup>7</sup> University of Washington, School of Environmental and Forest Sciences, Seattle, Washington. Current address: Michigan Technological University, School of Forest Resources and Environmental Science, Houghton, Michigan.

<sup>8</sup> U.S. Global Change Research Program.



## Abstract

Federal agencies with responsibility for natural resource management are mandated to consider climate change in planning and projects, and to begin preparing for the effects of climate change. Federal agencies are making significant progress in climate change adaptation, although lack of financial resources has slowed implementation of climate-focused activities. Currently, most agencies have broad-scale strategic plans that describe approaches and priorities for climate change in general and for adaptation in particular. Although adequate scientific databases, analytical tools, and decision support aids are generally available to assist with adaptation, on-the-ground projects and plans relevant to resource management have been implemented unevenly across agencies. Mainstreaming of climate-smart practices in agencies has been slow to develop, probably because it has not been required at local to regional scales and because systems of accountability are rare. At the management-unit scale, much of the progress to date has occurred where motivated resource managers and scientists have collaborated to develop climate change vulnerability assessments and adaptation options. These science-management partnerships provide a model for how adaptation can move forward across large landscapes, and can be emulated by others who want to begin the process. Because sustainable resource management typically encompasses restoration and building of resilience in ecosystems, agencies can build on existing practices, adjusting them as necessary to address risks posed by a changing climate. Progress can be accelerated through increased cooperation between management-based and science-based agencies and through collaboration with other organizations in the public and private sectors.

*The Transboundary Flathead River Watershed, home to key trout and salmon species, extends from British Columbia into Montana. (Photo by G. Lenz, USGS.)*



## Executive Summary

Increasing recognition of the importance of addressing climate change, along with Departmental- and Executive-levels orders have spurred a flurry of climate change activity in Federal natural resource science and management agencies over the last few years, leading to a variety of assessments, strategies, guiding documents, and new agency positions and organizations focused on climate change. This report documents progress to date in climate change adaptation by Federal natural resource science and management agencies<sup>9</sup> and tribes, providing a baseline for measuring future accomplishments. For agencies with a mandate to manage public land and/or water, the report focuses on: (1) guiding documents (strategic plans, climate change science and adaptation plans, etc.); (2) education efforts (for employees, stakeholders and the public); (3) partnerships (collaborations with other agencies, organizations, and stakeholders); (4) vulnerability assessments (activities that evaluate sensitivity, exposure, and adaptive capacity of resources to climate change); and (5) adaptation planning (efforts aimed at reducing vulnerabilities and minimizing impacts on agency mission). For agencies that produce science relevant to natural resource management, the report describes programs related to climate change science and adaptation and education programs.

Accomplishments in preparing for climate change differ across the many agencies responsible for managing land and water resources and for providing the science needed for resource management. This is to be expected, given the diversity of agency missions, organizational culture, programmatic structure, and scientific capability. Nearly all agencies included in this report have prepared a strategic plan for climate change adaptation, and several have additional strategic plans and programs that facilitate some consideration of climate change in the agency mission. Most agencies have informal or formal programs to educate employees, stakeholders and/or the public about climate change. Several agencies have conducted climate change vulnerability assessments for several to many of their units (and species present on their units). Many tribes have also made progress in assessing natural resource vulnerabilities to climate change and have developed adaptation strategies and plans. Some coordination of climate change activities has occurred between agencies, particularly in partnerships such as the Climate Change and Water Working Group, which involves coordination among both science-focused Federal agencies and Federal water management agencies and the U.S. Global Change Research Program's Adaptation Science Interagency Working Group, which ensures that Federal science effectively informs adaptation decisions at a range of scales, in diverse sectors.

Implementation of climate change adaptation has been slow, but seems to be most successful when national strategic objectives are linked to on-the-ground activities through a formal means of coordination

<sup>9</sup> Departments and agencies included in this report are (alphabetically by Department/Agency): National Aeronautics and Space Administration, National Science Foundation, Smithsonian Institution, U.S. Department of Agriculture, U.S. Forest Service, U.S. Department of Commerce National Oceanic and Atmospheric Administration, Department of Defense, U.S. Army Corps of Engineers, U.S. Department of the Interior, Bureau of Indian Affairs, Bureau of Land Management, Bureau of Reclamation, National Park Service, U.S. Fish and Wildlife Service, U.S. Geological Survey, and U.S. Environmental Protection Agency.



and a system of accountability. For example, the U.S. Forest Service has a national climate change office, a roadmap that guides response to climate change, a scorecard that tracks accomplishments in ten areas, and climate change coordinators at the regional and national forest levels. Supplemented by scientific information from its research and development branch, the Forest Service is progressively developing vulnerability assessments and adaptation plans throughout the United States. Similarly, the National Park Service has a national climate change office, a climate change response strategy, and a staff that conducts scenario planning and other activities in national parks. National forests and national parks often collaborate on climate change projects where their lands are adjacent.

Most Federal activities in climate change adaptation (those agencies that are noted in this document) focus on minimizing adverse effects on natural or cultural resources or facilities in order to support sustainable management, protect heritage resources, and provide for recreation and continued production of ecosystem services, including biodiversity. Adaptation is focused on maintaining forest productivity, protecting functional wetlands, conserving endangered animal species, and reducing road damage from flooding, to name a few. The Department of Defense also manages resources in the context of climate change and, in addition to developing ecosystem management adaptation strategies, is developing adaptation options to reduce impacts on military readiness.

This report is a snapshot in time (2013-2014) of the status of climate change adaptation in Federal land and water management and science agencies. The number and quality of adaptation efforts that have evolved during a period of declining Federal budgets are encouraging, signaling that adaptation has moved from conceptual to real. In many cases, Federal agencies are leading the way in climate change adaptation, providing models for other organizations to follow. It is now imperative to accelerate progress in response to recent Executive Orders and document rapid climate-related change. Progress can be facilitated by increased cooperation among federal agencies and organizations in the public and private sectors.

## Introduction

Climate change poses myriad challenges to the sustainable management of natural resources on Federal lands and waters in the United States (Burkett and Davidson 2012; Staudinger et al. 2012; Vose et al. 2012; Brewer et al. 2013). Adapting Federal natural resource management to climate change is critical to minimize the risks associated with climate change impacts. To address some of the challenges of climate change in Federal agencies, President Obama signed Executive Order (EO) 13514, “Federal Leadership in Environmental, Energy, and Economic Performance” (Obama 2009), which required Federal agencies to develop and implement “Strategic Sustainability Performance Plans.” These plans were required to include evaluation of climate change risks and vulnerabilities to minimize the short- and long-term effects of climate change on agency mission and operations. EO 13514 also required the Strategic Sustainability Performance Plans to include agency climate adaptation plans, which were first released in February 2013. These plans were to adhere to a set of “Implementing Instructions for Federal Agency Adaptation Planning,” issued by the White House Council on Environmental Quality (CEQ) in 2011 (CEQ 2011).

In June of 2013, the Executive Office of the President released “The President’s Climate Action Plan” (Executive Office of the President 2013). Part of this plan was focused on preparing the U.S. for the effects of climate change, and ongoing and planned Federal efforts to protect land and water resources in a changing climate were described. The President followed the Action Plan with EO 13653 in November 2013, “Preparing the United States for the Impacts of Climate Change” (Obama 2013). EO 13653 requires the heads of the Departments of Defense, Interior, and Agriculture, Environmental Protection Agency, National Oceanic and Atmospheric Administration, Federal Emergency Management Agency, Army Corps of Engineers, and other agencies to work with the Chair of CEQ and the Director of the Office of Management and Budget to, “complete an inventory and assessment of proposed and completed changes to their land- and water-related policies, programs, and regulations necessary to make the Nation’s watersheds, natural resources, and ecosystems, and the communities and economies that depend on them, more resilient in the face of a changing climate.” The assessments are required to include a timeline and plan for making changes to policies, programs, and regulations. EO 13653 also required agencies to update their climate adaptation plans, as per EO 13514, and provided additional guidance on what updated adaptation plans should include.

Increasing recognition of the importance of addressing climate change, along with Departmental- and Executive-levels orders, such as EOs 13514 and 13653, have led to a flurry of climate change activity in Federal natural resource science and management agencies over the last few years. This activity has led to a variety of assessments, strategies, guiding documents, and new agency positions and organizations focused on climate change. **This report describes past and ongoing climate change adaptation efforts by U.S. Federal agencies and entities that have a mandate to manage Federal public land and/or water resources, and/or produce scientific information relevant to climate adaptation in natural resource management.** We document progress to date in climate change adaptation by these Federal natural resource and science agencies, providing a baseline for measuring future accomplishments. Whereas other reports

have documented U.S. adaptation activities (e.g., Bierbaum et al. 2013, Hansen et al. 2013) and U.S. Federal climate change activities (e.g., Pew Center on Global Climate Change 2010, Center for Climate and Energy Solutions 2012, U.S. GAO 2013b), to our knowledge, this is the first summary of adaptation activities in Federal natural resource agencies. Because we wanted to put the focus on activities of natural resource agencies that are mandated to manage Federal public lands and water and/or produce science that provides the basis for public land and water management, we did not cover adaptation activities of all Federal agencies, and we did not include agencies that do not have direct responsibility for Federal land management. For example, the U.S. Department of Transportation may influence land management along Federal highways, but the land along Federal highways is not Federal land (it is state-owned). Similarly, the Natural Resource Conservation Service influences primarily private land management. Thus, these and similar agencies and programs were not included in the report.

The Intergovernmental Panel on Climate Change defined climate change adaptation as, “initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects” (IPCC 2007). To document climate change adaptation activities in Federal natural resource agencies and tribes, we focused specifically on the following types of information:

- **Guiding documents** – strategic plans, climate change science and adaptation plans, or any document that directs the agency or entity in regards to climate change adaptation.
- **Education efforts** – activities related to educating employees, stakeholders or the public about climate change.
- **Partnerships** – collaborations with other agencies, organizations, stakeholders, or groups initiated specifically to address climate change.
- **Vulnerability assessments** – any activities that attempt to describe and/or quantify vulnerability (a function of exposure, sensitivity and/or adaptive capacity sensu IPCC 2007) of resources to climate change. We used a broad definition of vulnerability assessments, since there is no standard within or between agencies at this point, and scope and detail of assessments is highly variable.
- **Adaptation efforts** – any efforts aimed at reducing vulnerabilities to climate change and minimizing the impacts of climate change on agency or entity mission and operations.

For agencies that are primarily focused on producing science (e.g., National Aeronautics and Space Agency, National Science Foundation, Smithsonian Institution, U.S. Geological Survey), we focused on descriptions of programs related to climate change science and adaptation, and where applicable, guiding documents and education programs. Some agencies play both science and management roles (e.g., Environmental Protection Agency, National Oceanic and Atmospheric Administration, U.S. Forest Service), and for these agencies we attempted to cover both scientific programs and management-oriented adaptation activities. Because of the different roles played by different agencies, section topic headings vary by agency in the report.

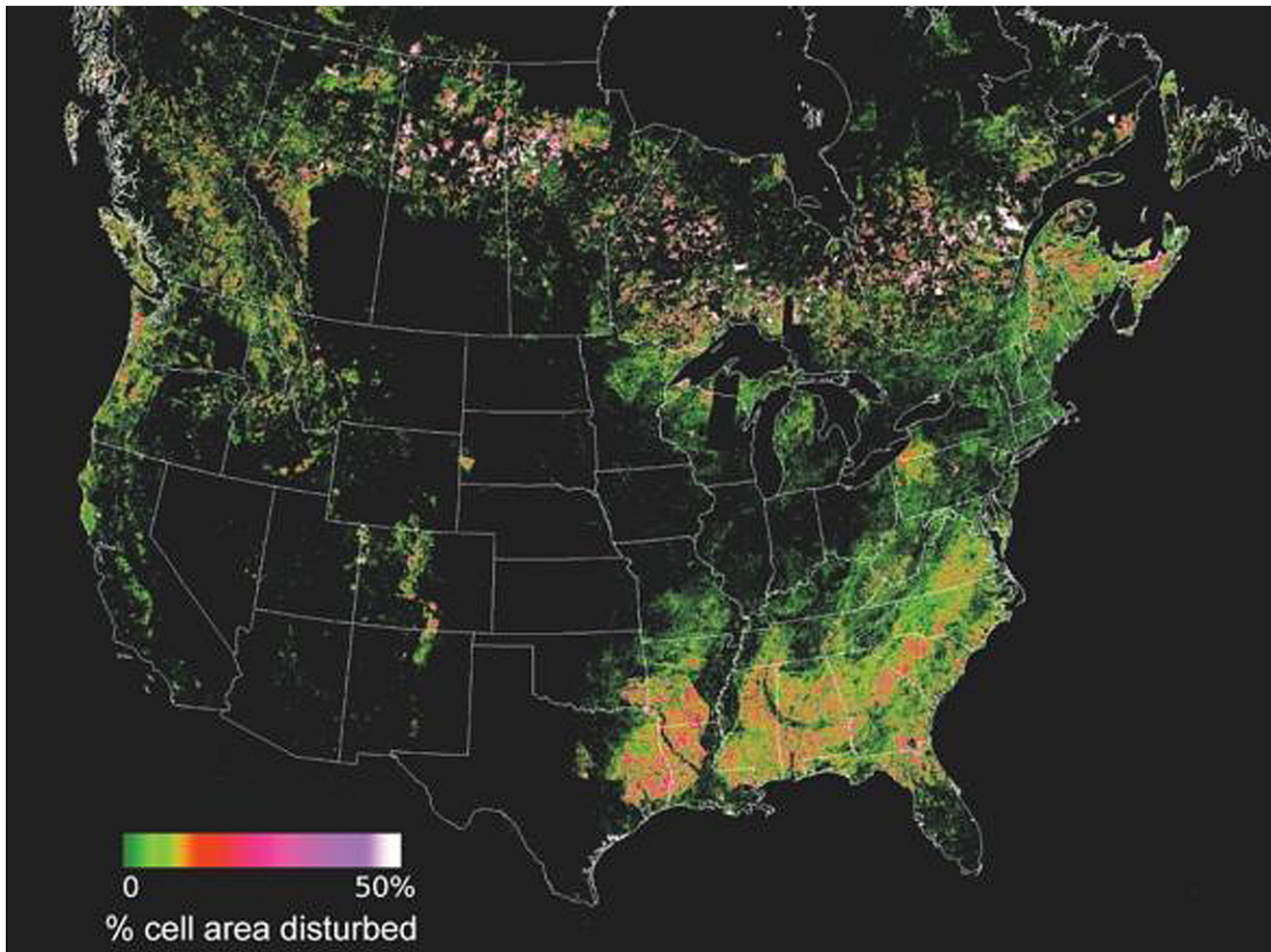
The information included for each agency was gathered and refined in a four-step process. First, we gathered all available web-based information for each agency relevant to our information categories (e.g., guiding documents and vulnerability assessments). Second, we conducted phone interviews with agency

representatives to verify collected information and gather additional relevant information. Third, we used information from the first two steps to develop draft report sections for each agency, which were reviewed by agency representatives. Finally, we incorporated revisions suggested by agency representatives into the final version of the report.

The information presented in this report is a “snapshot in time” that reflects the state of adaptation efforts as of 2013-2014. While we attempted to incorporate as much relevant information as possible, the report does not provide an exhaustive description of the climate change activities of the included agencies. However, it is our hope that the information in this report can help Federal land management agencies coordinate and promote adaptation efforts.

The document is organized alphabetically by Department or Office name and then by agency or entity name. A final section provides summaries and syntheses of agency activities, with conclusions on the state of adaptation in Federal natural resource science and management agencies in the United States.

*North American forest disturbance intensity, 1990 to 2000, mapped from about 2,200 Landsat images. Colors represent the percent of each 500 x 500 m cell disturbed during the mapping period. Credit: J. Masek, NASA/ Goddard Space Flight Center.*





# Adaptation Efforts by U.S. Natural Resource Science and Management Agencies

## National Aeronautics and Space Administration

### ***Background and Guiding Documents***

The National Aeronautics and Space Administration (NASA) was chartered in the National Aeronautics and Space Act of 1958 with, among other objectives, the expansion of human knowledge of the Earth and of phenomena in the atmosphere and space. In 1976, Congress expanded the mission of NASA to include space applications - applying space technology to advance fundamental scientific knowledge of our Earth system, solar system, and universe. NASA's Earth Science Division within the Science Mission Directorate supports a broad portfolio of research, driven by the goals of understanding how the Earth system is changing, the sources of change within the Earth system, how the Earth system will change in the future, and how Earth System science can improve mitigation of and adaptation to global change (NASA 2014). To address these goals, NASA and its partners have developed and launched a suite of Earth observing missions and ancillary satellites<sup>10</sup>. The Earth observing missions consist of satellites collecting land, sea, ice, and atmospheric observations around the globe, and these satellites provide long-term observations and information on solar activity, sea level rise, atmospheric and oceanic temperatures, changes in sea and land ice, air pollution, and the ozone. In addition, NASA supports wide-ranging Earth science research and applications programs involving thousands of competitively selected research tasks to advance science and understanding through analysis of NASA and non-NASA satellite measurements, as well as data from airborne campaigns and ground-based instruments. This work, coupled with that of NASA's partners provides much of the nation's knowledge base for understanding, mitigating, and adapting to climate change.

NASA's climate change-related research and applications are guided by policy statements and other strategic documents. In response to Executive Order 13514 and implementation instructions from CEQ, NASA released a policy statement on climate change adaptation in 2011, directing the agency to develop an adaptation plan (NASA 2011). The adaptation plan titled, "2012 NASA Climate Risk Management Plan: Managing Climate Risks & Adapting to a Changing Climate" was released in 2012 (NASA 2012). A 2010 report, called "Responding to the Challenge of Climate and Environmental Change: NASA's Plan for a Climate-Centric Architecture for Earth Observations and Applications from Space," describes how NASA planned to advance climate-related research (NASA 2010). Climate change-related research is also cited as a priority in the 2014 NASA Strategic Plan (NASA 2014) and Science Plan (NASA 2014).

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<sup>10</sup> The Earth Systematic Missions (ESM) Program encompasses the division's strategic and directed missions, including missions that were selected prior to the creation of the ESM Program Office, such as missions under the previously existing Earth Observing System Program approved in 1991. The missions within the Earth System Science Pathfinder Program are competitively selected under the program itself or as Earth Venture missions.



## ***Programs Related to Climate Change Science and Adaptation***

As a leading scientific research organization, NASA engages in a broad portfolio of climate-related space missions, including research and applications activities that provide essential inputs for adaptation decisions. NASA supports fundamental research as well as applications activities, which are geared to addressing the needs of managers who must cope with a changing climate. While not an exhaustive list, highlights of programs of particular relevance are discussed below.

### **NASA Earth Science Missions**

As of May 2014, NASA has 18 satellites comprising its fleet of Earth observing missions that study all aspects of the Earth system (oceans, land, atmosphere, biosphere, cryosphere). Measurements gathered from the Earth observing missions account for the majority of NASA contributions for advancing fundamental scientific knowledge of global climate variability and change and addressing the continuity of key climate measurements needed to inform policy and action decisions for adapting to climate change. For example, the Landsat Program, a series of Earth observing missions jointly managed by NASA and the U.S. Geological Survey (USGS) since 1972, launched the latest satellite, Landsat 8 (formerly the Landsat Data Continuity Mission), on February 11, 2013. This latest mission extends more than 40 years of global land observations that are critical in many areas, such as energy and water management, forest monitoring, human and environmental health, urban planning, disaster recovery and agriculture. Other key missions include NASA's Terra, Aqua, and Aura satellites providing atmospheric observations; data from the Gravity Recovery and Climate Experiment, Ice, Cloud, and Land Elevation Satellite missions, and spaceborne radar that detect rapid changes in the Earth's great ice sheets; and, the Ocean Surface Topography Mission/Jason-2 and Jason-1 missions recording measurements of sea level.

For the first time in more than a decade, NASA will be launching five Earth science missions in the same year, including two climate-monitoring instruments to the International Space Station. The first Earth science mission of 2014 was the Global Precipitation Measurement Core Observatory, a joint satellite project with the Japan Aerospace Exploration Agency launched on February 28, 2014, that will help answer questions about our planet's life-sustaining water cycle, and improve water resource management and weather forecasting. The expected November 2014 launch of the Soil Moisture Active Passive mission will allow NASA to map Earth's soil moisture, informing water resource management decisions on water availability around our planet, as well as aid in predictions of plant growth and agricultural productivity, weather and climate forecasts, and flood and drought monitoring.

### **Data and Information Systems**

NASA satellite and modeling products provide a huge volume of valuable data extending back more than 50 years across a broad range of spatial (local to global) and temporal (hourly to decadal) scales, and include many products that are available in near real time<sup>11</sup>. NASA's principal Earth Science information system is the Earth Observing System Data and Information System (EOSDIS), which has been operational since August 1994. EOSDIS provides services and tools needed to enable use of NASA's Earth science data in new models, research results, and decision support system benchmarking; the system also improves support for end users. In addition, EOSDIS is supporting the Administration's Big Earth Data

<sup>11</sup> See [www.earthdata.nasa.gov](http://www.earthdata.nasa.gov)

Initiative focusing on interoperability between environmental data systems at NASA, National Oceanic and Atmospheric Administration (NOAA), and USGS, and has helped pave the way for the USGCRP's Global Change Information System<sup>12</sup>. NASA Earth Science information is also archived at eight Distributed Active Archive Centers located across the United States.

NASA also maintains a website<sup>13</sup> that features information about climate change, including evidence for climate change, causes, and impacts, as well as recent news and events related to climate change.

### **Earth Science Applications**

The Applied Sciences Program primarily works through partnerships with organizations to find practical uses for Earth science data and scientific knowledge for decision makers and the public. The Program consists of four application areas (Disasters, Ecological Forecasting, Health and Air Quality, and Water Resources) and the Capacity Building Program.

The Ecological Forecasting Application area draws on various Earth observation measures, such as land cover/land use, precipitation, and topography, as well as ecological and other types of models to address issues related to biodiversity conservation, protected area management, and marine fisheries. Natural resource managers, overseeing terrestrial and marine resources, are a primary user community along with others involved in the conservation and sustainable use of ecosystems in the United States and abroad. Some of the key adaptation-related sponsored projects include:

- The Forest Carbon Management Framework – The Forest Service adopted this NASA Earth Science Division carbon assessment tool, which uses satellite imagery as part of an approach to enhance forest management.
- The Ecosystem Assessment, Geospatial Analysis, and Landscape Evaluation System – Together with the U.S. Fish and Wildlife Service (FWS), this project created an adaptable, unifying architecture that allows biologists and managers direct control and access to powerful data processing and modeling capabilities for landscape planning and management of focal species and their habitats.

The Water Resources Application area supports the integration of NASA Earth observations and technologies into management tools for the water resources management community through a diverse range of projects in its portfolio, addressing topics including drought monitoring and mitigation, snow monitoring and runoff forecasting, water quality, soil moisture, groundwater change, and climatic and ecological impacts on water resources. Specific projects furthering adaptation knowledge include:

- Enhancing the U.S. Department of Agriculture (USDA) Global Crop Production Decision Support System – The project seeks to improve USDA Foreign Agriculture Service commodity crop forecasts by integrating NASA soil moisture remote sensing products and land surface modeling/assimilation tools into the operational Foreign Agriculture Service global water balance modeling system.
- Fallowed Area Mapping for Drought Impact Reporting and Decision Making – Using Moderate Resolution Imaging Spectroradiometer (MODIS) and Landsat data, the project demonstrated the

<sup>12</sup> See <http://data.globalchange.gov/>

<sup>13</sup> See <http://climate.nasa.gov/>

feasibility of a remote sensing-based fallowed land monitoring service to improve support of within-season decision making. This was a joint effort by USGS Earth Resources Observation Systems, USDA National Agricultural Statistics Service, California Department of Water Resources, and NASA Ames Research Center.

- Improving Water Quality Management Observations in Spatially Referenced Regressions on Watershed Attributes (SPARROW) – This project will incorporate data products from MODIS to enable SPARROW to produce assessments every season and annually, instead of every five years. The project will also evaluate the enhanced SPARROW in supporting significantly more cost-effective water management strategies.
- Airborne Snow Observatory – Unprecedented snowpack maps from NASA’s prototype Airborne Snow Observatory mission helped water managers for 2.6 million residents of the San Francisco Bay Area achieve near-perfect water operations during the summer of 2013, despite the driest year in California’s recorded history. The three-year demonstration mission is a collaboration between NASA’s Jet Propulsion Laboratory in Pasadena, California, and the California Department of Water Resources in Sacramento.

