National Park Service
U.S. Department of the Interior

Cultural Resources, Partnerships, and Science
Climate Change Response Program

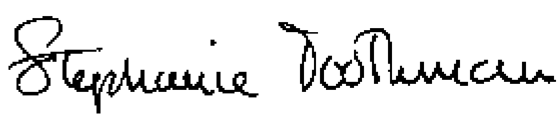
Cultural Resources Climate Change Strategy

FORWARD

In 2016 the National Park Service (NPS) celebrated the centennial of its 1916 Organic Act and the 50th anniversary of the passage of the National Historic Preservation Act (NHPA), which established the framework for the current national preservation program. The *National Park Service Cultural Resources Climate Change Strategy (CRCC Strategy)* responds to the mandates of both Acts. The *CRCC Strategy* provides guidance for NPS managers to anticipate, plan for, and respond to the real and potential effects of a changing climate on the cultural resources the 1916 Act commits us to protect unimpaired for future generations. Under the NHPA, it further provides guidance to our many partners in the national historic preservation program to recognize and respond to a wide range of environmental changes that are threatening cultural resources in communities throughout the Nation.

In 2014, NPS Director Jonathan Jarvis signed *Climate Change and Stewardship of Cultural Resources*, a policy memorandum outlining the NPS position on responding to climate change and its potential effects on cultural resources, emphasizing our stewardship and preservation program mandates. The *CRCC Strategy* represents an important step in providing direction for implementing the policies and direction of that memorandum. It defines the impacts of a changing climate on different cultural resources and organizes methods for evaluating these resources, assessing their vulnerabilities, and prioritizing our options to respond. It also recognizes that many of the resources we seek to preserve–from archeological sites to traditional structures and knowledge–hold valuable information on how earlier cultures responded to changing environments, can be part of a lower energy-demand future, and can inform us about the origins of modern climate change. The *CRCC Strategy* underscores the critical importance of preserving the information represented in the most vulnerable of these resources, and of taking steps to target our survey and documentation programs to capture this information before the resources are lost to rising seas, fire, and pests.

The *CRCC Strategy* joins a family of policy and guidance developed by the NPS as part of its Climate Change Response Program (see listing on pg. 1). Working together with colleagues across disciplines and boundaries, we can continue to move forward and realize the goals of both the Organic Act and the NHPA–to preserve our irreplaceable cultural and natural heritage with their educational, aesthetic, inspirational, economic, and energy benefits for present and future generations.



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"One of the most precious values of the national parks is their ability to teach us about ourselves and how we relate to the natural world. This important role may prove invaluable in the near future as we strive to understand and adapt to a changing climate."

– NPS Director Jon Jarvis
Statement to U.S. Senate, October 2009

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Rockman, Marcy, Marissa Morgan, Sonya Ziaja, George Hambrecht, and Alison Meadow. 2016. *Cultural Resources Climate Change Strategy*. Washington, DC: Cultural Resources, Partnerships, and Science and Climate Change Response Program, National Park Service.

Cover photo: "Weathering the storm in Cliff Palace" by Justin Kern (http://www.thegoldensieve.com/, reprinted with permission). Climate projections for the region surrounding Cliff Palace and Mesa Verde National Park in which it is located anticipate higher temperatures, with some uncertainty as to whether overall precipitation will increase or decrease. Risks to the remains of the homes of the Anasazi, who themselves experienced severe droughts nearly a millennium ago, include the effects of increased heat, wildfires, and subsequent erosion during extreme weather events.

CONTENTS

INTRODUCTION

Cultural resources are our record of the human experience. Collectively, archeological sites, cultural landscapes, ethnographic resources, museum collections, and historic buildings and structures connect one generation to the next. The National Park Service is charged with conserving cultural resources so that they may be enjoyed by future generations. Climate change is currently adding challenges to this role, and will continue to affect cultural resources in diverse ways. At the same time, through the tangible and intangible qualities they hold, cultural resources are also part of the solution to climate change. This Strategy sets out a vision and broad approach for managing impacts to and learning from cultural resources in this era of climate change.

The NPS Role for Cultural Resources

The National Park Service (NPS) is the lead federal agency in the United States for the care and management of cultural resources. Through the National Park System and national cultural resource programs such as the National Register of Historic Places and National Historic Landmark Programs, National Heritage Areas, American Battlefield Protection Program, National Scenic and National Historic Trails, the Federal Historic Preservation Tax Incentives Program, Technical Preservation Services, the National Center for Preservation Technology and Training, certification of local governments, and partnerships—including collaborations through the Landscape Conservation Cooperatives, and with Tribal governments, other Federal agencies, States, universities, and non-governmental partners—the NPS shapes the national framework for historic preservation inside parks and around the country.

Climate Change Threat

Modern anthropogenic climate change is the warming of the Earth's atmosphere due to emissions of greenhouse gases, deriving largely from the burning of fossil fuels and changes in land use. This warming is leading to changes in average long-term weather patterns and is being experienced through phenomena such as the melting of glaciers, polar ice, and permafrost, increases in sea level and extreme temperatures (particularly heat), and changes in patterns of precipitation and extreme weather events. Ocean acidification also is occurring due to absorption of greenhouse gases by the oceans.

(Opposite) Investment in repairs to Fort Jefferson, Dry Tortugas National Park, should consider historical integrity and long-term sustainability of the structure and the island, which are both vulnerable to climate change impacts (NPS Photo/M. Rockman).

The NPS Response to Climate Change

NPS Director Jon Jarvis has recognized climate change as "the greatest threat to the integrity of our national parks that we have ever experienced" (NPS 2010). In response, the NPS has taken an active role in addressing the issues climate change presents to parks and long-term resource stewardship. In 2009, the NPS established the Climate Change Response Program. Since then, the NPS has developed a family of documents that further support coordinated climate change response; to date these include: *Climate Change Response Strategy* (2010), *Climate Change Action Plan* 2012-2014 (2012), *Green Parks Plan* (2012), *Using Scenarios to Explore Climate Change: A Handbook for Practitioners* (2013), and Director's policy memoranda addressing management policies (PM12-02), cultural resources (PM 14-02), and facilities (PM15-01). Climate change is being incorporated into park planning documents and regional climate change action plans and a range of park-level assessments and projects are connecting climate science, policy, and practice across the Service. This Strategy builds on the foundation of PM14-02 and is intended primarily as a companion document to the *Climate Change Response Strategy* (2010). It incorporates approaches and methods from other NPS documents throughout.

Purpose of this Strategy

The purpose of this Strategy is to set out the broad scope of cultural resources in relation to climate change and identify major directions of action in cultural resources and climate change for the NPS. These directions in turn will shape and help support collaboration with cultural resource partners, both nationally and internationally. The Goals of this Strategy will be relevant as long as modern climate change persists. As knowledge and practice of cultural resources stewardship in relation to climate change develop, additional goals may be needed and action plans, handbooks, and detailed guidance prepared to support ongoing stewardship.

STRUCTURE OF THE STRATEGY

The NPS Director's Policy Memorandum 14-02, *Climate Change and Stewardship of Cultural Resources* (hereafter PM 14-02), released in 2014, set a foundation for management of cultural resources in the modern era of climate change. This foundation includes the following major points:

- There are two primary and equal considerations for cultural resources in relation to climate change: "(1) cultural resources are primary sources of data regarding human interactions with environmental change; and (2) changing climates affect the preservation and maintenance of cultural resources";

- As the material components of cultural resources often cannot change with the environment around them, a focus for climate change adaptation is our management of them;

- Management decisions for cultural resources should integrate diverse sources of information, prioritize according to vulnerability and significance, engage a broad array of stakeholders, and recognize the potential for loss; and

- Through the stories and understanding they anchor, cultural resources hold an essential role in climate change communication.

Since PM 14-02 was released, the NPS has moved forward through the work of the NPS Climate Change Response Program, regions, programs, parks, and partners and gathered additional experience and identified new issues. This Strategy integrates the foundation of PM14-02 and the scope of climate practice across the NPS and its partners to date. Taken together, this Strategy is forward looking, but grounded in experiences and discoveries of recent years.

Using this background as a starting point, this Strategy sets out the following four overarching Goals for cultural resources and climate change:

- CONNECT IMPACTS AND INFORMATION
- UNDERSTAND THE SCOPE
- INTEGRATE PRACTICE
- LEARN AND SHARE

(Opposite) Rock art in Dominguez-Escalante National Conservation Area (BLM Photo/Bob Wick).

Building on the NPS Climate Change Response Strategy

The NPS *Climate Change Response Strategy* (CCRS, 2010) established 15 Service-wide goals, ranging from use of best available science to reduction of carbon footprints to collaboration with diverse partners. This Strategy is inspired by these goals and has incorporated them throughout. The CCRS established Goal 7 explicitly for cultural resources: *Develop, prioritize, and implement management strategies to preserve climate-sensitive cultural resources*. This Strategy provides a strong and comprehensive basis for addressing Goal 7. The four objectives of the CCRS under its Goal 7 have been directly incorporated into this Strategy as follows:

Objective 7.1: *Use the best available science to develop and apply a process to prioritize cultural resource adaptation projects that combine established management tools with newer methods, such as vulnerability assessments.*
This objective is incorporated into Goal 3 of this Strategy.

Objective 7.2: *Increase the capacity and utility of the NPS Museum Program to preserve and protect resources.*
Work on this is underway in response to a directive in PM14-02. Tools to support this objective are also incorporated into Goal 2 of this Strategy.

Objective 7.3: *Strengthen partnerships with traditionally associated peoples through consultation and civic engagement to ensure the preservation of ethnographically significant resources and continued access to these resources.*
This objective incorporated into Goal 1, Goal 3, and Goal 4 of this Strategy.

Objective 7.4: *Expand the NPS capacity to conduct inventory and monitoring of archeological sites in anticipation of climate change impacts and support curation of artifacts and associated documentation.*
This objective is incorporated into Goal 3 of this Strategy.

GOALS

CONNECT IMPACTS & INFORMATION

Set the broad scope of cultural resources and climate change response by connecting the concepts of impacts and information with the four pillars of climate change response: science, adaptation, mitigation, and communication.

This Goal addresses the need to clearly indicate what it means to address climate change for cultural resources - what does climate change response for cultural resources look like? What are all of its parts? This Goal connects cultural resources to all four pillars of climate change response defined in the NPS *Climate Change Response Strategy* (2010) and responds to the call in PM14-02 to "help guide our collective actions with respect to climate change."

Work under Goal 1 **Connect Impacts and Information** begins with integrating the four pillars of climate change response identified in the NPS *Climate Change Response Strategy* (2010): science, adaptation, mitigation, and communication, with the two cultural resource management considerations set out by PM 14-02: addressing the effects of climate change (hereafter indicated by the term "Impacts"), and engaging with the capacity to learn from cultural resources (hereafter indicated by the term "Information").This integration yields an eight-part concept framework that encompasses the full range of action needed to address the needs and potentials of cultural resources in relation to climate change.

The concept framework developed under Goal 1 is a starting point for coordination and collaboration among and between partners. It is anticipated that no one institution will be able to work in all areas of the framework. However, the establishment of this framework provides a means to map priorities and planning and track diverse efforts to research and respond to climate change in relation to cultural resources.

UNDERSTAND THE SCOPE

Coordinate science, management, and communication to identify and improve understanding of the effects of climate change on cultural resources.

Goal 2 sets directions for initial climate change impacts-based research. All parts of the framework set out in Goal 1 are important. However it is difficult to learn from cultural resources, develop adaptation strategies for them, or incorporate them into mitigation plans if they have been damaged or destroyed. Therefore, work under Goal 2 is foundational to undertaking or furthering work in other parts of the overall framework.

Goal 2 **Understand the Scope** builds from the charge in PM14-02 to *2.C. Understand the Range of Climate Change Effects: Cultural resources are vulnerable to dramatic and well-publicized effects of climate change, such as sea level rise or storm surge. Evidence from across the Service is beginning to indicate they are also vulnerable to inland and other more subtle effects of climate change, such as the impacts of more freeze/thaw cycles on stone walls or more rapid wetting and drying cycles on adobe buildings. We must improve our understanding of these additional impacts, address them in our stewardship practices, and be able to communicate them to the public.*

INTEGRATE PRACTICE

Incorporate climate change into ongoing cultural resources research, planning, and stewardship.

Goal 3 recognizes that climate change data, projections, and responses must be an integral part of cultural resources management going forward. Climate change research, planning, and stewardship cannot be isolated to a given task, management phase, or practitioner, but rather must be ongoing and reflexive throughout the management cycle.

Goal 3 **Integrate Practice** sets the goal of aligning techniques that have been adopted particularly for the challenges of climate change, such as scenario planning and vulnerability assessment, with the processes of incorporating new climate information and changing climatic conditions into ongoing practices of cultural resources inventory, monitoring, management, education, and interpretation. This Goal draws from multiple topics set out in PM 14-02 for adaptation and decision-making, including:

1.C. Incorporation of Cultural Resources into Sustainability;
2.A. Refocus Inventory Responsibilities;
2.B. Integrate Resource Vulnerability and Significance;
2.D. Consult Broadly;
2.E. Value Information from the Past;
2.F. Recognize Loss; and the recognition that
3. "Every place has a climate story, many have more than one."

LEARN AND SHARE

Collaborate with partners to grow and use the body of knowledge and practice for cultural resources and climate change.

Goal 4 addresses the urgency of global climate change and the collective nature of human heritage. Science to date is indicating diverse environmental changes, some rapid, which are or likely are attributable to climate change. These changes are adding new and variable stresses to cultural resources around the world. In turn, as cultural resources are connected to human experiences in specific places, capacity to learn from them also extends around the world. As set out in Goal 1, collaboration from the local to international scale to share information and ideas is needed to build a robust and sustainable climate change response for cultural resources.

Goal 4 **Learn and Share** builds from the charge in PM 14-02 that *"We must be well-informed and creative in our approach to resource management given the effects of climate change. The paths climate change will take remain uncertain so we must be open to the unexpected, search out new and useful ideas, and share the innovations we develop. This cannot be a NPS-only effort, but instead will require a collaborative approach in order to be successful. This effort will include our international partners, as we learn from their work and perspectives, and share our own."*

HOW TO USE THIS STRATEGY

Each Goal in this Strategy is organized with an introduction, directions for action, supporting tools, and a major summary figure or table (hereafter termed as a central graphic). Relevant case studies are included throughout.

Goal introductions provide the context and basis for each Goal.

Directions for Action list specific next steps that can be taken toward each Goal. These actions are phrased such that they speak most directly to NPS cultural resources management, although it is anticipated that many of these actions also will be relevant for partners.

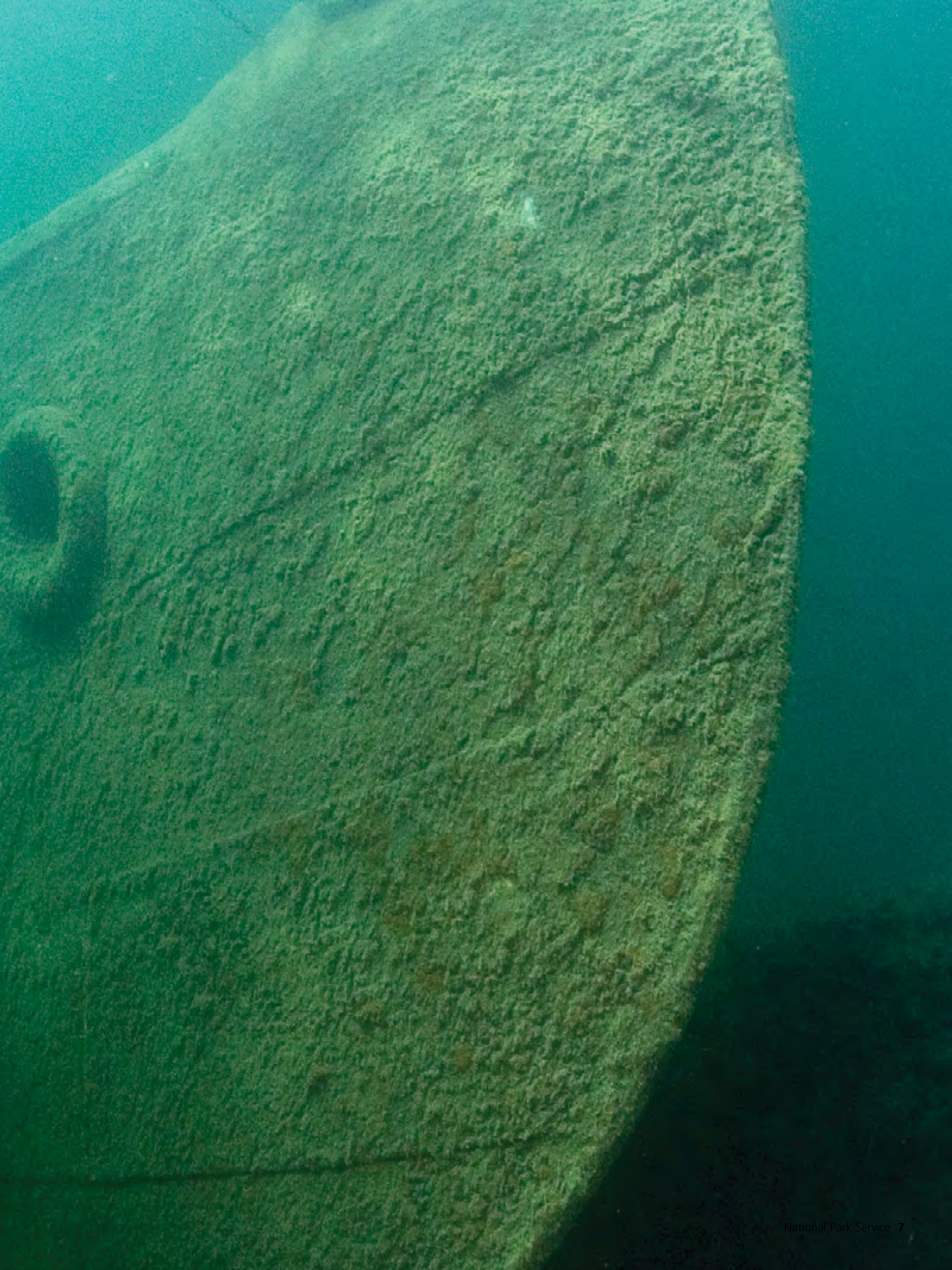
Supporting tools follow the opening context on pages with broad colored sidebars. The supporting tool pages provide summaries of existing work or directions and knowledge, or definitions of concepts called out in the Goal introduction. These pages are not handbooks in the conventional sense, as in most cases policy, practice, and guidance for the issues at hand are still being developed. However, the tools sections point to such information where it is available.

