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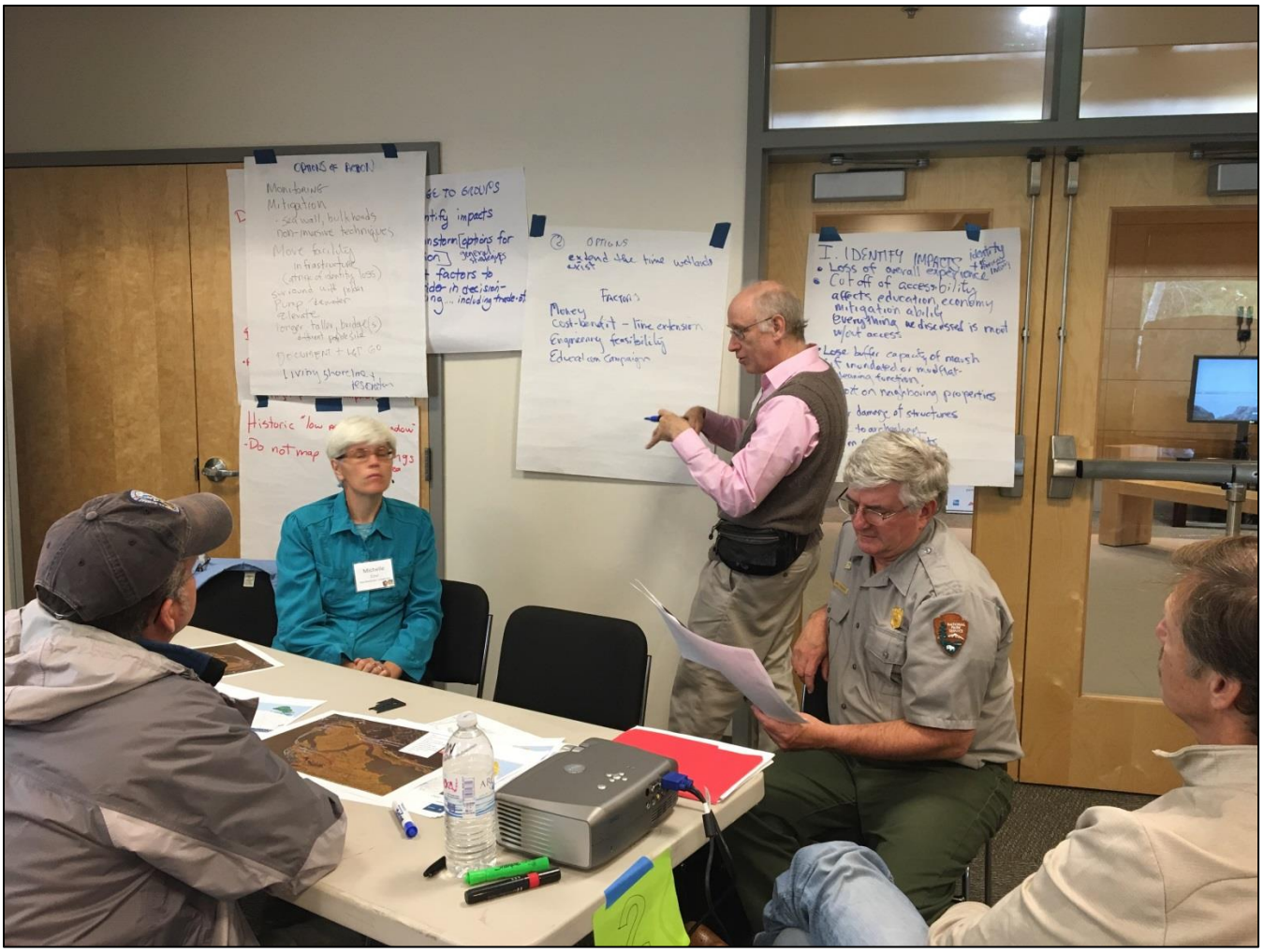
Natural Resource Stewardship and Science

# Method for Integrated Coastal Climate Change Vulnerability Assessment

Natural Resource Report NPS/NER/NRR—2019/1933



**ON THE COVER**
Photograph of the Colonial National Historical Park assessment stakeholder group discussing issues at one of the workshops. Photograph courtesy of the University of Rhode Island.