The Capacity Building Program manages specific activities to build skills and capabilities in the U.S. and developing countries to access and apply NASA Earth science data. It spans nine societal benefit areas, comprised of the Applied Sciences Program’s four application areas, plus Agriculture, Climate, Energy, Oceans, and Weather. Relevant programs include:

- DEVELOP – Supports young and transitioning professionals working on applied sciences projects, including a recent water project with the Chilean Natural Resources Information Center, to create a methodology using NASA Earth observations to improve their water allocation process.
- SERVIR – A joint venture between NASA and the U.S. Agency for International Development that provides satellite-based Earth observation data and science applications to help developing nations in environmental decision making. This program supports projects such as the Coupled Routing and Excess Storage Hydrologic Mapping Tool.
- Gulf of Mexico Initiative – Projects include the Decision Support for Vulnerability to Future Storms at NASA Kennedy Space Center and also ForWarn, a USFS, USGS, and Department of Energy Oak Ridge National Laboratory collaboration with the NASA Stennis Space Center for early warning of forest threats in the conterminous U.S. The ForWarn system uses Earth science data from the MODIS sensors onboard Terra and Aqua to assess vegetation health and evaluate environmental stress, enabling managers to rapidly identify forest and wildland changes and respond to threats.
- Applied Remote Sensing Training – Supports training modules such as flood monitoring using NASA remote sensing data.

The Applied Sciences Program also helps to organize NASA’s Climate Policy Speaker Series, a program designed to assist the NASA Headquarters community learn about climate and global change issues through briefings such as “Building Confidence in Adaptation: Managing water resources across institutions, sectors, disciplines, and climates” and “The Psychology of Climate Change: Messaging climate change/sea level rise to your community.”

## Earth Science Research

Using space-based and airborne observations, the Research Program advances the interdisciplinary field of Earth system science to provide a scientific basis for major periodic assessments of climate change. These major climate assessments include the Assessment Reports of the Intergovernmental Panel on Climate Change and the USGCRP National Climate Assessment (NCA). For the past four years, NASA has contributed in a variety of ways to the Third NCA report<sup>14</sup> by enabling development of tools, providing assessment capabilities and products, and participating in authorship of the assessment. NASA also provides funding to investigators who will advance assessment-relevant science that can be available for inclusion in future assessments. Projects relevant to climate assessment include:

- NASA Earth Exchange – Combining this platform with the supercomputing resources provided by the NASA Advanced Supercomputing facility at the NASA Ames Research Center, scientists have produced downscaled, high resolution climate datasets that make it easier for resource managers to quantify anticipated climate change impacts on a wide range of conditions and resources important to local communities, such as water supplies and winter snow packs, public health and the spread of insect-borne diseases, flood risk and potential impacts to critical urban infrastructure, wildfire frequency and severity, agricultural production, and wildlife and biodiversity.
- An Integrated Terrestrial Water Analysis System for the NCA – The project will provide a multi-model terrestrial water analysis from 1979-present based on the North American Land Data Assimilation System atmospheric inputs. It will produce improved characterization of the continental scale water budget, which will directly improve the monitoring and prediction of climate-relevant water availability indicators, including droughts and floods.
- CASA-CQUEST (Carnegie-Ames-Stanford Approach-Carbon Query and Evaluation Support Tools) Modeling for Carbon Cycle Assessments in Forested Ecosystems of the United States – This project is producing and delivering assessment products on forest carbon and greenhouse gas fluxes, including appropriate coordination with NCA and other agencies, as well as delivering freely available on-line visualization services to support analysis and communication of results for the NCA.

NASA also uses a wide array of research aircraft equipped with sophisticated sensors to advance Earth science research, and is sponsoring 12 flight campaigns in 2014 that will study the polar ice sheets, urban air pollution, hurricanes, ecosystem health and more over the United States, Central and South America, Antarctica, and the Arctic Circle.

## Additional Partnerships

The Goddard Institute of Space Studies (GISS), a partnership between NASA and Columbia University, has a particular focus on understanding likely changes and applying that understanding to prepare for the impacts of climate change. GISS has been working with New York City and other governments across the nation and the world to help build climate resilience. Key products have included downscaled climate hazard information (Horton et al. 2011), and impact and adaptation assessment tools (Rosenzweig and Solecki, 2010). In particular, as part of the City of New York's PlaNYC initiative, adaptation workshops were developed that in addition to considering built systems, integrated natural and workforce/

<sup>14</sup> See <http://nca2014.globalchange.gov/>

community systems for a fuller sense of the vulnerabilities and potential adaptation options. The Climate Impacts research group at GISS uses observed climate data and climate model outputs (e.g., temperature, precipitation, solar radiation) as inputs to impact models to forecast regional changes in variables such as crop yields, water availability, and forests. These changes may then be evaluated in terms of economic and social costs, including the number of people threatened by hunger, drought, or coastal storm surges. Specific projects include:

- Agricultural Model Intercomparison and Improvement Project – A global community working to improve the characterization of world food security as affected by climate variability and change, and to enhance adaptation capacity in both developing and developed countries.
- Coordinated Climate-Crop Modeling Project – This project aims to improve understanding of the impact of climate change on future agricultural production by utilizing site-calibrated crop models to coordinate projections of crop response under probabilistic climate change scenarios.
- Urban Climate Change Research Network – A consortium of individuals and institutions dedicated to the analysis of climate change mitigation and adaptation from an urban perspective.

NASA participates in the Earth to Sky Partnership (ETS), which is an inter-agency partnership between NASA, the U.S. Department of the Interior National Park Service (NPS), FWS, and University of California to collaborate on scientific and education products for educators. The partnership provides training and materials for NPS and FWS interpreters to help them communicate with park and refuge visitors about climate change. The material has recently focused on climate change education and communication, but ETS also covers planetary science and other areas of scientific interest. The ETS website<sup>15</sup> has archives of training presentations and examples. NASA is also a key participant in the Interagency Climate Change Adaptation Task Force, co-chaired by the CEQ, the Office of Science and Technology Policy (OSTP), and NOAA, and including representatives from more than 20 other Federal agencies.

To address climate risks affecting NASA's own property and operations, agency science and institutional leadership formed a partnership in 2008 to apply scientific data and expertise to improve climate resilience through interactive workshops and adaptation-focused research. NASA's Resilience and Adaptation to Climate Risks workshop process builds upon GISS/Columbia's New York City adaptation efforts, targeting a federal rather than municipal client. Through this series of workshops, NASA initiated local ownership of climate risks for four-fifths of its land, two-thirds of its constructed assets, and most of its workforce at NASA sites across the Nation. Since integrating adaptation into planning and operations is inherently a local activity, NASA engages local governments, industry, academia, and non-governmental organizations in learning about local risks, assessing vulnerabilities, exploring prudent responses, and integrating top priorities into management. The local workshops spur community partnerships, inform NASA's annual sustainability and climate plans, and prompt policy updates (such as integrating flooding risk management into its land use and capital investment processes in 2013)<sup>16</sup>. In addition, NASA offered the expertise gained from these adaptation workshops to planners and other stewards near its Washington DC headquarters through the Building a Climate Resilient National Capital Region series<sup>17</sup>, a combination

<sup>15</sup> See <http://www.earthtosky.org/>

<sup>16</sup> See <http://www.nasa.gov/agency/sustainability/index.html>

<sup>17</sup> See <http://www.mwco.org/environment/climate/resilience.asp>



of in-person workshops and preparatory webinars led by the National Capital Planning Commission, the Metropolitan Washington Council of Governments, the Smithsonian Institution, the General Services Administration, USGRCP, and NASA.

## National Science Foundation

### Background

The National Science Foundation (NSF) supports scientific research and education through competitive grant programs, funding thousands of projects and programs every year with a multi-billion dollar budget (\$7.03 billion in Fiscal Year 2012), including many climate change-related projects and programs. Research funded by NSF spans many disciplines, and includes research in atmospheric, earth, oceanic, biological, environmental, engineering, social, behavioral, and economic sciences. NSF education programs are aimed at developing resources for public science education and at increasing science knowledge and training in the U.S. workforce.

### Programs Related to Climate Change Science and Adaptation

Climate change-related programs and projects funded by NSF are numerous and include (but are not limited to):

- *Decision Making Under Uncertainty Centers*—collaborative groups that, through research, education, and outreach, increase understanding of decision-making processes and of the information needed by decision makers; develop tools to support decision-makers and increase their ability to make sound decisions; and to facilitate interaction among researchers and decision-makers. Recent grant competitions have focused on decision making under uncertainty with respect to climate change and other long-term environmental change.
- *Long-Term Ecological Research Network*—a collaborative effort among scientists and students studying ecological processes at sites strategically located around the United States, Puerto Rico, Tahiti, and Antarctica. The 26 network sites document long-term changes in plants, animals, microbes, and soils in relation to short-term weather and long-term climate changes.
- *National Center for Atmospheric Research*—a research facility that houses a number of research activities in atmospheric science, including the Community Earth System Model, which is one of the foremost U.S. global climate models and provides climate model projections that are key input for the reports of the Intergovernmental Panel on Climate Change, including the recent fifth assessment report (IPCC 2013). Scientists at the center use a collection of advanced tools and techniques, including models, radar, weather-balloon observations, and satellite data, to increase understanding of the impacts of global and regional climate variability and change.
- *National Ecological Observatory Network (NEON)*—a regional-to-continental scale ecological observing network that is under construction that will help increase understanding of the impacts of climate change, land-use change, and invasive species on ecology. NEON will gather data on ecological responses of the biosphere to changes in land use and climate, and on feedbacks with the atmosphere, water cycle, and other natural and human systems.

- *Science, Engineering, and Education for Sustainability programs*— a portfolio of programs focused on helping society address the challenges of achieving sustainability. Funding opportunities under these programs are supporting a number of projects related to climate change and adaptation, particularly under the Water Sustainability and Climate, and Decadal and Regional Climate Prediction using Earth System Models programs.
- *Dynamics of Coupled Natural and Human Systems*—a long-standing interdisciplinary program that has climate- and adaptation-related projects as part of its portfolio.
- *Office of Polar Programs*—provides major support for the academic community for basic research in the Arctic and Antarctic, areas where key observational data on global climate change as well as societal and economic impacts on the Arctic are gathered.

## Smithsonian Institution

### Background

The Smithsonian Institution is a group of museums and research centers administered by the U.S. government, including 19 museums and galleries, and nine research facilities. Increasing knowledge is one of the missions of the Smithsonian Institution, and one of Four Grand Challenges in the Smithsonian's 2010-2015 Strategic Plan (Smithsonian Institution 2010) is to understand and sustain a biodiverse planet by responding to the growing threat of environmental change. Thus, several of the Smithsonian Institution's research facilities and programs address climate change in the U.S.

### Programs Related to Climate Change Science and Adaptation

Within the Smithsonian Institution, climate change-related research is conducted at the Smithsonian Astrophysical Observatory, National Air and Space Museum, Smithsonian Environmental Research Center, National Museum of Natural History, Smithsonian Tropical Research Institute, and Conservation Biology Institute. Research programs strive to improve knowledge of the processes involved in climate change, and themes of Smithsonian research include atmospheric processes, ecosystem dynamics, observing natural and anthropogenic environmental change on daily to decadal time scales, and defining longer-term climate proxies in historical artifacts, records of museums, and the geologic record. The long-term perspective that much of the Smithsonian Institution's research provides makes it unique among Federal agencies.

### Education Efforts

The Smithsonian Institution has a several websites aimed at educating the public about climate change research findings. Recordings of the events at a 2009 climate change conference, called the Smithsonian Education Online Conference on Climate Change, are available online<sup>18</sup>. The Natural History Museum also has a program called the Forces of Change, with an associated website highlighting climate change science<sup>19</sup>.

<sup>18</sup> See <http://www.smithsonianconference.org/climate/>

<sup>19</sup> See <http://forces.si.edu/>

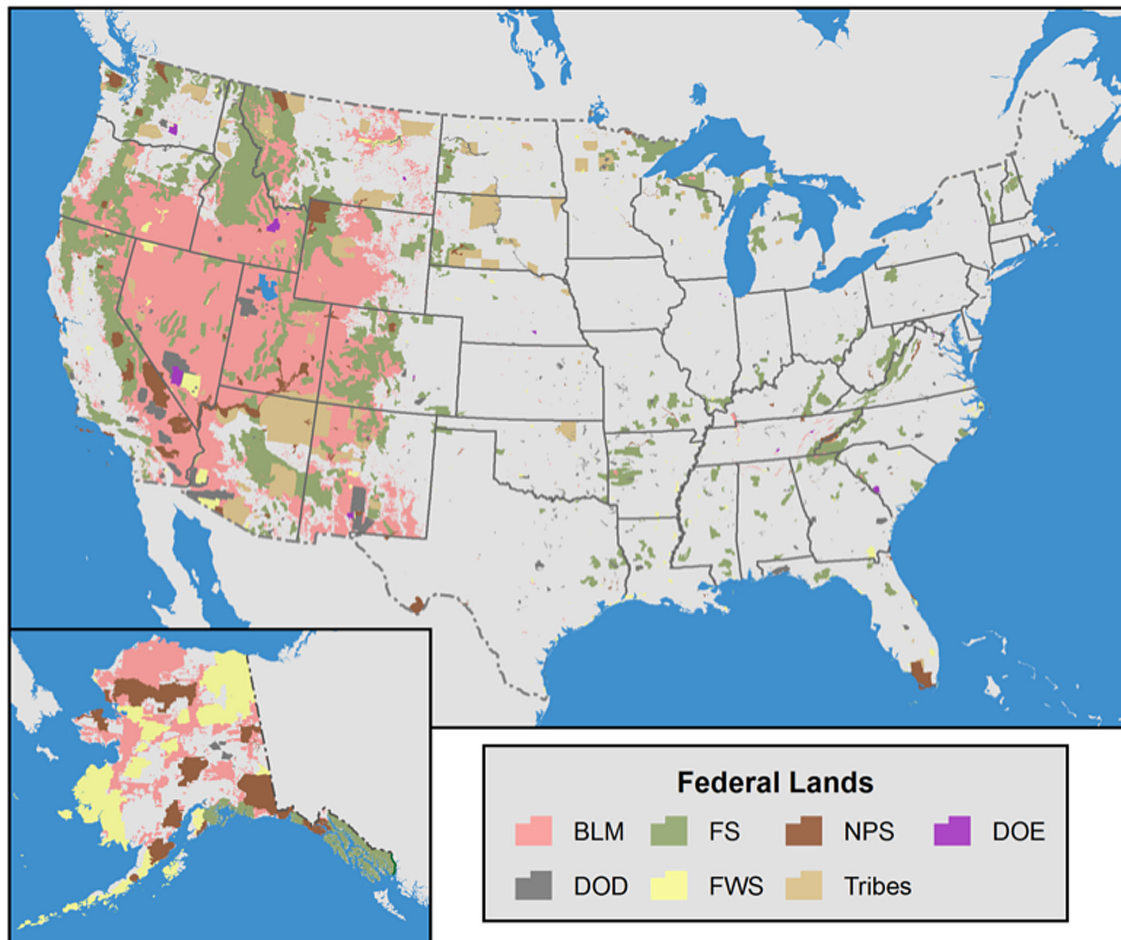
In the fall of 2013, through the Smithsonian-Mason School of Conservation, the Smithsonian convened a professional training course called, “Applied Climate Change: Gaining Practical Skills for Climate Change Adaptation.” The course was a two-week intensive session that provided information and training in climate change basics, climate change tools, and climate change effects in the areas of biodiversity, agriculture, tourism, and wine production. The course included a field tour that showcases real-life examples of climate change adaptation in water, biodiversity, agriculture, and tourism.

## Tribes

### Background

There are 566 Federally-recognized American Indian tribes and Alaska Natives that manage more than 22 million ha of land in the U.S. (*Figure 1*). These tribes are sovereign nations responsible for the well-being of their people and lands, and their natural resources are an important source of economic revenue and cultural heritage. Because of their ties to the land, tribal communities face considerable challenges from

*Figure 1. Federal land holdings in the United States. BLM = Bureau of Land Management, DoD = Department of Defense, DOE = Department of Energy, FS = Forest Service, FWS = Fish and Wildlife Service, NPS = National Park Service.*



climate change. The effects of climate change have become apparent in the altered timing and location of culturally important resources (Cordalis and Suagee 2008, Lynn et al. 2013).

### Adaptation Efforts

Tribes have begun to respond to climate change in a number of ways. Drought, wildfire, flooding, and other extreme weather events are among the climate change challenges that tribes face (NWF 2011). Many tribes have already experienced these events and are taking necessary actions to respond to further threats. Several tribes in the west and southwest have created drought contingency and mitigation plans to guide actions during extreme dry seasons (*Table 1*). For example, the Hualapai Tribe in Arizona has

*Table 1. Examples of climate change adaptation efforts by American Indian tribes across the nation. This table is not exhaustive but gives a sample of some of the actions being taken by tribes in response to climate change. Websites provide additional information on the listed adaptation efforts and guiding documents.*

Tribe	Location	Adaptation Efforts	Guides	Website(s)
Bad River Band of Lake Superior Chippewa	Northern Wisconsin	Examining climate change effects on forest resources Identifying possible adaptation options Incorporating climate change into Integrated Resources Management Plan	Integrated Resources Management Plan (in preparation)	<a href="http://forestadaptation.org/node/205">http://forestadaptation.org/node/205</a>
Confederated Tribes of Siletz Indians	Oregon	Working to restore and protect traditional foods from climate change through forest thinning treatments, hazardous fuel reductions, and meadow restoration		
Coquille Indian Tribe	Western Oregon	Preparing Climate Action Plan Established Climate Change Committee Researching climate change impacts, engaging the community, and strengthening partnerships	Climate Action Plan (in preparation)	<a href="http://www4.nau.edu/tribalclimatechange/tribes/northwest_coquille.asp">http://www4.nau.edu/tribalclimatechange/tribes/northwest_coquille.asp</a>
Fond Du Lac Band of Lake Superior Chippewa	Northeast Minnesota	Reforestation lands, prescribed burning, conducting fuel reduction treatments, and engaging in public education Resource management plan acknowledges several impacts of climate change and the need for more research and adaptation measures	Integrated Resource Management Plan	<a href="http://www4.nau.edu/tribalclimatechange/tribes/greatlakes.asp">http://www4.nau.edu/tribalclimatechange/tribes/greatlakes.asp</a> ; <a href="http://www.fdlrez.com/newnr/IRMP.pdf">http://www.fdlrez.com/newnr/IRMP.pdf</a>
Forest County Potawatomi	Northeast Wisconsin	Active participant in the Wisconsin Climate Change Task Force		<a href="http://www4.nau.edu/tribalclimatechange/tribes/greatlakes_fcpotawatomi.asp">http://www4.nau.edu/tribalclimatechange/tribes/greatlakes_fcpotawatomi.asp</a>
Grand Portage Band of Lake Superior Chippewa	Northeast Minnesota	Developing an adaptation and mitigation plan for climate change effects on subsistence species, fisheries, invasive species, and forests		<a href="http://www4.nau.edu/tribalclimatechange/tribes/greatlakes_Ischippewa.asp">http://www4.nau.edu/tribalclimatechange/tribes/greatlakes_Ischippewa.asp</a>
Hualapai Tribe	Arizona	Written plans for drought conditions and fire and watershed management	Drought Contingency Plan, Fire Management Plan, Watershed Management Plan	<a href="http://hualapai.org/index2.html">http://hualapai.org/index2.html</a>

(continued on next page)

(Table 1 continued)

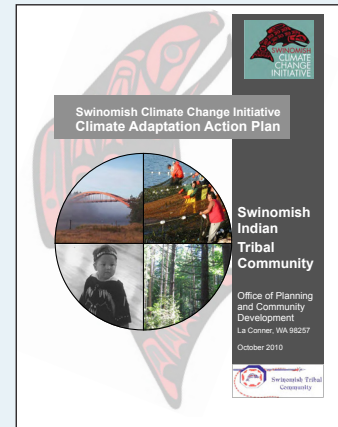
Tribe	Location	Adaptation Efforts	Guides	Website(s)
Karuk Tribe	Northern California	Integrate traditional ecological knowledge with science to inform ecosystem management Adaptation efforts include prescribed burns and forest thinning	Eco-Cultural Resource Management Plan	<a href="http://www.karuk.us/karuk2/departments/natural-resources/">www.karuk.us/karuk2/departments/natural-resources/</a>
Navajo Nation	Northeast Arizona, Northwest New Mexico, Southeast Utah	Used projections of future climate to inform a Drought Contingency Plan Conducted study of sand dunes highlighting climate change impacts Conducting a Land Use Planning Project that addresses climate change	Water Resources Development Strategy; Drought Contingency Plan	<a href="http://www4.nau.edu/tribalclimatechange/tribes/southwest.asp">http://www4.nau.edu/tribalclimatechange/tribes/southwest.asp</a> ; <a href="http://www.frontiernet.net/~nndwr_wmb/PDF/drought/drghtcon_plan2003_final.pdf">http://www.frontiernet.net/~nndwr_wmb/PDF/drought/drghtcon_plan2003_final.pdf</a>
Nez Perce Tribe	Northern Idaho	Developed Water Resources Division climate change adaptation plan Conduct surveys of natural resources	Clearwater River Subbasin (ID) Climate Change Adaptation Plan	<a href="http://www.mfpp.org/wp-content/uploads/2012/03/ClearwaterRiver-Subbasin_ID_Forest-and-Water-Climate-Adaptation-Plan_2011.pdf">http://www.mfpp.org/wp-content/uploads/2012/03/ClearwaterRiver-Subbasin_ID_Forest-and-Water-Climate-Adaptation-Plan_2011.pdf</a>
Oglala Lakota	Southwest South Dakota	Working on mitigating climate change, promoting sustainability, and developing adaptation measures	Oglala Lakota Plan (regional plan for sustainable development)	<a href="http://www4.nau.edu/tribalclimatechange/tribes/plains_ogla.asp">http://www4.nau.edu/tribalclimatechange/tribes/plains_ogla.asp</a> ; <a href="http://www.oglalalakota-plan.org/">http://www.oglalalakota-plan.org/</a>
Pueblo of Tesuque	Northern New Mexico	Conducting watershed management and planning, invasive species removal, water quality monitoring, wildland restoration, grassland restoration, forest thinning, and wildlife monitoring		<a href="http://www4.nau.edu/tribalclimatechange/tribes/southwest_tesuque.asp">http://www4.nau.edu/tribalclimatechange/tribes/southwest_tesuque.asp</a>
Saint Regis Mohawk Tribe	Northern New York	Bringing many Indian Nations together to identify priorities in adaptation planning Identifying changes in climate and resulting impacts, including cultural impacts		<a href="http://www4.nau.edu/tribalclimatechange/tribes/northeast_stregis-mohawk.asp">http://www4.nau.edu/tribalclimatechange/tribes/northeast_stregis-mohawk.asp</a>
Swinomish Tribe	Northwest Washington	Developed Impact Assessment Report on climate change effects for Swinomish communities Completed Climate Change Action Plan with recommendations, priorities, and steps for adaptation implementation	Climate Adaptation Action Plan	<a href="http://www.swinomish-nsn.gov/climate_change/climate_main.html">http://www.swinomish-nsn.gov/climate_change/climate_main.html</a>
Tulalip Tribe	Northwest Washington	Developed Tulalip Adaptation and Mitigation Policy Frameworks for Climate Change Strive to develop climate change policies and actions that are: integrated, cross-scale, adaptive, restorative, participatory, and sustainable		<a href="http://www.tulalip.nsn.us/pdf.docs/FINAL%20CC%20FLYER.pdf">http://www.tulalip.nsn.us/pdf.docs/FINAL%20CC%20FLYER.pdf</a>
Tuscarora Nation	Western New York	Practice land stewardship and conduct restoration of soil and fish and wildlife habitat to prepare for climate change		<a href="http://www4.nau.edu/tribalclimatechange/tribes/northeast_tuscarora.asp">http://www4.nau.edu/tribalclimatechange/tribes/northeast_tuscarora.asp</a>



## Box 1. Climate Change Adaptation on Native Lands

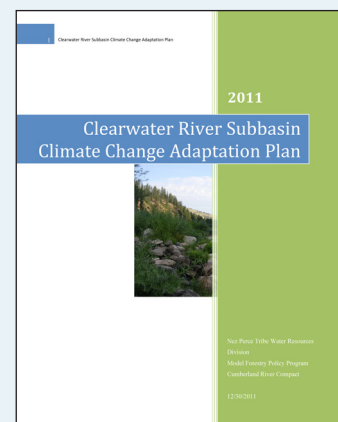
The Swinomish Indian Reservation is located in northwest Washington State. The Swinomish tribe is a community of coastal people that place great value in their cultural and natural resources. An extreme flooding event in 2006 prompted the Swinomish Tribe to examine climate change impacts on their lands and resources.