The central graphics summarize the context and supporting tools of each Goal. In the case of Goal 2, **Understand the Scope**, the central graphic is the supporting tool for that Goal.

Case studies included within each Goal illustrate work that has already been done in a park or by a partner on an aspect of that Goal.

Sections of the Strategy can be combined and used in different ways. For example, for an overview of the connections between cultural resources and climate change, refer to the introductions of each Goal, particularly Goals 1 and 4. For practical information on how to address climate change within cultural resources management, refer to Goals 2 and 3. For examples of what has been accomplished to date in cultural resources and climate change, review the case studies across Goals 1, 3, and 4 and the central graphic of Goal 2.

A diver examines the America shipwreck at Isle Royale National Park. Effects of climate change on submerged cultural resources are not yet well-defined (NPS Submerged Resources Center photo/Brett Seymour).



1 CONNECT IMPACTS AND INFORMATION

Set out the broad scope of cultural resources and climate change response by connecting the concepts of impacts and information with the four pillars of climate change response: science, adaptation, mitigation, and communication.

What does climate change response for cultural resources look like? What are its parts? The framework developed under Goal 1 sets out a vision of the broad scope of cultural resources and climate change and provides a starting point for coordination and collaboration within NPS and with partners. This framework provides a means to map priorities and plan and share diverse efforts to research and respond to climate change in relation to cultural resources.

PM14-02 established two considerations for cultural resources management in relation to climate change:

NPS cultural resource management must keep in mind that (1) cultural resources are primary sources of data regarding human interactions with environmental change; and (2) changing climates affect the preservation and maintenance of cultural resources.

These two considerations can be summarized as (1) Information and (2) Impacts.

Hereafter, Impacts are discussed first, followed by Information. While these two considerations are of equal importance, this reversal recognizes that Impacts often are more familiar and Information can be lost or hard to use if resources are damaged.

In turn, the NPS *Climate Change Response Strategy* (2010) set out four components, or pillars, for climate change response: science, adaptation, mitigation, and communication. Briefly, the science pillar encompasses gathering and testing of climate and impacts data and models. Adaptation develops flexible approaches for managing resources with respect to climate change. Mitigation reduces greenhouse gas emissions and improves energy efficiency and sustainability[1]. Communication shares information about climate change within the NPS and with partners and the public.

Integrating the two cultural resources considerations, Impacts and Information, with the four pillars of NPS climate change response yields an eight-part framework, shown in Graphic 1, *Concept Framework for Cultural Resources and Climate Change.* In this framework, concepts on the Impacts side of each pillar relate to or describe practical resource management challenges presented by climate change. Concepts on the Information side are the data and meaning cultural resources can provide in response to questions raised by the phenomenon of climate change for resource management and society as a whole.

Taken together, this array of concepts is the broad scope of action, investigations, and connections needed to address the needs and potentials of cultural resources in relation to climate change. The concepts shown in Graphic 1 are not exhaustive; the topics listed are illustrative and other concepts and topics can be added as they develop. This framework will support integration of resource management across cultural and natural resources management and facilities management by organizing the diversity of cultural resource impacts and information topics, many of which overlap with natural resources and facilities management.

The balance of this section of the Strategy provides more detail on topics listed in the concept framework. **Goal 1 Directions for Action** are developed within each section of the framework.

Melting ice patches, such as this one at Yellowstone National Park, are revealing artifacts that provide information on past environments and lifeways (NPS photo).

[1] In cultural resources management, the term mitigation refers to the practice of reducing the adverse effects of human actions on cultural resources. This Strategy follows the climate change definition of mitigation which refers to reductions of greenhouse gas emissions and related concepts of energy efficiency and sustainability.

SCIENCE		MITIGATION	
IMPACTS	INFORMATION	IMPACTS	INFORMATION
• Climate science at cultural heritage-relevant scales • Cultural resource (CR) vulnerability assessments • CR inventory/monitoring techniques and protocols • Integrated CR databases-geographic information system (GIS) • Preservation science • Documentation science	• Paleoclimate/paleoecology • Traditional ecological knowledge • Social climatic thresholds • Shifting baselines • Past land use and human impacts on environments • Paleogenetics	• Integration of historic buildings into energy efficiency plans • Resource conservation through historic or native landscapes • Reduce carbon footprint of CR management practices	• Past architectural and landscape techniques suited to local environments • Cultural heritage to conserve/reestablish sense of place and community stewardship

ADAPTATION		COMMUNICATION	
IMPACTS	INFORMATION	IMPACTS	INFORMATION
• Scenario planning • Adaptation options • Decision frameworks • Disaster risk reduction/ response connections • Policies and standards • Contexts/theme studies to support decision frameworks	• Past social adaptability per environmental change • Traditional ecological knowledge • Relating past adaptability to current issues, methods, and decisions	• Cultural resources climate change (CR-CC) literacy • Dialogue between impacts and information in all pillars • Links between CR-CC managers (local-tribal-intl.) • CR-CC links to public	Every Place has a Climate Story: • Change in material culture • Change in experience and lifeways • Insights on change from past societies • Origins of the modern climate situation

Graphic 1: *Concept Framework for Cultural Resources and Climate Change*. This framework applies two climate considerations for cultural resources, the effects of climate change on cultural resources (Impacts) and the capacity to learn about long-term human interactions with environmental and climatic change (Information), across the four pillars of the NPS climate change response: science, adaptation, mitigation, and communication (NPS 2010). The resulting matrix illustrates the broad scope of action needed to address the needs and potentials of cultural resources in relation to climate change.

SCIENCE

Adobe architecture of San Jose de Tumacácori Church is vulnerable to changes in rainfall (NPS photo).

Case Study: Tumacácori

The Franciscan church of San Jose de Tumacácori is a more than 200-year-old adobe church and one of the fundamental resources of Tumacácori National Historical Park (TUMA) in southern Arizona. In 2010, following an intense early winter rainfall, a hole developed around the west sanctuary window and caused the loss of nearly a ton of adobe and two lintels. Later the same year, after the summer monsoon, a large portion of the north wall of the sacristy collapsed. In 2015, a fireplace in the convento collapsed following an intense and unusually timed autumn rainfall.

Analysis of historical temperature records since 1900 in the TUMA area shows that mean annual temperatures in the 10-year interval 2003-2012 exceeded more than 90 percent of mean annual temperatures from the preceding century. Climate projections for the Southwest suggest that, along with increased temperatures, there will be less precipitation overall, with increased high intensity rainfalls and increased variability (meaning greater potential for heavy rainfall events at times of the year when previously they didn't happen).

So can the damage that developed at TUMA in 2010 and 2015 be linked to climate change? This is actually a difficult and complex question. To date, long-term monitoring of cultural resources in relation to environmental variables has been very limited. As well, assessment of damage such as seen at TUMA also must include preservation treatment histories, maintenance backlogs, condition of the building or resource, as well as the interactions of materials that make up cultural resources, such as adobe and gypsum plaster, with stresses caused by fluctuations in the local environment.

Therefore, in order to prepare for and better prevent similar damage in the future, recommendations out of the TUMA experience include cultural resource managers working more closely with climate scientists to understand fine-scale local climate patterns, increased local monitoring with real time weather stations, and working with material scientists to understand how changing climates could accelerate the breakdown of historic materials. This information should then inform the adaptation practice of scenario planning.

(Sources: communication with TUMA staff 2016, Monahan and Fisichelli 2014, Moss 2010)

The Science pillar of climate change response gathers and develops climate data, models, and related data acquisition, analysis, and response techniques. Work in the Impacts area of Science for cultural resources

Impacts

Science of climate impacts to cultural resources encompasses the following cultural resource management challenges:

- Identification of impacts and thresholds
- Assessment of vulnerabilities
- Monitoring for change
- Techniques for preservation and documentation

Science Impacts concepts include:

Climate science at spatial and temporal scales relevant to cultural resources
Using spatial and temporal data appropriate to the effects of climate change on cultural resources

Vulnerability assessments
Connecting exposure to climate impacts with resource-specific sensitivities to determine impact risk at site-specific and regional scales

Inventory and monitoring techniques and protocols
Integrating climate projections and associated impacts into baseline data gathering

Integrated databases and GIS
Using location to link existing descriptive databases and improve data consistency, quality, and accuracy

Preservation science
Developing and applying appropriate preservation tools developed by and with the historic preservation community to climate-vulnerable resources

Documentation science
Developing and applying recording tools and documentation standards to climate-vulnerable resources

Goal 1 Science-Impacts Directions for Action

- Identify and monitor cultural resource condition assessment "vital signs"
- Develop systems for indicating and comparing cultural resource vulnerability to climate impacts
- Build and maintain geospatial (GIS) interconnections between cultural and other asset and resource databases
- Identify gaps in resource inventory and documentation
- Connect preservation and documentation techniques to climate impacts; identify gaps and develop new techniques as needed

applies these to the effects of climate change. Work in the Information area of Science builds climate-relevant data, models, and analyses from cultural resources and related fields of practice.

Information

Archeological, anthropological, and historical sciences and traditional ecological knowledge provide data and models that are part of addressing climate change questions such as:

- How have climate and environments changed over time?
- How have animal and plant communities changed in relation to human use over time?
- How have humans changed environments and landscapes over time?
- How did past climate and environmental changes translate into living conditions for human societies?

Science Information concepts include:

Paleoclimate/paleoecology
Using materials from archeological sites, collections, and other resources to identify previous changes in climate/environment

Traditional ecological knowledge
Working with traditional and indigenous communities to better understand historical trends, how they are changing, and long-term human interactions with those trends

Social climatic thresholds
Using paleoenvironmental and archeological data, traditional ecological knowledge, and ethnographic accounts to assess how measurable changes in climate and environment affected living conditions for different human groups and economies

Shifting baselines
Assessing what is considered "normal" for animal and plant communities and how such communities and perceptions of them may have changed over time

Past land use and human impacts on the environment
Assessing how humans have used, managed, and modified landscapes and resources over time

Paleogenetics
Using archeozoological and archeobotanical remains as sources of genetic material from populations adapted to different climatic and/or social conditions

Goal 1 Science-Information Directions for Action

- Incorporate cultural resource science information concepts into collection and other research initiatives
- Prioritize research applications addressing cultural resource science information concepts
- Coordinate with funding partners to support research in cultural resource science information topics

SCIENCE

Erosion of shell mounds is removing human and paleoclimatic history along the Florida Gulf Coast (NPS Photo).

Case Study: De Soto National Memorial

Archeological sites in De Soto National Memorial (DESO), located on the Gulf Coast of Florida, include a series of seven curvilinear shell mounds. Pottery sherds and food remains mixed in with the shell confirm the mounds are middens (human-derived trash deposits), not natural shell deposits. Radiocarbon dating indicates the midden areas were occupied between 365 BC and AD 1395, with the inland mound being the oldest and those closest to the coast being the youngest. This dating pattern indicates shoreline progradation, meaning that when the site was first occupied the shoreline was further east than it is now. As the shoreline shifted westward, residents of the site moved with it, building new shell mounds along the new shorelines.

But that is not the only evidence of change. Analysis of shell from across the mounds shows that the older ridges contain the greatest number of individual specimens of fish and the greatest diversity of fish. The decrease in abundance and biodiversity illustrated in these shell middens could have been due to climatic or environmental change, overexploitation of local resources, habitat degradation, or some combination of all three. Therefore, additional research is now underway to explore these possibilities.

(Source: Schwadron 2000)

ADAPTATION

Officer's Row at Fort Hancock, Gateway National Recreation Area, was damaged during Superstorm Sandy in October 2012 (NPS photo).

Case Study: Gateway National Recreation Area

Gateway National Recreation Area (GATE), located in New York City and New Jersey, is made up of three park units. These include a large and diverse array of cultural resources, including a National Historic Landmark (Fort Hancock and Sandy Proving Ground), nine historic districts (cultural landscapes) and more than 600 historic structures, numerous gun batteries, airfields, missile silos, and prehistoric archeological sites. To better manage this inventory and its maintenance needs, GATE created a prioritization process for cultural resources, identifying management banding (preserve, stabilize, and ruin) that considered characteristics such as resource condition, use potential, and uniqueness.

Unfortunately, the effects of climate change do not wait for planning; GATE's prioritization work was incomplete when Hurricane Sandy hit on October 29, 2012, and had not yet incorporated climate change vulnerability. The experience of Hurricane Sandy made this an imperative. NPS staff used Sandy's damage patterns to identify levels of resource vulnerability, as updated flood maps were not yet available. This data reorganized some of the resource prioritization orders, and a programmatic agreement between GATE and the New York and New Jersey Historic Preservation Office outlined a path for consultation regarding resources within the ruin band. The updated prioritization banding is now part of the GATE General Management Plan (GMP). While acknowledging that prioritizing the preservation of certain sites over others can be an uncomfortable fit with the ideals of the NPS mission, GATE's experience with Hurricane Sandy confirmed that prioritization will help with good rapid decisions in the face of future challenges, and that planning is an important part of adaptation. Other NPS units, including but not limited to Yellowstone and Grand Teton National Parks and the National Capitol Region, are also undertaking prioritization processes for their cultural resources. Coordination of similar approaches across the Service, with cultural resource subject matter experts, will be an important next step.

(Source: GATE park staff, personal communications, 2013-16)

Adaptation has been defined by the Intergovernmental Panel on Climate Change and adopted by the NPS (2010) as "an adjustment in natural or human systems that moderates harm or exploits beneficial opportunities in response to change."

Impacts

Adaptation for climate impacts gathers interlinking approaches needed to address the diversity, variability, and uncertainty of climate change effects in cultural resources management, including:

- Policy
- Planning
- Stewardship
- Decision-making

Adaptation Impacts concepts include:

Scenario planning
Practice in flexible thinking and identification and testing of robust actions for cultural resources under uncertain future conditions

Adaptation options
Developing and testing an array of management options to best support cultural resources, given their vulnerability, significance, material thresholds, and other management considerations

Planning and decision frameworks
Integrating climate change into ongoing cultural resources research, planning, consultation, and stewardship practices

Connecting with disaster planning and response
Integrating cultural resources into disaster preparation and response plans and practices; Building consistency between climate change adaptation approaches for cultural resources and disaster preparation and response plans and practices

Context statements and theme studies
Research and analysis to incorporate capacity to learn about human adaptability from cultural resources into significance assessments and landscape scale decision-frameworks

Policies and guidelines
Support for adaptive management and decision-making

Goal 1 Adaptation-Impacts Directions for Action

- Develop guidance to relate historic preservation legislation and programs to climate change adaptation
- Develop adaptation approaches for long-term climate change impacts and acute disasters
- Build adaptation option case studies and guidance for cultural resources
- Develop methods for prioritization of vulnerable cultural resources for adaptive action
- Practice robust decision-making for cultural resources through scenario planning

ADAPTATION

As cultural resources are or may include non-living components, they have limited or no capacity to adapt to changing conditions. Climate change adaptation for cultural resources therefore lies in our use and management of them.

Information

The Information side of the Adaptation pillar provides the means to assess the pasts of civilizations, societies, social groups, and communities and ask: what does it mean to adapt? What do resilience and sustainability look like? No past society is a direct stand-in for the present. However, research in and information from the past across different temporal, geographic, and social scales allow us to explore and expand our ideas about what change and adjustment of human systems could look like. As such, information from cultural resources should be part of responses to the following questions:

- How do we define adaptation and resilience for individuals, communities, and societies?
- What do successful adaptation and resilience look like, for individuals, communities, and societies?
- How have economies and societies changed through time, particularly in response to environmental change and disasters?

Adaptation Information concepts include:

Past social adaptability per environmental change
Assessing and testing models and definitions of adaptability, resilience, sustainability, and change with information from the past

Relating past adaptability to current issues, methods, and decisions
Examining the origins of modern environmentally related perspectives and behaviors to inform adaptation options going forward and finding inspiration for alternatives and the process for change through examples of past change

Traditional ecological knowledge
Incorporating knowledge, traditions, practices, and ethnographic accounts/ethnohistory with connections to the local environment into adaptation plans and practices

Goal 1 Adaptation-Information Directions for Action

- Incorporate cultural resource adaptation information concepts into field, collections, and other research initiatives
- Prioritize research and workshop/conference applications addressing adaptation information concepts
- Coordinate with funding partners to support research in cultural resource adaptation information topics
- Practice incorporating insights from cultural resources adaptation information into adaptation planning

The Channel Islands were home to the Chumash California Indians for many generations (NPS photo).

Case Study: Chumash, Channel Islands

The Chumash people of central California, including the islands now encompassed within Channel Islands National Park (CHIS), have lived there for a very long time. Archeological research has illustrated changes in lifeways from earlier hunter-gatherer patterns to later settled villages with stratified society and complex craft traditions and trade connections.

Paleoenvironmental studies have added information about the world in which these lifeways were set. For instance, the period between AD 450 and 1300 was characterized by cold, highly unstable marine conditions, high marine productivity, and an inferred dry (low productivity) terrestrial climate. The later end of this time period, the Medieval Warm Period, is also known for extended droughts in the American Southwest, which contributed to migrations from that area and the depopulation of the settlements now preserved as ruins in Mesa Verde National Park and Chaco Culture National Historical Park, among others.

But the Chumash stayed in place. Archeological and linguistic evidence indicates social and economic changes, including expansion of and changes in the control of trade. In turn, bioarcheological evidence shows this time period was not without stress, through both malnutrition and an increase in violent conflict.

Stories and ethnographic information shared by the Chumash in historic times includes an annual tradition that recognizes the ongoing uncertain balance of good weather and drought as a conflict between Coyote and the Sun. It is not known if this tradition was part of Chumash society during the Medieval Warm Period or captures their experiences during that time. Taken all together, however, the cultural history of the Chumash is an important touch point for the modern world in understanding concepts such as resilience, adaptation, change, persistence, and how different cultural systems can embody them.

(Source: Rockman 2012)

MITIGATION

Historic window repair at Saint-Gaudens National Historic Site improves energy efficiency (NPS photo).