# Method for Integrated Coastal Climate Change Vulnerability Assessment

Natural Resource Report NPS/NER/NRR—2019/1933

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# Executive Summary

Many of the National Park Service (NPS) coastal parks are at risk to climate change. To quickly gain a deeper understanding of how parks are vulnerable across their natural resources, cultural resources, and facilities, an integrated climate change vulnerability assessment led by division leaders and drawing upon readily available information is recommended as a practical starting point. The goals of a rapid assessment are to help park managers identify priority vulnerable resources/assets to inform their adaptation planning processes and justify near term funding requirements. Managers will also be able to inform investment prioritization for resources that are highly vulnerable but have a low ability to be conserved or to adapt.

Highlights of the method tested and described in this report include:

- Incorporating different divisions that have their own terminology, concepts, mandates, and priorities. To balance the need for integrating across divisions and have a means to apply across divergent sites, this method is detailed, yet flexible to be responsive to the needs of each park.
- Focusing on comparing vulnerability across the resources managed by each division at a site. The method is not intended to compare relative vulnerability between different parks. Instead, the focus remains on the relative vulnerability of different resources and assets across an individual park to address the unique context for a park and its staff.
- Applying existing data and expert knowledge of staff and partners. This enables the assessment to be done relatively quickly, using the best available science based on local understanding of the complexities and management needs of a place.
- Ensuring a high degree of participation within and outside of the NPS by engaging key stakeholder groups for each park. It cannot be overstated how valuable the social process is to the method, especially for working across divisions.

The vulnerability assessment is organized into nine steps – beginning with the identification of resources and climate projections for three time periods followed by analysis of vulnerability and integration across priority issues. Workgroups for natural resources, cultural resources, and facilities are established to gather the necessary expertise. Most of the scoring of exposure, sensitivity, and adaptive capacity, as well as integration across divisions, happens at three workshops, each 1.5 days in length.

At the conclusion of the vulnerability assessment, the following products are produced:

- Vulnerability Assessment Report: A detailed assessment report is produced for the park. It summarizes the method and results, provides recommendations for next steps, and includes the raw data in the appendices.
- GIS (Geographic Information System) Database: All data is given to the park's GIS manager for record keeping and uploading to the system. There is the option to share the information

layers provided in an online map viewer during the workshop process with the general public and partners in the assessment.

# Acknowledgments

Thanks are extended to the park staff and partners who provided input through participation at the pilot workshops and written comments on the draft document. Jim Kendrick contributed significantly to the methods development for the cultural resources workgroup. This report was improved through review comments by Josh Lawler, Robert Young and Pei-Lin Yu. This project was funded by the NPS Climate Change Response Program. Thanks to Gregor Schuurman for serving as the peer review manager and Robin Baranowski for formatting assistance.

# Acronyms

| | |
|---|---|
| AC | Adaptive capacity |
| ASMIS | Archeological Site Management Information System |
| CCRP | Climate Change Response Program |
| FMSS | Facilities Management Software System |
| GIS | Geographic Information System |
| H, M, L | High, Moderate, low |
| I&M | Inventory & Monitoring |
| IPCC | Intergovernmental Panel on Climate Change |
| NER | Northeast Region of NPS |
| NHP | National Historical Park |
| NOAA | National Oceanic and Atmospheric Administration |
| NPS | National Park Service |
| NRCA | Natural Resource Condition Assessment |
| SLR | Sea level rise |
| SOP | Sustainable Operations Program |
| USGS | United States Geological Survey |
| WCU | Western Carolina University |

# Introduction

Many coastal parks are at risk due to climate change in the coming decades. To gain a deeper understanding of how parks are vulnerable across their natural resources, cultural resources and facilities, an integrated climate change vulnerability assessment is recommended. The goals of the assessment are to help park managers identify priority vulnerable resources/assets to inform their adaptation planning processes and justify near term funding requirements to learn more about potential climate change vulnerabilities. Managers will also be able to inform investment prioritization for resources that are highly vulnerable, but have a low ability to be conserved or to adapt.