- The Swinomish Senate issued a proclamation for the Swinomish Climate Change Initiative (Initiative) in 2007.
- The Initiative began in 2008, focusing on assessing climate change impacts and vulnerabilities and identifying adaptation options to address these issues.
- A comprehensive Impact and Assessment Technical Report was released in 2009 (SITC 2009). The report covered a number of climate change impacts and vulnerabilities for natural and human systems.
- The Initiative produced a Climate Change Adaptation Action Plan in 2010 (SITC 2010). The plan features an adaptation strategy toolbox, recommendations for action, and ways to implement these action plans.



The Nez Perce Tribe, in northwestern Idaho, values its land and resources surrounding the Clearwater River. The tribe's Water Resources Division recognized the need to consider climate change information in planning, and in 2011, the tribe received a grant from the Model Forest Policy Program, which helped the tribe organize and write a climate change adaptation plan.

- A technical team composed of tribal members and other stakeholders spent a year gathering and analyzing information and developing adaptation strategies.
- For the adaptation report, the team followed the strategies outlined by the Climate Solutions University's Forest and Water Strategies Program.
- The Clearwater River Subbasin (ID) Climate Change Adaptation Plan (Thaler and Griffith 2011) focused on the climate change impacts to forest and water resources, and regional economics, and outlined adaptation goals.



The Bad River Band of Lake Superior Chippewa Indians is concerned about climate change effects on the shores of the Bad River and Lake Superior. The Bad River Natural Resources Department is working with the BIA and the NIACS to begin an adaptation project on reservation lands.

- The project team used the adaptation workbook from *Forest Adaptation Resources: Climate Change Tools and Approaches for Land Managers* (Janowiak et al. 2012) to consider climate change effects and actions for Bad River lands.
- Possible adaptation option for increasing future forest resilience include invasive species monitoring, stand diversification, thinning, prescribed burning, and planting certain species, like white pine.
- The Bad River Natural Resources Department plans to incorporate these actions and climate change lessons into its Integrated Resource Management Plan.
- With NIACS, the Bad River Natural Resources Department will share their project stages, lessons, and outcomes with other resource managers through the Shared Landscapes Initiative<sup>20</sup>.

<sup>20</sup> See <http://www.sharedlandscapes.org/>

developed a drought contingency plan, fire management plan, and watershed management plan to alleviate possible threats (Hualapai Department of Natural Resources). Other tribes are responding to climate change by practicing restoration techniques like invasive species removal or forest thinning (e.g., the Confederated Tribes of Siletz Indians in Oregon; Lynn et al. 2013; [Table 1](#)).

### **Partnerships**

Tribes are partnering with local, state and federal entities in their adaptation efforts. For example, the Confederated Tribes of Siletz Indians are partnering with the Forest Service Willamette National Forest in conducting forest thinning, hazardous fuels reduction, and meadow restoration to enhance traditional foods, including huckleberries (*Vaccinium* spp.) and camas (*Camassia quamash*) root, and protect them from the effects of severe wildfires and climate change (Lynn et al. 2013). Similarly, the Nez Perce Tribe in Idaho partnered with the Model Forestry Policy Program, University of Idaho, Columbia River Intertribal Fish Commission, Nez Perce-Clearwater National Forest, and senator's offices in development of a climate change adaptation plan (Thaler and Griffith 2011). See [Table 1](#) and [Box 1](#) for other examples of guiding documents and climate change adaptation work being done by tribes around the U.S.

## **U.S. Department of Agriculture**

### **Background and Guiding Documents**

The USDA is responsible for developing and executing U.S. policy on food, agriculture, natural resources, rural development, nutrition, and related issues. The vision for the USDA in its most recent strategic plan is, "To expand economic opportunity through innovation, helping rural America to thrive; to promote agriculture production sustainability that better nourishes Americans while also helping feed others throughout the world; and to preserve and conserve our Nation's natural resources through restored forests, improved watersheds, and healthy private working lands" (USDA 2010a). Climate change has the potential to impede the USDA in meeting these goals.

In 2010, the USDA released its Strategic Plan for fiscal years 2010-2015 (USDA 2010a). The strategic plan cited four main strategic goals, all of which had associated objectives (totaling 14). Strategic goals included: 1) Help increase prosperity in rural communities; 2) Ensure national forests and private working lands are conserved, restored, and made more resilient to climate change, while enhancing water resources; 3) Help promote agricultural production and biotechnology exports to increase food security; and 4) Ensure U.S. children have access to safe, nutritious, and balanced meals. Strategic Goal 2 had several objectives, including Objective 2.2, which was to lead efforts to mitigate and adapt to climate change. A performance measure under this objective was to bring all national forests into compliance with a climate change adaptation and mitigation strategy. The strategic plan further calls on the USDA to mitigate and adapt to climate change through Strategic Goals 1, 3, and 4.

A Climate Change Science Plan (USDA 2010b) was released by the USDA in 2010. The objective of this plan was to incorporate climate change into the scientific missions of the USDA. The plan identified four main elements, or research goals, including: 1) understand the direct and indirect effects of climate change on ecosystems; 2) develop knowledge, models, and tools to enable adaptation to climate change

and increase ecosystem resilience; 3) develop knowledge and tools to increase the role of agriculture and ecosystem management in climate change mitigation; and 4) provide science-based decision-support to USDA agencies, stakeholders and collaborators. The plan also identified specific priorities under each element.

In response to Executive Order 13514 and the 2011 CEQ adaptation implementation instructions (CEQ 2011), the USDA developed a climate change adaptation policy statement, issued as a Departmental Regulation (DR-1070-001) in 2011 (USDA 2011), which required the USDA and each agency within to prepare a climate change adaptation plan. Response to this directive was managed by the USDA Climate Change Program Office (CCPO), which coordinates climate change-related activities and policy issues in the USDA. The CCPO coordinated adaptation planning in all USDA agencies and offices, issuing guidance for adaptation plan development. The CCPO also developed a High-Level Analysis of Agency Vulnerability to Climate Change (USDA 2012a), and a Climate Change Adaptation Plan for the USDA, which was included in the USDA 2012 Strategic Sustainability Performance Plan (USDA 2012b). The Climate Change Adaptation Plan outlined planned efforts by USDA agencies to increase capacity to respond to climate change, processes for assessing climate change effects and vulnerabilities, and challenges in determining those effects and vulnerabilities. The plan also included separate adaptation plans for each USDA agency.

In February 2014, Secretary of Agriculture Tom Vilsack announced that the USDA has established seven Regional Climate Hubs, including one in the Northeast, Midwest, Southeast, Northern Plains, Southern Plains, Pacific Northwest, and Southwest. The hubs are intended to serve as a source of data, interpreted climate change assessments and projections, and practical information to support decision-making and adaptation planning in agriculture and natural resource management.

USDA vulnerability assessments, education, and adaptation efforts relevant to Federal land management are detailed in the U.S. Forest Service section below.

## U.S. Forest Service

### ***Background and Guiding Documents***

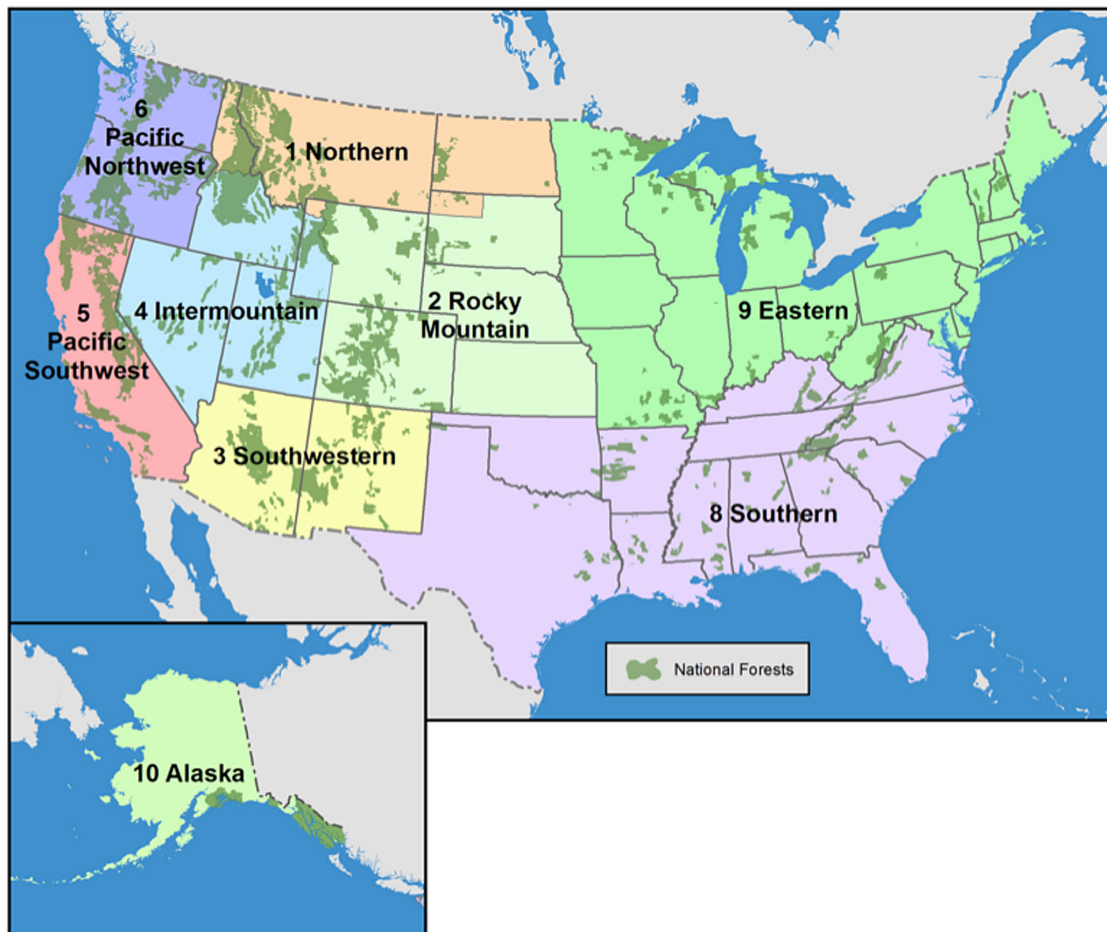
The U.S. Forest Service (Forest Service hereafter) administers over 78 million ha of land in 155 national forests and 20 national grasslands across the United States (*Figures 1 and 2*). The Forest Service is responsible for restoring, sustaining, and enhancing forests and grasslands while providing and sustaining benefits to the American people. The Forest Service supports both a research and development branch as well as advises and cooperates with private, state, and international forest land managers. Because of their responsibilities, Forest Service scientists and land managers are tasked with reducing the effects of climate change on ecosystem function and services.

The Forest Service released the Strategic Framework for Responding to Climate Change (USDA FS 2008) in 2008, which included seven strategic goals to address climate change:

1. **Science** – advance scientific understanding of climate change effects and related adaptation and mitigation actions
2. **Education** – advance public understanding of sustainable resource and land management under a changing climate.
3. **Policy** – integrate climate change into Forest Service policies, program guidance, and communications
4. **Alliances** – build alliances for sustainable forest management in a changing climate
5. **Adaptation** – increase the capacity of forests and grassland to adapt to a changing climate and provide ecosystem services
6. **Mitigation** – promote the management of forests and grasslands to reduce the buildup of greenhouse gases
7. **Sustainable operations** – reduce the carbon footprint of Forest Service operations

The Forest Service research and development branch has a climate change strategic plan called the Forest Service Global Change Research Strategy (Solomon et al. 2009). The focus of the strategy is to increase

Figure 2. U.S. Department of Agriculture Forest Service regions, and National Forests within regions.



understanding of forest, woodland, and grassland ecosystems so they can be managed to sustain and provide ecosystem services into the future. Focus research elements in the strategy include:

1. Research to enhance ecosystem sustainability (i.e., adaptation research)
2. Research to increase carbon sequestration (i.e., mitigation research)
3. Research to provide decision support
4. Cross-cutting research needs, including infrastructure, scientific collaboration, and science delivery

In response to Goal 2 in the USDA Strategic Plan (USDA 2010a), the Forest Service built on the Strategic Framework for Responding to Climate Change, releasing the National Roadmap for Responding to Climate Change (USDA FS 2011a) and a Climate Change Performance Scorecard (USDA FS 2011b) for national forests. The National Roadmap for Responding to Climate Change specified that the Forest Service will respond to climate change by:

1. Assessing current risks, vulnerabilities, gaps in knowledge, and policy and management effectiveness;
2. Engaging employees and stakeholders to find solutions to climate change issues; and
3. Managing for resilience in ecosystems and human communities through adaptation, mitigation, and sustainable operations.

The intention of the document was for individual units to implement the guidelines therein based on regional guidance; local (National Forest scale) implementation would be tracked using the Performance Scorecard (*Table 2*). The Performance Scorecard (Scorecard hereafter) rates national forests on how well they are responding to climate change based on ten criteria (*Table 2*). Each national forest is expected to meet seven of the ten criteria by 2015, with one criteria met in each of four dimensions, including organizational capacity, engagement, adaptation, and mitigation (*Table 2*). Progress in meeting Scorecard criteria is overseen by the Forest Service Climate Change Advisor's Office (the Climate Change Advisor was appointed by the Chief of the Forest Service to coordinate climate change communication and activities within the agency). The Forest Service research and development branch and regional and national programs support Scorecard efforts, particularly on the education, science and management partnerships, assessing vulnerability, adaptation actions, and carbon assessment and stewardship elements.

## Partnerships

The Forest Service has partnered with numerous state and Federal agencies, tribes, and non-governmental organizations in climate change adaptation efforts, as described above and in other efforts. For example, several national forests, including Lolo National Forest and San Juan National Forest, have partnered with non-governmental organizations such as Climate Solutions University<sup>21</sup> and the Mountain Studies Institute<sup>22</sup> in community-based climate change adaptation efforts. The Forest Service actively participates in the Landscape Conservation Cooperatives (LCC) Network. There are several partnerships between Forest Service research stations and tribes on climate change, as a part of the nationwide Forest Service

<sup>21</sup> See <http://www.mfpp.org/>

<sup>22</sup> See <http://www.mountainstudies.org/>



Coordinated Approach to Tribal Climate Change Research project<sup>23</sup>. For example, the Rocky Mountain Research Station is a founding partner in the Southwest Tribal Climate Change Project<sup>24</sup>, and the Pacific Northwest Research Station is a founding partner in the Tribal Climate Change Project in the Pacific Northwest<sup>25</sup>. The National Forest System also has a new initiative to collaborate with tribes to enhance resilience and adaptation to climate change, with flagship partnerships in each Forest Service region (*Figure 2*). By linking national forests and their associated tribe(s) in a joint adaptation learning effort, this initiative will facilitate collaboration on wide range of common natural resources issues facing both national forest and tribal land managers.

Table 2. The Forest Service Climate Change Performance Scorecard, which is completed annually by each national forest or grassland (unit) to rate unit success in meeting climate change adaptation and mitigation goals.

Scorecard Element	Unit Name	Yes/No
<b>Organizational Capacity</b>		
1. Employee education	Are all employees provided with training on the basics of climate change, impacts on forests and grasslands, and the Forest Service response? Are resource specialists made aware of the potential contribution of their own work to climate change response?	
2. Designated climate change coordinators	Is at least employee assigned to coordinate climate change activities and be a resource for climate change questions and issues? Is this employee provided with training, time, and resources to make his/her assignment successful?	
3. Program guidance	Does the Unit have written guidance for progressively integrating climate change considerations and activities into Unit-level operations?	
<b>Engagement</b>		
4. Science and management partnerships	Does the Unit actively engage with scientists and scientific organizations to improve its ability to respond to climate change?	
5. Other partnerships	Have climate change related considerations and activities been incorporated into existing or new partnerships (other than science partnerships)?	
<b>Adaptation</b>		
6. Assessing vulnerability	Has the Unit engages in developing relevant information about the vulnerability of key resources, such as human communities and ecosystem elements, to the impacts of climate change?	
7. Adaptation actions	Does the Unit conduct management actions that reduce the vulnerability of resources and places to climate change?	
8. Monitoring	Is monitoring being conducted to track climate change impacts and the effectiveness of adaptation activities?	
<b>Mitigation and Sustainable Consumption</b>		
9. Carbon assessment and stewardship	Does the Unit have a baseline assessment of carbon stocks and an assessment of the influence of disturbance and management activities on these stocks? Is the Unit integrating carbon stewardship with the management of other benefits being provided by the Unit?	
10. Sustainable operations	Is progress being made toward achieving sustainable operations requirements to reduce the environmental footprint of the Agency?	

<sup>23</sup> See <http://www.fs.fed.us/research/docs/tribal-engagement/factsheets/forest-service-research-tribal-factsheet.pdf>

<sup>24</sup> See [http://www4.nau.edu/itep/climatechange/tcc\\_SWProj.asp](http://www4.nau.edu/itep/climatechange/tcc_SWProj.asp)

<sup>25</sup> See <http://tribalclimate.uoregon.edu/>

## Education Efforts

There are numerous efforts within the Forest Service to educate employees about climate change. Employee education is one of the 10 climate change-related criteria included in the Scorecard. Recently, an instructional package was developed through the Forest Service Office of the Climate Change Advisor containing information and suggestions for conducting all-employee climate change training. The goal was to provide information that national forest-level climate change coordinators can use to plan and coordinate training for their co-workers. To build general Scorecard success, the Pacific Southwest Region of the Forest Service also conducts a quarterly webinar series for their national forest climate change coordinators to provide tools and information relevant to completing Scorecard elements.

The Climate Change Resource Center website<sup>26</sup> is a Forest Service-sponsored portal developed to provide information and tools to land managers and decision makers to address climate change. To support adaptation and mitigation in the Forest Service and beyond, the site provides basic climate science information, including a climate change primer and frequently asked questions, short topic pages that explain climate and climate impacts, video lectures, links and information on tools, decision support models, and case study examples.

Scientists in Forest Service research and development have also provided climate change education to Forest Service employees through scientist-manager workshops, and development of courses and educational materials. For example, scientist-manager workshops were conducted on the Mount Baker-Snoqualmie and Okanogan-Wenatchee National Forests as a part of the North Cascadia Adaptation Partnership (Raymond et al. 2013, Raymond et al. in press), and a series of climate change workshops were conducted on national forests in the northeastern United States through the Northern Institute of Applied Climate Science (NIACS<sup>27</sup>). NIACS also developed a Training in Advanced Climate Topics course, which is a week-long course in climate change concepts for natural resource managers that provides advanced instruction on climate change science, concepts, and strategies for managing ecosystems for an uncertain future, and a climate change module for the Forest Service National Advanced Silviculture Program.

## Vulnerability Assessments

Climate change vulnerability assessments have been conducted by national forest specialists and Forest Service research scientists throughout the United States, including the Rocky Mountain (Rice et al. 2012), Eastern (Swanston et al. 2011), Pacific Northwest (Aubry et al. 2011, Halofsky et al. 2011, Devine et al. 2012, Raymond et al. 2013, Raymond et al. in press), Southern (Wear and Greis 2011), and Southwestern regions (Coe et al. 2012) (Forest Service Regions shown in *Figure 2*). Other vulnerability assessments are currently being conducted in some of these and the remaining four Forest Service regions, including the Alaska, Intermountain, Pacific Southwest, and Southwestern Regions. For example, in the Pacific Southwest and Pacific Northwest Regions, socio-economic vulnerability assessments are being conducted on national forests, in collaboration with Forest Service research scientists. In addition, as specified in the 2012 planning rule for land management planning for the National Forest System (USDA FS 2012), national forests are required to address the potential effects of climate change in their land management plan revision process, and several forests have developed climate change assessment reports that incorporate

<sup>26</sup> See [www.fs.fed.us/ccrc](http://www.fs.fed.us/ccrc)

<sup>27</sup> See <http://www.nrs.fs.fed.us/niacs/>

resource vulnerabilities for their land management plans, including the El Yunque, Francis Marion and Nantahala-Pisgah National Forests.

Another joint national forest and Forest Service research vulnerability assessment effort focused on the vulnerability of watersheds to climate change (Furniss et al. 2013). The watershed vulnerability assessments, conducted on 11 national forests throughout the United States, were locally focused (at a national forest scale) and included water resource values, hydrologic reaction to climate change, watershed condition and landscape sensitivity. The assessments were intended to help national forest managers identify where limited resources could be best invested to increase watershed resilience to climate change.

### **Adaptation Efforts**

National Forests have partnered with scientists in Forest Service research and local universities to begin the process of adapting to climate change. Projects that have focused on climate change adaptation in national forests, with Forest Service research stations as partners, include the Climate Change Adaptation and Mitigation Management Options project<sup>28</sup>, covering national forests in the southeastern U.S.; the Climate Change Response Framework project (Swanston et al. 2012<sup>29</sup>), involving over 10 national forests in the Midwestern and Northeastern United States; the North Cascadia Adaptation Partnership (Raymond et al. 2013, Raymond et al. in press), involving two national forests in the Pacific Northwest; the WestWide Climate Initiative (Peterson et al. 2011), involving the Inyo, Olympic, Shoshone, and Tahoe National Forests in the western U.S; and an adaptation effort on the Colville and Okanogan-Wenatchee National Forests in Washington State (Gaines et al. 2012).

Forest Service scientists and specialists have developed several resources for use by managers in climate change adaptation, in the form of websites, tools, and reports. Examples of these resources are:

- *Climate Project Screening Tool (CPST)* – The CPST (Morelli et al. 2011) helps Forest Service and other land managers integrate climate change considerations into project planning and develop concrete adaptation options. The tool involves a series of questions, both broad and narrow, that guide managers in evaluating projects and in determining whether or not climate change was considered or needs to be considered in project planning and implementation. The CPST can help managers address uncertainty by allowing them to explore potential effects of both climate change and management actions.
- *Forest Adaptation Resources: Climate Change Tools and Approaches for Land Managers* – This report contains a collection of resources for managers to incorporate climate change in land management (Swanston and Janowiak 2012). Information in the report was derived from vulnerability assessments, partnership efforts, workshops, and collaborative work between scientists and managers. The report includes chapters on adaptation strategies, a workbook process to help implement climate change science into management decisions, and examples of how the resources can be used in real world situations.
- *Responding to Climate Change in National Forests: A Guidebook for Developing Adaptation Options* – This guidebook contains science-based principles, processes, and tools to assist land managers in

<sup>28</sup> See <http://www.srs.fs.usda.gov/news/482>

<sup>29</sup> See <http://forestadaptation.org/>

developing adaptation options (Peterson et al. 2011). Information in the report is based largely on knowledge and experience gained through a series of science-management adaptation partnerships established among Forest Service scientists, national forests, and adjacent national parks.

- *System for Assessing Vulnerability of Species* – This tool is designed for resource managers to help them determine relative vulnerability of vertebrate species to climate change (Bagne et al. 2011). The tool uses a questionnaire of 22 criteria to develop vulnerability scores. Six scores are produced, including a score indicating overall level of vulnerability, four categorical scores (habitat, physiology, phenology, and biotic interactions) that indicate sources of vulnerability, and an uncertainty score reflecting user confidence in the predicted response.
- *Template for Assessing Climate Change Impacts and Management Options (TACCIMO)* – TACCIMO<sup>30</sup> is a web-based tool that gives land managers access to geospatial climate change projections and peer-reviewed scientific literature on climate change effects and management options, relevant to their geographic area of interest. Based on user inputs, TACCIMO produces customized assessment reports summarizing available science and related planning information (Forest Service users only). The TACCIMO website includes user guides and training videos. Information is routinely added and reorganized.

## U.S. Department of Commerce

### National Oceanic and Atmospheric Administration

#### **Background**

The mission of NOAA is to understand and predict changes in climate, weather, oceans and coasts; share that knowledge with others; and conserve and manage coastal and marine ecosystems and resources (NOAA 2010c). NOAA's Next Generation Strategic Plan cites a vision of "healthy ecosystems, communities, and economies that are resilient in the face of change," and includes "an informed society anticipating and responding to climate and its impacts" as one of its long-term objectives (NOAA 2010c).