Case Study: Saint-Gaudens Window Repair

In 2010, Saint-Gaudens National Historic Site, located in western New Hampshire, acquired a neighboring property, Blow-Me-Down Farm, and incorporated it into the park. The farm, located directly on the banks of the Connecticut River, has nine historic structures that have yet to be restored and opened to the public, including a farmhouse, a large barn, and a dance hall. Recently, the park carried out a wooden window restoration project for the dance hall, which both kicked off stewardship of the new properties and provided training in historic preservation for NPS staff and members of the public. Although intended for preservation purposes, this project also helped mitigate climate change in two ways. First, by making the historic windows weathertight again, the building will be more energy efficient with minimum input of new materials. Second, by opening the class to the public, the park provided a basis for additional similar restorations in surrounding communities.[1]

This follows the recommendations of the NPS Technical Preservation Services, which notes that “The common misconception that replacing windows will save as much as 50% in energy costs is simply not true. The windows in many historic buildings have functioned for more than 100 years and, with regular maintenance, will usually survive longer and work better than any replacement window. A replacement window does not generally pay for itself in a reasonable length of time. Unlike historic windows, new window assemblies cannot be repaired; they can only be replaced once again. The sustainable choice is to repair historic windows whenever possible.”[2]

(Sources: 1. Fishburn 2013; 2. NPS Technical Preservation Services: Weatherization: Windows & Doors, http://www.nps.gov/tps/ sustainability/energy-efficiency/weatherization/ windows-doors.htm)

Mitigation addresses reduction of greenhouse gas emissions and overall environmental footprint. To date, both the Impacts and Information sides of this pillar focus on historic buildings and structures and cultural

Impacts

The impacts side of the Mitigation pillar addresses the role of cultural resources in achieving the management goals of:

- Reducing emissions of greenhouse gases
- Improving energy efficiency
- Enabling expanded use of renewable energy

Mitigation Impacts concepts include:

Integration of historic buildings into energy plans
Continued use of existing buildings

Use of energy efficient technologies in alignment with maintenance of historic character

Resource conservation through historic or native landscapes
Use of native plants where appropriate to reduce water use and enhance pest control

Reduction of carbon footprint of cultural resource management practices
Reducing energy-intensiveness of cultural resources maintenance, research, and assessment techniques and practices

Goal 1 Mitigation-Impact Directions for Action

- Maximize the energy efficiency of historic buildings through continued maintenance (such as caulking, etc.)
- Reduce energy needs through use of original energy-saving features (shutters, crosswinds, etc) and historic landscape management techniques
- Following The Secretary of the Interior’s Standards for Rehabilitation & Illustrated Guidelines on Sustainability for Rehabilitating Historic Buildings, continue to add energy efficiency and renewable energy methods to historic buildings, landscapes, and parks

landscapes sectors of cultural resources, as buildings and landscape use and maintenance tend to be energy intensive. It is anticipated however, that all sectors of cultural resources can and will play a role in Mitigation.

Information

The information side of the Mitigation pillar engages with lower energy and resource use practices from the past and the broad scope of historical and present relationships between energy, lifeways, and place.

As such, information from cultural resources can contribute to answering such questions as:

- What are the many possible ways to live and build in a place that are energy and resource efficient?
- How can the history of a place support environmental stewardship?

Mitigation Information concepts include:

Preserve and learn from past architectural and landscape techniques
Showcasing innovations and adaptations from the past and indigenous and traditional communities that used or use lower inputs of energy

Conserve or re-establish sense of place, which can support improved community and environmental stewardship
Expanding and engaging historic preservation and public archeology at the community level

Goal 1 Mitigation-Information Directions for Action

- Incorporate historic energy saving features into NPS Climate Friendly Parks training and other NPS Green Parks Plan programs
- Share historic and landscape energy-saving features as a part of communication and interpretation plans

MITIGATION

Engineered logjam under construction at Mount Rainier National Park (NPS photo).

Case Study: Mount Rainier Log Jams

Roads in Mount Ranier National Park (MORA), in Washington, are an excellent example of rustic and naturalistic design. In fact, they are part of the MORA National Historic Landmark District, designated to recognize the NPS-wide influence of "NPS Rustic" architecture first developed at MORA. The roads follow the natural corridors of the mountain as much as possible. And road engineers in the 1910s – 1920s, including those who built Nisqually Road, used log structures to shore-up embankments, which were then revegetated with native species. These log-crib structures had several characteristics that made them well-suited to the environment around Mount Rainier: they reflected the natural environment of the region, provided habitat for native species, and their rough surfaces slowed the flow of river water, which helped them stay in place during flood events.

However, beginning in the 1950s, road repair in MORA and elsewhere turned to the use of riprap – large, angular rocks placed at an angle of repose to support an embankment. These riprap embankments have not withstood the pressures of flooding in MORA. As average global temperatures warm and glaciers melt, MORA has experienced an increase in extreme flood events. Increases in glacial melting have led to an increase in the amount of sediment flowing downstream, which has caused aggradation of streams and rivers, leading in turn to higher floods. Even very large boulders in rip rap have washed away during extreme floods, taking large sections of road with them.

In response, MORA has begun repairing roads and constructing erosion control structures using log structures and engineered log-jams, techniques reminiscent of historic construction methods that preserve the naturalistic features of the park, are more resistant to flood damage, and provide habitat for fish and other aquatic species, including the threatened species Bull Trout. These log structures show how components of older technology, which had been designed with the immediate environment in mind, can increase the resiliency of infrastructure to the hazards, such as flooding, most common in that environment.

(Sources: Catton 1996, Dolan and Gilbert 2004, Walkinshaw and Dolan 2013)

COMMUNICATION


Interpretation in action at Colonial National Historical Park (NPS photo).

Case Study: Climate Change Interpretation Training

Interpreting Climate Change is an NPS course developed by the Climate Change Response Program and the Stephen T. Mather Training Center to build skills in sharing climate change information with park audiences. Pre-course work includes basic training in the theory and methods of interpretation. The course then builds out practical knowledge and skills for interpreters to develop effective, engaging climate change programming for both natural and cultural sites. Participants work with a range of engagement techniques such as facilitated dialogue, skills for dealing with controversy, and presenting multiple perspectives. These and other techniques are applied to an overview of climate science and audience research. Participants share best practices and–through collaboration and group discussion–build confidence and identify meaningful climate change connection at their work sites. While the focus of this course is on personal interpretation, many of the best practices also apply to media development.

Cultural resources are integrated throughout the course through explorations of climate impacts to cultural resources, the historical development of climate change, and how cultures past and present have dealt with large-scale environmental change. The course is offered on a virtual platform – which saves travel costs and carbon! – and as a self-study module. Additional information can be found at: *http://idp.eppley.org/icc*.

Communication connects all of the pillars of climate change response and enables sharing of climate change information effectively within the NPS and with partners and the public. While there are strong connections between Impacts and Information for all cultural resource climate change pillars, these connections are particularly strong for Communication.

Impacts

The Impacts side of the Communication pillar addresses practical and coordination considerations for cultural resources climate change communication, such as:

- Training programs
- Publication, web, and social media platforms
- Networks between practitioners
- Community, volunteer, and youth connections
- Tribal consultation

Communication Impacts concepts include:

Cultural resources climate change literacy
Incorporating cultural resources topics and issues as part of climate change training

Dialogue between impacts and information across all pillars of climate change response
Establishing and maintaining connections between managers and researchers in science, adaptation, mitigation, and communications fields

Links between cultural resources-climate change managers (local-international)
Creating and participating in opportunities to share issues, approaches, and action across scales of management (local-international) practices

Cultural resources-climate change links to public
Creating and maintaining methods for sharing information about cultural resources and climate change with multiple audiences, including youth

Listening and partnering
Building and maintaining means of hearing from communities and providing opportunities for participation, volunteers, and collective action

Goal 1 Communication-Impacts Directions for Action

- Incorporate cultural resources into climate change training and academies
- Incorporate climate change topics/issues into cultural resources management training
- Form and participate in formal and informal cultural resources and climate change networks and communities of practice
- Develop and maintain cultural resources content in climate change communication platforms
- Build or expand climate change components of community engagement, public archeology, and citizen science programs

In fact, for Communication, the Impacts side can be seen as establishing the pathways for communication, while the Information side helps with content for communication.

Information

The Information side of the Communication pillar is about the essential data and profound meanings of cultural resources for climate change shared well. These help us answer questions such as:

- How can we connect the broad patterns of climate change with individual places?
- How do we find meaning in cultural resources for the challenges climate change presents to contemporary societies?
- How is climate change felt and understood at a human scale?
- How can sound climate science be merged with narratives and storytelling?

Communication Information concepts are founded on the idea that every place has a climate story. It is possible to connect climate change and human heritage in any place that has been a home to people at some point in time through at least one of the following themes:

Change in the material world
How do we see change happening in the material world (houses, artifacts, monuments, landscapes) around us?

Change in experience and lifeways
How are traditional and indigenous communities experiencing change in their practices, lifeways, and in relation to traditional knowledge? How are modern communities experiencing change? How do memories of and expectations for local climate and environments connect with current climatic conditions?

Insights on change from past societies
How have past societies interacted with and responded to past climatic variability and environmental change?

Origins of modern climate change situation
How has the modern climate change situation come to be?

Goal 1 Communication-Information Directions for Action

- Research and write climate stories of each park
- Incorporate climate stories in park interpretation programming and other outreach and education materials

COMMUNICATION

View of Sunset Crater from Wupatki National Monument (NPS photo).

Case Study: Sample Climate Story, Insights from the Past Theme, Wupatki National Monument

As discussed further in Goal 3, climate change stories are vehicles for communicating best available sound science while connecting climate change, cultural resources, and an experience of place. Climate stories are not fiction, but research organized as a narrative. One approach to preparing climate stories is the AND, BUT, THEREFORE (ABT) method. For example:

Circa AD 1064, Sunset Crater in northern Arizona erupted. The area now known as Wupatki National Monument (WUPA), 15 miles north of Sunset Crater, received 2-4 inches of ash and corn cobs encased in lava are evidence of the damage from the eruption. AND tree rings show that weather patterns in the area that had been wet turned dry at about this time and continued predominantly dry for several decades.

BUT despite the stresses of the eruption and change in climate, the local Sinagua people remained nearby. They moved to the plains below the crater, and began to farm again, with the addition of cinder mulch.

Stones and lithic material have been used to improve soil conditions in many places around the world in prehistory, but had not previously been used in northern Arizona. The cinders helped the dry soils retain moisture and may have improved farm yields beyond pre-eruption levels. Protection of the cinders may have waned after several decades, possibly alongside the continuing drought, but this innovation helped the Sinagua reestablish their lives after the volcanic disaster.

THEREFORE, the history and archeology of this area provide an example of traditional agriculture and innovation using local materials that may be useful in some places in the future as the climate becomes hotter and drier.

(Sources: for story content, N. Arendt (WUPA), personal communications, 2015; for And-But-Therefore storytelling method, see Olson (2015). For more about climate stories, see Goal 3.)

2 UNDERSTAND THE SCOPE

Coordinate science, management, and communication to identify and improve understanding of the effects of climate change on cultural resources.

Cultural resources have always been subject to environmental forces. The risks of climate change for cultural resources lie in the alteration and recombination of these forces, which together are increasing the diversity and intensity of impacts on cultural resources.

According to the best available climate assessments, by the Intergovernmental Panel on Climate Change (IPCC) and the third U.S. National Climate Assessment, some global climatic changes are already underway and cannot be avoided. With continued greenhouse gas emissions, projections predict a hotter Earth with larger and more unpredictable swings in precipitation and increases in sea level.

Cultural resources, given their diversity of types (see next page), materials and locations, living and non-living components, and tangible and intangible elements, interact with climatic changes in diverse ways. Some climate change impacts on cultural resources are being observed across the NPS, both in coastal zones and in the interior. These include visible and sometimes dramatic effects of climate change, such as sea level rise, storm surges, and wildfires.

Evidence from across the NPS is also beginning to indicate cultural resources are vulnerable to other, more subtle processes as well, such as the impacts of more freeze/thaw cycles on stone materials or more rapid wetting and drying cycles on adobe buildings, and the loss of human knowledge traditionally associated with material culture.

All parts of the concept framework for cultural resources and climate change set out in Goal 1 (see Graphic 1, p.9) are important. However it is difficult to learn from cultural resources, develop adaptation strategies for them, or incorporate them into mitigation plans if they have been damaged or destroyed. Therefore, work under Goal 2 is foundational to undertaking or furthering work in other parts of the framework.

Following from this, **Goal 2 Directions for Action** include:

- Continue research to identify the full range of effects of climate change on cultural resources. This may include citizen science.
- Gather and further develop research to assess tipping points and thresholds of cultural resources with respect to climate change impacts

Graphic 2, *Climate Change Impacts to Cultural Resources*, provides a starting point for this work.

Taos Pueblo threatened by the 2003 Encebado Fire (U.S. Forest Service photo/Ignacio Peralta, permission requested).

Climate Change Impacts on Cultural Resources

The following table, Graphic 2, is a first step in identifying the broad range of climate impacts to cultural resources, subtle to dramatic and coastal to interior, so that they can be included in stewardship practices. Given the diversity and uncertainty of climate change, this table cannot be exhaustive; other impacts to cultural resources likely will be identified as climatic changes develop.

However, it can be used as a guide for identified impacts and motivation for continued research, monitoring and understanding of all effects of climate change. While Graphic 2 is designed to support resource managers and planners within the NPS, the resource types and associated impacts reach beyond the boundaries of parks and information throughout the table is applicable to much cultural heritage around the world.

The table is organized according to the major trends of climate change: Temperature Change, Precipitation Change, Sea Level Rise, Combined Stressors, and Increased Greenhouse Gas (GHG) Emissions. Left hand columns in the table list the major observable phenomena of these climate trends, in other words – how these changing trends are being and will be experienced. These observable phenomena are how cultural resources are and will be exposed to climate change. The impacts listed within the table are examples of the sensitivities of cultural resources to climatic changes. Taken together, exposure and sensitivity are the primary components of cultural resources climate change vulnerability.

The impacts in this table were identified through a combination of literature review and consultation with cultural resource management specialists from across the NPS. An initial draft table was compiled from literature review which the specialists reviewed and expanded based on their field of expertise, including Archeology, Museum Collections, Cultural Landscapes, Ethnographic Resources, and Buildings and Structures. Subsequent peer review of the full table also included representatives from each cultural resource field.

Overall, Graphic 2 shows a diverse range of climate change impacts on cultural resources. Impacts include a combination of events and changing trends, which are occurring and will occur on coasts and throughout the interior. Given this diversity, it is likely that cultural resources in all park units are or will be affected by climate change in some way.

Cultural Resources

Archeological Sites

Physical evidence of past human occupation or activity (prehistoric and historic archeological sites).

Cultural Landscapes

Geographic areas associated with a historic event, activity, or person; or that exhibits other cultural or aesthetic values (this category includes designed, vernacular, and ethnographic landscapes). Cultural landscapes encompass both cultural and natural resources as well as wildlife or domestic animals that have historic associations with the landscape.

Ethnographic Resources

Sites, structures, objects, landscapes, and natural resources or features of traditional importance to a contemporary cultural group through associations three generations or more in length.

Museum Collections

Material things that possess scientific, historical, cultural, or aesthetic values (usually movable by nature or design).

Buildings and Structures

Constructed works created to serve human activity (usually immovable by nature or design- buildings, bridges, earthworks, roads, rock cairns, etc.).

	Impact on Cultural Resources				
	Archeological Resources	**Cultural Landscapes**	**Ethnographic Resources**	**Museum Collections**	**Buildings & Structures**
Increased Global Temperature	• Microcracking of site contexts from thermal stress[1] • Faster deterioration of newly exposed artifacts and sites[2] • Deterioration of newly exposed materials from melting alpine snow patches[3] • Accelerated rusting in submerged and littoral resources from warmer ocean temperatures[1] • More rapid decay of organic materials[1] • Damage from increased biological activity at shallow (~<100m) underwater sites[61] • Increased risk of damage due to decline/loss of protective sea grass or nearby coral reefs[61,62]	• Decline/disappearance of some vegetation species, other species favored[4] • Heat stress on culturally significant vegetation[4] • Increased stress (e.g. desiccation, warping, cracking, etc.) on constructed landscape features[4]	• Loss of necessary habitat for culturally significant species[4] • Potential loss of culturally significant species due to increased disease threat[5] • Changes in prevalence of culturally relevant plant and animal species[60] • Changes to crop yields and food security[6] • Limited winter hunting from increased winter snows[5] • Limited access to hunting areas due to reduced sea ice[7] • Altered place meaning due to loss of snow pack[7]	**Facilities** • Increased stresses on HVAC systems in storage facilities[8] • Increased space constraints due to more items requiring protection in storage facilities[8] • Increased need for environmental controls in facilities/house collections[9] **Collections (without appropriate climate controls)** • Increased rate of chemical decay[11] • Increased stress due to fluctuations in environmental conditions[10]	• Increased crystallization of efflorescent salts due to increased evaporation rates, leading to increased rates of structural cracking, deterioration[1] • Increased demand for complex air conditioning systems that can add stress to the building envelope and often requires significant alterations to a structure (including insulation, routing of extensive ducts and pipes, etc.)[12]
Increase Freeze/Thaw Cycles	• More rapid decay of organic materials[1] • Disruption of soil structure, especially in permafrost[26] • Destruction of archeological deposits due to increased solifluction (downhill flow of saturated soil) activity[3] • Increased rates of deterioration in metals from thermal stress[27]	• Decline/disappearance of some vegetation species due to recurrent freezing[4] • More rapid deterioration of constructed materials of landscape features (e.g. corrosion, decay, desiccation)[4]	• Food stress or starvation of foraging animals (horse, caribou) from impenetrable ice layers more likely to form on grazing fields[5]	**Facilities** • Surface cracking, flaking, and sugaring building stone and spalling of brick due to increase in wet-frost[1,10,16] • Greater structural damage due to fluctuating environment, causing cracks in building that allow more access for pests to invade and damage collections[10]	• Surface cracking, flaking, and sugaring of building stone and spalling of brick due to increase in wet-frost[1,10,16] • Damage to foundations due to increased frost heave action[1] • Spalling and collapse of caves and bedrock alcoves onto structures inside them[22] • Increased absorption of salts from road and sidewalk treatments which can lead to efflorescence, cracking, and spalling, etc.[12]
Permafrost Melt	• Loss of artifacts and contexts from increased erosion[6] • More rapid decay of organic materials[26] • Disruption of stratigraphy from changed soil structure, solifluction[52]	• Decline/disappearance of some vegetation species[4] • More rapid decay, dessication of constructed materials of landscape features[4]	• Destruction of land and buildings due to increased coastal erosion[6] • Forced relocation of communities[5] • Loss of access to wildlife corridors due to terrain that can no longer be traversed by foot or vehicle[15]	**Facilities** • Destabilization of buildings from cracks in foundations and other infrastructure[10]	• Destabilization of buildings; settlement into the ground[6,16] • More rapid decay of organic building materials[16,48] • Change in use or abandonment due to changes in access as the surrounding ground becomes boggy[22]
Higher Relative Humidity	• More rapid decay of organic materials[16] • Increased corrosion of vulnerable/less stable metals[2] • Increased mold, especially in enclosed sites (e.g. vaults, tumuli, and caves)[2]	• Decline/disappearance of critical vegetation species, other species favored[4] • Increased desiccation, warping, and cracking of constructed landscape features[4]	• Decline/disappearance of important vegetation species, other species favored[4] • Increase/spread of some vegetation species[4]	**Facilities** • Increased wear on HVAC systems, and energy use to stabilize drastic changes in humidity[28] **Collections (without appropriate climate controls)** • Increased rusting/corrosion of metals[16] • Damage to paintings[8] • Warping, cracking of wood[16] • Damage to archival, paper, book, and photo collections[10] • Increased risk of mold, especially organic collections[10] • Increased salt damage to ceramics with humidity fluctuations[11] • Increase in pest populations[29] • Accelerated deterioration of museum items exhibited outside[19]	• For brick and porous stone, increased moisture absorption, leading to increased risk of frost damage, mold growth, and stress from salt crystalization[16] • Decrease in crystallization and dissolution of salts within stone and masonry[16] • Sulfur dioxide deposits on wet/damp surfaces, corroding stone, metal, and glass[16] • Swelling and cracking of wooden building materials and architectural features[16] • Increased growth of destructive organisms (e.g. mold, algae) for wood, stone, and masonry[16,22] • Increased potential for rot in wood and other organic material[16]
Increased Wind	• Increased moisture penetration into porous materials[20] • Burial through redistribution of soil[14] • Abrasion of petroglyph and pictoglyphs[14] • Erosion and deflation of archeological deposits[2]	• Damage or loss of culturally significant plants[4] • Change in historic/culturally significant vegetation patterns[4] • Increase in need for protective structures that shelter landscapes[4]	• Reduced access to marine hunting grounds due to stronger/unusual wind patterns and shifting sea ice[7] • Reduced access to animals in open spaces due to wind chills that drop temperatures[15]	**Collections** • Damage to wooden, paper, textile and organic objects from decreased relative humidity[10]	• Direct wind damage[16] • Scouring/abrasion of exterior surfaces[1] • Increased cracking, spalling, splintering, weathering of buildings due to accelerated drying[1] • Damage from wind borne debris[2]