To serve these needs, NPS Northeast Region (NER) partnered with the University of Rhode Island Graduate School of Oceanography's Coastal Resources Center to develop a method for an integrated climate change vulnerability assessment for coastal NPS parks. An initial method was piloted at the Colonial National Historical Park (NHP) by assessing natural resources, cultural resources, and facility assets using existing data, local knowledge, and subject matter expertise. Based on lessons from that pilot, this report summarizes a refined method has been developed for conducting future assessments. One benefit of this method is that divisions can use the results of the assessment for their own planning as well as larger park-wide integrated planning. The method is intended to be transferrable to other coastal parks with a diverse range of available resources, and could be further developed to be applicable to riverine and terrestrial parks.

The method is unique in that it simultaneously incorporates concerns and information from different park divisions, each of which has their own terminology, concepts, mandates, and priorities. To balance the need for integrating across divisions and have a means to apply across divergent sites, this method can be detailed, yet flexible. Therefore, the method is not intended to compare relative vulnerability between different parks, which was determined to be a different goal beyond the scope of this effort. Another important element is that the method relies upon the use of existing data and expert knowledge of staff and partners. This enables the assessment to be done relatively quickly, based on best available science using local understanding of the complexities and management needs.

The method is highly participatory, incorporating staff and stakeholders from within and outside of the NPS. To increase awareness, buy-in, and likelihood for taking action, the method encourages most of the divisions to engage in the assessment process. It can involve NPS staff from park, regional, and Washington office levels. Additionally, it invites participation from key stakeholders in local government, neighboring partners, academics, and national groups. Together, these actions provide support to move recommendations forward and broaden the conversation. It cannot be overstated how valuable the social process is to the method, especially for working across divisions.

The following guidelines were used to develop the method:

- Be aware that the park is part of a regional landscape of stressors and actors.
- Consider both climate and non-climate stressors.

- Analyze vulnerability from a decision-making mindset.
- Integrate analysis and planning across natural resources, cultural resources, and facilities divisions.
- Start with existing vulnerability frameworks and definitions.
- Consider how institutional and organizational dynamics influence decisions (adaptive capacity).
- Revisit park goals during and after the vulnerability analysis.
- Build on existing data and expert judgment.
- Highlight near and long-term time frames.
- Consider adaptation pathways of key decision points (past, present, future).

The method set out in this publication is based on the pilot experience of Colonial NHP. Feedback from the assessment team and stakeholders has been incorporated to produce this refined version to consider the needs of the NPS, while also producing a detailed and informative analysis for the park to use for adaptation planning and interpretation. Lessons from the Colonial NHP assessment have been summarized in the appropriate sections of this document to provide the reader with some insight as to why the method made certain decisions; a separate vulnerability assessment report for Colonial NHP can be referenced for more detail (Ricci et al. 2019). A beta assessment was done for Fire Island National Seashore which further informed this method.