#### **Programs Related to Climate Change Science and Adaptation**

NOAA supports a Climate Predictions Center under its National Weather Service. The Climate Predictions Center provides 8-10 day to tri-monthly forecasts and issues regular reports for spring floods, El Niño/La Niña, hurricanes, and winter, spring, summer, fall temperature and precipitation. The Climate Predictions Center also provides bi-monthly drought outlooks. These climate outlooks can be used by communities and land and water managers to take action before conditions develop.

NOAA research laboratories and the Climate Program Office conduct research on climate systems. There are seven NOAA research labs in the U.S. that have formal collaborative agreements with universities and non-profit organizations to conduct research on the earth's oceans, inland waters, arid lands, atmosphere, and arctic environment. The Climate Program Office oversees competitive research programs that fund climate-related science. Grant activities under the Climate Programs Office are organized into four programs, including the:

<sup>30</sup> See <http://www.taccimo.sgcp.ncsu.edu/>

- *Climate Observations and Monitoring Program* – oversees the design, building, and maintenance of a global climate observation system and produces information and analyses on ocean and atmospheric conditions.
- *Earth System Science Program* – works to increase basic understanding of the climate system and supports improvement of climate models and predictions.
- *Modeling, Analysis, Predictions, and Projections Program* – aims to improve capability to predict variability and changes in the Earth's climate system.
- *Climate and Societal Interactions Program* – supports research, assessments and climate services development to facilitate climate change adaptation.

The Climate and Societal Interactions Program includes several programs that provide information directly relevant to climate change adaptation, including the:

- *Coastal and Ocean Climate Applications Program* – supports research on climate-related issues in coastal and marine environments to aid stakeholders in decision-making.
- *International Research and Applications Project* – funds research that integrates climate research and assessments with applied risk management and adaptation activities in key regions worldwide.
- *National Integrated Drought Information System* – provides drought information for the U.S. and supports research on drought risk assessment, forecasting, management, and development of decision support.
- *Sectoral Applications Research Program (SARP)* – aims to build an applied knowledge base and facilitate the creation and exchange of information to help stakeholders understand and address climate-related resources management issues in key social and economic sectors (e.g., coastal, water resources, agriculture, and health).
- *Regional Integrated Sciences and Assessments (RISA) Program* – supports interdisciplinary, user-focused research that improves understanding of how climate affects various regions of the U.S. and informs resource management, planning, and public policy.

Climate and Societal Interactions programs work with other climate programs and initiatives within NOAA, including, for example, the NOAA National Climate Data Center, which helps make climate information relevant and accessible to people across the U.S. The National Climate Data Center currently manages six Regional Climate Centers, which are a Federal-state cooperative effort. The six centers are engaged in the timely production and delivery of useful climate data, information and knowledge for decision makers and other users at the local, state, regional and national levels.

Foci of the Climate and Societal Interactions SARP are water resource management initiatives for coping with drought, and extreme event preparedness. The Program's goals are to:

- Provide a better understanding of the climate-related risks and opportunities faced by resource managers and planners, and assess their needs for decision support tools, data, and information services;
- Equip resource managers and planners with tools, knowledge, methodologies, and forums to cope with climate-related extreme events;



- Help decision-makers better understand their vulnerabilities to a changing climate and plan adaptation and mitigation strategies in accordance with their priorities and values;
- Infuse scientific information about climate risks and uncertainties into societal decision-making processes on local to national scales; and
- Promote partnerships between the climate science and decision-making communities to improve societal use of climate data, forecasts, and projections.

SARP brings together like-minded stakeholders and researchers to share knowledge, develop tools and best practices, and initiate mutually beneficial collaborations towards coping with and adapting to a changing climate. Lessons learned from grant-supported research are transferred to other locations and venues as part of the grant award. Examples of recent topics of interest include work on examining economic impacts and costs of climate-related extremes and adaptation; assessing urban areas' vulnerability to extreme hydrologic events; developing tools and methods to help decision-makers better understand, use, and communicate scientific information in planning and adapting to climate-related changes; and integrating climate data, forecasts, and projections into their management of water resources.

The Climate and Societal Interactions RISA program works to integrate science in management and policy frameworks and promote relationships between scientists, managers, and policy-makers to help them make decisions in the face of uncertainty. RISA provides funding for research and information development that is relevant to adaptation of land and water management to climate change. The program was established by NOAA in the mid-1990's and currently supports 11 RISA teams throughout the country (*Figure 3*) on five-year cooperative agreement awards: Alaska Center for Climate Assessment and Policy, California Nevada Applications Program, Carolinas Integrated Sciences and Assessments, Climate Assessment for the Southwest, Climate Impacts Research Consortium (Pacific Northwest U.S.), Consortium for Climate Risk in the Urban Northeast, Great Lakes Integrated Sciences and Assessments Center, Pacific RISA, Southeast Climate Consortium, Southern Climate Impacts Planning Program, and Western Water Assessment (Colorado, Utah, and Wyoming) (*Figure 3*). RISA research team members are mostly based at universities, although some are affiliated with government research facilities, non-profit organizations, and private sector entities. Partnerships are an important component of the RISA program. Many of the RISAs collaborate with the LCC Network and Climate Science Centers (CSCs), and future collaboration with USDA Hubs is planned. A diversity of approaches is encouraged among RISAs, because issues of concern vary among regions (e.g., in the Great Lakes region there is concern about the potential effects of climate change on tourism, whereas in the southeastern United States there is concern about the effects of the changing conditions on agriculture). The research approach for RISAs typically involves needs assessments and identification of key issues; integrated research on topics of concern to stakeholders; and dissemination of information and tools to aid in decision-making. To date, research has focused on the fisheries, water, wildfire, and agriculture sectors, with more recent activity in public health issues and coastal restoration. See *Table 3* for examples of research by RISA teams.

### **Adaptation Efforts in Stewardship and Outreach**

NOAA also has stewardship responsibilities and provides information to facilitate climate change adaptation to coastal managers and the public. NOAA manages a network of marine protected areas, including 13 National Marine Sanctuaries and a Marine National Monument. NOAA's Office of National Marine

Sanctuaries issued a policy statement in 2009 (NOAA 2009b) that established a commitment to work with NOAA's Climate Program Office to assess potential climate impacts on National Marine Sanctuaries and develop measures to mitigate potential impacts. In 2010, the Office of National Marine Sanctuaries launched a Climate-Smart Sanctuary Initiative to address the potential impacts of climate change in the national marine sanctuary system. Under this initiative, each marine sanctuary is required to develop a climate change action plan, including strategies for management, operations, science, and outreach. Sanctuaries that meet specific standards will receive climate-smart certification. To date, three sanctuaries have received climate-smart certification.

Figure 3. Locations of National Oceanic and Atmospheric Administration Regional Integrated Sciences and Assessments (RISA) teams and affiliated institutions. ACCAP = Alaska Center for Climate Assessment and Policy, CCRUN = Consortium for Climate Risk in the Urban Northeast, CIRC = Climate Impacts Research Consortium, CISA = Carolinas Integrated Sciences and Assessments, CLIMAS = Climate Assessment for the Southwest, CNAP = California Nevada Applications Program, GLISA = Great Lakes Integrated Sciences and Assessments Center, SCIPP = Southern Climate Impacts Planning Program, SECC = Southeast Climate Consortium, and WWA = Western Water Assessment.



Table 3. Examples of research topics addressed by the 11 National Oceanic and Atmospheric Administration Regional Integrated Sciences and Assessment centers across the U.S. Adapted from NOAA 2012a.

Regional Integrated Sciences and Assessment Center	Example 2012 Research Topics
Alaska Center for Climate Assessment and Policy	Food security in the Kenai Peninsula
California Nevada Applications Program	Impacts of climate and weather extremes
Carolinas Integrated Sciences and Assessments	Vulnerability and adaptation planning processes for coastal communities
Climate Assessment for the Southwest	Future climate in the city of Tucson
Climate Impacts Research Consortium	Adaptation to changes in hydrology in the Big Wood River Basin of Idaho
Consortium for Climate Risk in the Urban Northeast	Modeling coastal storm surges in the northeast
Great Lakes Integrated Sciences and Assessments Center	Climate assessment for the mid-west
Pacific RISA	Current state of knowledge about climate change impacts on Pacific Islands and adaptive capacity in the region
Southeast Climate Consortium	Corn crop irrigation and winter rainfall storage in Alabama
Southern Climate Impacts Planning Program	Historical storm surges along the Gulf Coast and worldwide
Western Water Assessment	Drivers of snow accumulation and melt in the Upper Colorado River Basin and improving quantitative streamflow forecasts

The Office of National Marine Sanctuaries recently released a National Marine Sanctuary System Condition Report (Gittings et al. 2013). The report provides a system-wide summary of the conditions of water, habitat, living resources, and maritime archaeological resources. The report also identifies emerging pressures and threats to sanctuary resources. Climate change (e.g., sea surface temperature variability, sea level change, and changes in living resource phenology) and, in particular ocean acidification, are identified as threats to nearly every sanctuary or Marine National Monument.

The Climate Regimes and Ecosystem Productivity (CREP) Program provides Federal, state, tribal and private-sector decision-makers with information on how climate variability and change is impacting U.S. marine ecosystems and the communities and economies that depend on them. This information is critical to fulfilling NOAA core management responsibilities for marine-related fisheries, protected species and habitats in a rapidly changing world. CREP is currently limited to providing information, assessments and projections of climate-related impacts on living marine resources of the Bering Sea and Gulf of Alaska (North Pacific Climate Regimes and Ecosystem Productivity project). To provide information and projections of climate-related impacts on valuable fisheries and other marine resources, CREP works with many partners to collect data on climate, ocean and living marine resource conditions through a leveraged network of in situ and remote observing systems.

The NOAA Sea Grant Program provides integrated research, communication, education, extension and legal programs to coastal communities to aid sustainable use of ocean, coastal and Great Lakes resources. In 2012, Sea Grant held its second Coastal Communities Climate Adaptation Initiative grants competition to help enhance planning for climate adaptation in coastal communities. Sea Grant also supports communities of practice among extension, outreach and education professionals to ensure continued dialogue and information exchange on sea level rise and other climate-change issues.

The NOAA Office of Ocean and Coastal Resource Management (OCRM), in accordance with the Coastal Zone Management Act (CZMA 1972), provides support to state coastal programs. Many of these state coastal programs are using this support to adapt natural resources and infrastructure, and the communities that depend on them, to climate change. To further facilitate adaptation efforts in coastal areas, the NOAA Office of Habitat Conservation and OCRM released a, “Programmatic Framework for Considering Climate Change Impacts in Coastal Habitat Restoration, Land Acquisition, and Facility Development Investments” in 2010 (NOAA 2010c). In response to framework recommendations, the OCRM developed a guide to help coastal managers develop and implement adaptation plans to reduce climate change impacts on coasts (Adapting to Climate Change: A Planning Guide for State Coastal Managers; NOAA 2010a). The OCRM also developed a “Voluntary Step-by-Step Guide for Considering Potential Climate Change Effects on Coastal and Estuarine Land Conservation Projects” (NOAA 2012b), which provides an approach for coastal management partners to consider how climate impacts might affect conservation projects and how to incorporate climate change consideration into planning processes.

The Estuarine Reserves Division of NOAA’s OCRM oversees the National Estuarine Research Reserve System (NERRS), a network of 28 protected areas, each representing different biogeographic regions of the United States, established through partnerships between NOAA and coastal states. The reserves are for the focus of place-based coastal research, long-term water-quality monitoring, education, and coastal stewardship. The NERRS has identified climate change, water quality, and habitat protection as strategic areas of focus and investment through 2016. The NERRS Sentinel Sites initiative combines the research, monitoring, outreach and training capacity at each reserve into a network of sites to better understand the impacts of climate change and anthropogenic stressors on estuarine ecosystems and coastal communities. The current focus of NERRS Sentinel Site initiative is on assessing the impacts of sea level change and inundation on tidal wetlands, submerged aquatic vegetation, and mangroves to inform coastal management. By linking NERRS ecosystem monitoring to geospatial infrastructure of the National Spatial Reference System and National Water Level Observation Network, reserves can inform and develop tools such as inundation maps, integrated ecosystem models, and vulnerability assessments to assist coastal managers in adapting to climate change. A national-scale climate sensitivity analysis of U.S. estuaries, based on the 28 NERRS sites, was released in 2013 (Robinson et al. 2013).

The NERRS Science Collaborative<sup>31</sup> supports applied research projects that actively engage relevant stakeholders sometimes address issues relevant to the effects of climate change on communities, including coastal inundation. Ongoing collaborative research projects relevant to the coastal inundation issue include “Promoting resilient shorelines in an era of rapid climate change” in the Hudson River NERR, New York; “Assessing coastal uplift & habitat changes in a glacially influenced estuary system” in the Kachemak Bay NERR, Alaska; “Planning for sea level rise: A pilot study to evaluate and improve the development and delivery of habitat vulnerability assessments and adaptive conservation designs to coastal decision-makers” at Guana Tolomato Matanzas NERR, Florida; “Building the capacity of coastal communities to address climate change risks through the use of role-play simulations” at four New England reserves, “Collaborative planning for climate change adaptation: A case study in the Great Bay NERR”, New Hampshire; “Integrating socio-ecological research and collaborative learning to promote marsh and community resilience” at the Chesapeake Bay, Maryland NERR,; and “Our Coast-Our Future: Planning for sea level rise and storm hazards in the San Francisco Bay area” at the San Francisco Bay NERR, California.

<sup>31</sup> See <http://nerrs.noaa.gov/ScienceCollaborative.aspx>

A broader NOAA Sentinel Site Program was initiated in 2012 to leverage coastal monitoring and data collection tools, sanctuaries, estuarine reserves, marine protected areas, and other assets located in coastal areas around the nation. These places and equipment serve many functions, such as protecting natural resources, measuring tides, and establishing accurate height measurements. The first task for NOAA's Sentinel Sites Program is to shed light on impacts of climate change, focusing on sea level change and coastal inundation. This effort will gather people from many backgrounds and disciplines—NOAA and other federal experts, state and local government decision makers, university researchers, and other people who have a stake in a particular region. The intent is to create a cooperative atmosphere that leads to the development of novel solutions to real-world local problems, such as how to protect a development from rising sea levels or how to best protect a sensitive shoreline habitat.

NOAA has sought to disseminate information on climate change and coasts to users through trainings and regional workshops. NOAA Sea Grant extension agents, NERRS staff, and National Marine Sanctuary staff regularly interact with the public and resource managers in coastal areas to communicate relevant science to users and to provide technical assistance in carrying out adaptation activities (C2ES 2012). NOAA also hosts workshops, webinars, roundtables, and other interactive events to help end users better understand what information the agency has to offer, and work directly with them to apply the information. An example is the training workshop “Planning for Climate Change”, which was developed by the NERRS Coastal Training Program. This workshop introduces local and state planners to climate change, as well as the planning processes and actions that can help their communities prepare for climate change impacts. Additionally, the course “Introducing Green Infrastructure for Coastal Resilience”<sup>32</sup> teaches green infrastructure concepts that support resilience and provides community networking to advance resilience efforts.

NOAA's Coastal Services Center, which is housed within NOAA's National Ocean Service, provides technology, information, and management strategies used by local, state, and national organizations to address complex coastal issues. The Center has offices and staff members in all six regions of the U.S. coastal zone (including the Gulf Coast, Southeast and Caribbean, Mid-Atlantic and Northeast, Great Lakes, West Coast, and Pacific Islands), and helps local and state governments address the challenges associated with flooding, hurricanes, sea level rise, and other coastal hazards by providing data and the technical expertise in how to use that data to make decisions. For example, in collaboration with the Nature Conservancy, the Coastal Services Center developed a report, titled “Marshes on the Move”, to help managers understand potential impacts of sea level rise on coastal wetlands (TNC and NOAA 2011). Another publication, called “Local Strategies for Addressing Climate Change” volumes one and two (NOAA 2009a, NOAA 2010b), contains articles about important coastal issues and profiles of innovative coastal programs. It includes information on creating a climate change preparedness team, identifying community vulnerabilities to climate change, and identifying, and selecting and implementing adaptation options. The report “What Will Adaptation Cost? An Economic Framework for Coastal Community Infrastructure” (Eastern Research Group, Inc. 2013) provides a four-step approach communities can use for a holistic assessment of costs and benefits of different adaptation approaches across a community, or to focus in on select infrastructure.

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<sup>32</sup> See <http://www.csc.noaa.gov/digitalcoast/training/green>



The Coastal Services Center developed Digital Coast<sup>33</sup>, which provides information for those working to address issues such as coastal conservation, hazards, land use, and climate change. The Digital Coast is founded on the need for geospatial data, but the premise of the site is that data alone are not enough; people need the associated tools, training, and information that turn data into information that can be implemented on the ground. Digital Coast aims to provide these resources in one easy-to-use package. Tools provided on Digital Coast include:

- *CanVis* – a visualization program used to illustrate potential impacts from coastal development or sea level rise
- *Coastal Inundation Toolkit* – provides context and guidance for connecting the resources in the Digital Coast to the needs of coastal managers
- *Coastal County Snapshots* – provides information that can help communities become more resilient to coastal hazards by turning complex data into easy-to-understand stories, complete with county-specific charts and graphs
- *Coastal Flood Exposure Mapper* – supports community discussions about coastal hazard vulnerabilities and assets with maps that show people, places, and natural resources exposed to coastal flooding. The current geography includes most of the Hurricane Sandy impact area (coastal counties of Delaware, New Jersey, Pennsylvania, and New York). Expansion plans are underway for the rest of the East Coast and Gulf of Mexico.
- *Habitat Priority Planner* – aids in making decisions about habitat conservation, restoration, and land use planning by providing a means of obtaining critical habitat analyses that are consistent, repeatable, and transparent
- *Roadmap for Adapting to Coastal Risk* – a participatory process for assessing a community's vulnerability to hazards and for incorporating relevant data and information about hazards and climate into ongoing local planning and decision-making
- *Sea Level Rise and Coastal Flooding Impacts Viewer* – enables visualization of potential impacts from sea level rise in coastal communities

The Coastal Services Center also hosts a number of climate change-related trainings. For example, the Center hosts a three-day training called Climate Adaptation for Coastal Communities<sup>34</sup>, which teaches participants about the latest climate science and fundamental concepts of adaptation planning while developing the necessary skills to proactively address impacts of climate change in coastal communities. Opportunities for local collaboration and next steps for adaptation planning and implementation are emphasized through discussion, participant activities, and incorporation of local speakers and examples. The coastal inundation mapping course is a popular GIS-based training that provides information on coastal inundation issues and teaches spatial techniques for mapping inundation, with a focus on sea level rise.

The NOAA Climate Adaptation Team was established in 2011 to coordinate all NOAA climate adaptation assets and efforts. The Climate Adaptation Team uses an integrated approach to facilitate

<sup>33</sup> See <http://www.csc.noaa.gov/digitalcoast/>

<sup>34</sup> See <http://www.csc.noaa.gov/training/climate-adaptation.html>

partnerships and communication about NOAA adaptation programs and efforts. Similarly, the Climate Program Office Communication and Education team supports both the Climate Program Office and the NOAA Climate Mission. The Communication and Education team hosts and participates in dialogues and workshops to build better relationships with different publics, and to help them find and use data and information in climate-related decisions; manages and maintains the NOAA Climate.gov Portal (in a partnership) to provide easy, online access to climate data and information products; partners with other agencies, organizations, and businesses who have mutual interests in serving priority publics; and conducts initiatives within NOAA and among partners to increase capacity for communication, education, and engagement.

## U.S. Department of Defense

### ***Background and Guiding Documents***

The U.S. Department of Defense's (DoD) mission is to train the military forces needed to deter war, and to test the equipment they need to protect national security. There are three Military Departments within the DoD, including the Department of the Army, Department of the Navy, and Department of the Air Force. The DoD is one of the largest land management agencies in the U.S., managing over 10 million hectares of land (*Figure 1*) on over 425 military installations.

The DoD's 2010 Quadrennial Defense Review Report (QDR; DoD 2010) recognized the need for climate change information to be incorporated into national security efforts. The QDR identified two main ways that climate change will impact the DoD, including shaping the operating environment, roles, and missions that the DoD undertakes, and affecting DoD facilities and military capabilities. Because the QDR translates plans from the National Defense Strategy into actionable policies and procedures, it was an important step in integrating vulnerability and adaptation options into DoD operations.

In 2011, the DoD issued an Instruction (4715.03; DoD 2011) pertaining to its Natural Resources Conservation Program, requiring DoD to address climate change in Integrated Natural Resources Management Plans, to use best available science to assess potential climate change impacts, and to use an adaptive strategy to address those impacts. This Instruction was followed by a DoD Manual in 2013, the Integrated Natural Resources Management Plan Implementation Manual (DoDM 4715.03; DoD 2013b), which provided procedures to prepare, review, update, and implement Integrated Natural Resources Management Plans in accordance with Instruction 4715.03.

In early 2013, as a part of its Fiscal Year 2012 Strategic Sustainability Performance Plan, the DoD released a Climate Change Adaptation Roadmap (CCAR; DoD 2013a). The CCAR was developed in response to Executive Order 13514 (Obama 2009), which required Federal agencies to address climate change risks and vulnerabilities in short- and long-term planning. The CCAR expanded on the QDR by providing DoD with broad climate change adaptation goals to: (1) develop a coordinating committee that will address climate change; (2) use the best available science to inform decisions; (3) integrate climate change information into current projects; and (4) encourage partnerships with other agencies (DoD 2013a). The Climate Change Action Working Group was established in response to the first CCAR goal and serves to facilitate collaboration among the DoD and Military Departments.

## Partnerships

The DoD's primary responsibility is national security, making international and intra-national collaborations an important aspect of DoD operations. One of the CCAR goals is to partner with Federal and foreign agencies on climate change impacts and adaptation. The DoD works with the State Department and foreign defense agencies and militaries to collaborate on climate change issues that affect national security. For example, the Defense Environmental International Cooperation Program facilitates dialogue with foreign defense force counterparts on environmental issues that affect infrastructure, training space, or operations; increasing resilience to climate change is thus a priority (C2ES 2012). Internally, the DoD recognizes the need to work with individual Federal agencies as well as in cross-agency forums. The DoD participates in climate change-related working groups, including the Interagency Forum on Climate Change Impacts and Adaptations, the Climate Change Natural Resources Working Group, and various Council on Environmental Quality climate change working groups. The DoD also contributes to the National Climate Assessment.

## Education Efforts

The DoD has hosted and currently participates in various climate change workshops and meetings. DoD-hosted workshops have focused on educating personnel across the DoD branches on climate change science, vulnerability, and adaptation; and has presented tools and strategies to help assess and implement climate change information into planning and operations. The DoD Natural Resources Conservation Program hosted a workshop on climate change tools for adapting management strategies at the 2010 National Military Fish and Wildlife Association Annual Meeting<sup>35</sup>. Another example of a DoD-hosted climate change workshop was the Climate Change Vulnerability Assessment Guidance for Conserving DoD Ecological Resources workshop<sup>36</sup>.

## Vulnerability Assessments

Assessing the DoD's vulnerability to climate change is a large component of the CCAR framework, because of its importance in minimizing risks and threats to national security. The CCAR includes a detailed table highlighting specific climate change effects, potential impacts, and potential DoD vulnerabilities. New guidelines have been adopted that require the Military Services to consider climate change, including current and future climate, vulnerability of structures and resources, and adaptation options, in installation Integrated Natural Resource Management Plans.

The DoD Strategic Environmental Research and Development Program (SERDP), a joint venture between the DoD, the Department of Energy, and the Environmental Protection Agency (EPA), provides support for research on natural resource issues on DoD lands. The DoD Environmental Security Technology Certification Program (ESTCP) supports demonstration and validation of environmental technology, and the Legacy Resource Management Program supports monitoring and management of natural resources. Projects funded under these programs have included climate change vulnerability assessments of endangered or threatened species on DoD lands, and risks to coastal areas (Bagne and Finch 2010a; Bagne and Finch 2010b; Donnelly 2010; Wiens et al. 2011; Linkov et al. 2013). SERDP also has invested in projects that develop models and tools to assess climate-related vulnerabilities of DoD infrastructure

<sup>35</sup> Presentations available at: <http://www.dodworkshops.org/files/ClimateChange/CC-Presentations.html>

<sup>36</sup> See <http://www.denix.osd.mil/nr/upload/10-460-WorkshopTraining-Materials.pdf>

## Box 2. Climate Change and the U.S. Navy

The Navy Task Force Climate Change (TFCC) was created in 2009 to research and address the effects of climate change on naval operations. One of the first concerns the TFCC addressed was changing conditions in the Arctic, which prompted release of the U.S. Navy Arctic Roadmap (NAVY 2009). The Arctic Roadmap acknowledges climate change and its extreme effects in the Arctic. Strategies, policies, operations, communication, and other security issues in the Arctic are discussed in the Roadmap, with specific goals in mind for each of these objectives. The Roadmap also introduces an action plan split into three phases for the Navy to follow from 2010 to 2014.