Temperature Change, cont'd

	Impact on Cultural Resources				
	Archeological Resources	**Cultural Landscapes**	**Ethnographic Resources**	**Museum Collections**	**Buildings & Structures**
Increased Wildfire	**During Fire** · Damage or destruction of associated structures[30] · Heat alteration of artifacts[30] · Heat fracturing of stone artifacts[30] · Paint oxidation, color change[30] · Physical damage from firefighting efforts (fire lines)[30] · Decreased accuracy of carbon-14 dating due to carbon contamination[30] **Post-Fire** · Damage from fire-killed tree fall[30] · Increased susceptibility to erosion and flooding[31] · Increased looting after fire exposure[31]	· Loss or damage of associated structures[23] · Change in vegetation density and composition[4] · Bedrock and border spalls[23] · Increased susceptibility to erosion and flooding[23] · Loss of soil fertility due to high heat[23] · Damage to structure and/or associated cultural landscape from fire retardants[22]	**During Fire** · Discoloration, exfoliation, spalling, and smudging of culturally significant rock images, geoglyphs[30] · Change in subsistence resources over large areas[15] · Loss of traditional knowledge due to change/loss of culturally significant resources[15] · Loss of critical and/or culturally significant species due to decreased soil fertility from high heat[30] **Post-Fire** · Altered migratory patterns of traditionally hunted animals[6] · Significant alteration of landscape features critical for navigating during foraging, hunting, or other necessary movements[30]	**Facilities** · Damage to storage facilities and contents[8] · Increased strain on existing museum facility and staff due to increased advance preparation and salvage operations[32] · Smoke damage, strain on HVAC systems[29] **Collections** · Damage to items and disassociation of materials and records during emergency evacuations[11]	**During Fire** · Damage or loss of whole structures, or combustible components[22] · Cracking, physical damage of masonry components from extreme thermal stress[30] · Discoloration caused by smoke and/or heat[30] · Damage from fire-killed tree fall[30] · Damage to structure and/or associated cultural landscape from fire retardants[22] **Post-Fire** · Buildings may shift or settle due to associated erosion[33,22] · Pressure to change character defining features such as wood shake roofing to fire resistant alternatives[34]
Changes in Seasonality and Phenology	· Site disruption from longer growing seasons and/or changing land use (irrigation use, harvest times)[13] · Changes in site or regional accessibility[14] · Reductions or alterations in length and timing of archeological field seasons, affecting capacity for identification or mitigation of climate and other impacts[14] · Possible reductions in site visibility[14]	· Loss of synchronicity between species[54] · Altered landscapes due to shifts in blooming times[54] · Loss of pollinators reduces plant fertility in historic agricultural landscapes[4]	· Loss of synchronicity between species[54] · Potential loss or reduction of plants used for medicine and ceremonies performed at particular times of the year[15] · Loss of plants used for ceremonies, medicine, and food due to early frosts[15] · Shifts in migratory patterns of significant marine animals due to changes in sea ice[7] · Limited access to winter marine hunting areas due to longer summers[7] · Food sources threatened by shifts in harvest time (esp. feed for herd animals)[5]	**Facilities, Collections** · Increased stress on buildings and materials due to increased range of temperature swings during seasonal transitions (particularly collections without appropriate climate controls)[9]	· Longer growing seasons lead to increased growth of invasive vegetation[12]
Species Shift	· Physical damage, loss of integrity, and spatial coherence from new/increased plant growth[16] · Physical impacts from associated adaptive behavior of animals following plant species movements[2] · Disruption from new foraging or nesting animals, including insects[2] · Changes in soil chemistry due to root penetration of new vegetation[17] · Increased shrub growth on former tundra, may obscure features and artifacts[3] · Possible reductions in site visibility[14]	· Changes in historic/culturally significant vegetation patterns[4] · Emigration and/or local extinction of culturally significant species[5] · Changes in landscape appearance from altered growth patterns of lichen[16]	· Loss of major food sources[42] · Loss of culturally significant plant and animal species[5] · Altered appearance of important ceremonial sites[42] · Breaks in memory, traditions, and context due to loss of species, species access, resource predictibility[18]	**Collections** · Increased need to expand voucher specimens (used for reference) in collection[19] · Increased need to identify existing voucher specimens, many uncatalogued in non-federal repositories, to serve as baselines[19]	· Increased growth of destructive organisms as temperatures warm (e.g. mold, algae)[1] · New threats to historic structures as incoming/colonizing species use them as habitat[22] · Spread of destructive vegetative species (like kudzu) farther north into new areas[12] · Loss of species that are necessary for historically appropriate repairs[20] · New/different micro-organisms cover surfaces of stone buildings - may reduce deterioration (possible benefit)[21]
Invasive Species/Pests	· Physical damage, loss of integrity and spatial coherence from altered habitat structure[16] · Data loss, subsidence, feature collapse, structural damage from invasive consuming organics[2] · Damage from new and increased number of burrowing animals[23] · Possible reductions in site visibility[14]	· Potential loss of significant plants due to introduction of new pests[4] · Potential biological selection pressure for incompatible vegetation or other biotic species[4] · Changes in viewsheds (e.g. battlefield parks)[24]	· Damage to distribution of subsistence crops, culturally significant plants[5] · Loss of culturally important animals due to changes in habitat from invasive plant species[15]	**Facilities** · Need for updated integrated pest management plans to account for new pest risks[11] · Invasion of pests via new routes created by thermal stress on facility[11] **Collections** · Increase in pest populations that damage organic materials (animal skins, wool)[11]	· New threats to wood structures and wooden architectural features as termites and other pests expand territory due to warmer, longer summers[25] · Spread of destructive vegetative species (like kudzu) farther north into new areas[12]

	Impact on Cultural Resources				
	Archeological Resources	**Cultural Landscapes**	**Ethnographic Resources**	**Museum Collections**	**Buildings & Structures**
Less Precipitation/Drought	• Loss of stratigraphic integrity due to crack/ heave damage in drier soils[17] • Destabilization of wetland or waterlogged sites[13] • Exposure of submerged sites due to lower water levels in lakes[14] • Sites more vulnerable to fire and wind[14] • Increased exposure from vegetation loss and erosion[14]	• Water stress may inhibit growth of some species[4] • Decline/disappearance of some vegetation species; other species favored[4] • Soil infertility due to decreased microbial activity[4] • Limited water supply inhibits established maintenance practices[17] • Increased soil erosion[4] • Challenges to current irrigation practices[4]	• Stress on culturally significant species impacts subsistence practices[6] • Indirect effects to ceremonial cycles and religious practices involving weather control[15] • Decline/disappearance of important vegetation species, other species favored[23] • Loss of some harvestable animals[15] • Disruption of social networks dependent upon regular water supplies (transportation)[15] • Loss of regular sources of water for drinking, medicine, ceremony, paints, etc.[15] • Loss of culturally relevant plants and animals[15] • Limitation on travel due to loss of water sources[15]	**Facilities** • Limited water supply for cooling, landscaping, other equipment[8] • Reduced humidity stress on building (possible benefit)[23] **Collections (without appropriate climate controls)** • Damage to wooden, paper, textile and organic objects from drying due to lower relative humidity[10]	• Increase in dry salt deposits near masonry and porous stone which hydrate and infiltrate during infrequent rain events causing spalls and fractures[12,1] • Reduced humidity stress on buildings (possible benefit)[23] • Cracking and splitting of wooden/ organic features due to complete drying[12]
More Precipitation and/or Heavier Precipitation	• Site erosion from overflow and new flood channels[17] • Soil destabilization/ shifting (ground heave, landslide, subsidence)[14] • Damage to unexcavated artifact and site integrity from direct force of water[35]	• Increased tree fall due to waterlogging[17] • Limited ability to plant in waterlogged soil[4] • Loss of historical integrity with improved drainage systems[17] • Decline/disappearance of some vegetation species[4] • Decreased soil fertility from erosion, waterlogging, leaching[4] • Loss of landscape features[4] • Increased susceptibility to destructive fungi[36] • Erosion of earthworks[24] • Disruption or delay of traditional maintenance practices (e.g. burning)[24]	• Altered harvest times, especially haying in herd cultures due to changes in precipitation patterns[5] • Delays in planting cycles, shifting whole agricultural calendar[6] • Increasing difficulty in predicting storms[37] • Indirect effects to ceremonial cycles and religious practices involving weather control[15]	**Facilities** • Added strain on existing museum facilities and staff due to salvage operations[32] • Potential leaks in collection storage areas and potential wetting of museum objects[10] • Increased cracking associated with ground heave and subsidence; destabilization of buildings and pipes[10] **Collections (without appropriate climate controls)** • Increase risk of mold, especially organic collections[10] • Increase rusting/corrosion of metals[10] • Humidity damage to paintings[10] • Warp, crack, damage wood[10] • Humidity damage to archival, paper, book, and photo collections[10]	• Swelling/distortion of wooden building materials and architecture features due to wetness and damp[38] • Increased risk of rot and fungal/insect attack[38] • Historic building drainage systems unable to cope with downpours[17] • Erosion of supporting ground around structure[38] • Sewage backup and overflow leading to saturation and related flooding, contamination and damage[22] • Increased rates of deterioration due to increase frost events in cold regions that were formerly dry[21] • Accelerated decay of masonry units and mortars due to increased extremes of wetting and drying[39] • Cracks in building infrastructure and associated destabilization of buildings and pipes due to ground heave and subsidence/ shrink swell soils[10] • Severe damage and loss of historic structures made of adobe[12] • Spalling, weathering of wood, brick, and stone materials due to salt infiltration during drying[1] • Corrosion of external masonry from agricultural runoff[40] • Increased pressure to relocate or elevate structures, and/or surrounding structures[23]
Increase of Flooding Events	**During Flood** • Direct physical damage to site, from floating materials during floods[14] • Destruction/loss of artifacts during flooding[16] • Site erosion from overflow and new flood channels[17] **Post-Flood** • Increased risk of post-flood subsidence[17] • Impacts from post-flood mitigation (clean up, construction)[14]	• Wash out or damage to roads, trails, and landscape features throughout parks[4] • Decline/disappearance of important vegetation species, other species favored[4] • Loss of landscape features[4]	• Loss of cultural places due to inundation/saturation[5] • Loss/disruption of the use of foraging grounds[5] • Loss of both plant and animal species for subsistence, medicine, ceremony, etc[15] • Degradation of vital coral reef habitats from increased sediment discharge[42]	**Facilities** • Added strain on existing museum facilities and staff due to salvage operations[32] • Damage to items and disassociation of materials and records during emergency evacuations[19] • Structural collapse from moving force of floodwaters, particularly from flash floods[41] • Sewage backup and overflow leading to saturation and related flooding, contamination and damage[22] • Walls "implode" from hydrostatic force of standing water[41] • Damage to utilities, generators, and electrical systems[51] **Collections** • Increased rusting/corrosion of metals[10] • Increased risk of rot/insect attack, mold and mildew[10,16] • Swelling/distortion of absorbent objects (such as wood) due to wetting[10,38] • Widespread, unpredictable direct damage and destruction from flood waters[10]	**During Flood** • Structural collapse from moving force of floodwaters particularly during flash floods[41] • Sewage backup and overflow leading to saturation and related flooding , contamination and damage[22] • Walls “implode” from hydrostatic force of standing water[41] • Damage to utilities, generators and electrical systems[51] **Post-Flood** • Increased risk of rot, fungal/insect attack, mold and mildew[38] • Swelling/distortion of wooden building materials and architecture features due to inundation[38] • Spalling, weathering of wood, brick, and stone materials due to salt infiltration during drying[1] • Corrosion of external masonry from agricultural runoff[40] • Increased pressure to relocate or elevate structures, and/or surrounding structures (may also be pre-flood)[23]

Sea Level Rise

Climate Change Related Impacts by Cultural Resource

	Impact on Cultural Resources				
	Archeological Resources	**Cultural Landscapes**	**Ethnographic Resources**	**Museum Collections**	**Buildings & Structures**
Inundation and Increased flooding events	• Total submersion of coastal sites[20] • Downstream movement of items due to undercut shoreline sediments[4] • Changes in pH of buried artifacts and/or buried environments[20] • Reduced site integrity due to ground heave and subsidence[14] • Increased risk of looting from exposure[14] • Increased erosion of sites due to encroaching water levels, wave action exposure, and increased exposure to wet/dry cycles[36]	• Variable damage/ loss of organic and inorganic materials and landscape features[20] • Decline/ disappearance of some vegetation species, other species favored[4] • Soil erosion[4] • Soil infertility due to waterlogged, anaerobic conditions[4]	• Loss of or limited access to traditional places[43] and culturally important sites (e.g. burial grounds, subsistence areas)[48] • Loss of plant and animal species for subsistence, medicine, ceremony, etc[15,20] • Submersion of homelands in island and coastal communities[42] and corresponding stresses to and loss of social connections and interactions [20]	**Facilities** • Added strain on existing museum facilities and staff due to salvage operations[32] • Increased cracking associated with ground heave and subsidence[10] • Potential leaks in collection storage areas and potential wetting of museum objects[10] **Collections** • Increase risk of mold[10] • Increase rusting/corrosion of metals[10] • Damage and destruction post-flood from humidity and moisture[28]	**During Flood** • Submersion of coastal sites[22] • Increase in nuisance flooding leading to problems of access and higher likelihood of range of flood damage[53] • Damage to or overwhelming of drainage systems, leading to associated building damage[53] **Post-Flood** • Deterioration/corrosion of infrastructure not designed for inundation or salt water exposure[53] • Increased cracking due to associated ground heave and subsidence[10] • Crystallization of salts introduced to buildings by seawater[22] • Disassociation of historic districts, settings due to increased pressure to relocate or elevate structures or surrounding structures[23] • Loss of access leading to loss of use[60] (See also: Precipitation: More Rainfall/Heavier Downpours, Increased Flooding Events; Sea Level Rise: Storm Surge)
Increased Frequency and/or Severity of Storm Surges	**During Surge:** • Destruction - total site loss[17] • Erosion from wave action[17] **Post-Surge** • Disturbance or removal during response and clean-up[14] (See also: Precipitation: Increased Flooding Events)	• Immediate alteration/ destruction of historic landscape[44] • Decline/ disappearance of some vegetation species, other species favored[4] • Soil infertility from soil erosion, loss of topsoil[4] • Loss of landscape features[4]	• Increased risk of inundation of homes and towns, esp. during unpredictable and extreme weather[42] • Increased risk of loss of natural and cultural resources[15] • Increased risk of loss of traditional knowledge associated with natural and cultural resources[15]	**Facilities** • Added strain on existing museum facilities and staff due to emergency operations[22,54] • Damage to utilities, generators and electrical systems[51] • Structural collapse from moving force of storm surge[41] • Changes to surrounding landforms or vegetation, which may affect future drainage[38] **Collections** • Damage to items and disassociation of materials and records during emergency evacuations[19] • Increase risk of rot, fungal/insect attack, mold and mildew[10] • Increase rusting/corrosion of metals[10] • Widespread damage and disassociation from flood waters[10] (See also: Precipitation: Increased Flooding Events)	**During Surge** • Structural damage or collapse from moving force of storm surge[41] • Damage to utilities, generators and electrical systems[51] **Post-Surge** • Cracks in building and associated destabilization of buildings and pipes due to ground heave and subsidence/shrink-swell soils[10] • Erosion of supporting ground around structure[38] • Changes to surrounding landforms, which may affect future drainage[38] • Increased pressure to relocate or elevate structures, and/or surrounding structures (may also be pre-flood)[23] (See also: Precipitation: More Rainfall/Heavier Downpours, Increased Flooding Events)
Increased Coastal Erosion	• Full loss of coastal sites and artifacts[17] • Partial loss of sites and artifacts[14] • Exposure of new and known archeological sites[16] • Altered erosion patterns from reduction/changes in Arctic sea ice[3] • Increased risk of looting from exposure[14]	• Decline/ disappearance of some vegetation species, other species favored[4] • Soil infertility from loss of topsoil[4] • Loss or compromise of associated structures[23]	• Loss of cultural memory and connections to homeland due to increased migration and splitting of traditional communities[42] • Loss of culturally significant symbols, plants, and animals[6] • Increased risk of loss of traditional knowledge associated with both natural and cultural resources[15]	**Facilities** • Limited storage capacity to protect growing numbers of at-risk artifacts[54] • Added strain on existing museum facilities and staff due to salvage operations[32]	• Loss or compromise of structure[23] • Increased pressure to relocate or elevate structures, and/or surrounding structures[23] • Increased rusting, corrosion, and salt deposits due to increased salt in the environment as the coastline encroaches[12]
Higher Water Table	• Damage to artifacts, stratigraphy, soil features from saturation of site from below[14]	• Decline disappearance of important vegetation species, other species favored[4] • Soil infertility due to waterlogged, anaerobic conditions[4]	• Loss of or limited access to culturally important sites (eg burial grounds)[18] • Decrease in productivity of arable land[15]	**Facilities** • Potential for higher relative humidity levels in collections storage areas[10] • Increased risk of rising damp/rot from higher water tables[17]	• Rising damp, often marked by efflorescence/ salt deposits[12] • Rot of subsurface components from higher water table[17] • Flooding damage in basements and other below grade features[22] • Structural damage due to buoyant forces[12]