## Assessment Framework

Although the NPS has used a variety of frameworks to do vulnerability assessments, the starting point for this climate change vulnerability assessment framework follows the common approach used by the Intergovernmental Panel on Climate Change (IPCC) and in the multi-agency guide *Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment* (Glick et al. 2011). It has been adapted through what was learned in a review of NPS NER vulnerability assessment experience (Ricci et al. 2017) and the Colonial NHP pilot assessment (Ricci et al. 2019). This version of the framework is also substantially aligned with other NPS assessments (as described in the NPS Coastal Hazards & Climate Change Asset Vulnerability Assessment Protocol, a document that focuses on facilities and infrastructure and is hereafter referred to as NPS 2016) or the Sustainable Operations Program (SOP) facility assets assessment protocol), with which much of this methodology is integrated with. In our framework (Figure 1), vulnerability is the combination of a resource's/asset's exposure to climate stressors and its degree of climate change sensitivity. One significant difference from the IPCC and Glick et al. (2011) approach--but consistent with NPS (2016) and Rockman et al. (2016)--is the fact that this framework does not treat adaptive capacity as a component of vulnerability. It should be noted, however that there are differences among this framework, NPS (2016), and Rockman et al. (2016), in terms of justification, definitions, and the degree to which the concept of adaptive capacity is used at all. For example, NPS (2016) uses the term *adaptation strategies analysis* instead of adaptive capacity.

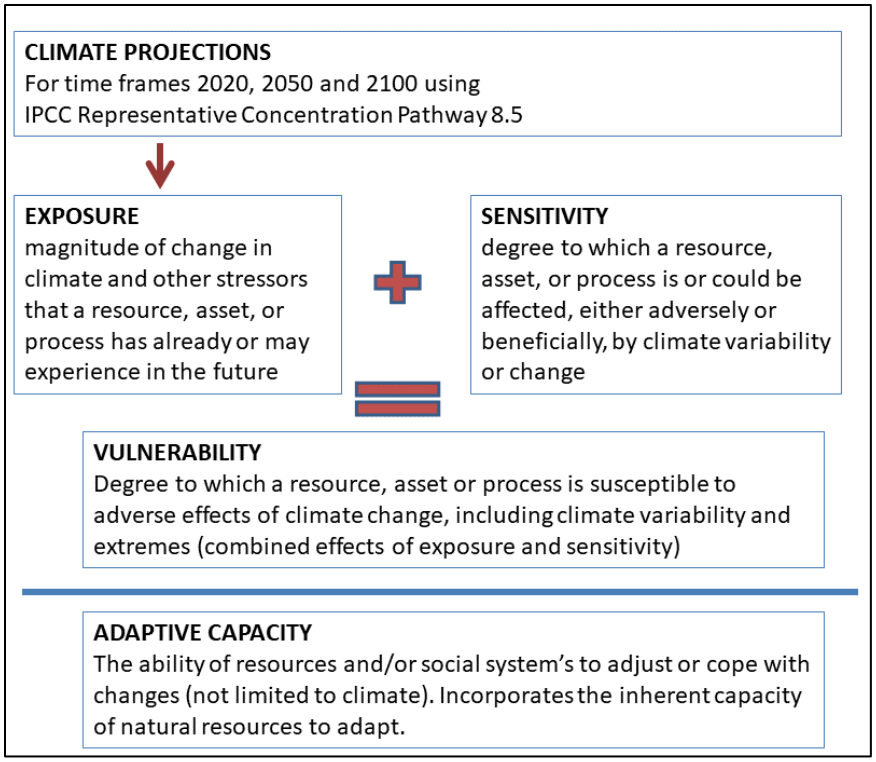


**Figure 1.** Overview of the climate change assessment framework.

This pilot diverges from other frameworks discussed above in 1) defining adaptive capacity as including non-intrinsic components to include management adaptive capacity based on factors such as non-living physical, social, organizational, and economic adaptive capacity, and 2) treating adaptive capacity as distinct from vulnerability even for natural resources. Since these non-intrinsic factors of adaptive capacity are not inherent to the resource and rely on management actions which cannot be certain, assessment of adaptive capacity is handled separately. This simplification of combining the intrinsic and non-intrinsic components of adaptive capacity means that vulnerability of living resources may be overestimated; for future assessments it would be important to test separating the components and seeing the difference, both in the results and in effectiveness of communication. For communication and planning purposes, the notion of adaptive capacity for non-living resources as an attribute that reduces vulnerability was thought to counteract the park's ability to make a strong enough case for highlighting the importance of a likely problem and could limit the ability to the resources needed to adapt. Park staff believe that the vulnerability score based solely on sensitivity and exposure, without modifications from adaptive capacity, may be helpful in targeting research questions, prioritizing research efforts, selecting adaptation methods, and allocating funding. The approach used in our work is an experimental effort, and will inform ongoing efforts to develop consistent approaches and concepts across NPS efforts.