Following the Arctic Roadmap publication, the TFCC released its Climate Change Roadmap in 2010 (NAVY 2010). The Climate Change Roadmap is meant to expand on the Arctic Roadmap, addressing climate change in areas other than the Arctic. Similar to the Arctic Roadmap, the Climate Change Roadmap summarizes actions focused on strategies, policies, and plans that the Navy will implement to address climate change. One of the core objectives for these actions is to ensure that the Navy is capable of responding to climate change, while maintaining naval security.

Beyond increasing the capacity of the Navy to incorporate climate change into its missions, the Climate Change Roadmap outlines several more specific goals. Sea level rise is an important issue for naval operations, and the Climate Change Roadmap identifies the effects it will have on naval operations. The Navy also recognizes the importance of partnerships, both within the Federal government and with other nations and foreign militaries. Strengthening partnerships will allow for a sharing of resources and information related to climate change.

The Climate Change Roadmap contains a framework for action that is divided into three phases. One objective for the first phase in fiscal year 2010 was to introduce climate change impacts education into Naval War College courses. The second phase objectives for fiscal year 2011-2012 included incorporating climate change into strategic guidance, fleet training, and planning, creating new partnerships to further the Navy's ability to address climate change, and developing recommendations for addressing climate change requirements. The final phase, to be completed in 2013-2014, will include completing budget actions set aside for climate change and beginning partnership activities to further the Navy's ability to address climate change. The Climate Change Roadmap frames the Navy's climate change objectives into actionable items to be completed by 2014, when the Roadmap will be revised to incorporate new findings and guidelines.

*The USS Hampton, an attack submarine, surfaces at the North Pole during an operational exercise beneath the polar ice cap. Melting ice in the Arctic may lead to increased resource development, research, and tourism, and could reshape the global transportation system. These developments offer opportunities for growth, but also are potential sources of competition and conflict for access and natural resources. Reducing the uncertainty in these projections and enabling the Navy to make better-informed investment and policy decisions in the Arctic were key objectives of the Navy Arctic Roadmap. U.S. Navy photo by Chief Journalist Kevin Elliott.*





(these models and tools will be validated under ESTCP). Active projects include those that examine the effects of climate change on Pacific Island and Southeastern DoD installations.

### **Adaptation Efforts**

The CCAR is the guiding document for DoD adaptation efforts. There are several identified areas of concern in the CCAR that are already being evaluated and addressed by the DoD, including coastal zones, the Arctic (*Box 2*), Alaska, deserts, and the Pacific Islands. For example, the DoD has been researching permafrost change in Alaska, and its effects on infrastructure, lands, and training procedures. Ongoing projects and future research will continue to increase the DoD's knowledge of climate change impacts and vulnerabilities, which will help integrate effective adaptation measures into all aspects of DoD operations.

## **U.S. Army Corps of Engineers**

### **Background and Guiding Documents**

The U.S. Army Corps of Engineers (USACE) is an Army command responsible for delivering public and military engineering services to strengthen U.S. security and reduce risks from disasters. The USACE Civil Works Directorate provides engineering expertise to the U.S. by carrying out missions in the areas of water resource development, including flood risk management, navigation, recreation, hydropower generation, environmental restoration, water resource-related infrastructure management, and emergency preparation and response.

Climate change will affect water resources projects and infrastructure operated by the USACE in many ways (GAO 2013a). In recognition of these impacts, a policy statement issued in 2011 (USACE 2011c) called for incorporating climate change adaptation in all facets of USACE planning, priority setting, decision making, and operations. The policy established the Climate Change Adaptation Steering Committee to coordinate agency adaptation planning. Building on the policy statement, and in response to Executive Order 13514 (Obama 2009) and 2011 CEQ instructions (CEQ 2011), the USACE produced a climate change adaptation report in 2011 (USACE 2011b). The report included information on USACE activities concerned with climate change adaptation, including its high-level vulnerability analysis, descriptions of additional climate adaptation activities and planning elements, current adaptation progress, and future priorities. The adaptation plan was updated and released for public comment in 2013 (USACE, draft). The updated plan is also included as an appendix in the 2012 Sustainability Plan (USACE 2012).

Prior to the 2011 policy statement and adaptation report, the USACE had recognized the potential for sea level change impacts on its civil works operations and projects. The USACE has had policy on sea level change since 1986 and in 2009 released the updated Engineer Circular "Water resource policies and authorities incorporating sea-level change considerations in civil works" (USACE 2009), which set forth a multi-scenario approach for future planning and included guidance on incorporating ocean warming and ice melt in planning. Guidelines were updated in 2011 with another Engineer Circular (USACE 2011a), and the USACE continues to develop guidance on implementing climate change into sea level planning (*Box 3*). In addition to developing guidance for management in coastal areas, the USACE is also currently developing guidance to planning and operations staff for managing inland water resources under a changing climate (GAO 2013a).



## Partnerships

The USACE works in collaboration with many Federal agencies, nonprofits, and state and local entities, such as public utilities. Many of these other agencies and organizations are associated with water resources management, and the USACE endeavors to collaborate and partner on common issues (GAO 2013a). For example, the USACE worked with the Federal Emergency Management Agency (FEMA), NOAA, USGCRP, CEQ, and the New York City Panel on Climate Change to combine sea level change knowledge and information into user-friendly tools<sup>37</sup>.

The Climate Change and Water Working Group (CCAWWG)<sup>38</sup> is a partnership of the USACE, Bureau of Reclamation, NOAA, and USGS that was established in 2007 to facilitate collaboration on climate-related water management issues. The objectives of CCAWWG are to bring together the water management community, identify knowledge gaps in adaptive capacity to climate change, conduct research to close identified information gaps, and implement water resource planning training (CCAWWG 2012). Since its establishment, CCAWWG has added the EPA, FEMA, NASA, and USDA to its list of partners (GAO 2013a). The collaborative work of the group provides an interface for networking and contact between agencies. CCAWWG partners with other programs to meet its objectives, and recently created training material with the University Corporation for Atmospheric Research (UCAR) Cooperative Program for Operational Meteorology, Education and Training (COMET).

The USACE also participates on the Interagency Forum on Climate Change Impacts and Adaptations. As a part of this forum, the USACE and NASA cohost informal meetings on climate change impacts and adaptation that are open to other agencies and interested individuals.

## Education Efforts

Many USACE educational efforts are formalized through CCAWWG. With the UCAR COMET program, CCAWWG is creating a pilot series that will include self-paced online courses and live workshops to help water resource managers assess and prepare for the potential effects of climate change. The first product of this educational collaboration is “Preparing Hydro-climate Inputs for Climate Change in Water Resource Planning”.<sup>39</sup> Additional courses on sedimentation and water resource ecology are being developed.

## Vulnerability Assessments

The USACE 2011 Climate Change Adaptation Plan and Report included guiding questions for vulnerability assessments (USACE 2011b). These questions are meant to guide and inform USACE offices on climate change effects information and internal USACE vulnerability resources, and suggest other agencies developing similar assessments. The USACE is currently developing tools for use in USACE districts to screen plans for coastal vulnerabilities to sea level change (see *Box 3* for more detail). The USACE also assesses vulnerability for different management sectors, such as flooding, recreation, and hydropower generation. An example of this type of vulnerability assessment is described in “Social Vulnerability Analysis for Corps Planning” (Dunning and Durden 2011). This report provides methods to identify vulnerable

<sup>37</sup> See <http://www.globalchange.gov/browse/sea-level-rise-tool-sandy-recovery>

<sup>38</sup> See <http://ccawwg.us>

<sup>39</sup> See <http://www.corpsclimate.us/ccaceslcurves.cfm>

### Box 3. Addressing Sea Level Change in the U.S. Army Corps of Engineers

The USACE has a long history of policy and guidance regarding sea level change. In March of 1986, the USACE issued a guidance letter to introduce the use of historical tide records to project future sea level. In 2000, the need to account for the possibility of larger increases in sea level prompted an update of the 1986 guidance letter. USACE "Planning Guidance Notebook" had a specific section on sea level rise that called for a sensitivity assessment for sea level change requiring historical sea level records to be extrapolated based on the potential for increases in sea level caused by ocean warming and ice melt (USACE 2000).

The "Planning Guidance Notebook" sea level section was updated again in 2009 by Engineer Circular 1165-2-211. This new policy expanded on previous policy by requiring that three scenarios of sea level change be included in planning new civil works: a low-level scenario, which was the extrapolation of NOAA tide gauge records, an intermediate scenario that included potential volume change due to warming, and a high scenario that considered possible increases in ocean temperature and ice melt (USACE 2009). In 2011, the sea level guidance was updated again, including a tool to help calculate sea level change based on the three-scenario approach identified in the 2009 guidance<sup>40</sup>.

USACE policy and guidance for sea level change is currently being updated (USACE 2013). The guidance will be published as an Engineer Technical Letter, "Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaptation." The current 2011 policy has prompted development of a modified sea level change tool, which will enable calculation of future sea level change using non-NOAA tide gauges.

To complement the efforts in sea level change guidance, the USACE is developing a tool to support climate change vulnerability assessments in coastal areas. The tool will help USACE districts assess the vulnerability of coastlines to sea level change and will be based on the sea level scenarios in the 2011 guidelines and the developing non-NOAA tide gauge tool. A more detailed vulnerability assessment based on monthly extreme water levels and three sea level change scenarios is also being developed for USACE planning use. These tools are set to be released for agency-wide use in 2014.

*The U.S. Army Corps of Engineers works to repair a levee breach caused by Hurricane Sandy in Montoloking, New Jersey. Photo courtesy of the U.S. Army Corps of Engineers.*



<sup>40</sup> See <http://www.corpsclimate.us/ccaceslcurves.cfm>

populations at high risk for flooding effects and to incorporate this social information into planning processes. The USACE plans to conduct other inland vulnerability assessments in the future and is currently developing and testing a methodology for watershed-scale vulnerability assessments of its inland missions, operations, programs, and projects (GAO 2013a). The watershed-scale vulnerability assessments are intended to assist initial determinations on where adaptation strategies are needed and prioritize efforts accordingly (GAO 2013a). The USACE plans to eventually combine the coastal and inland assessments into a unified methodology.

The USACE is collaborating with NOAA to develop a Federal web portal to provide information on water resources and climate change data applications and tools for assessing the vulnerability of water programs and facilities to climate change (GAO 2013a). The “Federal Support Toolbox” website is now available online<sup>41</sup>.

### **Adaptation Efforts**

The USACE seeks to incorporate climate change adaptation into its projects, planning, and operations, guided by an overarching policy statement on adaptation (USACE 2011c). An initial adaptation effort involved development of the report, “Climate Change and Resource Management: A Federal Perspective” (Brekke et al. 2009). The report was produced through the USGS by CCAWWG and includes chapters on adaptation and needed research. In an effort to understand the needs of water resource professionals, CCAWWG produced two other reports on climate change planning. The first report guides water managers in incorporating climate change into long-term planning (Brekke et al. 2011), and the second report focuses on how climate change is incorporated into decisions for shorter-term projects (Raff et al. 2013). These reports do not describe adaptation options, but rather set out informational needs and gaps in knowledge, and describe available tools.

The USACE is currently developing guidance for considering adaptation in all agency activities, and pilot studies are being conducted to support the development of adaptation guidance and a portfolio of adaptation approaches (GAO 2013a). Fifteen pilot studies will be conducted nationwide to test different methods and frameworks for adapting to climate change; five of these studies are complete, and ten others are ongoing. The 15 pilots are led by 13 different USACE districts and address project planning, engineering, operations, and maintenance, and a variety of different infrastructure types, such as flood risk reduction projects, reservoirs, and canals. The pilot projects are expected to provide a body of knowledge and methods that will serve as the foundation for USACE guidance and future adaptation efforts (GAO 2013a).

Sea level change is an extensive focus of USACE work (see *Box 3*). The scenarios laid out in USACE sea level guidance documents are designed to project future changes in sea level. Web-based sea level change calculators provide information on the likely impacts of climate change on coastal areas. These tools allow for adaptation options to be developed and built into project plans.

The Responses to Climate Change Program was established in the USACE with the goal of developing and implementing policies, methods and approaches for climate change adaptation in USACE projects, systems, and programs. Additional support on climate change comes through the USACE Actions for Change program. The Responses to Climate Change Program has helped to support CCAWWG

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<sup>41</sup> See <http://www.watertoolbox.us/>

workshops, guidance on sea level change, and several climate change adaptation pilot studies at the project scale (USACE 2011b). Additional work has been planned to build on the foundation of the Responses to Climate Change Program and increase the sustainability and resilience of USACE built infrastructure and the natural environment through a framework and program of actions that will minimize the impacts and costs of global change. Initial work has focused on updating drought contingency plans, evaluating USACE projects with respect to sea level change, developing strategies to address changes in coastal zones, updating reservoir sedimentation studies according to strategic and priority needs, and integrating adaptation and mitigation (USACE 2011b).

## U.S. Department of the Interior

### *Background and Guiding Documents*

The DOI is responsible for the managing and conserving over 200 million hectares of Federal land and other natural resources, and administering programs related to native peoples. The DOI has issued Secretarial Orders, manuals, and plans guiding climate change response within DOI agencies. The DOI mission includes protecting and managing U.S. natural resources and providing scientific and other information about those resources. Climate change is likely to inhibit the ability of DOI to protect natural resources in the future.

Secretarial Order 3289, signed in 2009 and amended in 2010, states that potential climate change effects necessitate changes in how the DOI manages natural resources and requires DOI agencies to incorporate climate change in planning, prioritization, and decision-making (DOI 2009a). Secretarial Order 3289 established an Energy and Climate Change Council to develop a coordinated strategy for climate change response across DOI agencies and bureaus. The Order also established two main initiatives to address the effects of climate change on U.S. natural and cultural resources, including CSCs and LCCs (described in detail below).

Other guiding documents for DOI climate change adaptation activities include Secretarial Order 3285 (DOI 2009b), which established an Energy and Climate Change Task Force that responds to the Energy and Climate Change Council. In 2011, the Task Force created a Climate Change Working Group to coordinate climate change adaptation efforts across DOI. A 2012 manual (manual 523; DOI 2012), developed by the DOI Office of Policy Analysis, established Departmental policy, and, “provides guidance to bureaus and offices for addressing climate change impacts upon the Department’s mission, programs, operations, and personnel.” Directives in the manual include using the best available science to determine potential climate change effects, develop responses, and inform decision making; and incorporate climate change adaptation strategies into policies, planning, programs, and operations. Building on Secretarial Order 3289 and Manual 523, the DOI developed a Climate Change Adaptation Plan for Fiscal Year 2013 (DOI 2013a), giving an overview of DOI vulnerabilities to climate change and setting forth guiding principles for climate change adaptation in the DOI. An Interim Climate Change Adaptation Plan was released in 2014 (DOI 2014), and similar to the 2013 plan, the 2014 plan gives an overview of DOI climate change vulnerabilities and guiding principles for climate change adaptation. The 2014 plan also reviews the status of adaptation in DOI agencies. Although focused mostly on climate change mitigation,



Secretarial Order 3330 (DOI 2013b), issued in October 2013, calls for the use of a landscape-scale approach to identify and facilitate investments in conservation priorities in a region.

The following sections describe the LCC Network and CSC initiative, and how agencies within the DOI are responding to departmental directives through vulnerability assessments, and education and adaptation efforts.

### **Landscape Conservation Cooperatives Network**

LCCs are a network of partnerships that provide the scientific and technical expertise to support conservation planning at broad spatial scales while promoting collaboration across agencies and partners. The LCC network brings together diverse partners (states, tribes, Federal agencies, non-governmental organizations, universities, and others) in broad, collaborative forums to work together on broad conservation issues including climate change (see *Box 4* for examples of climate-focused LCC work).

There are 22 LCCs as part of this network, designated by ecosystem/ecoregion (*Figure 4*). Each LCC is self-directed and independent, with the agenda and goals determined by a steering committee. The steering committee consists of 15-30 conservation leaders. Federal and state agencies, non-government and non-profit organizations, and tribes and tribal groups are represented in the steering committees. Many, but not all, LCC steering committees identify climate change adaptation work as a conservation priority.

The LCCs have two major guiding roles:

- Coordinating and developing applied science for land manager use; and
- Bringing together partners to develop landscape-level visions and ensure robustness of conservation planning approaches.

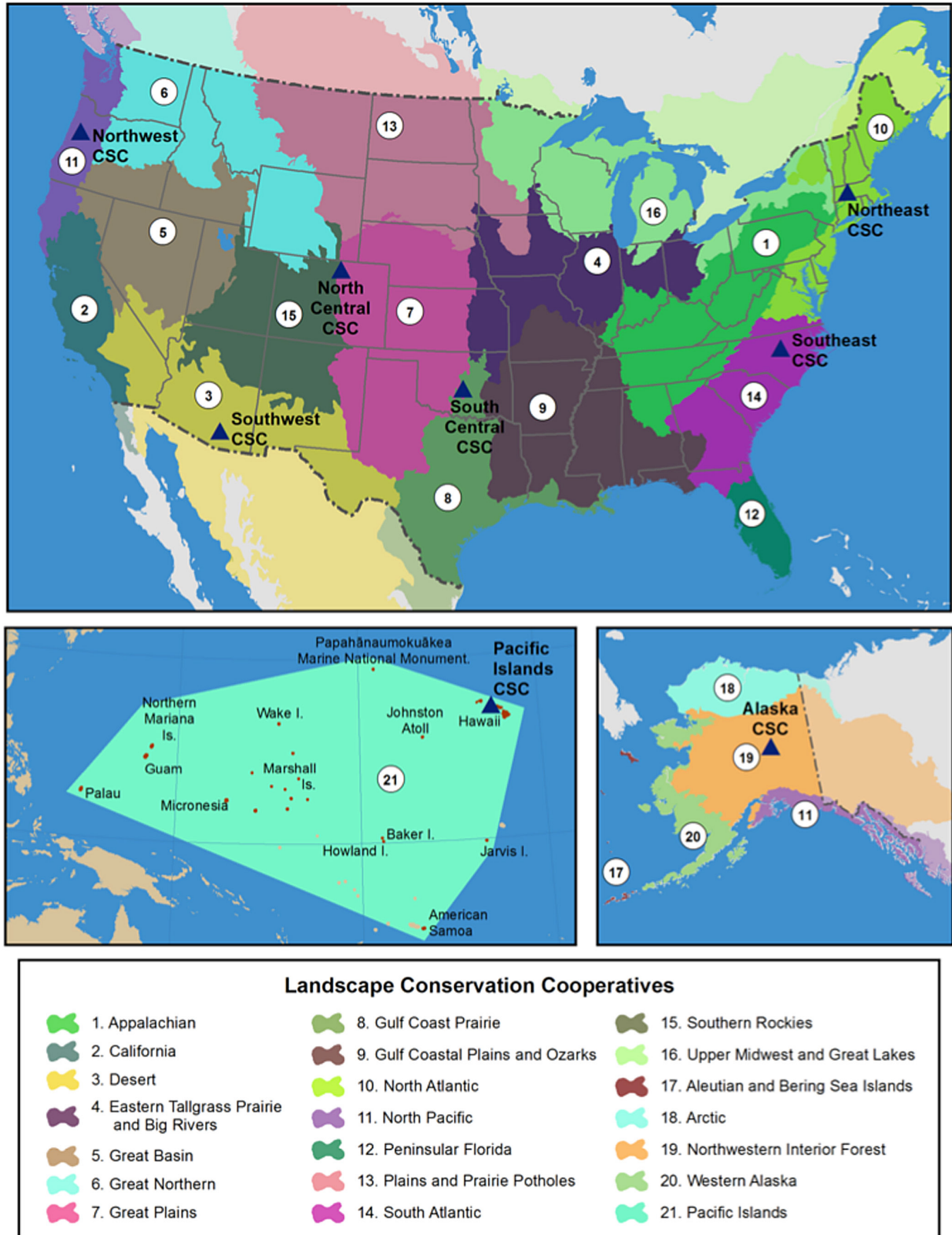
LCCs provide a forum for existing partnerships and programs to develop common goals for landscape change and adaptation. These partnerships combine science knowledge, perspectives, and even financial resources, and are intended to allow partners to reap the benefits of the different agency resources. The goal is for LCC partners to leverage resources efficiently and effectively, leading to improved collective works. Because LCCs are a vehicle for identifying work and a forum for ideas to be realized, the LCCs themselves do not generally prepare vulnerability assessments, educational resources, or adaptation guides. Instead, LCCs mainly work through contracts with other partners and interagency agreements. Research and model development are done through partnerships with other organizations (see *Box 3* and <http://lccnetwork.org/OurWork/Projects> for examples).

An integral part of the LCCs is collaboration with the Climate Science Centers (CSC – described in detail below). As a part of DOI's response to climate change, the CSCs provide scientific information relevant to land management, and the LCCs advanced landscape planning using the CSC science information. LCCs identify research needs that the CSCs can address, and CSCs provide the LCCs with direction as to what planning approaches are suitable.

LCCs connect partners through working groups, symposia, workshops, and email mailing lists. Different planning scenarios, modeling approaches, and vulnerability assessment plans exist among the different



Figure 4. Locations of U.S. Department of the Interior Landscape Conservation Cooperatives and Climate Science Centers (CSCs).



agencies, creating some inconsistency among LCC members. At a national scale, structures are being developed to improve communication within and among LCCs, and a National Council of LCCs will address collaboration among Federal agencies.

### Climate Science Centers

CSCs are eight regional centers that provide climate change science and adaptation information to users through both directed funding and competitive proposal processes. CSCs are located in the north central, northeast, northwest, south central, southeast, and southwest United States, and in Alaska and the U.S. Pacific Islands (*Figure 4*). All CSCs respond to the USGS National Climate Change and Wildlife Science Center, which coordinates activities among CSCs. CSCs are relatively new, with three centers established in 2010 and the remaining five established in 2011 and 2012. Seven of the eight CSCs currently have permanent directors, and the first round of CSC funding in response to a request for proposals was distributed in September 2012. In 2013, the Secretary of the Interior established a Federal advisory committee to provide guidance on operations of the National Climate Change and Wildlife Science Center and the eight CSCs.

All CSCs involve cooperative endeavors between the DOI and universities, funding scientists from universities, USGS, other Federal agencies, tribes, and non-governmental organizations to develop scientific

#### Box 4. Climate Change Adaptation in Landscape Conservation Cooperatives

Many LCCs focus on climate-related issues. For example, the Arctic LCC, located at the northern most part of Alaska and Canada, works to have a better understanding of the effects of climate change on its landscape in order to inform decisions and adaptation options for future conditions. Several of the Arctic LCC-funded projects emphasize climate change vulnerability, impacts, and projections for important Arctic features like wetlands, glaciers, aquatic resources, and bird habitat (e.g., Liebezeit et al. 2012). Another project developed an Integrated Ecosystem Model for Alaska (Rupp et al. 2012). This integrated model incorporates several pre-existing models for vegetation succession, disturbances, hydrology, and permafrost dynamics. The goals of this project were to utilize one model to forecast future habitat and ecological conditions under different climate scenarios, to improve the understanding of Arctic ecosystem response to climate change, and to inform monitoring and adaptation activities.

The Pacific Islands LCC, called the Pacific Islands Climate Change Cooperative (PICCC), also focuses attention on climate change research. The PICCC includes the islands of Hawaii, Guam, American Samoa, and other smaller Pacific islands. Projects funded by the PICCC include climate modeling, climate downscaling, climate and ecosystem modeling, sea level rise, and coral reef management. The PICCC also supports conservation through invasive species research, vulnerability assessments for important species, creating management tools, and developing adaptation strategies for ecological and cultural resources important to Pacific Island heritage.