Combined Stressors

	Impact on Cultural Resources				
	Archeological Resources	**Cultural Landscapes**	**Ethnographic Resources**	**Museum Collections**	**Buildings & Structures**
Salt Water Intrusion	• Deterioration of some artifacts due to change in surrounding soil and water chemistry[14,20] • Compromise of the site due to changes in soil and water chemistry[14,22]	• Decline/disappearance of important vegetation species[4] • Soil infertility[4]	• Reduction in or loss of habitat for culturally significant plants and animals[6] • Loss of drinking water supplies[6] • Loss of arable land for growing crops[15] • Loss of some harvestable animals[15]	**Collections** • Increased risk of corrosion/ rusting[10]	• Increased risk of corrosion/rusting[16] • Introduction of additional salts into the ground and into building materials[22]
Extreme Weather Events	• Erosion of coastal sites due to higher, stronger storm surges[17] • Disturbance/exposure/ burial due to stronger wave action[45] • Deflation or abrasion due to stronger winds[2,14] • Disturbance or removal during response and clean-up[14] • Destabilization/damage to underwater sites through movement of sediment and/or protective vegetation[62] (See also: Temperature Change: Increased Wind; Precipitation: Heavier Downpours; Sea Level Rise: Increased Storm Surge)	• Immediate alteration/ destruction of historic landscape[44], particularly trees[57] • Decline/dissappearance of some vegetation species, other species favored[4], particularly colonizing species in disturbed areas[57] • Reduction in or loss of access due to washing out or damage to roads, trails, and landscape features[4] (See also: Temperature Change: Increased Wind; Precipitation: Heavier Downpours; Sea Level Rise: Increased Storm Surge)	• Potential straining of connections between traditional knowledge and extreme events[37,47] • Limited access to cultural sites due to increased closures of parks and other areas[13] • Need for new emergency response plans due to changes in hurricane strengths and tracks[9], and surrounding land use practices[49] (See also: Temperature Change: Increased Wind; Precipitation: Heavier Downpours, Increased Flooding Events; Sea Level Rise: Increased Storm Surge)	**Facilities** • Direct damage from wind and wind-blown rain[8,54] • Damage from wind-borne debris[2] • Limited relocation opportunities due to growing demands for storage facilities[51] • Added strain on existing museum facilities and staff due to salvage operations[32] • Cracked pipes and swelling due to large and rapid temperature swings[54] . (See also: Temperature Change: Increased Wind; Precipitation: Heavier Downpours; Sea Level Rise: Increased Storm Surge)	• Added stress from sudden thermal expansion/shock[16] • Direct damage from wind-blown rain[54] • Damage from wind-borne debris[2] • Cracked pipes and swelling due to large temperature swings[54] (See also: Temperature Change: Increased Wind; Precipitation: Heavier Downpours; Sea Level Rise: Increased Storm Surge)
Pollution	• Rusting due to increased CO2 exposure[16] • Artifacts threatened by pesticides used to combat invasive species[59]	• Dissolution of stone due to increases in acid rain, particulate matter, and ground-level ozone[26] • Decline/disappearance of some vegetation species inc. favored[4] • Soil infertility due to toxicity and depletion of nutrients[4] • Loss of landscape features, especially plantings, buildings[4]	• Bleaching/damage to coral reefs[42] • Reduction or loss of culturally significant view sheds[4] • Increased difficulty for young and elderly people to perform outdoor harvesting tasks[15] • Potential erosion or deterioration of pictographs still visited by contemporary peoples for prayer or ceremony[15]	**Facilities** • Increased need for special air filtration for repositories[19] **Collections** • Corrosion of metal objects and films: pitting and perforation, deterioration/ loss of coating[48]	• Erosion of carbonate stones due to acidic precipitation[1] • Continued stone blackening[1] • Increased chemical weathering of stone materials due to altered atmospheric composition[21] • Cracked walls and increased water penetration due to corrosion[48]
Development	• Disruption/damage from fire management (eg fire lines)[30] • Disruption/damage from changing land use[30] • Degraded site integrity due to climate change mitigation (eg construction of levees and dams, dredging)[35] • Increased risk of looting or vandalism[23] • Heightened vulnerability to landslides due to land use changes and increased rainfall and runoff pressures[50]	• Increased abundance of invasive species along roadways[4] • Degraded integrity of historic viewsheds[4] • Loss of undeveloped buffer areas around cultural landscapes[4] • Loss of culturally significant plants from soil compaction, limited root zones, temperature stress from heat island effect, high urban soil contaminant levels[36] • Loss of adjacent natural habitat for native species[36]	• Increased development in Arctic due to warmer conditions[6] • Loss of food sources due to habitat loss, fragmentation, over-exploitation[46] • Reduction or loss of adaptive flexibility due to development encroachment[6] • Loss of access to traditional cultural places, including landscapes[15] • Loss of coral reefs critical for tropical fish habitats needed for local subsistence and marine tourism[42] • Loss of ancestral homelands that are considered sacred[15] • Loss of traditional knowledge associated with natural and cultural features on the landscape[15]	**Facilities** • Added strain on existing museum facilities and staff due to environmental research compliance and salvage operations[32,23] • Potential for fracking-induced earthquake damage[29]	• Increased conflicts of land-use needs due to population growth/ urbanization[58] • Loss of historic character due to changes to the site or setting[63]

Increased GHG Emissions

	Impact on Cultural Resources				
	Archeological Resources	**Cultural Landscapes**	**Ethnographic Resources**	**Museum Collections**	**Buildings & Structures**
Ocean Acidification	• Metal corrosion in submerged resources[45] • Degradation of stonework, especially limestone and mortar in coastal areas[2] • Possible acceleration in cliff erosion where cliffs have lime or shell components[55] • Increased risk of damage to shipwrecks due to loss/decline of protective concretions and/ or nearby coral reefs[61,62]	• Coastal soil erosion/ infertility[4] • Loss or deterioration of culturally significant landscape features[4]	• Decline in reefs, vital to subsistence cultures, from coral bleaching[56] • Physical abnormalities, including weakened shells, in traditional food sources[42] • Weakened/destroyed local economies dependent on shellfish supplies[51] • Possible increased degradation of rock art along shores that is sacred to and visited by contemporary peoples[15]	*Impacts not identified*	*Impacts not identified*

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INTEGRATE PRACTICE

Incorporate climate change approaches with ongoing cultural resources research, planning, and stewardship practices

Under current projections, even with the most effective global mitigation, development of and impacts from climate change are anticipated to continue for decades to come. Therefore, climate change data, projections, and responses must be an integral part of cultural resources management going forward. Climate change should not be isolated to a given task, management phase, or program, but rather should be ongoing and reflexive throughout the management cycle.

Integrating climate change into cultural resources management is a merging process. On the one hand, climate change response has developed data and adopted techniques to characterize risk from changing climatic conditions and respond to long-term uncertainty, such as climatic projections, vulnerability assessment, scenario planning, and climate change communication. Cultural resource managers must determine how best to employ these climate data and techniques so that they address the specific considerations of cultural resources, including tangible and intangible components, integrity and significance, and connections to place and communities.

On the other hand, it also is necessary to incorporate new climate data and changing climatic conditions into ongoing cultural resource management practice, including mandates of National Historic Preservation Act (NHPA) Sections 106 and 110, such as inventory, significance evaluation, treatment, and consultation.

Overarching these processes are the ongoing needs to continue to improve sustainability and reduce greenhouse gas emissions and connect climate change practice with disaster preparedness and response plans.

Goal 3 sets the broad objective of climate change-cultural resource integration. Many NPS programs, regions, and parks have already or are developing detailed climate change guidance, action, and stewardship plans which include cultural resources in a variety of ways. Goal 3 supports these diverse efforts by organizing and illustrating points of intersection between developing approaches for climate change and established cultural resources management practice.

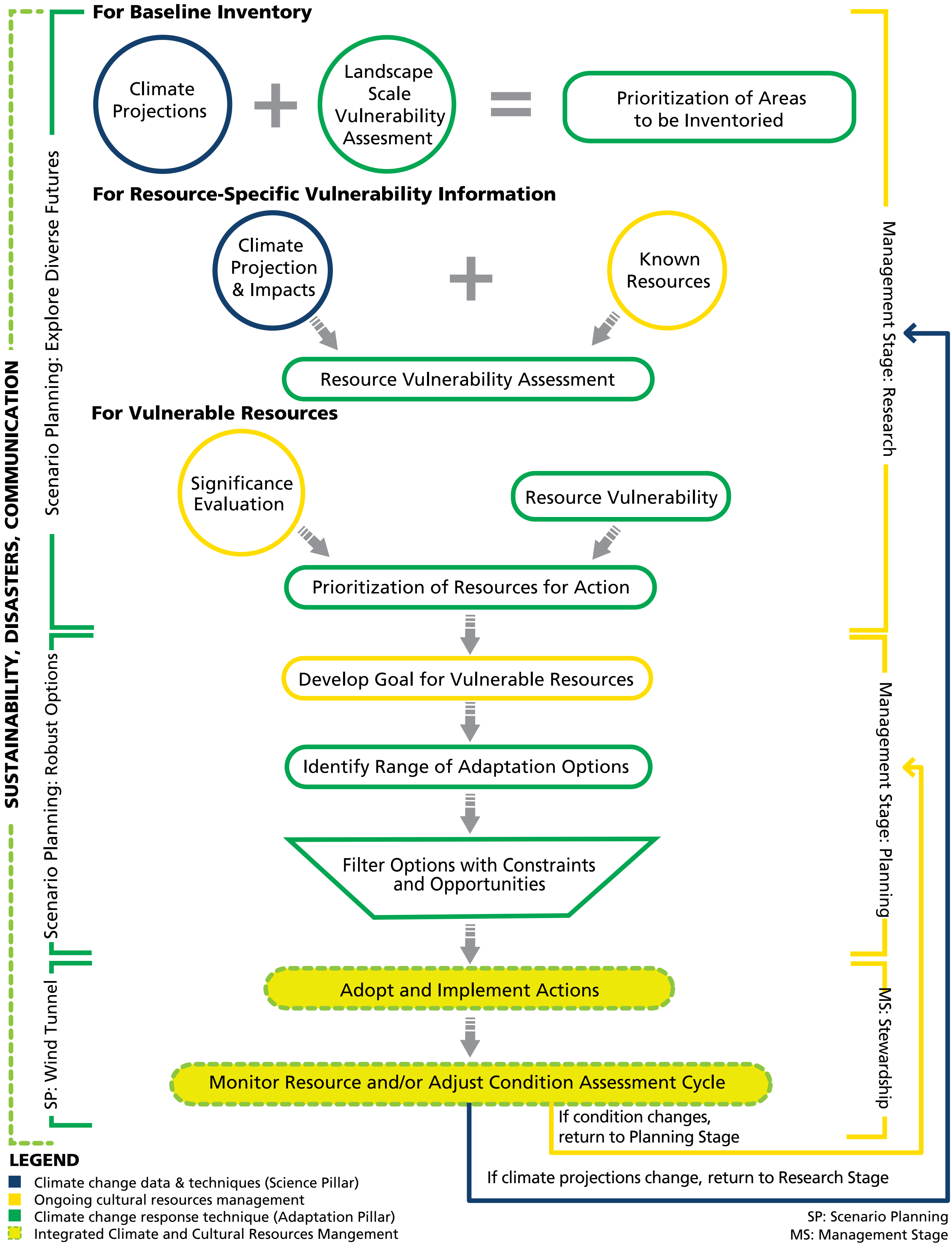
Therefore, the **Goal 3 Directions for Action** include:

- Merge cultural resources with major climate change approaches,
  - Sustainability and mitigation
  - Disaster risk reduction and response
  - Scenario planning
  - Climate change communication

- Integrate climate change into ongoing cultural resource management practices,
  - Research
  - Planning
  - Stewardship

Graphic 3 *Cultural Resources-Climate Change Integration Flow Chart,* provides a schematic for both of these broad Directions for Action. Climate data and actions (drawn from Goal 1, Science pillar) are integrated with major categories of cultural resources management to outline practices of climate adaptive management. Relative positions of approaches from Adaptation, Mitigation, and Communication pillars (from Goal 1) and groupings of actions according to *NPS Management Policies 2006* are shown alongside. Complexity of the resulting graphic reflects the current state of the art in integrating climate change with resource management. Further work on topics throughout Goal 3 is needed to develop best practices for the steps involved and clarify connections between them.

Detailed preservation work on adobe at Tumacácori National Historical Park (NPS photo).



Graphic 3. *Cultural Resources Management- Climate Change Integration Flow Chart.* This chart outlines major touchpoints between climate change and research, planning, and stewardship stages of cultural resources management.

San Juan National Historic Site combines old and new technology to conserve water (NPS photo).

Case Study: San Juan National Historic Site Water Capture

As part of the efforts for conserving water and natural resources, reducing greenhouse gas emissions, and decreasing water utility costs, the San Juan National Historic Site (SAJU) in Puerto Rico decided to restore the historical water cisterns located in two of the major fortifications. With design work that began in 2010, modern technology has been combined with 18th century engineering to restore seven cisterns with a storage capacity of over 932,000 gallons of rainwater. These cisterns are now supplying non-potable water for all the utilities in the park. Subsequent work through the Climate Friendly Parks program has focused on connecting additional buildings and treatment systems to produce potable water. SAJU has documented this work in multiple publications and a movie.

(Source: N. Medina, personal communication, 2016)

Integration of climate change with cultural resource management has several overarching considerations. These include: sustainability and mitigation, disaster preparedness and response, scenario planning, and communication.

Sustainability and Mitigation

The NPS established the *Green Parks Plan* (2012) to further sustainability and mitigation. The *Green Parks Plan* applies to all parks, including those with a primarily historical or cultural focus. NPS has developed guidance to assist with sustainability specifically in relation to cultural resources, including Secretary of the Interior's *Standards for Rehabilitation and Illustrated Guidelines on Sustainability for Rehabilitating Historic Buildings* and Technical Preservation Brief 3, *Improving Energy Efficiency in Historic Buildings* (Hensley and Aguilar 2011). *The Energy Saving Features of Older Buildings* (Burns 1982) helps identify sustainability features already inherent in the historic built environment.

Climate Change Practice and Disaster Preparedness and Response

Climate change will unfold as a long string of disasters of varying rates and intensities. Climate impacts listed in Graphic 2 include impacts that will occur as a result of events and impacts that will develop due to changing trends. The processes outlined in Graphic 3 are organized as a long term management approach.

Good planning can assist in disaster recovery when such events and impacts occur. In turn, disasters often demand rapid management decisions and provide opportunities to implement new approaches. It is important to ensure that all types of cultural resources are incorporated into disaster response plans.

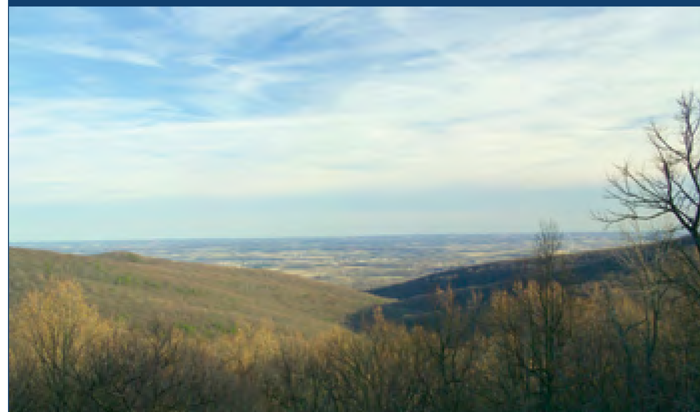
Integrating Historic Property and Cultural Resource Considerations into Hazard Mitigation Planning: State and Local Mitigation Planning How-To Guide (FEMA 2005) currently is the primary reference in this field. As well, the NPS State, Tribal and Local Plans and Grants program has begun to incorporate disaster planning and resiliency into the operation of the Historic Preservation Fund (HPF) grants-in-aid program authorized by the NHPA, as amended.

Scenario Planning

Scenario planning has been adopted by the NPS as part of climate change response. Scenario planning is "a vehicle for developing multivariate climate change responses and strategies, and test decisions in a context of uncontrollable and uncertain environmental, social, political, economic, or technical factors." Therefore, this technique can be applied in multiple places for multiple different purposes throughout the integration and decision process.

Guidance on conducting climate change scenario planning is provided in *Using Scenarios to Explore Climate Change: A Handbook for Practitioners* (Rose and Star 2013) and *Addendum I: Using Scenarios to Explore Climate Change: A Handbook for Practitioners* (NPS 2014). Guidance on integrating multiple scenarios into resource planning is being developed in *Planning for a Changing Climate* (NPS forthcoming).