Many other LCCs are supporting climate change vulnerability assessments and adaptation efforts. For example, the Appalachian LCC is compiling climate change vulnerability assessments and other relevant information on vulnerable species and habitats to discern the methodologies and criteria used in the assessments, and recommend the most efficient, effective, and appropriate methods for conservation and adaptation planning in the region. The Appalachian LCC is also funding the development of a web-based tool to identify priority areas for riparian restoration in the context of predicted climate change at the appropriate scale needed by practitioners. The North Atlantic LCC is using projected effects of climate change, urban growth, and other stressors with population-habitat models to assess ecological processes, future capacity of habitats to support populations under different scenarios, and adjust population objectives if needed based on current and likely future habitat capacity. The Upper Midwest and Great Lakes LCC is working with the University of Wisconsin to develop downscaled climate data that address climate change challenges at a local scale.

information, tools, and techniques for resource managers to adapt to climate change. The CSCs were also created to gauge regional climate science needs, such as potential effects of rising sea level in the Southeast, glacial melt in Alaska, and wildfire in the West. Each CSC has a stakeholder advisory committee, with representatives from Federal and state agencies and tribes, to identify research priorities and coordinate climate science and adaptation efforts. A science agenda for each CSC establishes areas of research emphasis and forms the basis for funding calls. Well-established CSCs (i.e., the CSCs established in 2010) also have strategic plans that provide a blueprint for short-term operations.

Part of the mission of the CSCs is to deliver climate change science and applied tools that directly reflect expressed constituent needs in each region. The CSC program is working to develop multi-year science programs that focus on key priorities and integrate work across CSCs. Delivering science that is understandable to users and policy relevant, but not policy prescriptive, is a key objective of the CSC network.

## Bureau of Indian Affairs

### *Background and Guiding Documents*

The Bureau of Indian Affairs (BIA) is the lead agency for most tribal programs and has a fiduciary responsibility to the 566 recognized American Indian Tribes that manage over 22 million hectares of land (*Figure 1*). The mission of the BIA includes enhancing the quality of life and economic opportunity of American Indians, Indian tribes, and Alaska Natives. Climate change presents a threat to American Indian quality of life and economic opportunity. The BIA recognizes this threat and is in the process of developing an internal adaptation policy report to guide climate change efforts.

### **Partnerships**

The BIA works with other agencies with tribal program responsibilities to provide services and deliver on-the-ground applications. For example, EPA, USGS, NOAA, and state and local governments all have tribal obligations; some of these obligations relate to climate change. Improved coordination of interagency tribal support of adaptation can build and sustain tribal capacity to plan for and address impacts.

### **Education Efforts**

A network of formal and informal working groups in the BIA and other agencies is working with tribes in climate change planning. These groups coordinate climate change efforts and provide climate change science and training. An internal communication network within the BIA has thus far focused efforts on tribes that are interested and proactive on the issue of climate change to help them incorporate climate change into planning.

### **Adaptation Efforts**

Each of the 566 tribes is sovereign, and the BIA cannot require tribes to do adaptation planning without adequate funding. In Fiscal Years 2011 and 2013, BIA was funded to provide competitive grants addressing adaptation planning. This funding was also used for tribes to participate in local LCCs and CSCs and attend conferences, meetings, and trainings related to climate change. In Fiscal Year 2011, 14 grants for \$470,000 were awarded, and in Fiscal Year 2013, \$600,000 was offered to tribes under the Cooperative Landscape Conservation Program. Leveraging of partnerships and funding was encouraged through the grant process.

The BIA participated in the National Fish, Wildlife, and Plants Climate Adaptation Strategy effort (NF-WPCAP 2012); there was a representative from the BIA, tribes, or tribal organizations on each steering committee, working group, and writing committee for the plan.

To increase involvement in climate change adaptation work, the BIA recently funded a national climate change coordinator position. Short-term goals of the BIA climate change efforts include enabling tribes to complete their own climate change adaptation planning through grants and training, and ensuring that all BIA projects and future plans incorporate climate change considerations.

## Bureau of Land Management

### **Background and Guiding Documents**

The Bureau of Land Management (BLM) administers over 100 million surface hectares and 283 million subsurface hectares of public lands in the United States. The BLM mission is to sustain the health, diversity and productivity of public lands for the use of present and future generations.

BLM is developing a landscape approach to managing public lands with increased recognition that partnerships and large-landscape management are needed to address complexities that transcend traditional management boundaries. In response to DOI secretarial order 3289 (DOI 2009), the BLM is developing a climate change adaptation strategy that builds on the landscape approach. This strategy will address the November 2013 Executive Order that calls for close cooperation and coordinated planning among agencies, and Secretarial Order 3330 (DOI 2013b), which calls for a landscape-scale approach to identify and facilitate investments in regional conservation priorities.

### **Partnerships and Education Efforts**

The BLM partners with, and in some cases provides funding to, state and Federal agencies and a variety of universities to conduct assessments, climate-related research and implement projects. The BLM works with the USGS, CSCs, LCCs and other Federal agencies such as the Forest Service to address climate-related research needs. The BLM also works with partners to identify shared objectives, priorities and projects. Climate-related assessments in the BLM may be increasingly integrated with that of the DOI network of LCCs (see DOI section above).

To increase employee education on climate change, some BLM employees are participating in climate change training programs offered at the U.S. Fish and Wildlife Service National Conservation Training Center. The BLM also conducts and participates in climate change focused conferences, webinars, and scenario planning efforts.

### **Vulnerability Assessments**

The BLM is conducting 15 Rapid Ecoregional Assessments (REAs) within ecoregions where BLM has surface or sub-surface responsibilities (*Figure 5*). The REAs cover all lands within the ecoregion. Recognizing the value of existing geospatial data layers and models, the need to assess adequacy of existing data to address management questions in a relatively rapid process, these assessments compile existing information relevant to resource issues within each ecoregion. Teams of resource specialists, including representatives from partner agencies, are convened to develop key management questions for each ecoregion. These



questions address conservation elements of concern (e.g., greater sage-grouse [*Centrocercus urophasianus*]) and regional-scale change agents, including climate change, invasive species, wildfire, urban development, and energy production for all lands within each ecoregion. Contractors then gather information and develop models that can help address priority conservation issues.

Key REA results are presented in final reports, with all maps and data available to partners and the public for use and can be accessed through the BLM REA data portal at [www.blm.gov/wo/st/en/prog/more/Landscape\\_Approach/reas/datadisclaimer.html](http://www.blm.gov/wo/st/en/prog/more/Landscape_Approach/reas/datadisclaimer.html). In 2013 and 2014, BLM publicly released the Colorado Plateau (Bryce et al. 2012), Sonoran Desert (Strittholt et al. 2012), Central Basin and Range (Comer et al. 2013a), Mojave Basin and Range (Comer et al. 2013b), and Seward Peninsula-Nulato Hills-Kotzebue Lowlands (Harkness et al. 2012) REA reports. Public release of the Northwestern Plains (Ojima et al. 2012a), Middle Rockies (Ojima et al. 2012b), and Northern Great Basin (SAIC 2013) REA reports is

Figure 5. Locations of Bureau of Land Management Rapid Ecoregional Assessments.





expected in Fiscal Year 2014. In 2015, the public release of the following REA reports is expected: Wyoming Basins, Northern Basin and Range/Snake River Plain, Yukon/Kuskokwim, Madrean Archipelago, Southern Great Plains, Chihuahuan Desert, and North Slope. Public release of the Central Yukon/Ray Mountain REA report is expected in Fiscal Year 2016. Combined, these assessments cover over 760 million acres of public and private lands.

### **Adaptation Efforts**

The BLM began developing a comprehensive climate change adaptation strategy in 2013. The strategy builds on the landscape approach to managing public lands that has science and geospatial services as underpinnings. Data and information from regional assessments of existing and projected resource conditions (REAs, described above) and other large-scale assessments will be used to develop regional strategies to establish development, restoration and conservation priorities. Land use plans and plan amendments, cumulative impact analyses, and use authorizations will reflect these management priorities. On-the-ground projects will implement strategies in the field, and monitoring will be conducted to assess trends and adapt management practices to changing conditions. The BLM will build on current adaptation efforts, including greater sage-grouse planning, regional offsite mitigation strategies, and the Assessment, Inventory, and Monitoring Strategy (Toevs et al. 2011).

## **Bureau of Reclamation**

### ***Background and Guiding Documents***

The U.S. Bureau of Reclamation (Reclamation hereafter) oversees water resource management in the western United States, including operation of water diversion, delivery, and storage projects for irrigation, public water supply, and hydroelectric power generation. Reclamation's mission is to help meet the increasing water demands of the western United States while protecting the environment and the public's investment in infrastructure.

Legislatively mandated in the Omnibus Public Land Management Act of 2009 (2009), the SECURE Water Act recognizes the importance of water supplies in the United States and the need to consider the impacts of climate change in water resource planning. Section 9503 of the SECURE Water Act identifies the "Reclamation Climate Change and Water Program" as Reclamation's starting point for addressing climate change. The program objectives are to coordinate with other Federal agencies to assess the effects of climate change on water resources and to develop mitigation, adaptation, and monitoring strategies to address the identified issues. Section 9503(c) of the SECURE Water Act requires Reclamation to report findings to Congress every five years starting in 2011, prompting the 2011 report, "SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water" (Reclamation 2011). This report provides an overview of projected climate changes relevant to water resources in the western U.S., information on historical and future climate for major river basins (e.g., Colorado and Columbia), uncertainties in hydrologic projections, activities undertaken in response to the SECURE Water Act, and current adaptation actions.

In 2010, DOI Secretarial Order 3297 established the WaterSMART Program (DOI 2010), designed to promote sustainability of the U.S. water supply through efficiency and conservation. WaterSMART serves as a vehicle for Reclamation to respond to SECURE Water Act mandates. The WaterSMART

Program includes cost-share grants for conservation, water and energy management improvement projects, basin-wide efforts to evaluate and address the impacts of climate change, Title XVI Water Reclamation and Reuse projects, establishment and expansion of collaborative watershed groups, and smaller-scale water conservation activities through the Water Conservation Field Services Program. Together, these programs form an important part of Reclamation's implementation of the SECURE Water Act and the Cooperative Watershed Management Act (Subtitle A of Title IX), and Title XVI of P.L. 102-575.

### **Partnerships**

As primary water management agency for the DOI, Reclamation partners with other Federal, state, and local agencies, tribes, and nonprofit organizations to advance water research and integration of climate change in water management. Reclamation participates in the Interagency Climate Change Task Force and the Water Resources Adaptation Workgroup, supporting adaptive management for the Nation's water resources. Reclamation, along with USACE, NOAA, USGS, EPA, NASA, and FEMA, is part of the CCAWWG (see USACE Partnership section for more on CCAWWG).

Reclamation also partners directly with FWS to co-lead two of the twenty-two LCCs and provides funding to its regional offices for employees to participate in their own regional LCCs. Reclamation relies on the LCCs to serve as a communication forum to facilitate engagement and partnerships with other agencies, stakeholders, and water practitioners. LCCs also work at interfacing the management and science communities through the DOI CSCs. Reclamation works with LCCs and CSCs to identify and address the climate science needs of water managers.

### **Education Efforts**

Reclamation builds the capacity of its employees, stakeholders, and water practitioners, to manage water resources efficiently and with the best available science and practices. CCAWWG and the UCAR COMET Program are coordinating the development of a pilot training resources addressing climate change and water management. The first product of this effort is an online course, titled "Preparing Hydro-climate Inputs for Climate Change in Water Resource Planning"<sup>42</sup>. This is a self-paced course aimed at preparing water planners to assess the potential effects of climate change on water resources and incorporate these into management. The collaboration has subsequently focused on developing residence and virtual course offerings addressing specific natural resources impacts (e.g., surface water hydrology, crop irrigation requirements, water temperature, sedimentation).

### **Vulnerability Assessments**

As part of the WaterSMART Program, Reclamation implemented the West-Wide Climate Risk Assessments (WWCRA). These are broad impacts assessments on water supplies, demands, and operations that are completed internally by Reclamation. The intention of the WWCRA is to provide a foundation and starting point for more focused analyses in later stages of the WaterSMART initiative. At the time of this report, the WWCRA effort has completed a water supply analysis of climate change impacts to hydrology in the western 17 states, an analysis of climate change effects on crop water demands, which is due to be released in Fiscal Year 2014, and two WWCRA impact assessments on Reclamation operations covering the Upper Rio Grande, Sacramento, and San Joaquin basins.

<sup>42</sup> See [https://www.meted.ucar.edu/training\\_module.php?id=959](https://www.meted.ucar.edu/training_module.php?id=959)

Future changes in climate and hydrology and future implications for water and environmental resources were included in Reclamation's report in response to the SECURE Water Act. These two topics were addressed by basin and can be considered brief vulnerability assessments.

### **Adaptation Efforts**

Reclamation's main adaptation work consists of basin studies for major river basins, or watersheds, in the United States. These basin studies assess the future supply-and-demand gaps and identify adaptation options in the context of climate change. Reclamation has so far funded 19 studies, beginning in 2009, and supports Federal and non-Federal agencies in compiling study reports. Reclamation has completed four basin studies to date covering the Yakima, Colorado, Milk/St. Mary's, and the Santa Ana Basins. Reclamation will be completing three more basin studies in the near future, covering the Lower Rio Grande, Henry's Fork of the Snake River, and Southeast California basins. The WaterSMART program is designed to progress from the coarser regional vulnerability assessments (WWCRAs) to more local-scale adaptation planning (basin studies) and feasibility studies. The next step in the WaterSMART program is to target promising adaptation options identified in the basin studies and conduct localized feasibility studies. These are likely to be large-scale projects that may require more detailed assessments to address all issues. An anticipated challenge to the feasibility studies is the ability and time required for stakeholders to absorb and act upon adaptation options. Despite this challenge, Reclamation is planning to begin the studies in 2014. The WaterSMART program is also developing guidance for incorporating climate change into feasibility studies outside of the WaterSMART initiative, and Reclamation is updating its Feasibility Study Directives to require climate change be considered as part of the without-plan condition, which is a characterization of future conditions without the proposed Reclamation action, but includes actions that may be expected by others.

Reclamation has additional resources and support to help address adaptation efforts for water resource planning. Reclamation's Science and Technology program supports development of improved datasets, assessment methods, and tools that support climate change adaptation planning. For example, the program supported development of an online database for downscaled climate/hydrological projections, which were used in the WWCRAs and basin studies and could inform decisions about adaptive water planning. Tools development to assist adaptation occurs through Climate Data Analysis Tools grants offered through the WaterSMART program, where tool development priorities match those from the SECURE Water Act. Reclamation also provides grants for water and energy conservation and systems optimization.

Reclamation works with partners to assess science needs surrounding vulnerability assessment and adaptation. A report by CCAWWG set the stage for additional research into user needs for climate change planning by including two chapters that focus on adaptation options and research needs (Brekke et al. 2009). Currently, CCAWWG has completed two user needs assessments for climate change and water management, which consider short-term (Raff et al. 2013) and long-term planning (Brekke et al. 2011). In addition, Reclamation has developed and periodically updated a literature synthesis on the current and projected effects of climate change on hydrology and water resources (Reclamation 2013). These reports are a precursor to adaptation options, but define the knowledge and tools needed to make informative adaptive decisions.

## National Park Service

### Background and Guiding Documents

The NPS manages a National Park System covering over 30 million hectares of land (*Figure 1*) in over 400 sites, including parks, national monuments, military parks, preserves, and recreation areas. The fundamental purpose of the NPS is to conserve park resources and values and to provide for public enjoyment of parks while avoiding or minimizing impacts that would impair park resources. Climate change presents a major challenge to park conservation. In response to DOI Secretarial Order 3289, NPS released a Climate Change Response Strategy (NPS 2010). In the strategy, the director of the NPS also created the Climate Change Coordinating Group to guide the implementation of the strategy. The strategy provides direction to the agency and employees in addressing climate change, and describes goals and objectives of four related components (NPS 2010):

1. **Science** – Conduct scientific research and vulnerability assessments to support adaptation, mitigation, and communication efforts. Collaborate with scientific agencies and institutions to meet the needs of management in dealing with climate change, and apply the best available climate change science.
2. **Adaptation** – Identify and implement actions in anticipation of climate change effects to preserve natural and cultural resources and infrastructure under climate change. Use tools such as vulnerability assessments and scenario analysis in adaptation planning. Prioritize and implement actions, and monitor the results.
3. **Mitigation** – Reduce the carbon footprint of the NPS through energy efficiency and sustainable practices, and integrate these practices into planning and operations.
4. **Communication** – Effectively communicate with the public about climate change and associated impacts. Train park staff and managers in climate change science and decision tools.

Building on the Climate Change Response Strategy, the NPS released its Climate Change Action Plan 2012-2014 (NPS 2012), which described high priority actions, and contained further guidance for National Park managers and staff on planning for and responding to climate change. The Action Plan included criteria to help prioritize actions in the short-term, and a set of high-priority actions that meet those criteria, towards the goal of incorporating climate change considerations into all aspects of NPS operations. Near term goals aim to provide a framework for building capacity and meeting needs for tools and information. The Action Plan also included guidance for preparing to meet uncertain long-term changes and circumstances. As a living document and a catalyst for response at all levels of the agency, the Action Plan is intended to be reviewed and revised regularly, with the first revision scheduled to begin in 2014.

### Partnerships

The NPS collaborates with other agencies in climate change adaptation efforts. NPS participates in LCCs and supports four LCC staff positions. Several national parks have joined with adjacent national forests in vulnerability assessment and adaptation efforts (Halofsky et al. 2011, Raymond et al. 2013, Raymond et al. in press), and the Southern Sierra Conservation Cooperative, a collaborative effort involving NPS, USGS, Forest Service, and the University of California, provides information to Sequoia, Kings Canyon, and Yosemite National Parks and Sequoia National Forest to adapt fire management to changing climate.

In conjunction with multiple agencies and non-governmental organizations, NPS staff members helped to develop a guide for climate-smart conservation (Stein et al. 2014). NPS also participated in the steering committee and technical teams that developed the National Fish, Wildlife, and Plants Climate Adaptation Strategy (described below; NFWPCAP 2012) and serves on the Joint Implementation Working Group for the Strategy.

The NPS is also involved in several collaborative projects to support adaptation in national parks. For example, a cooperative project with the Geological Society of America and the University of Colorado is underway to develop sea level rise and storm surge projections for all coastal park units. A cooperative project with the Program for the Study of Developed Shorelines, Western Carolina University and Duke University will develop adaptation options for coastal park units. Another collaborative project with the Forest Service, Great Northern Landscape Conservation Cooperative, Plains and Prairie Potholes Landscape Conservation Cooperative, North Central Climate Science Center, Greater Yellowstone Coordinating Committee, EcoAdapt, and Oregon State University, called the Northern Rockies Adaptation Partnership, will assess the vulnerability of natural resources and ecosystem services to climate change in the Northern Rockies and develop science-based adaptation strategies that can be used by resource managers to understand and mitigate the negative effects of climate change.

### **Education Efforts**

The NPS has developed training modules and tools to help raise awareness among staff at all levels and disciplines about climate change. For example, as part of workshops associated with the NPS Climate Friendly Parks Program<sup>43</sup> (which mostly targets facility managers), NPS is providing basic climate science information as well as sessions focused on mitigation. A week-long online training called “Interpreting Climate Change” has been developed for NPS interpreters and others interested in learning how to more effectively communicate about climate change. This course will be offered twice in 2014 and is available through DOI Learn. The NPS developed a climate change leadership webinar series specifically for park managers and superintendents to explore best management practices and lessons learned for responding to climate change. This series was offered in 2012 and 2013, is underway in 2014, and will continue in coming years (C. Hawkins Hoffman and A. Richman, personal communication). NPS currently hosts a monthly web-based seminar series featuring climate change experts speaking on science, adaptation, mitigation and communication topics relevant to parks, which is open to other agencies, tribes, and non-governmental organizations. An archive of past webinars is available for the past five years.

NPS has initiated efforts to engage park visitors about climate change. For example, in an exhibit project involving 13 parks, a series of waysides are being developed that will highlight park-specific effects of climate change and allow visitors to use quick response codes to connect to other parks and learn about interconnected climate change issues (e.g., glacial melt in Alaska and sea level rise in Florida). The NPS Mather Training Center is developing “boot camps” to train interpreters and educators in conducting facilitated dialogues with park visitors, and climate change is one of four key topic areas. The NPS is also part of the Earth to Sky partnership with NASA, FWS, and University of California, Berkeley, which focuses on teaching climate change science and motivating NPS interpreters to then develop interpretive and educational products and programs for use in refuges and parks.

<sup>43</sup> See <http://www.nps.gov/climatefriendlyparks/>



### **Vulnerability Assessments**

The NPS is partnering with USGS and universities on vulnerability assessments that examine the three components of vulnerability (exposure, sensitivity, and adaptive capacity) for specific ecosystems and species in national parks. For example, vulnerability assessments have been conducted for coasts and lake shores in 22 national parks, Mediterranean ecosystems in Point Reyes National Seashore, cultural and natural resources in three national parks in Hawai'i, salt marshes in Acadia National Park, grasslands and cultural resources in Badlands National Park, and bristlecone pine (*Pinus aristata*), desert tortoise (*Gopherus agassizii*, *G. morafkai*), and Shivwits milk-vetch (*Astragalus ampullarioides*) in three Utah national parks. Other assessments in progress include analyses of desert bighorn sheep (*Ovis canadensis nelsoni*) in nine southwestern U.S. national parks, giant sequoia trees (*Sequoiadendron giganteum*) in Sequoia and Kings Canyon National Parks, the Karner blue butterfly (*Lycaeides melissa samuelis*) at Indiana Dunes National Lakeshore, pika (*Ochotona princeps*) in eight western U.S. national parks, an endangered salamander in Shenandoah National Park, and threatened and endangered beach mice at Gulf Islands National Seashore.

The NPS is also developing a risk assessment tool for evaluating climate change risks to park facilities, historic structures and other resources in coastal parks. This tool will characterize vulnerability and identify parks with assets most at risk. Still in development, the tool was initially tested in two case studies in coastal parks, specifically considering effects of sea level rise and storm-related coastal inundation and erosion (NPS 2012).

### **Adaptation Efforts**

In 2007, the NPS Director established the Climate Change Response Program (CCRP), under the Natural Resource Stewardship and Science Directorate, to develop a cross-cutting approach to climate change. In 2009, the Climate Change Response Steering Committee was created to serve as an advisory group to the CCRP and NPS leadership. Prior to the creation of the steering committee, several working groups facilitated communication and explored the needs and issues of parks and regions. With release of the NPS Climate Change Response Strategy, the NPS Director established a Climate Change Coordinating Group at the Associate Director level, which replaced the steering committee and oversees implementation of climate change response activities in all NPS programs. The CCRP provides subject-matter expertise, guidance, and technical assistance to parks and NPS offices to implement activities that support adaptation. In recent years, major initiatives have included resource vulnerability and risk assessments, adaptation and scenario planning, collaboration with partners, communication and training, and initiation of enhanced monitoring capability at 94 parks to address rapid climate change (NPS 2012).

The NPS has conducted at least 18 climate change scenario planning workshops that included 28 case study examples. Some workshops met training or research goals, while other workshops focused on application to park decision-making or strategic plans. Workshops included representatives from over 89 NPS units (i.e., parks, networks of parks, and regional or central offices), and 122 partners (other agencies or non-governmental organizations).

Climate change is being incorporated in key NPS strategic planning documents and guidance. For example, strategies to address climate change were included in the NPS National Long Range Transportation Plan (in preparation), which will provide a vision for transportation within the NPS and help to strategically guide transportation investments. In addition, NPS planning teams are completing new "foundation

documents” for all parks by 2016, which describe fundamental resources and values, as well as priority issues and planning needs, and serve as the platform for all additional park plans. Each of these foundation documents must address climate change. To inform planning efforts, the NPS is analyzing spatial patterns of historical and projected climate for each park. Downscaled climate projections from global climate models used in the Intergovernmental Panel on Climate Change 2013 assessment report will be made available for every unit in the NPS in 2014 (through collaboration with the University of Wisconsin Center for Climatic Research). The NPS is preparing a “State of the Park” report for each of the 400 NPS units, incorporating information on trends in historical climate observations and projections. Additionally, the NPS is developing guidelines and strategies for addressing climate change effects on cultural resources (e.g., archaeologic, historic, cultural landscapes, and traditional use areas).

## U.S. Fish and Wildlife Service

### ***Background and Guiding Documents***

The FWS manages migratory birds, inter-jurisdictional fish, threatened and endangered species, and over 60 million hectares (*Figure 1*) encompassed in 561 National Wildlife Refuges, 38 wetland management districts, and other protected areas. The mission of the FWS is to work with others to conserve, protect, and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American people. Climate change is likely to have major effects on fish, wildlife, and plants in the U.S., and many National Wildlife Refuges and other field offices are already responding to changes to habitats and trust species on the ground.

In response to this growing threat, a planning team within FWS created a strategic plan called “Rising to the Urgent Challenge: Strategic Plan for Responding to Accelerated Climate Change” to address climate change effects on fish and wildlife in three ways: adaptation, mitigation and engagement efforts (FWS 2010). The planning team also developed a draft action plan for implementing the strategic plan; although the action plan was never finalized, it helps guide FWS’s initial implementation of the strategic plan. Adaptation goals in the strategic plan include long-term biological planning, conservation actions, and research partnerships aimed at increasing the capacity to help the nation’s fish and wildlife survive climate change impacts. Mitigation goals focus on carbon neutrality, and the engagement strategy focuses on providing climate change information to FWS employees and external sources and creating partnerships across a broad range of conservation community members. A National Climate Team was created to implement the FWS strategic plan. The National Climate Team developed annual “climate change action priorities” in 2009 and 2010-11 to be completed by service regions and programs to implement the strategic plan.

In 2013, a new FWS Manual chapter on climate change adaptation (056 FW 1)<sup>44</sup> was issued that established initial FWS policy and staff responsibilities on climate change adaptation, stepped down from DOI policy. A second FWS Manual chapter establishing a “climate adaptation network” to help lead climate change activities was issued in June of 2014 (056 FW 2)<sup>45</sup>. The National Wildlife Refuge System has proposed a policy to implement a strategic approach to growth, recognizing that FWS cannot fulfill its

<sup>44</sup> See <http://www.fws.gov/policy/056fw1.pdf>

<sup>45</sup> See <http://www.fws.gov/policy/056fw2.pdf>

mission in the face of challenges related to climate change and other stressors unless it provides consistent direction for adding lands and waters to the system. FWS has also been working to integrate climate change into agency grant programs to help incentivize adaptation planning at a variety of scales.

### **Partnerships**

Partnerships are a large part of FWS climate change work, in accordance with the focus on engagement in the strategic plan. FWS was the original coordinator of LCCs (see LCC section above), and FWS personnel still actively participate in all of the 22 LCCs. The National Fish, Wildlife, and Plants Climate Adaptation Strategy (NFWPCAP 2012) is an example of collaborative adaptation work by FWS and various partners. Development of this collaborative strategy was the top priority of the FWS climate change strategic plan. The adaptation strategy was spearheaded by FWS to create a high-priority climate change strategy for the broader conservation community and to develop an intergovernmental effort among Federal, state and tribal agencies responsible for wildlife stewardship. Along with FWS, NOAA and the New York Division of Fish, Wildlife, and Marine Resources (on behalf of state wildlife agencies) co-chaired the development of the strategy. Other state fish and wildlife agencies, tribes and tribal organizations, and additional Federal agencies were also part of the effort. The Association of Fish and Wildlife Agencies (the national association of state fish and wildlife agencies) provided support for this project. The steering committee for the plan consisted of representatives from 15 Federal agencies, five state fish and wildlife agencies and two inter-tribal natural resource commissions. The technical teams that drafted the strategy and the management team that oversaw its completion were also composed of a variety of partners.

### **Education Efforts**

The FWS National Conservation Training Center (NCTC) in West Virginia provides climate change education through its Climate Change Learning Center. Trainings, courses, and webinars through the Climate Change Learning Center are not just for FWS employees, but are intended to be utilized by the whole conservation community (e.g., state, tribal, and local governments, non-governmental organizations, etc.). Having a community approach allows for the climate change trainings, frameworks, and ideas to be widespread. This is well suited to climate change, which is a cross-boundary, broad scale challenge.

One course at NCTC is on climate change vulnerability assessments. The training is based on a climate change vulnerability assessment guide developed by the National Wildlife Federation, FWS, and other partners (Glick et al. 2011). The training focuses on important issues to include when conducting vulnerability assessments, rather than specific methods to conduct vulnerability assessments that may not fit every scenario. Several of these courses were held at NCTC, but they have also been held around the country. NCTC encourages participation from scientists and managers from different agencies in order to enhance the discussions and create connections across boundaries.

The NCTC offers several other climate change courses, including Decision Analysis for Climate Change, Climate Change Scenario Planning, and a 10-month online course called Climate Academy, which educates on climate science and provides adaptation resources. NCTC holds webinars on a variety of climate change topics<sup>46</sup> and strives to continually update its training to stay current and create a common language in the conservation community.

<sup>46</sup> Archived at: [http://training.fws.gov/CSP/Resources/climate\\_change/webinars.html](http://training.fws.gov/CSP/Resources/climate_change/webinars.html)

### **Vulnerability Assessments**

The National Wildlife Refuge System, which is part of the FWS, and the nonprofit organization NatureServe, collaborated to design a set of vulnerability pilot projects. The purpose of these projects was to identify climate change vulnerabilities on the nation's wildlife refuges and to develop management strategies to approach identified issues. The "Vulnerability Assessment and Strategies for the Sheldon National Wildlife Refuge and Hart Mountain National Antelope Refuge Complex" report investigated vulnerability and management options for a large, Western-based, interior complex (Crist et al. 2011), and the "Resource Vulnerability Assessment and Strategies for Management Options for the Eastern Shore of Virginia and Fisherman Island NWRs" report was for two smaller, eastern located, coastal refuges (Bulluck et al. 2011). These pilot assessments produced two guiding reports (Crist et al. 2012a,b); a technical guide introduces methodology for producing Resource Vulnerability Assessments like the pilot studies above, and a manager's guide is aimed at assisting managers in using the methodology defined in the technical guide in practical terms (for example, costs, and timeframes for conducting a Resource Vulnerability Assessment).

The nationally-coordinated Refuge System Inventory and Monitoring initiative works with partners to assess the status of refuge lands, waters, plants and animals, including recording the impacts of environmental stressors such as climate change. In addition, the NCTC course on conducting vulnerability assessments (described above) is a helpful guide for any agency within the conservation community that is pursuing climate change vulnerability assessments.

### **Adaptation Efforts**

Introduced in the above Partnership section, the National Fish, Wildlife, and Plants Climate Adaptation Strategy (NFWPCAP 2012) is a large focus of the FWS climate change adaptation work. The Strategy was released in 2013, with the goal of providing the conservation community with a starting point for helping living resources survive the foreseeable impacts of climate change. The report documents current and projected climate change effects, actions for climate resiliency, and adaptation; guides implementation and integration of adaptive management; and encourages collaboration within the conservation community. In particular, the adaptation chapter introduces seven goals for managing fish, wildlife, and plants under a changing climate. The goals specify strategies and actions that can be taken to increase the resiliency and adaptive capacity of species and natural systems. Itemized checklists are also provided to track progress.

Currently the FWS is co-leading a Joint Implementation Working Group with NOAA, the Great Lakes Indian Fish and Wildlife Commission, and the state of California to promote implementation of the Strategy and report on implementation progress. Internally, the Service is also reviewing the Strategy and determining which aspects of climate change adaptation have already been accomplished within the agency, and which actions need to be taken going forward. Overall, FWS's approach to addressing climate change vulnerabilities has focused on both adaptation planning and field-driven adaptation activities, through a variety of science-based management actions and projects including habitat restoration and work to build resilience to sea level rise, removing barriers to fish passage, developing climate change information and tools, and planning for impacts to our facilities.

The FWS also pursues adaptation measures through the LCC network (see LCC section above). The diverse LCC membership of state, Federal, tribal and private conservation organizations make them well suited to support regional adaptation activities through collaborative processes.

## U.S. Geological Survey

### **Background**

The USGS is a science-focused agency that provides information on ecosystem and environmental health, natural hazards, natural resources, and the impacts of climate and land-use change. The latest USGS science strategy (USGS 2007), which covers the years 2007 to 2017, established increasing understanding of climate change and its effects as one of six top priorities. The Climate and Land Use Change Science Strategy (Burkett et al. 2013) built on the science strategy and identified seven goals for USGS global change science and strategic actions that may be implemented in the short term (1–5 years) and the longer term (5–10 years) to improve understanding of rates, causes, and impacts of past global changes; the global carbon cycle; biogeochemical cycles and their coupled interactions; land-use and land-cover change rates, causes, and consequences; droughts, floods, and water availability under changing land-use and climatic conditions; coastal response to sea level rise, climatic change, and human development; and biological responses to global change.

### **Programs Related to Climate Change Science and Adaptation**

The USGS has programs within several mission areas, including Ecosystems, Natural Hazards, Water, and Climate and Land Use Change, which produce science and information relevant to climate change and adaptation. The Ecosystems Mission Area supports research and monitoring of freshwater, terrestrial, and marine ecosystems, and provides information to Federal and state natural resource managers to help them sustainably manage and conserve biological resources. The Natural Hazards Mission Area involves monitoring, assessment, and research on natural hazards, including many that are likely to be affected by climate change, including wildfire, sea level rise, coastal storms, and landslides, to increase public preparedness and resilience. Under the Water Mission Area, the USGS provides water data for the nation, including current and historic streamflow, groundwater, water quality and use data, and information on flooding and droughts.

Programs and centers under the Climate and Land Use Change Mission Area directly address climate change and include the Research and Development Program, Land Change Science Program, Earth Resources Observation and Science Center, and National Climate Change and Wildlife Science Center. The USGS Climate and Land Use Change Research and Development Program supports fundamental research to increase understanding of processes that control response of the Earth system's physical, chemical, and biological components to climate change and increase understanding of climate change effects on ecosystems and other natural resources. The Land Change Science Program aims to increase understanding of the patterns and consequences of changing land use and land cover, resulting from both natural and human actions, including anthropogenic climate change. The Earth Resources Observation and Science Center conducts remote sensing research, data management, and systems development to increase understanding of land change at local to global scales.

The National Climate Change and Wildlife Science Center (NCCWSC) was created by USGS in 2008 to assist land managers in meeting the challenges of climate change and its effects on wildlife. The NCCWSC planned and currently manages eight CSCs, joint Federal-university partnerships, on behalf of the



Department of the Interior. In addition to managing the CSCs, goals of the NCCWSC focus on funding and producing science that forecasts changes in habitat and fish and wildlife populations as a result of climate change; assesses species and habitat vulnerability to climate change; links physical climate models with ecological and population models; and develops standardized approaches to monitoring. Both the NCCWSC and individual CSCs rely upon partnerships with governmental and non-governmental natural resource agencies and scientists to identify key priorities to guide research, information collection, and development of tools for managers.

## U.S. Environmental Protection Agency

### ***Background and Guiding Documents***

The United States EPA mission is to protect human health and the environment. The agency writes and enforces environmental regulations based on laws passed by Congress, administers grant and educational programs, and conducts environmental assessments and research. The EPA partners with many different organizations in agency work, including businesses, non-profit organizations, and state and local governments.

In 2010, the Administrator of the EPA issued seven priorities for future progress, with one of these priorities focusing on “taking action on climate change.” This priority included integrating into EPA’s future plans consideration of the effects climate change will have on its core mission. In 2011, in response to the implementation instructions for climate change adaptation set forth by the CEQ (CEQ 2011), the EPA released a policy statement that called for the development and implementation of a climate change adaptation plan (EPA 2011). It also directed that every national program office and all 10 regional offices develop an implementation plan to provide more detail on how it will carry out the work called for in the agency-wide plan. The EPA Climate Change Adaptation Plan, an agency-wide effort that was coordinated through the EPA Office of Policy, was released for public comment in February 2013 (EPA 2013b). The agency-wide plan included information on climate change impacts, identified areas where EPA’s mission, facilities, and operations may be adversely affected by climate change, and summarized adaptation priorities. Implementation plans produced by the program and regional offices were released for public comment in November 2013.

### **Partnerships**

The 2011-2015 EPA Strategic Plan states the importance of encouraging partnerships to effectively share knowledge and resources (EPA 2010b). The 2013 draft Climate Change Adaptation Plan contains a section specifically on the role of partners in climate change adaptation efforts (EPA 2013b). The EPA participates in the interagency Council on Climate Preparedness and Resilience, USGCRP, and other adaptation-related working groups. The EPA contributed to the National Climate Assessment (Melillo et al. 2013), and also to the “National Action Plan: Priorities for Managing Freshwater Resources in a Changing Climate” (Interagency Climate Change Adaptation Task Force 2011) and the “National Fish, Wildlife, and Plants Climate Adaptation Strategy” (NFWPCAP 2012), which are cross-cutting national strategies relevant to adaptation planning at EPA.

## Education Efforts

The EPA climate change website<sup>47</sup> has basic information on climate change science, impacts, and adaptation in different sectors. The EPA website features a page devoted to education resources, which includes ideas for students to bring to the classroom and resources for educators to introduce to students.

## Vulnerability Assessments

The EPA has produced numerous reports that provide guidelines for vulnerability assessments and/or assess the vulnerability of specific resources to climate change. These include:

- “A Screening Assessment of the Potential Impacts of Climate Change on Combined Sewer Overflow Mitigation in the Great Lakes and New England Regions” (EPA 2008a) - assessed the effects of climate change on combined sewer overflow mitigation in the Great Lakes and New England Regions to determine whether the issue warranted further consideration, and evaluated the need for decision support tools and information enabling managers to better incorporate climate change into their decision making processes.
- “Effects of Climate Change on Aquatic Invasive Species and Implications for Management and Research” (EPA 2008b) - reviewed available literature on climate-change effects on aquatic invasive species and examined state-level aquatic invasive species management activities and plans to determine their capacity to incorporate information on climate change.
- “A Framework for Categorizing the Relative Vulnerability of Threatened and Endangered Species to Climate Change” (EPA 2009a) - guided users through a framework to determine vulnerability of a species to climate change, and several examples of the use of the framework were provided for users.
- “Assessment of the Impacts of Global Change on Regional U.S. Air Quality: A Synthesis of Climate Change Impacts on Ground-level Ozone” (EPA 2009b) - provided information on the potential effects of climate change on regional air quality in the U.S.
- “Climate Change Vulnerability Assessments: A Review of Water Utility Practices” (EPA 2010a) - described different approaches to climate change vulnerability assessments in water utility practices.
- “Watershed Modeling to Assess the Sensitivity of Streamflow, Nutrient, and Sediment Loads to Potential Climate Change and Urban Development in 20 U.S. Watersheds” (EPA 2013d) - characterized sensitivity of streamflow, nutrient (nitrogen and phosphorus), and sediment loading in different regions of the nation to a range of potential climate change and urban development scenarios.

## Adaptation Efforts

The EPA released a draft of its agency-wide Climate Change Adaptation Plan for public review (EPA 2013b). The plan summarizes vulnerabilities the EPA is facing with climate change, introduced guiding principles and priorities for adaptation efforts, and provided measures to evaluate progress. Under the overarching climate change adaptation plan, EPA program offices (e.g., Office of Water) and regional offices then developed individual implementation plans. These program- and office-level plans address implementation of the agency-wide plan.

<sup>47</sup> See <http://www.epa.gov/climatechange/>

The Office of Research Development within the EPA conducts research and assessments related to climate change impacts and adaptation. Different offices within EPA also complete their own vulnerability assessments and climate change adaptation reports. For example, the Office of Water updated its water program strategy from 2008 with the “National Water Program 2012 Strategy: Response to Climate Change” (EPA 2012). The strategy identifies options and actions for water resources to respond to climate change.

The EPA Global Change Research Program’s Integrated Climate and Land Use Scenarios project is developing future land use scenarios. These scenarios are broadly consistent with global-scale, peer-reviewed storylines of population growth and economic development that are used by climate modelers. These scenarios allow exploration of the potential interactions between climate change and land use change.

With help from partners, EPA has compiled the third edition of a report that presents indicators, including ecosystem indicators, to understand observed long-term trends related to the causes and effects of climate change (EPA 2014). The report describes the significance of these climate-related trends and their possible impacts on people and the environment. The indicators are based on peer-reviewed information from various government agencies, universities, and other organizations. EPA also annually updates a “Report on the Environment,” which presents the best available indicators of information on conditions and trends in air, water, land, human health, and ecological systems. A substantially-revised 2014 version of this report is currently available for public review<sup>48</sup>.

The EPA Office of Sustainable Communities Smart Growth Program has supported several climate change adaptation projects. For example, the Smart Growth Program sponsored a project in which EPA and FEMA worked with state and local leaders in Iowa to determine how information on changing weather patterns due to climate change could be integrated into local and state planning efforts to adapt to and mitigate future natural disasters. The program also sponsored a technical assistance project with the Metropolitan Washington Council of Governments that gave local governments policy options to consider when preparing for climate change (EPA 2013c).

Another example of an EPA adaptation effort is the Office of Water’s Climate Ready Estuaries program that works with the National Estuary Program and the coastal management community. The program helps coastal communities integrate climate change into planning by providing tools to assess vulnerabilities, create adaptation strategies, and engage and educate the public. For example, the program developed a coastal toolkit webpage<sup>49</sup> with links to vulnerability assessments, adaptation guides, and other programs with coastal information. There are also EPA estuary projects outside of the Climate Ready Estuaries and National Estuary Programs, such as the in Chesapeake Bay Program, which has projects to examine how climate change affects both Bay resources and decisions about specific management practices designed to improve those resources.

Climate Ready Water Utilities is an EPA Office of Water initiative that is focused on climate change adaptation by water utilities. The Climate Ready Water Utilities initiative assists the water sector, which includes drinking water, wastewater, and stormwater utilities, in addressing climate change impacts.

<sup>48</sup> See <http://cfpub.epa.gov/roe/>

<sup>49</sup> See <http://water.epa.gov/type/oceb/cre/toolkit.cfm>



There is a web-based toolkit for the Climate Ready Water Utilities program featuring links to resources on utilities and climate change<sup>50</sup>. The program's Climate Resilience Evaluation and Awareness Tool<sup>51</sup> provides information on potential climate change impacts and helps users assess risks and identify adaptation options. An updated Adaptation Strategies Guide for Water Utilities was recently released (EPA 2013a), and a guide for planning workshops based on extreme weather events is a new item for the toolkit.

*Satellite image of West Coast wildfires. (Source: NASA)*



<sup>50</sup> See <http://www.epa.gov/safewater/watersecurity/climate/toolbox.html>

<sup>51</sup> See <http://water.epa.gov/infrastructure/watersecurity/climate/creat.cfm>

# Interagency Adaptation Efforts by the U.S. Global Change Research Program

## U.S. Global Change Research Program

### **Background**

The U.S. Global Change Research Program (USGCRP), overseen by the White House Office of Science and Technology Policy, coordinates and integrates research efforts on climate change and its societal impacts across 13 federal agencies. Beginning as a Presidential initiative in 1989, USGCRP was later codified by Congress in the Global Change Research Act of 1990 (GCRA 1990). Since then, USGCRP has been assisting the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change through interagency partnerships, working groups, and collaborations with experts.

USGCRP contributes to and develops several different types of reports and assessments, the National Climate Assessment (NCA)<sup>52</sup> being one of the most prominent. The NCA is produced every four years, with the most recent report released in May 2014 (Melillo et al. 2014). Compiling the NCA is a large task that involves participants from all aspects of the Nation's research community, including federal, university, nonprofit, and private sector researchers and decision-makers. The NCA describes climate impacts on different sectors and in eight regions, from the environment to human health, and describes mitigation and adaptation efforts around the Nation.

In addition to the NCA, USGCRP contributes to the Intergovernmental Panel on Climate Change assessments, produces annual reports, and develops strategic plans that help guide interagency research activities over longer timeframes. The annual reports submitted to Congress, called "Our Changing Planet," highlight progress in meeting USGCRP goals, the use of funds, and future priorities. A strategic 10-year plan<sup>53</sup> for global change research was released by USGCRP in 2012 (USGCRP 2012). This plan reflects recommendations from multiple reports of the National Academies, dozens of listening sessions with stakeholders around the country, and collaborative planning among the USGCRP member agencies to direct the path for program in the next 10 years. Priorities for USGCRP over the next decade include advancing climate change science and making research on climate and climate impacts applicable to real-world decisions and actions.

### **Education Efforts**

The 2012 USGCRP strategic plan (USGCRP 2012) included education and communication as one of four main goals for the program. The need for public engagement and increased understanding of climate

<sup>52</sup> See <http://nca2014.globalchange.gov/>

<sup>53</sup> See <http://data.globalchange.gov/assets/d0/67/6042585bce196769357e6501a78c/usgcrp-strategic-plan-2012.pdf>



change science is recognized by USGCRP, and the program seeks to meet these needs through dissemination of relevant, timely, and credible global change information, while also engaging their stakeholders to better understand their decisions in a changing climate that help identify science and information needs. USGCRP also aims to strengthen the scientific workplace and increase knowledge about climate and global change in the research community. In keeping with both public engagement and science workplace goals, USGCRP held town hall-style meetings for the release of the most recent draft NCA. These relatively small meetings, held around the nation and open to scientists, managers, decision-makers, and the general public, focused on findings of the NCA for the specific region where the meeting was held.

### **Adaptation Efforts**

USGCRP's Adaptation Science Interagency Working Group (ASIWG)<sup>54</sup> puts forth a major effort to inform climate change adaptation at multiple scales through actionable science. This workgroup was initially formed under CEQ, but was transferred to USGCRP in 2010. The group identifies research needs and priorities at local, regional, and federal levels and strives to bridge gaps in knowledge and communication between researchers and decision-makers. For example, in the latest NCA, regional climate scenarios were used to predict future impacts to resources in New England, and the technical information behind these predictions filled 80 pages. The ASIWG worked with the scientists to translate the technical text into a two-page summary<sup>55</sup> of main points that are understandable and useful to a broader audience.

In addition to science translation, the ASIWG continually works to identify adaptation research and information needs from its stakeholders. One such effort to identify these needs occurred upon public release of the Federal Agency Climate Change Adaptation Plans in February 2013. The ASIWG began a crosscutting review<sup>56</sup> of the Agency Climate Change Adaptation Plans to identify common themes across the agencies on adaptation research and information needs. In addition, the ASIWG recently conducted a review<sup>57</sup> of publications, resources, and approaches around the world to monitor and evaluate coastal adaptation actions, as evaluating and monitoring effective adaptation is critical to improving the understanding of how the Earth system is responding to global change.

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<sup>54</sup> See <http://www.globalchange.gov/about/iwgs>

<sup>55</sup> See <http://scenarios.globalchange.gov/node/1155>

<sup>56</sup> See <http://www.globalchange.gov/browse/federal-adaptation-resources>

<sup>57</sup> See <http://www.globalchange.gov/browse/federal-adaptation-resources/observations-and-monitoring>

# Synthesis and Conclusions

## Current Status of Adaptation Efforts

Federal natural resource science and management agencies have made significant progress in developing guidance on climate change adaptation. Of three Departments (Agriculture, Defense, Interior) and eight agencies (BIA, BLM, EPA, Forest Service, FWS, NPS, Reclamation, and USACE) focused primarily on land and/or water management, almost all have developed strategic documents guiding adaptation of management to climate change as of 2013. Several departments and agencies have built on initial strategic documents to develop more detailed plans for assessing vulnerabilities and adapting management to climate change (e.g., the Forest Service National Roadmap for Responding to Climate Change (USDA FS 2011a) and the NPS Climate Change Action Plan (NPS 2012)). Most agencies with mixed or more science-focused roles, including NASA, NOAA, Smithsonian Institution, and USGS, have included climate change as a research priority in a strategic document. See [Table 4](#) for a complete list of documents guiding agency climate change adaptation and major agency accomplishments in climate change science and adaptation.

Most agencies have informal or formal programs to educate employees, stakeholders, and/or the public about climate change. The FWS NCTC Climate Change Learning Center is the best known and most formal. Education takes many forms, including written material, websites, webinars, and online training packages. Face-to-face communication has been less common in recent years because of low budgets, travel restrictions, and the desire for agencies to reduce their environmental footprint.

Many federal natural resource agencies have conducted climate change vulnerability assessments. For example, DoD, FWS, Forest Service, and NPS have conducted climate change vulnerability assessments for several to many of their units (and species present on their units). Many tribes have also made progress in assessing natural resource vulnerabilities to climate change and have developed adaptation strategies and plans. The geographic scope and level of detail of assessments and adaptation approaches differ greatly, ranging from watersheds to millions of hectares, focusing on a single resource (e.g., fish) in some cases and on several resources in others. While there is no standard within or between agencies at the present time, it is unclear if having standard protocols would encourage the proliferation of assessments or be considered by resource managers to be too prescriptive.