While the overall process of scenario planning is similar regardless of resource type, implications of different scenarios for cultural resources requires information about known and anticipated effects of climate variability on cultural resources, such as compiled in Graphic 2. Traditional ecological knowledge (TEK) also is an important source of information and insight into how different climate scenarios may be experienced in different areas; for instance, TEK may describe historical weather patterns and help identify the nature and scope of impacts when such weather patterns change or are disrupted.



Scenario planning at Catoctin Mountain Park in 2012 looked at robust options for both natural and cultural resources (NPS photo).

Types and Uses of Scenario Planning (from Graphic 3)

Explore Diverse Futures

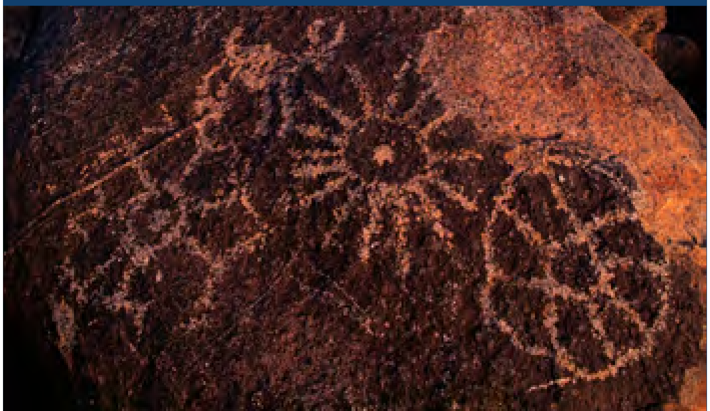
This type of scenario planning focuses on large scale thinking and identifying multiple major forces, or drivers, that govern how we live and work. These drivers include both climate change and trends in social, cultural, political, and economic spheres. Listing these drivers and envisioning how they might develop and combine provides a solid basis for creating potential plausible futures. This form of scenario planning provides training in flexible thinking and considering the drivers that affect cultural heritage and preservation most.

Robust Options

This type of scenario planning is used to develop and compare response strategies across different possible futures. Actions or strategies that work well across all scenarios are "no regrets" or robust strategies. Other strategies may be appropriate only in one or a few scenarios. Outcomes of this type of scenario planning should help in identifying actions that (1) do well in all scenarios and should be implemented; (2) are successful and should continue; or (3) that will be irrelevant or maladaptive in potential futures.

Wind Tunnel

Once a certain management option is selected, this type of scenario planning can be used to test it against potential future scenarios. As described in the *NPS Scenario Planning Handbook*, "Think of scenarios as a wind tunnel, similar to the wind tunnels that engineers use to test aircraft. Consider actions, policies or strategies as a model aircraft. As you run the models through the wind tunnel, you may see that under certain conditions they perform well, while in others, the wings come off."



Hohokam petroglyphs tell old stories at Saguaro National Park (Thinkstock photo, used with permission).

Writing a Climate Story

Climate stories are called stories, but they are not fiction. Rather, they are vehicles for best available sound science. Following the AND, BUT, THEREFORE (or ABT) method of storytelling (Olson 2015), information is organized so that something happens. A climate story is not necessarily about an individual, but it has a beginning, a middle, and an end:

AND is where the story starts

BUT creates the tension

THEREFORE provides the resolution

The writing process also may use the WORD, SENTENCE, PARAGRAPH (or WSP) technique (Olson 2015). The WORD conveys the overall concept of what the story is about, and can be linked to previously identified park interpretive themes. The SENTENCE is phrased as an ABT. It can be a long sentence, but it should have all three parts. The PARAGRAPHS, as many as needed, expand on all the parts of the ABT to create a full-fledged story. They may include citation and quotations as appropriate.

Communication

Integration of climate change and cultural resources communication involves an array of connections between people and programs. Some of these connections already exist, others need to be developed. A current challenge for cultural resources climate change communication is awareness–of the links between cultural resources impacts and information across climate change science, adaptation, and mitigation (Goal 1) and of the diversity of observed and projected climate change impacts to cultural resources (Goal 2).

Climate change communication for cultural resources includes literacy and training for all involved in the care, maintenance, and interpretation of cultural resources, connections between colleagues working in climate science, adaptation, mitigation, and in fields on either side of "Impacts" and "Information" within each pillar of climate change response (Graphic 1). Within cultural resources management, communication also encompasses the process of consultation, including the processes required by NHPA Section 106. Climate change does not alter these requirements and consultation will be needed through planning and decision-making processes.

Finding a Climate Story

One of the challenges climate change presents for communication is sharing best available sound science and other information clearly and in ways that support meaningful discussion. NPS has multiple programs and tools for interpretation, education, and outreach in relation to climate change. Many of these are captured in the *NPS National Climate Change Interpretation and Education Plan and Toolkit* (NPS 2016). As noted in PM14-02, "every place has a climate story." The "Every Place has a Climate Story" approach is an additional tool designed to support the NPS interpretation and communication in connecting cultural resources and climate change information in ways that are engaging and meaningful. While to date this approach has been used primarily to create supporting information for interpretation in parks, this approach and its framework of topics may be used to connect cultural resources impacts and information and stewardship and science activities in other communication settings.

Four themes for communication of cultural resources information are developed under Goal 1:

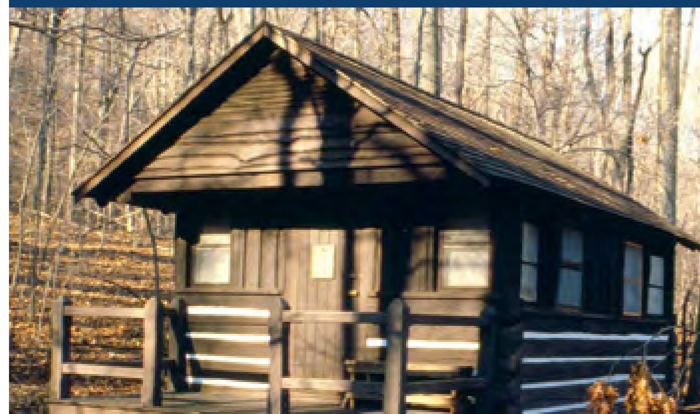
1. Change in the material world
How do we see change happening in the material world (houses, artifacts, monuments, landscapes) around us?

2. Change in experience and lifeways
How are traditional and indigenous communities experiencing change in their practices, lifeways, and in relation to traditional knowledge? How are modern communities experiencing change? How do memories of and expectations for local climates and environments connect with current climatic experiences?

3. Insights on change from past societies
How have past societies interacted with and responded to past climatic variability and environmental change?

4. Origins of modern climate change
How has the modern climate change situation come to be?

Finding a climate story is a process of working iteratively with these story themes and park resources, staff, and associated communities, to identify place-based story topics. It is likely that in any give place at least one story theme will apply. Likely, several will.



Cabin at Catoctin Mountain Park (NPS photo).

Sample ABT sentences include:

Story Theme 1: Material Change

Word: Stewardship

The Catoctin cabins were built as the first recreational camp for disabled children in the 1930s AND are still in use today as nature retreats, BUT projections indicate increasing temperatures will lead to structural damage from more intense rainfall events, THEREFORE NPS is researching ways to preserve historic mortar.

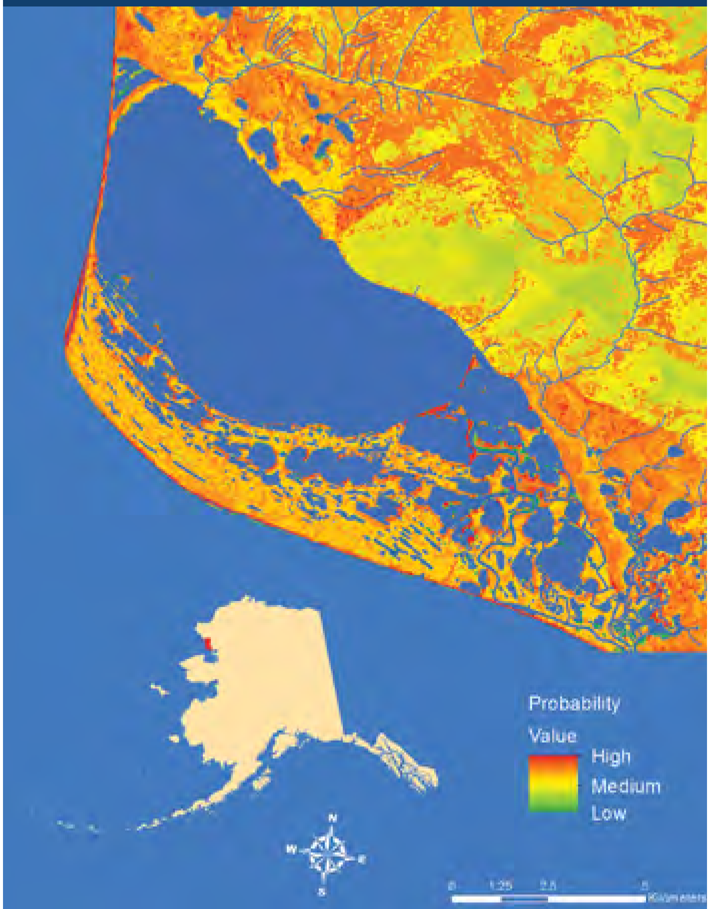
Interpretive garden at Wupatki National Monument preserves native plants (NPS photo).

Story Theme 3: Insights from Past

Word: Innovation

Sentence:

Sunset Crater erupted in circa AD 1064 AND covered an area already affected by drought with ash AND made agriculture difficult to impossible for several years, BUT the local Sinagua population stayed and developed the technique of cinder mulching, which helps retain soil moisture, THEREFORE providing an example of traditional agriculture that may be useful in the future as the climate becomes hotter and drier.



Map of coastal erosion probability of a section of Cape Krusenstern National Monument (NPS photo).

Landscape-scale Vulnerability Assessments

Using climate change projections, and with vulnerability defined as the relationship between exposure and sensitivity, it may be possible to identify geographic areas most at risk for particular types or combinations of climate change impacts. These findings can then inform planning for inventory and/or condition assessment and reassessment.

Case Study: Bering Land Bridge, Cape Krusenstern Prioritization of Areas for Inventory

Rapid temperature increases, loss of sea ice, rising sea levels, and changes in storm patterns and the severity of their effects are exposing and removing archeological resources along the coast of Bering Land Bridge National Preserve and Cape Krusenstern National Monument. Much of this coast line has not yet been surveyed. To improve management of this situation, the Alaska Regional Office is creating a GIS-based vulnerability assessment to determine which areas of the park coasts are most vulnerable to erosion and which of those areas are most likely to contain archeological sites. The model combines predictive local climate scenarios, a coastal erosion model, and a predictive archeological model based on physical site characteristics.

(Source: Devenport and Hays 2015)

Integration of climate change with cultural resource management also includes multiple touchpoints with established practices. As shown in Graphic 3, these connections can be organized according to management phases outlined in NPS *Management Policies 2006*: research, planning, and stewardship. Research incorporates actions to gather substantive information and data in order to make informed decisions.

Climate projections

Climate projections derive from global climate models and outline anticipated trajectories in temperature and precipitation. Uncertainty in future greenhouse gas emission pathways and global climate system responses frame the potential climate futures incorporated into scenario planning (see previous). Currently, downscaled climate projections are being prepared for each unit in the NPS system. They are available through the NPS Integrated Resource Management Applications System (IRMA).

Climate change impacts

Changes in global temperatures and precipitation are and will be manifested in a range of observable phenomena. As detailed in Graphic 2, it is through these phenomena (sea level rise, storm surges, changes in ecosystems, and others) that climate change will impact cultural resources. Some impacts are and will be dramatic and sudden, others the result of long-term changing trends.

Vulnerability assessments

Vulnerability "encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt" (IPCC AR5). Within resource management, vulnerability with respect to climate change is often expressed in the following formula: vulnerability = exposure + sensitivity – adaptive capacity.

As outlined in Goal 1, Adaptation, cultural resources are, or often include, components that are non-living and as such they have limited capacity to adapt to changing conditions. As a result, climate change adaptation for cultural resources lies in our use and management of them. Adaptive use and management can draw from a wide range of options (see Goal 3, Planning). Therefore, for cultural resources, a variation of the vulnerability formula that separates adaptive capacity from exposure and sensitivity is more appropriate:

Vulnerability = Exposure + Sensitivity

This formula has been developed and adopted by the NPS Sustainable Operations and Climate Change Branch for its management of park facilities and infrastructure in the *Coastal Hazards & Climate Change Asset Vulnerability Assessment Protocol* (Western Carolina University 2016).

Inventory and Climate Change

As set out in PM14-02, areas most at risk for an impact or combination of impacts that have not yet been inventoried should be prioritized for inventory. Factors to consider in prioritization include the time frame of the risk (acute or catastrophic impact vs. gradual trend) and results of modeling of areas most likely to have cultural resources.

Baseline Cultural Resource Data

Baseline data for cultural resources includes (1) location; (2) condition; (3) significance; (4) national, regional, and local contexts. Locational data is critical for determining potential exposure of cultural resources to climate change phenomena. Condition information can help identify sensitivities of cultural resources to climate impacts, monitor effectiveness of management actions, and detect change (see return arrows at the base of Graphic 3).

As outlined in PM14-02, significance and national, regional, and local contexts should be combined with vulnerability to prioritize resources for adaptation attention.

Significance Evaluation

Significance evaluation is part of the baseline information developed for cultural resources identified during inventory. As noted in PM14-02, the National Register of Historic Places (NRHP) eligibility criteria provide a sound framework for assessing significance. As well, contemporary significance indicated during consultation with diverse stakeholders may add to previous evaluations of significance. How a resource's significance is conveyed (such as through spatial relationships or architectural and artistic components) should be a focus in assessments of a resource's sensitivity to projected climate impacts.

Capacity to learn about the past from cultural resources is recognized in NRHP eligibility Criterion D. Climate change adds new questions to which such information needs to be addressed. The Information concepts in Goal 1 (see Graphic 1) list many of these, ranging from paleoclimatic data and lower energy practices to examples of past adaptation to past environmental variability.

Connecting Significance and Vulnerability

For parks and regions in which there are multiple resources at risk from climate impacts, it may be necessary to prioritize them with respect to the planning and implementation of management action. PM 14-02 set out that significance combined with vulnerability is the recommended basis for such prioritization.

Prioritization for Action

Prioritization is the process of assessing resource characteristics to develop an order for management attention. These should include resource vulnerability and significance; many parks are also incorporating capacity to reuse a resource, resource condition, visibility/accessibility for visitors, and uniqueness of the resource within the park.

Point Reyes National Seashore has analyzed climate vulnerability of archeology in different microenvironments (NPS photo).

Resource Vulnerability Assessments

The vulnerability of individual cultural resources to climate impacts is developed through climate projections for the area in which a resource is located (exposure) that may lead to specific climate impacts (see Graphic 2) which can then be related to the materials and relationships of the resource (sensitivity).

Case Study: Point Reyes National Seashore

The first detailed NPS climate change vulnerability assessment for coastal archaeological resources was conducted for Point Reyes National Seashore. This study examined exposure of different ecozones across the park to chemical weathering, coastal erosion and sea level rise, temperature changes, vegetation changes, and fire, and the sensitivities of different site types to these impacts.

(Source: Newland 2013)


Community members at the 2010 biannual homecoming at Portsmouth Village, Cape Lookout National Seashore (NPS photo).

Case Study: Structured Decision Making at Cape Lookout National Seashore

In 2015-2016, Cape Lookout National Seashore (CALO) piloted a structured decision-making process (SDM) to help develop management approaches for its two historic villages. The park is set on a series of barrier islands in coastal eastern North Carolina. Both historic damage patterns and climate projections indicate rising water is and will be a major ongoing stress for the villages, and sea level rise/storm surge were chosen as the focus for this project. Working with researchers from North Carolina State University, coastal researchers at Western Carolina University, the North Carolina State Historic Preservation Office, members of the local community, and with support of the U.S. Geological Survey Southeast Climate Science Center, NPS park, regional, and other program staff crafted a draft decision-support tool. This tool characterizes buildings within each village according to significance and climate vulnerability, and models allocation of potential available budgets across various adaptation options (see list of options on pages 36-37).

(Source: Fatorić and Seekamp 2016)

Planning encompasses the analysis and development of the decision-making component of resource management. Within cultural resources, Planning documents include Cultural Landscape Reports, Historic Structure Reports, Museum Collection Management Reports, and Archeological Assessments, and resource-

Planning for a Changing Climate

NPS planning guidance for climate change, *Planning for a Changing Climate* (NPS forthcoming), outlines the processes and considerations for incorporating multiple climate scenarios into resource management from the point of establishing resource management goals forward.

Review Management Goals for Vulnerable Resources

Current management goals for cultural resources include preservation, rehabilitation, and restoration. With the compilation of resource condition, significance, and climate risk information, the goal for a resource or sets of resources can be reviewed and assessed for appropriateness and sustainability. Management approaches to achieve those goals are then developed. Wherever possible, maintenance should be recognized as a primary approach, as a well-maintained built environment or healthy natural environment is generally better able to withstand new stresses presented by climate change. Subsequent management approaches may be developed in an iterative process through consideration of cultural resource Adaptation Options (below). Alternative climate and other futures should be considered in this process, such as through scenario planning (robust options) or structured decision making. Consultation processes, as for other resource stewardship decisions, should continue throughout.

Addition of Loss to Management Goals

Current primary NPS cultural resource management goals anticipate preservation in perpetuity. In growing recognition of climate projections and impacts, PM14-02 stated that:

"Responsible stewardship requires making choices that promote resilience and taking sustainable management actions. Funding temporary repairs for resources that cannot, because of their location or fragility, be saved for the long term, demands careful thought. Managers should consider choices such as documenting some resources and allowing them to fall into ruin rather than rebuilding after major storms."

Toward this, approaches for responsible preparation for unavoidable impacts and potential loss are incorporated into the Adaptation Options below. As with all management goals, decisions for loss must be made with appropriate consultation and compliance.

to-park level planning documents such as Foundation documents, Resource Stewardship Strategies and General Management Plans. Integration of climate change into planning requires incorporation of uncertain projected environmental change and related observed or anticipated impacts into management goals and plans for vulnerable regions and resources.