## Approaches to Adaptation

Most departments and agencies are utilizing existing agency structures to address climate change, while others, such as the DOI, have created new structures to increase capacity for climate change adaptation. Regardless of the approach, agencies have considerable geographic variation in on-the-ground activities and in accountability for accomplishing climate change activities related to adaptation. There appears to

be a growing realization that sustainable resource management and adaptive management in general, both of which typically encompass restoration and building resilience in ecosystems, are highly compatible with climate-smart management. Therefore, agencies can build on existing practices, adjusting them as necessary to address risks posed by a warmer climate.

Employee education and engagement on climate change are components of many agency adaptation strategies. Agencies realize that adaptation is unlikely to be successful unless their own employees have a consistent, basic knowledge about climate change and its effects. Some agencies have encouraged this education to occur at all levels of the organization, including administrative, clerical, and maintenance workers, thus facilitating a true shift in attitudes about agency priorities. In addition, agencies already committed to significant engagement with local stakeholders in planning and project management are now increasingly including climate change as part of the dialogue. Public support is critical for implementation of climate-smart management, just as it is for other aspects of resource management.

Partnerships (within and among agencies, stakeholders, non-governmental organizations) have played and continue to play a key role in nearly all efforts. For example, in Washington State, two national forests and two national parks led a collaboration in which over 40 different organizations participated in some way, typically along resource lines (vegetation, fisheries, etc.) associated with the specific interest of each organization (Raymond et al. 2013, Raymond et al. in press). Adaptation projects that include several partners typically generate more diverse ideas during workshops and more adaptation tactics that can be applied on the ground. Although these partnerships typically work better when built on established relationships and trust between Federal agencies and other organizations, new participants are finding common ground with Federal agencies based on how climate change may affect natural resources and restoration efforts.

Although nearly all agencies have an overarching response strategy for adaptation and in some cases a framework for doing so, systematic accountability for developing adaptation options is still emerging among Federal agencies. Field units are often encouraged to consider climate change in planning and management, but are rarely required to assess the sensitivity of resources to climate change or develop adaptation responses. A notable exception is the Climate Change Performance Scorecard developed by the Forest Service to rate unit success in meeting goals related to climate-smart management, including adaptation. The Forest Service Planning Rule (USDA FS 2012) also requires that climate change be considered when new land management plans are developed by national forests. It is encouraging that some agencies are now including climate change in the development of target conditions and management actions in restoration planning.

## The Role of Science-Focused Agencies

Using the best available science is a goal of most departments and agencies in adapting to climate change. They typically rely on information generated or funded by science-focused agencies (many of which participate in USGCRP), often in cooperation with universities, to provide scientific information relevant to climate change adaptation. The manner in which scientific information is accessed and used differs greatly, depending on the objectives of a specific project, organizations involved, and available budget.

This diversity does not necessarily affect the relevance and quality of adaptation, and to our knowledge, no one has assessed whether adaptation plans within and between agencies conflict in any way.

Partnerships between these science-focused agencies and land and water managers are playing a key role in climate change education and helping resource managers assess vulnerabilities to climate change and develop adaptive strategies in some locations. For example, CCAWWG, a partnership among USACE, Reclamation, NOAA, USGS, EPA, NASA, and USDA, facilitates collaboration on climate-related water management issues. The CCAWWG brings together the water management community, identifies knowledge gaps in adaptive capacity to climate change, conducts research to close identified information gaps, and implements water resource planning training. The ETS partnership with NPS, NASA, FWS, and University of California provides interpretive and educational products and programs for use in wildlife refuges and national parks, focusing mainly on climate change science and communication in recent years. The USGS has collaborated with some national park units to conduct vulnerability assessments and conduct climate scenario planning. The relatively new CSCs are beginning to provide climate change science to local LCCs. NOAA-funded RISAs have existed for nearly 20 years as university-based sources of scientific information, although direct engagement of stakeholders and participation in adaptation efforts has differed by region. In addition, during the past decade, Forest Service Research and Development has developed many partnerships with national forests to assess vulnerabilities and develop adaptation options.

In our experience, resource managers in field units rarely feel that they have insufficient scientific information about climate change to infer the sensitivity of resources or develop adaptation options. Rather, they are often overwhelmed by the amount of available information and lack the ability to determine its credibility and relevance for specific applications. Science agencies typically focus on adding to this information base, fine-tuning projections of biophysical effects, and improving certainty about causation. In contrast, resource managers are seeking high-quality syntheses (as opposed to new analyses) and scientific information that is accessible (understandable) and relevant to applications in land and water management. In part, as a result of this mismatch in objectives, the number of on-the-ground adaptation projects implemented by Federal agencies is relatively small compared to the quantity of existing science.

## Picking up the Pace: A Challenge for the Future

Climate change is currently a high-profile issue for national leadership in many Federal agencies, and recent Executive Orders have mandated development of and periodic updates to agency adaptation plans. At the field-unit scale, many land managers would like to develop vulnerability assessments and adaptation plans, but in the absence of a mandate and sufficient budget to do so, progress has been slow.

The rate at which Federal agencies are developing vulnerability assessments and adaptation plans can be increased by mainstreaming climate change as a part of standard operations in natural resource management. Climate change is one of many risks to which natural resources are subjected, and most land managers already engage in risk management in making decisions about a myriad of issues that affect the condition of natural resources—adaptation is a new component of risk management. Thus, climate change can be incorporated in thoughts, actions, and management guidance, becoming a normal part of

sustainable management, similar to the transition of ecosystem management and ecological restoration from concepts to paradigms in the 1990s. Including climate change as one many factors considered in risk management, rather than a separate “special” topic, will hasten mainstreaming while reducing costs associated with additional analyses.

Interagency coordination is crucial to provide timely, effective mainstreaming of climate change in agency operations. Unfortunately, due to institutional barriers and diversity of missions, it is common for agencies to develop disparate approaches for any given task, often “reinventing the wheel” even if sharing of information and processes would improve efficiency. For example, applying tactics such as managed species relocation in the name of adaptation, but without coordinating with others, may be maladaptive to broader goals for adaptation. Adaptation progress can be accelerated through increased cooperation between management-based and science-based agencies and through collaboration with other organizations in the public and private sectors. At the national level, coordination can occur through the efforts of USGCRP and other interagency working groups. At the regional to local levels, interaction among leadership and resource staff directors across agencies seems to be the most effective. Opportunities for shared learning can be created.

Climate change research programs will have maximum utility if they explicitly inform specific resource management and policy issues—these linkages are needed at the national, regional, and local scales. Interagency coordination can reduce redundancy and competition across scientific programs, facilitate synthesis and delivery of data to practitioners in accessible formats, and ensure that future research is relevant for adaptation.

Accelerating climate change adaptation during a period of flat or declining budgets will be challenging, because the ability of most agencies to meet their current missions is already stretched to capacity. Nevertheless, we must face the reality that the magnitude of the effects of climate change—sea level rise, wildfire, insects, invasive species, etc.—may override the “normal” range of variability currently addressed by resource management and policy, with implications for sustainable resource production, local economies, and community stability. Each year that climate change adaptation is delayed narrows the window of opportunity for effective actions. A timely, coordinated response by Federal agencies will ensure that a maximum number of viable adaptation options are both available and implemented.



Table 4. Example mission, major climate change science and adaptation accomplishments, and documents guiding climate change science and adaptation in Federal land and water management agencies.

Agency	Mission	Science and Adaptation Accomplishments	Primary Guiding Documents
<b>National Aeronautics and Space Administration</b>	Expand human knowledge of the Earth and of phenomena in the atmosphere and space	<p>Deployed 18 satellites that study all aspects of the Earth system and advance fundamental scientific knowledge of global climate variability and change</p> <p>Supports an Earth Observing System Data and Information System that provides services and tools needed to enable use of NASA's Earth science data in new models, research results, and decision support system benchmarking; the system also improves support for end users.</p> <p>Developed a website that features information about climate change</p> <p>Supports an Applied Sciences Program that works through partnerships with organizations to find practical uses for Earth science data and scientific knowledge for decision makers and the public</p> <p>Developed a Climate Risk Management Plan (2012, 2014)</p>	<p>2010 – <a href="#">Responding to the Challenge of Climate and Environmental Change: NASA's Plan for a Climate-Centric Architecture for Earth Observations and Applications from Space</a></p> <p>2011 – <a href="#">NASA Policy Statement: Adapting to a Changing Climate</a></p> <p>2012 – <a href="#">2012 NASA Climate Risk Management Plan: Managing Climate Risks and Adapting to a Changing Climate</a></p> <p>2014 – <a href="#">NASA Strategic Plan 2014</a></p> <p>2014 – <a href="#">Science Plan 2014</a></p> <p>2014 – <a href="#">2014 Climate Risk Management Plan</a></p>
<b>National Science Foundation</b>	Promote and advance scientific progress in the United States	Funds research and programs related to climate change, including Decision Making Under Uncertainty Centers, the Long-Term Ecological Research Network, National Center for Atmospheric Research, National Ecological Observatory Network, Science, Engineering, and Education for Sustainability programs, Dynamics of Coupled Natural and Human Systems, and the Office of Polar Programs	
<b>Smithsonian Institution</b>	Increase and diffuse knowledge	<p>Supports climate change-related research at the Smithsonian Astrophysical Observatory, National Air and Space Museum, Smithsonian Environmental Research Center, National Museum of Natural History, Smithsonian Tropical Research Institute, and Conservation Biology Institute</p> <p>Developed several websites aimed at educating the public about climate change research findings</p> <p>Convened a professional training course called, "Applied Climate Change: Gaining Practical Skills for Climate Change Adaptation"</p>	2010 – <a href="#">Inspiring Generations through Knowledge and Discovery (Strategic Plan for Fiscal Years 2010-2015)</a>
<b>Tribes</b>	See Table 1		
<b>U.S. Department of Agriculture (USDA)</b>	Develop and execute U.S. policy on food, agriculture, natural resources, rural development, nutrition, and related issues	<p>Conducted High-Level Analysis of Agency Vulnerability to Climate Change</p> <p>Developed a Climate Change Science Plan</p> <p>Developed a Climate Change Adaptation Plan (2012, 2014)</p>	<p>2010 – <a href="#">Strategic plan for FY2010-15: Strategic Goal 2</a></p> <p>2010 – <a href="#">Climate Change Science Plan</a></p> <p>2011 – <a href="#">Climate Change Adaptation Policy Statement (DR-1070-001)</a></p> <p>2012 – <a href="#">High-Level Analysis of Agency Vulnerability to Climate Change</a></p> <p>2012 – <a href="#">Climate Change Adaptation Plan for the USDA</a></p> <p>2014 – <a href="#">Climate Change Adaptation Plan for the USDA</a></p>
<b>USDA Forest Service</b>	Sustain the health, diversity, and productivity of the Nation's forests and grassland to meet the need of present and future generations	<p>Developed the National Roadmap for Responding to Climate Change</p> <p>Developed the Climate Change Performance Scorecard to track unit success in meeting adaptation and mitigation goals</p> <p>Supports the Climate Change Resource Center</p> <p>Conducted climate change vulnerability assessments throughout the U.S.</p> <p>Established several science-management adaptation partnerships</p> <p>Developed a Forest Service Climate Change Adaptation Plan as part of the broader USDA Adaptation Plan</p>	<p>2008 – <a href="#">Strategic Framework for Responding to Climate Change</a></p> <p>2009 – <a href="#">Forest Service Global Change Research Strategy</a></p> <p>2011 – <a href="#">National Roadmap for Responding to Climate Change</a></p> <p>2011 – <a href="#">Climate Change Performance Scorecard</a></p> <p>2014 – <a href="#">USDA Individual Agency Climate Change Adaptation Plans – Forest Service</a></p>

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(Table 4 continued)

Agency	Mission	Science and Adaptation Accomplishments	Primary Guiding Documents
<b>Department of Commerce National Oceanic and Atmospheric Administration</b>	Understand and predict changes in climate, weather, oceans, and coasts; share that knowledge and information with others; and conserve and manage coastal and marine ecosystems and resources	<p>Supports a Climate Predictions Center</p> <p>Supports research laboratories and a Climate Program Office that conduct research on climate systems</p> <p>Supports the Regional Integrated Sciences and Assessments Program</p> <p>Launched a Climate-Smart Sanctuary Initiative to address the impacts of climate change in the national marine sanctuary system</p> <p>Supports the Climate Regimes and Ecosystem Productivity Program, which provides decision-makers with information on climate change impacts on U.S. marine ecosystems</p> <p>Supports a Coastal Services Center that provides technology, information, trainings, and management strategies used by organizations to address coastal issues</p> <p>Developed the Digital Coast website</p> <p>Established a Climate Adaptation Team to coordinate all climate adaptation assets and efforts.</p> <p>Manages and maintains the Climate.gov portal (in a partnership) to provide easy, online access to climate data and information products</p>	<p>2009 – <a href="#">Policy Guidance, Office of National Marine Sanctuaries</a></p> <p>2010 – <a href="#">Next Generation Strategic Plan</a></p>
<b>Department of Defense (DoD)</b>	To train soldiers, sailors, and airmen/airwomen, and test the equipment they need for war-fighting and peace-keeping, and to protect our nation and its citizens	<p>Established requirement to assess and, as possible, address anticipated impacts from climate change in installation Integrated Natural Resources Management Plans</p> <p>Developed a Climate Change Adaptation Roadmap (2013, 2014)</p> <p>Active partner in CEQ Climate Change Working Groups</p> <p>Established a DoD Climate Change Action Working Group to facilitate collaboration among DoD and the Military Departments</p> <p>Conducted workshops to educate employees about climate change</p> <p>Conducted adaptation research in coastal zones, the Arctic, Alaska, deserts, and the Pacific Islands</p> <p>Conducted vulnerability assessments on species, ecosystems, and infrastructure</p>	<p>2010 – <a href="#">Quadrennial Defense Review Report</a></p> <p>2011 – <a href="#">DoD Natural Resources Conservation Instruction (DoDI 4715.03)</a></p> <p>2013 – <a href="#">Integrated Natural Resources Management Plan Implementation Manual (DoDM 4715.03)</a></p> <p>2013 – <a href="#">Climate Change Adaptation Roadmap</a></p> <p>2014 – <a href="#">Quadrennial Defense Review Report</a></p> <p>2014 – <a href="#">Climate Change Adaptation Roadmap</a></p>
<b>DoD U.S. Army Corps of Engineers</b>	Deliver public and military engineering services to strengthen U.S. security and reduce risks from disasters	<p>Active partner in the Climate Change and Water Working Group</p> <p>Developed sea level guidance and tools</p> <p>Developed a Climate Change Adaptation Plan (2011, 2014)</p> <p>Provided guidance for vulnerability assessments</p> <p>Conducted pilot studies to test adaptation methods and frameworks</p> <p>Developed “Federal Support Toolbox” website for water managers with NOAA</p>	<p>1986 – <a href="#">Planning Guidance Notebook</a> (with sea level rise section; updated in 2000)</p> <p>2011 – <a href="#">Engineer Circular, Sea-Level Change in Considerations in Civil Work Programs</a></p> <p>2011 – <a href="#">Climate Change Adaptation Policy Statement</a></p> <p>2011 – <a href="#">Climate Change Adaptation Plan</a></p> <p>2013 – <a href="#">Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaptation</a></p> <p>2014 – <a href="#">Climate Change Adaptation Policy Statement</a> (reaffirms and supersedes the 2011 policy statement)</p> <p>2014 – <a href="#">Climate Change Adaptation Plan</a></p>

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Agency	Mission	Science and Adaptation Accomplishments	Primary Guiding Documents
<b>Department of Interior (DOI)</b>	Protect America's natural resources and heritage, honor our cultures and tribal communities, and supply the energy to power our future	<p>Required all DOI agencies to incorporate climate change in planning, prioritization, and decision-making</p> <p>Developed a Climate Change Adaptation Plan (2012, 2014)</p> <p>Initiated Landscape Conservation Cooperatives and Climate Science Centers</p> <p>Developed guidance for agencies on addressing the impacts of climate change (through Manual 523)</p>	<p>2009 – <a href="#">Secretarial Order 3285</a></p> <p>2009 – <a href="#">Secretarial Order 3289: Addressing the Impacts of Climate Change on America's Water, Land, and Other Natural and Cultural Resources</a></p> <p>2012 – <a href="#">Office of Policy Analysis Manual 523</a></p> <p>2013 – <a href="#">Climate Change Adaptation Plan</a></p> <p>2013 – <a href="#">Secretarial Order 3330</a></p> <p>2014 – <a href="#">Climate Change Adaptation Plan</a></p>
<b>DOI Bureau of Indian Affairs</b>	Enhance the quality of life, promote economic opportunity, and carry out the responsibility to protect and improve the trust assets of American Indians, Indian tribes, and Alaska Natives	Awarded grants to tribes to facilitate education on climate change and enable planning for climate change impacts	2015 – <a href="#">FY 2015 Tribal Cooperative Landscape Conservation Program Funding</a>
<b>DOI Bureau of Land Management</b>	Sustain the health, diversity, and productivity of America's public lands for the use and enjoyment of present and future generations	Completed four Rapid Ecoregional Assessments, with 11 others in progress	Under development
<b>DOI Bureau of Reclamation</b>	Manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public	<p>Participates in the Climate Change and Water Working Group and Landscape Conservation Cooperatives</p> <p>Completed West-Wide Climate Risk Assessments in the 17 western states</p> <p>Completed four basin studies, and funded an addition 15 studies to facilitate adaptation planning</p> <p>Invested in climate-related data and tool development</p> <p>Completed and updated a literature synthesis on projected effects of climate change on hydrology and water resources</p>	<p>2009 – <a href="#">SECURE Water Act</a></p> <p>2010 – <a href="#">DOI Secretarial Order 3297</a></p> <p>2011 – <a href="#">SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water, Report to Congress</a></p>
<b>DOI National Park Service</b>	Preserves unimpaired the natural and cultural resources and values of the National Park system for the enjoyment, education, and inspiration of this and future generations	<p>Participates in Landscape Conservation Cooperatives</p> <p>Developed training modules to educate staff about climate change</p> <p>Partnered with universities and other agencies to conduct vulnerability assessments of ecosystems and species</p> <p>Developing guidance for addressing climate change effects in facilities design and construction</p> <p>Conducted over 18 climate change scenario workshops</p> <p>Initiated efforts to engage National Park visitors on climate change</p>	<p>2010 – <a href="#">Climate Change Response Strategy</a></p> <p>2012 – <a href="#">Climate Change Action Plan</a></p> <p>2014 – <a href="#">Climate Change Action Plan</a></p>

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(Table 4 continued)

Agency	Mission	Science and Adaptation Accomplishments	Primary Guiding Documents
<b>DOI Fish and Wildlife Service</b>	Work with others to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people	<p>Developed a strategic plan for responding to climate change and created a National Climate Team to implement the strategic plan</p> <p>Coordinated and participates in the Landscape Conservation Cooperatives</p> <p>Provides climate change education through the National Conservation Training Center</p> <p>Co-led development of the National Fish, Wildlife, and Plants Climate Adaptation Strategy</p> <p>Conducted vulnerability assessment on some National Wildlife Refuges</p> <p>Developed technical and managers' guides to resource vulnerability assessments</p>	<p>2010 – <a href="#">Rising to the Urgent Challenge: Strategic Plan for Responding to Accelerated Climate Change</a></p> <p>2013 – <a href="#">National Fish, Wildlife, and Plants Climate Adaptation Strategy</a></p> <p>2014 – <a href="#">Taking Action: A Progress Report on the National Fish, Wildlife, and Plants Climate Adaptation Strategy</a></p>
<b>DOI U.S. Geological Survey</b>	To provide reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life	<p>Supports programs within several mission areas, including Ecosystems, Natural Hazards, Water, and Climate and Land Use Change, which produce science and information relevant to climate change and adaptation</p> <p>Supports the National Climate Change and Wildlife Science Center, which assists land managers in meeting the challenges of climate change and its effects on wildlife and currently manages eight DOI Climate Science Centers</p>	<p>2007 – <a href="#">Facing tomorrow's challenges—U.S. Geological Survey science in the decade 2007–2017: U.S. Geological Survey Circular 1309</a></p> <p>2013 – <a href="#">Climate and Land Use Change Science Strategy</a></p>
<b>Environmental Protection Agency</b>	Protect human health and the environment	<p>Developed a Climate Change Adaptation Plan (2012, 2014)</p> <p>Produced reports giving guidelines for vulnerability assessments or assessing vulnerability of specific resources</p> <p>Office of Water developed a National Water Program 2012 Strategy that identifies potential responses to climate change</p> <p>Developed Climate Ready Estuaries and Climate Ready Water Utilities programs.</p>	<p>2014 – <a href="#">Climate Change Adaptation Plan</a></p> <p>2014 – <a href="#">Adaptation Implementation Plans for Program and Regional Offices</a></p>
<b>U.S. Global Change Research Program</b>	Assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change	<p>Coordinates and integrates research efforts on climate change and its societal impacts across 13 federal agencies</p> <p>Produces the National Climate Assessment every four years</p> <p>Supports the Adaptation Science Interagency Working Group, which identifies research needs and priorities at local, regional, and federal levels and strives to bridge gaps in knowledge and communication between researchers and decision-makers.</p>	<p>2012 – <a href="#">The National Global Change Research Plan 2012-2021: A Strategic Plan for the U.S. Global Change Research Program</a></p> <p>2014 – <a href="#">Third U.S. National Climate Assessment</a></p>

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## Acronyms and Shorthand

ASIWG – U.S. Global Change Research Program Adaptation Science Interagency Working Group

BIA – Bureau of Indian Affairs

BLM – Bureau of Land Management

CCAR – Department of Defense Climate Change Adaptation Roadmap

CCAWWG – Climate Change and Water Working Group

CCPO – U.S. Department of Agriculture Climate Change Program Office

CCRP – National Park Service Climate Change Response Program

CEQ – White House Council on Environmental Quality

COMET – Cooperative Program for Operational Meteorology, Education, and Training

CPST – Climate Project Screening Tool

CREP – National Oceanic and Atmospheric Administration Climate Regimes and Ecosystem Productivity Program

CSC – U.S. Department of the Interior Climate Science Center

DoD – U.S. Department of Defense

DOI – U.S. Department of the Interior

EOSDIS – National Aeronautics and Space Administration Earth Observing System Data and Information System

EPA – Environmental Protection Agency

ESTCP – Department of Defense Environmental Security Technology Certification Program

ETS – Earth to Sky Partnership

FEMA – Federal Emergency Management Agency

Forest Service – U.S. Department of Agriculture Forest Service

FWS – U.S. Fish and Wildlife Service

GISS – National Aeronautics and Space Administration Goddard Institute of Space Studies

ILMAG – Interagency Land Management Adaptation Group

LCC – U.S. Department of the Interior Landscape Conservation Cooperative

MODIS – National Aeronautics and Space Administration Moderate Resolution Imaging Spectroradiometer

NASA – National Aeronautics and Space Administration

NCA – National Climate Assessment

NCCWSC – U.S. Geological Survey National Climate Change and Wildlife Science Center

NCTC – U.S. Fish and Wildlife Service National Conservation Training Center

NEON – National Ecological Observatory Network



**NERRS** – National Estuarine Research Reserve System

**NIACS** – Forest Service Northern Institute of Applied Climate Science

**NOAA** – National Oceanic and Atmospheric Administration

**NPS** – National Park Service

**NSF** – National Science Foundation

**OCRM** – National Oceanic and Atmospheric Administration Office of Ocean and Coastal Resource Management

**QDR** – U.S. Department of Defense Quadrennial Defense Review Report

**PICCC** – Pacific Islands Climate Change Cooperative

**REA** – Bureau of Land Management Rapid Ecoregional Assessment

**Reclamation** – Bureau of Reclamation

**RISA** – National Oceanic and Atmospheric Administration Regional Integrated Sciences and Assessments

**SARP** – National Oceanic and Atmospheric Administration Sectoral Applications Research Program

**Scorecard** – Forest Service Climate Change Performance Scorecard

**SERDP** – U.S. Department of Defense Strategic Environmental Research and Development Program

**SPARROW** – National Aeronautics and Space Administration Spatially Referenced Regressions on Watershed Attributes

**TACCIMO** – Template for Assessing Climate Change Impacts and Management Options

**TFCC** – Navy Task Force Climate Change

**UCAR** – University Corporation for Atmospheric Research

**USACE** – U.S. Army Corps of Engineers

**USDA** – U.S. Department of Agriculture

**USGCRP** – U.S. Global Change Research Program

**USGS** – U.S. Geological Survey

**WWCRA** – Bureau of Reclamation West-Wide Climate Risk Assessment