Identify Range of Adaptation Options

Adaptation options are management approaches to address identified climate vulnerability of cultural resources and provide a means of adaptive capacity. Many of the practices that support these options are already in use in the NPS; this listing provides a common language for the options to promote coordination about them across the Service. As organized below, they range from responses to minimally disruptive change (1) to destructive change (5-7). These options may be used individually or combined with others in a sequence.

Relation of Adaptation Options and the Compliance Process

Ideally, analysis and selection of adaptation options and the environmental and historic preservation compliance process, such as NHPA Section 106, should happen in parallel with the analysis identifying climate risk to cultural resources. For example, in preparing alternatives, different options may be developed as Section 106 alternatives, or multiple alternatives may be developed within one option. If a more conceptual vulnerability assessment or planning process has taken place resulting in management recommendations to be implemented at a future time, these assessments and planning documents should be used as starting points for the Section 106 compliance process.

Difficulties are most likely when it appears a management decision has been reached before the compliance process starts. In scoping participants for consultation about vulnerability assessment, management options, or selection of adaptation options, these participants should be considered as possible stakeholders for consultation during Section 106 compliance.

Filter of Constraints and Opportunities

While prioritization of resources for action should be based primarily on vulnerability and significance, selection of adaptation option(s) requires consideration of both the resource(s) and the context within which management decisions are being made. This context includes financial, technological, time-frame/urgency and constraints and opportunities that may derive from technology, tribal consultation, public engagement and participation, and cost-sharing, among others.

Facilitators at Preserving Coastal Heritage gathered many ideas from participants (NPS photo).

Case Study: Preserving Coastal Heritage Workshop

The National Park Service hosted the Preserving Coastal Heritage workshop at Federal Hall National Memorial in April 2014 to bring together a diverse range of partners to develop a draft decision framework for managing cultural resources vulnerable to climate change impacts. Using parks in the New Jersey and New York area that had been affected by Hurricane Sandy as case examples, the participants clarified a series of adaptation options and identified components of an overall cultural resources climate change planning process.

(Source: NPS 2014)

Documentation of the *E.C. Waters* shipwreck at Yellowstone National Park (NPS Submerged Resources Center photo/Brett Seymour).

Adaptation Options

1. No Active Intervention

Taking no action is a decision. This may be an appropriate decision in situations of low vulnerability (no action warranted) or when, due to one or more of a range of constraints, including lack of technological or economic feasibility, no action can be taken. This decision may include assessment of the need for monitoring of resource condition, with a plan to revisit a no-action decision at a future point in time.

2. Offset Stress

Removing or deflecting stress is one or more actions taken at some distance from the resource to reduce or remove the environmental or other force(s) acting on the resource. The goal of this option is to enhance survival while minimizing physical or material changes to the resource. Constraints on this option are likely to include impacts of actions to surrounding resources, such as natural habitat or infrastructure.

Examples include: temporary measures such as sandbags or levee plugs; an offsite retaining wall, living shoreline, or engineered logjam to reduce shore erosion; upstream re-vegetation to reduce flood hazards, or changes in adjacent forest management to reduce wildfire risk.

3. Improve Resilience/Resistance

Improving resilience/resistance consists of one or more actions that change the nature and/or setting of a resource that are designed to make a resource better able to withstand or be recovered from environmental or other forces. The goal of this option is survival of the resource, despite possible impacts of actions on integrity of the resource, although this option does not necessarily mean the resource will be impaired.

Examples include: treatment of structural materials to better withstand increased moisture, wind, or an invasive species; elevation of a building to raise it above projected flood levels; addition of a cap over an archeological site; changes in landscape plantings or soil treatments; and alternate storage arrangement of museum materials.

4. Manage Change

Managing change is an action or set of actions that incorporate change into the form of the resource and/or into its management plan. The goal of this option is to maintain character-defining features of a resource, even if original specific materials or individual species are no longer part of the resource.

Examples include: change in tree species on cultural landscapes by removing an original species that has died and replacing it with a species that is healthy in that environment and will provide similar visual characteristics including shade and foliage conditions.

5. Relocate/ Facilitate Movement

Relocating/facilitating movement includes two types of action: (a) moving a resource, and (b) allowing movement to happen.

(a) Moving a resource is an action or set of actions to relocate all or a portion of a resource that cannot move on its own to a less vulnerable location.

Examples include: moving the Cape Hatteras Lighthouse inland from the coast. Another example is the temporary relocation of the NPS collections from Ellis Island following Hurricane Sandy to a facility in Maryland. Assisting with relocation of a human community to a safer location and assisted migration of a culturally important species to a refugium it would not have been able to reach on its own (for instance, salmon species to a new watershed) are also examples of this option. Movement is not feasible for some cultural resources such as cultural landscapes; in such instances movement may be an appropriate choice for components of a landscape once a decision has been made that the whole can no longer be saved.

(b) Allowing movement to happen involves action(s) either to enable movement or otherwise remove impediments to movement of living portions of resources to less vulnerable or more stable locations.

Examples include: allowing ecosystems such as a marsh or barrier island with cultural significance or which contains culturally significant species to migrate inland, or a given species with cultural significance to shift ranges. Such shifts may move all or components of a resource outside of documented resource or park boundaries.

6. Document and Prepare for Loss
Any action modifying a resource includes appropriate documentation. "Document and Prepare for Loss" is a set of actions to record a resource and then subsequently allow the geographic location of the resource to undergo full effects of environmental or other forces that are likely to destroy or remove all or portions of the resource.

Documentation may be exhaustive, such as data recovery (full excavation) of an archeological site, or detailed recording of a building or structure or cultural landscape (such as HABS/HAER/HALS photographic, drawing, and laser scanning documentation, or a Cultural Landscape Inventory). Documentation also may be done at a less than exhaustive level. This may be appropriate when exhaustive approaches are infeasible (due to limitations in access, time, or financial constraints), not warranted (due to nature and scale of impacts), or there is merit in not recovering or preserving the whole of the resource (such as an archeological site may become inaccessible, but is not anticipated to be destroyed). This option differs from the data recovery in that it requires consideration and documentation of the sampling and preservation approach. Other examples of documentation techniques that may be used in either approach include collection of pollen and seeds or plant cuttings, and oral histories and video.

7. Interpret the Change
Climate change is the heritage of the future. Interpreting the Change is an action or set of actions that acknowledges and then serves to engage people in the future with the effects of climate change on a resource. This option may be used on its own or in combination with any of the other options.

Examples include: dramatic approaches such as preservation of a coastal resource such that its location and form remains either intact or otherwise visible from the coast once it is offshore or partially submerged. A hypothetical example would be Dry Tortugas National Park's Fort Jefferson encased in a large dome to protect it from rising seas and storm damage. Other examples include interpretive signage of freeze-thaw cracking in historic bricks, or photo series of changes in garden phenology or vegetation across a landscape. While interpretation may be developed across any of the adaptation options on this list, for this option, interpretation addresses not only preservation issues and history of the cultural resource, but also climate change itself, and seeks to tell the story of the place and climate change and how they are interacting.

Although not designed explicitly as a climate change adaptation option, the 1999 decision to move the Cape Hatteras Light Station inland is an iconic example of relocation of a valued cultural resource (NPS photo).

The Cultural Landscape Report for Rapidan Camp, Shenandoah National Park, has a multi-decade plan for managing disease-affected trees (NPS photo/Knepley).

Case Study: Cultural Landscape Management Cycle Condition Reassessment

The NPS Parks Cultural Landscape Program has recently developed criteria for determining the appropriate condition assessment interval cycle, taking into consideration factors such as the condition, management category (including: Must be preserved, Should be preserved, May be preserved, May be released), landscape sensitivity, and facility management type. A resource is assigned points based on its priority within each of these categories; the points are tallied to determine the condition reassessment interval—1-3 years for high priority; 4-6 years for medium priority; and 7-10 years for low priority.

Stewardship encompasses using the most effective concepts, techniques, and equipment to protect and preserve cultural resources from environmental and other threats that may affect them.

Adopt and implement actions; Monitor resource and/or adjust condition assessment

Once a management approach for a vulnerable resource has been selected, it should be adopted and implemented. Monitoring and condition assessment schedules to identify and track changing conditions are integral parts of the integration of climate change response and stewardship. Stewardship for cultural resources under climate change will be dynamic and need to respond to changing and unanticipated conditions. If resource condition changes unexpectedly, management approaches should return to the planning stages. If climate projections change, management approaches should return to the research stage (see Graphic 3).

If resource condition changes, return to Planning stage

Condition assessment is an established component of cultural resources management. Following cultural resources climate change impacts listed in Graphic 2 and vulnerability assessment developed in Research stages above, condition assessment should look for cues of environmental stress. Intervals between condition assessment also may be revised to better respond to the resource's sensitivity to change and/or exposure to changing environmental stresses (vulnerability). Other sources of information about potential changes in resource condition and exposure include the NPS Inventory and Monitoring Network Vital Signs program. If unexpected changes are identified in resource conditions, management approaches should return to the Planning stages to reassess resource goals and selected adaptation option(s) and implementation plan.

If climate projections change, return to Research stage

Climate projections may change as climate models are further developed, mitigation decisions are made at many levels, and greenhouse gas trajectories are better understood. As new climate data are received, previous assessments of resource exposure and sensitivity should be reviewed. If landscape or resource vulnerability changes with the new information, research, planning, and stewardship steps should be undertaken accordingly.

(Opposite) Wreck of the *George L. Olson* floats in the water after being cut loose to drift to the North Spit along the Oregon coast (Photo courtesy of the Coos Historical and Maritime Museum).

LEARN AND SHARE

Connect with partners to grow the body of knowledge for cultural resources and climate change.

Goal 4 addresses the urgency of global climate change and the collective nature of human heritage. Science to date is indicating diverse environmental changes, some rapid, which are or likely are attributable to climate change. These changes are adding new and variable stresses to cultural resources around the world. In turn, as cultural resources are connected to human experiences in specific places, the capacity and need to learn from them also extends around the world. As set out in Goal 1, collaboration from the local to international scale to share information and ideas is necessary to build a robust and sustainable climate change response with and for cultural resources.

Threats to cultural resources from climate change are many and diverse (Graphic 2). Impacts are already identified in many parks, and uncertainty in timing and severity of future impacts adds urgency to the need to develop and implement programs and techniques to address them. As discussed throughout Goal 3, management of cultural resources in relation to climate change includes prioritization. The intent of prioritization is to use available resources wisely, including knowledge and research resources. Coordinating with partners and learning from the array of knowledge and practice they have developed is an important component of this.

National partners of the NPS in cultural resources management and historic preservation throughout the U.S. include other Federal agencies, collaborations through the Landscape Conservation Cooperatives, Tribal governments, State governments, Certified Local governments, academic institutions, and non-governmental organizations. The cultural resources managed and held by these partners are being challenged by climate change in the same diverse ways at the same time as those of the NPS (Graphic 2). These partners work under the same national cultural resources and environmental legislation as the NPS, but due to differences in scale and agency or institutional mission they have developed other types of approaches with different emphases.

There is great diversity of existing and potential international partners. International organizations such as UNESCO's World Heritage Organization, International Council on Monuments and Sites (ICOMOS) and the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM) have and continue to produce white papers and practical workshops that address the threats climate change presents for cultural resources. National and regional-scale organizations, governmental and non-governmental, are mobilizing strategic plans and programs as well. These are concentrated in Western Europe and Japan, though there are many projects going on around the world that are addressing specific regional and site situations.

In turn, the NPS has much to share with the global cultural heritage and historic preservation community from its work on climate change. From the joint cultural and natural resource management across the diverse histories and ecosystems of the National Park System, to the millions of one-to-one personal interactions of visitors each year with interpretive rangers that build meaning and foster learning, the NPS has innovations that are not yet replicated widely elsewhere in the world. Working together, this collective global community can not only help each other address impacts from climate on cultural resources, but also build practice for and awareness of the roles of cultural resources information in addressing the challenges of climate change.

Following this, **Goal 4 Directions for Action** include:

- Coordinate with partners to learn from and adapt approaches to managing cultural resources in relation to climate change
- Coordinate with partners to share the NPS approaches to managing cultural resources in relation to climate change.

In support of the Direction for Action regarding sharing, this Strategy, including case studies and approaches and data incorporated throughout Goals 1-3, is a starting summary of the contributions of the NPS for partners in cultural resources and climate change both in the U.S. and around the world.

Graphic 4, *Four Pillars of Cultural Resources Climate Change Response around the World*, and the following descriptions and case studies provide a starting point for building connections toward learning from colleagues in the U.S. and around the world. Programs included in Goal 4 were selected through a joint project with the University of Maryland to highlight the variety of activity around the issue of climate change and cultural resources at different scales, and each one has a clear presence online with readily accessible data, tools, or program and policy documents. Activities of some programs are relevant to more than one pillar, particularly in the areas of Science and Communication. For this reason, the category of Citizen Science is added to describe these programs.

Graphic 4. *Four Pillars of Cultural Resources Climate Change Response Around the World*. This map shows a distribution of major programs that have developed transferrable tools and techniques for cultural resources and climate change.

SCIENCE

Research at the Oxford Rock Breakdown Laboratory aids preservationists in protecting stone buildings (Oxford University photo used with permission).

Case Study: The Oxford Rock Breakdown Laboratory

The Oxford Rock Breakdown Laboratory (OxRBL) at Oxford University in the UK studies the impacts of changing environmental conditions on stone, especially in relation to cultural heritage sites. Methods such as tomography are used to study effects of climate phenomena such as increasing moisture. While stone is commonly held to be among the most resistant of building materials, studies by OxRBL are showing that increasing moisture can have rapid and destructive effects. Given that so many cultural heritage properties are made of or include stone, these findings indicate there are alarming vulnerabilities in what seem to be the most robust cultural heritage sites.

(Source: Oxford Rock Breakdown Laboratory website, http://www.oxrbl.com/)

Science for cultural resources in relation to climate change identified around the world covers both Impacts (techniques for identifying and measuring effects of

Impacts

ArcBurn (Southwest US)
ArcBurn is an experimental collaboration between the U.S. Forest Service, the NPS, and the Forest Stewards Guild. The core of this program is measuring and quantifying the types and extent of damage that can happen to cultural resources as a result of wildfires. Damage includes both direct damage (from fires themselves) and indirect (i.e. from the firefighting process). Research includes field and laboratory work. Results of this project will be integrated into fire management plans, which will allow better protection of cultural resources at risk from fire threats.

The Climate for Culture (European Union [EU])
This EU Commission-funded project, which ran 2009-2014, developed multiple products about impacts of climate change on cultural heritage. These included a series of case studies modeled according to Intergovernmental Panel on Climate Change (IPCC) climate scenarios.

Firesense (EU)
The Firesense project is creating monitoring and modeling technology focused on predicting frequency and power of wildfires in the Mediterranean region, with particular attention to threats to cultural heritage sites.

Noah's Ark Project (University College London [UCL], UK)
Noah's Ark Project leads research into the impacts of changing climates on cultural heritage, with the goal of determining which climate factors will be the most destructive to cultural heritage over the next century. The project includes research on the impacts of climate change on a variety of materials and sites. The *Atlas of Climate Change Impact on European Cultural Heritage: Scientific Analysis and Management Strategies* (Sabbioni et al. 2012) is a product of Noah's Ark.

Oxford Rock Breakdown Laboratory (Oxford University, UK)
The Oxford Rock Breakdown Laboratory is leading research into the response of rock (emphasis on historic stonework) to various environmental conditions, such as increasing humidity, increased biotic activity, changing precipitation patterns.

World Heritage Institute for Training and Research Asia Pacific Region (WHITR-AP) (Shanghai, China)
Under the auspices of UNESCO, WHITR-AP is a nongovernmental institute working to increase the resources dedicated to cultural heritage at the scientific level in the Asia Pacific region. It has recently published on the dangers of anthropogenic climate change to cultural heritage in Asia.

climate change on cultural resources) and Information (learning from cultural resources to support adaptive response to climate change).

Information

Future Earth (hubs located in Colorado, Montreal, Paris, Stockholm and Tokyo)
Future Earth is sponsored by the Science and Technology Alliance for Global Sustainability, which represents the International Council for Science (ICSU), International Social Science Council (ISSC), the Belmont Forum, UNESCO, and UN Environment Program (UNEP) among others, and is an international research hub for the coordination of interdisciplinary research focused on global sustainable development and sustainability. Future Earth projects include Past Global Changes (PAGES), a program supporting understanding of past environments in order to predict future conditions, and Integrated History and Future of People on Earth (IHOPE, see below), both of which are specifically focused on learning from cultural resources in order to facilitate present day adaptation and mitigation.

Integrated History and Future of People on Earth (IHOPE, Future Earth)
IHOPE is a global network of researchers with the goal of using our understanding of the past as a way to ensure a robust and equitable future. All of the projects under this umbrella organization focus on the idea of learning from the past in order to assist current and future management issues. The projects cover many different environmental and cultural contexts and are a source of case studies in how to integrate learning from the past into various modern situations.

North Atlantic Biocultural Organization (NABO, internationally distributed research network)
NABO is an international research cooperative focused on the North Atlantic. This group has developed multiple and diverse research projects centered on learning from cultural resources. These range from from historic maritime resource use to historic animal husbandry and landscape change.

Ritsumeikan University Institute of Disaster Mitigation for Urban Cultural Heritage (Kyoto, Japan)
Ritsumeikan University's Institute of Disaster Mitigation provides vulnerability assessments, urban planning, workshops on specific mitigation techniques. The Institute hosts an annual workshop on Disaster Risk Management of Urban Cultural Heritage in partnership with UNESCO, ICOMOS and ICCROM.

SCIENCE

Archeological research at Lake Myvantn shows a millenium of sustainable egg harvesting (M.Rockman photo, used with permission)

Case Study: North Atlantic Biocultural Organization (NABO) Research on Sustainability at a Millennial Scale

NABO research in the Myvatn region of northern Iceland has revealed a compelling counterpoint to the many stories of human mismanagement of natural resources from the past and present. Lake Myvatn is a major breeding ground for both North American and Eurasian waterfowl. Lake Myvatn hosts huge numbers of waterfowl and one of the widest assortments of species of waterfowl found anywhere on the planet. Archeological sites in the region routinely produce significant numbers of waterfowl eggshell. Bones from the waterfowl themselves are however largely absent though bones from terrestrial full-time residents such as grouse are evident. Current egg collecting practices on the lake limit any collector from taking more than half the eggs in any one nest. The taking of the ducks themselves also is prohibited. This system has allowed for a stable waterfowl population and a sustainable harvest of their eggs for a very long time. Historic documents describe such management practices as dating back into the 18th century. Archeological evidence suggests that these practices go back even further, to the first settlement of the region in the early 10th century. This combined evidence strongly suggests that human exploitation of the Myvatn bird populations is an example a sustainable harvesting system operating at a millennial scale.

(Source: Hicks et al 2015)

ADAPTATION

Cultural resources along the California coast are vulnerable to diverse climate impacts (BLM photo).

Case Study: BLM Pilot Project for Coastal Impacts on Cultural Resources

BLM manages the California Coastal National Monument (CCNM). The CCNM has a small land base but extends the entire length of the state. A partnership of BLM, Sonoma State University, and the Society for California Archeology has established a pilot project along CCNM to identify and study climate impacts on coastal cultural resources. This project combines volunteer field surveys and preparation of a general workplan that can be used by other institutions for research grant proposals about coastal-climate impacts.

(Source: K. Winthrop, P. Capron [BLM], personal communication 2016)

Adaptation includes research and approaches for resource management actions that address conditions developing from or related to climate change.

Impacts

U.S. Bureau of Land Management (BLM, U.S. nationwide)

The BLM's cultural heritage program is developing a management framework that incorporates climate change impacts into BLM's overall multi-use land management stewardship goals. The program includes identifying and evaluating cultural resources during land use planning; assessing vulnerability, risk, and resilience across different types of resources and impacts; identifying practical approaches to enhance resilience for high priority sites and representative samples of different site types; mitigating on-going impacts and building resilience where possible; and integrating this work into emergency and disaster planning.

World Monuments Fund (WMF, based in New York City, NY)

The WMF funds projects across the world for preservation of cultural heritage. The WMF program "Climate Change Threats to Cultural Heritage" is one of its special initiatives and funds efforts towards adaptive preservation of cultural heritage sites threatened by climate change.

Noah's Ark (UCL, UK)

The Noah's Ark project, hosted by the UCL Sustainable Heritage Centre, is producing tools at a Europe-wide scale intended to be used in support of adaptation for cultural heritage threatened by climate change. The *Atlas of Climate Change Impact on European Cultural Heritage: Scientific Analysis and Management Strategies* (Sabbioni *et al*. 2012) is a product of Noah's Ark.

Ritsumeikan University Program in Disaster Management (Kyoto, Japan)

Developed in partnership with UNESCO until 2014, this program is now part of the Ritsumeikan University Institute of Disaster Mitigation for Urban Cultural Heritage. This program offers an annual training course as well as a variety of symposiums and literature about disaster and cultural heritage. The Institute is also a research facility focusing on catastrophic impacts on cultural heritage. This institute focuses on all disasters, natural and otherwise; much of its work is relevant to hazards linked to climate change.

Information

Research Institute for Humanity and Nature (RIHN)-Ano Nuevo State Park Collaboration (Kyoto, Japan-California)

The RIHN is running a comparative project to examine hunter-gatherer landscapes in Japan and Northern California. This project is a collaboration between RIHN and Ano Nuevo State Park, California. One result of this collaboration has been testing of traditional resource and environment management (TREM) methods shared by local tribal stakeholders and identified through archeology.

(Opposite) Arena Cove as seen from the Cypress Abbey Public Lands, CA (BLM photo/Jeff Fontana).

MITIGATION

National Trust Historic Preservation Green Lab research demonstrates energy efficiency of reusing historic buildings (NTHP photo, used with permission).

Case Study: The National Trust for Historic Preservation - Preservation Green Lab

One of the central ideas around the work of the Preservation Green Lab can be expressed as 'the greenest building is the one that already exists.' Further, the greenest building might be the smaller building constructed in the past when passive climate control was a necessity rather than an innovation. Two Preservation Green Lab projects illustrate this well. The 'Older, Smaller, Better' project analyzed a number of cities and looked at the relationship between the age of buildings and sustainability as measured by economic, social and environmental variables. The results show the key role older buildings play in preserving and building sustainable communities. The 'America Saves!' project offers energy saving strategies to small business owners in the US. This project focuses on 'no hassle' energy efficiency methods, including efforts to decrease the carbon footprint of small businesses and create savings for these small businesses that will benefit them as well as the community in which they are based.

(Source: National Trust for Historic Preservation 2016)

Relatively few organizations appear to be working to incorporate cultural resources into climate change mitigation. As mitigation is commonly understood in cultural resource terms as reduction of impacts on cultural resources from projects and other undertakings (in this Strategy, these fall under adaptation), cultural resource links to reduction of greenhouse gas emissions and environmental footprints can be difficult to identify.

Impacts-Information

Building Resilience (The Federal Provincial Territorial Collaboration on Historic Places in Canada, Canada)
This collaboration has produced a series of guidelines to help developers and property owners through the process of sustainable renovation and rehabilitation. The 'inherent sustainability' of historic buildings is used as much as any technological solutions to greener structures. The guidelines go into detail by building material (such guidelines for roofs, materials, interior features etc.).

The Climate of Culture Project (EU)
This EU Commission-funded project, which ran 2009-2014, developed multiple products about impacts of climate change on cultural heritage. Case studies from this project include mitigation in historic structures and museum contexts.

Historic England (UK)
Historic England is the heritage management organization in England and has a large number of publicly available documents that describe many aspects of the relationship between climate change and cultural heritage. These include *Energy Efficiency and Historic Buildings* (2011) and others listed in their 2016 *Climate Change Adaptation Report*.

Historic Scotland (UK)
Historic Scotland, the primary cultural resource management entity in Scotland, has made reducing the carbon footprint of the properties under their control a priority. Reducing energy use in buildings under their management as well as improving energy efficiency in traditional building are among the strategic themes of the *Climate Change Action Plan for Historic Scotland, 2012-2017.*

Reduced Footprint of Monumental Structures, Landscapes and Buildings (ReFoMo, Utrecht, The Netherlands)
The goal of ReFoMo is to assess the demand for carbon footprint reduction in historic structures and landscapes and then develop products that will meet this demand. This project has been centered on three case studies focusing on a historic fortification, a historic public building and an example of industrial heritage. The project makes available their case studies and related materials.

The National Trust for Historic Preservation, Preservation Green Lab (US)
The NTHP's Preservation Green Lab investigates the dynamics between older structures and the creation of greener cities. Their research into the carbon footprint of older buildings is used to create energy saving and carbon footprint reduction strategies for individual structures. On a larger scale, they also have examined relationships between older buildings and small businesses and present strategies and policy recommendations for the revitalization and greening of decayed urban centers.

COMMUNICATION

International work on cultural heritage-climate change has produced much fundamental research and policy (World Heritage Magazine cover, permission requested).

Effective communication extends in multiple directions, including efforts by organizations to educate different stakeholders through the dissemination of information about climate change threats to cultural heritage and innovative ways to facilitate connections between local communities and management agencies to care for cultural heritage at risk.

Impacts

U.S. Cultural Landscape Practice Knowledge Community (US/CLICK)
US/CLICK is a collaboration between US/ICOMOS and the University of Massachusetts, Amherst, supported in part by the NPS. It serves as a forum for the online exchange of news and research relevant to cultural landscape research throughout the world. Climate change, particularly impacts from climate change, is one of a range of cultural landscapes issues covered by this forum.

Historic England (UK)
Historic England has developed multiple products to share cultural heritage-climate change information with the UK government and public. These include:

- The Heritage Counts survey, an annual survey developed to explore the social and economic role of heritage in the context of select themes. Climate change was the theme in 2008.
- The Heritage at Risk Register, an annual registry of historic buildings at risk to climate change impacts, among other threats.
- The Climate Change and Your Home program (now completed) provided a toolkit to homeowners of historic buildings for reducing energy consumption and impacts from climate change.

RIHN (Kyoto, Japan)
The work of RIHN in reaching out to affiliated tribes in order to test and use TREM techniques in the management of the Ano Nuevo State Park in California is an example of communication between cultural resource managers and public stakeholders in relation to climate change adaptation.

International Organizations and Policy Statements (UNESCO-ICOMOS-ICROM-WHC-WMF)
International cultural heritage organizations have prepared multiple major and useful policies and guidance documents addressing climate change, alongside their local and site-specific activities (see case study).

Case Study:
Key International Documents

2006 United Nations Educational, Scientific, and Cultural Organization (UNESCO), World Heritage Center (WHC) Predicting and Managing the Effects of climate change on World Heritage (Vilnius Declaration):
Source: whc.unesco.org/document/6670

2007 UNESCO-WHC: Case Studies on Climate Change and World Heritage
Source: whc.unesco.org/document/106621

2008 UNESCO-WHC: Policy Document on the Impacts of Climate Change on World Heritage Properties
Source: whc.unesco.org/document/10046

2010 UNESCO-WHC-International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM)-International Council on Monuments and Sites (ICOMOS): Managing Disaster Risk for World Heritage-World Heritage Resource Manual
Source: whc.unesco.org/document/104522

2010 Sabbioni, C., P. Brimblecombe, and M. Cassar: The Atlas of Climate Change Impact on European Cultural Heritage: Scientific Analysis and Management Strategies. London, New York: Anthem.

2012 A Climate Change Action Plan for Historic Scotland 2012-2017
Source: https://www.historicenvironment.scot/media/2611/climate-change-plan-2012.pdf

2012 Historic England: Climate Change and the Historic Environment
Source: https://content.historicengland.org.uk/images-books/publications/climate-change-and-the-historic-environment/climate-change.pdf/

2015 Historic England: Historic England Action Plan 2015-2018 (2.2.1)
Source: https://historicengland.org.uk/images-books/publications/he-action-plan-2015-18/

CITIZEN SCIENCE

View from edge of shore-fast ice at Barrow, AK (Photo by Matt Drunkenmiller via ELOKA).

Citizen science is the collection and analysis of data relating to the natural world by members of the public in collaboration with professional scientists, a combination of Science and Communication.

Case Study: Exchange for Local Observations and Knowledge of the Arctic

As the effects of climate change become more apparent, Arctic residents and indigenous peoples have been increasingly involved in observations of environmental responses to changing weather patterns. Through local and traditional knowledge research and community-based monitoring, Arctic communities make significant contributions to understanding the nature of climate-driven environmental changes.

A key challenge is access to appropriate means to record, store, manage and share data and information from these monitoring efforts. Funded by the National Science Foundation, the Exchange for Local Observations and Knowledge of the Arctic (ELOKA) is a response to this challenge and provides multiple pathways for sharing of knowledge between Arctic residents, scientists, educators, policy makers, and the general public.

ELOKA is currently collaborating with Indigenous community members of the Hudson Bay region, Baffin Island, and Greenland. These community members are observing and reporting changes in their environments and sharing wisdom from generations of living in Arctic environments.

(Source: ELOKA website, https://eloka-arctic.org/)

Climate Change and California Archeology Volunteer Surveys (Society for California Archeology [SCA])

To address the risk coastal processes exacerbated by climate change pose to coastal archeological sites, SCA has organized a major effort to survey the full coastline of California. SCA members work with volunteers to conduct surveys and prepare survey reports. Teams include students and members of local Tribes. University departments, cultural resource management companies, state and federal agencies, and heritage non-profit organizations provide resources and logistical support. The first report on this work begins with climate change, its likely impacts to archeological resources, and the overall strategy for the SCA volunteer program. Subsequent reports cover results of surveys in different parts of the state (SCA 2016).

Exchange for Local Observations and Knowledge of the Arctic (ELOKA, National Snow and Ice Data Center, University of Colorado, Boulder)

ELOKA is a gathering place and facilitator of 'local observations and knowledge' for the Arctic. The ELOKA project is organized around archiving and dissemination of observations and research by local communities in the Arctic. It also provides technical support and networking between researchers.The ELOKA website hosts many different products focusing on local traditional knowledge (LTK) and climate monitoring. The Atlas of Community-Based Monitoring in a Changing Arctic, for example, is one such collaborative project that serves as a central database for projects centered on local community based monitoring of climate impacts on both cultural and natural resources.

CITIZEN SCIENCE

Citizen science for cultural resources in relation to climate change to date is often organized primarily around impacts, although the community engagement it fosters brings in the information and meaning components of cultural resources.

Scottish Coastal Archeology and the Problem of Erosion Trust (SCAPE, University of St. Andrews, Scotland)
SCAPE has developed multiple citizen science projects to address the challenges of long coastlines, large numbers of diverse cultural heritage sites at risk from coastal erosion, and limited staff and other resources. These projects include:

• *Scottish Coastal Heritage at Risk (SCHARP):* engages citizen volunteers to identify and monitor at-risk coastal heritage sites and gather data on the rate and scale of coastal erosion. Citizen monitoring is carried out through a smartphone app. The app includes a map of at-risk coastal cultural heritage prioritized by vulnerability and significance and encourages volunteers to submit photos and complete short site forms. These data are used to update site records and support research initiatives on erosion impacts and loss of coastal cultural heritage.

• *ShoreDigs:* works with selected communities associated with at-risk heritage to consider different preservation options and choose an approach that is most effective and meaningful for them. These include options such as community excavations, oral histories, films, and 3D models incorporated into museum exhibits.

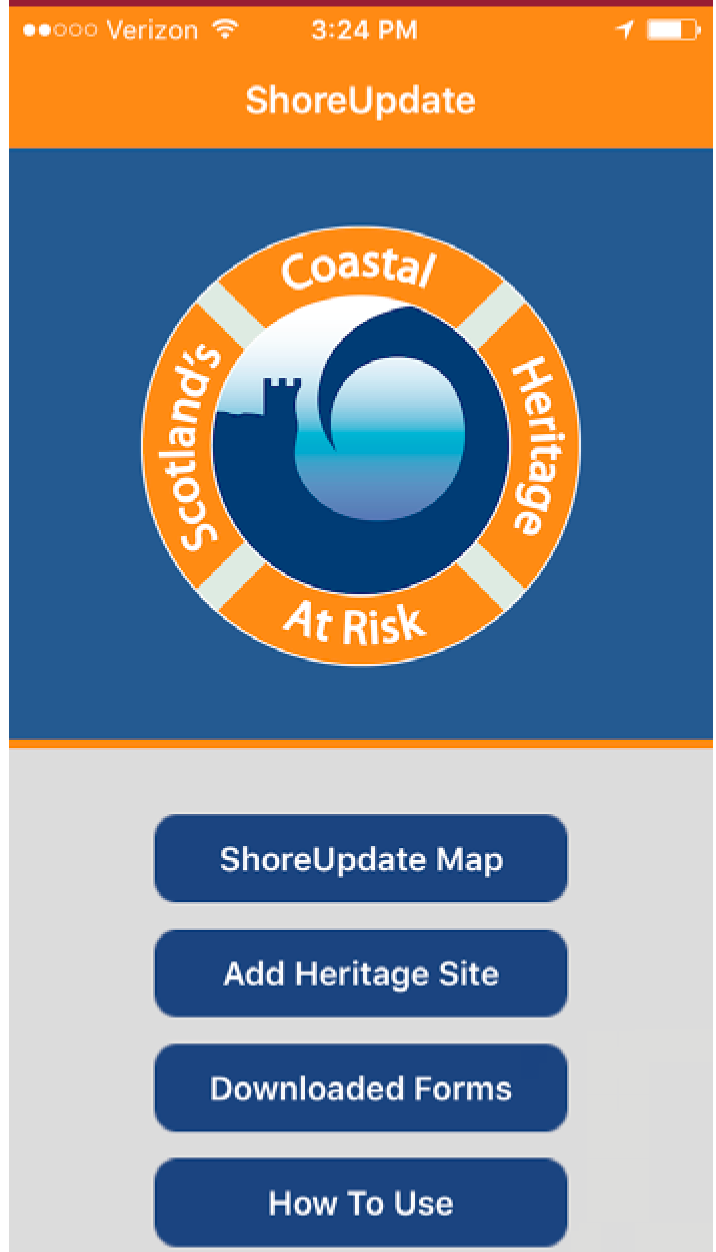
Adaptations of the SCHARP model in other countries include:

• Archéologie Littorale et Réchauffement Terrestre (ALeRT, France)
Focuses on Brittany and works through a network of archeology departments, volunteers, regional societies, and museums. Volunteers are linked to specific areas of study and are alerted when weather conditions indicate a need for monitoring.

• Arfordir Coastal Heritage (Wales)
Pan-Wales project to identify and monitor condition of archeological sites under threat of erosion in the coastal zone.

• Coastal and Intertidal Zone Archaeological Network (CITiZAN, England)
Three-year project covering all coasts of England with teams in Portsmouth, London, and York. Engages trained citizens ("citizans") and other members of the public. Training includes introduction to the intertidal zone, specialist skills and onsite training, and research and dissemination.

• Monitoring the Archeology of Sligo's Coastline Project (MASC, Ireland)
Pilot project in County Sligo. It began with no funding and is organized to address private land access restrictions, which in Ireland begin at the high tide line. The project engages members of the public who use the coastline regularly, such as bird watchers, divers, sunbathers, and dog walkers, encourage them to report eroding cultural heritage. Reports are reviewed, acknowledged, and written up in news stories for the local media.



Screenshot of the SCHARP mobile app, which supports a citizen science approach for cultural heritage at risk from climate change

(NPS photo/M. Rockman).

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The NPS *Cultural Resources Climate Change Strategy* is the work of many hands. Issues and approaches for cultural resources were identified through multiple NPS-lead climate change-focused workshops, climate change projects in Cultural Resources, Partnerships, and Science Directorate programs, development of planning documents and handbooks through the Climate Change Response Program, on-site discussions with NPS park, regional, and program staff, technical assistance requests, park and regional funding proposals, and discussions of the Climate and Culture community of practice from 2011-2016. Architecture, case studies, and primary text of this Strategy were developed through partnerships with the University of Arizona and University of Maryland, College Park. In addition to the lead writers listed here, writing assistance for the case studies is credited in the individual case studies.

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For additional information on the NPS response to climate change, visit www.nps.gov/climatechange.

Back cover photo: Portion of a Native Alaskan fishing camp near the edge of Bering Land Bridge National Preserve. The Alaska region has been experiencing notably warmer temperatures, resulting in loss of sea ice, melting permafrost, increases in coastal erosion, and concurrent damage to Native Alaskan villages and lifeways and diverse cultural resources (NPS photo/M. Rockman).

National Park Service
U.S. Department of the Interior

Cultural Resources, Partnerships, and Science
Climate Change Response Program