Adaptive Capacity is a key factor in understanding how to respond to vulnerability of a resource or asset in the future, as nature and people will likely respond to climate change impacts overtime.

**Adaptive capacity** is defined as the **ability of a resource, asset or process** to adjust to climate change (including climate variability and damages, to take advantage of opportunities, or to cope with extremes), i.e. to **moderate potential consequences**.

(from IPCC (2014) and NPS (2016))

Note that this definition is different than that in Figure 1, which was the definition that was used in the pilot workshops, in the inclusion of the social system. This integrated method was experimental in an effort to explore a way to include a broad definition of adaptive capacity that includes both management adaptation and intrinsic adaptive capacity. Each resource/asset will have to be managed as a part of a system. Guided by insights to systems in the hazards sector (Bruneau et al. 2003), ecology (Campbell et al. 2001), and social development (Carney, 1998), it appears that many systems require a combination of capacities. These adaptive capacities are encompassed in the four areas – physical, organizational, social, and economic (POSE) – to make effective changes. The POSE framework can help understand and assess the ability of nature, people, and organizations to collectively manage and adapt to climate impacts (Figure 2). While additional areas could be identified, this method uses these four (POSE) capacities which are general enough to fit most needs. To reflect the intrinsic adaptive capacity of living resources, the physical category is subdivided into natural/intrinsic and infrastructure/technology.

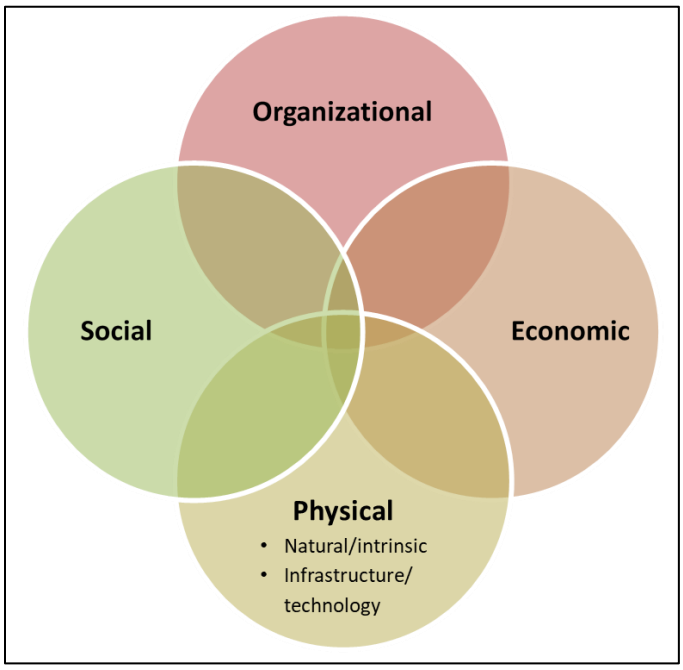


**Figure 2.** Four capacities in the POSE model for adaptive capacity.

As this method is applied in the future and we learn what is most useful to park application, adjustments to terminology and where components are communicated in the framework may help with consistency across NPS efforts that are in concurrent development.

### Focus on Park Manager Needs

The emphasis in the method is ensuring that park management staff at the site, regional, and national offices can use the results to take action. Therefore, each phase of the method is focused on answering key management questions (Figure 3).

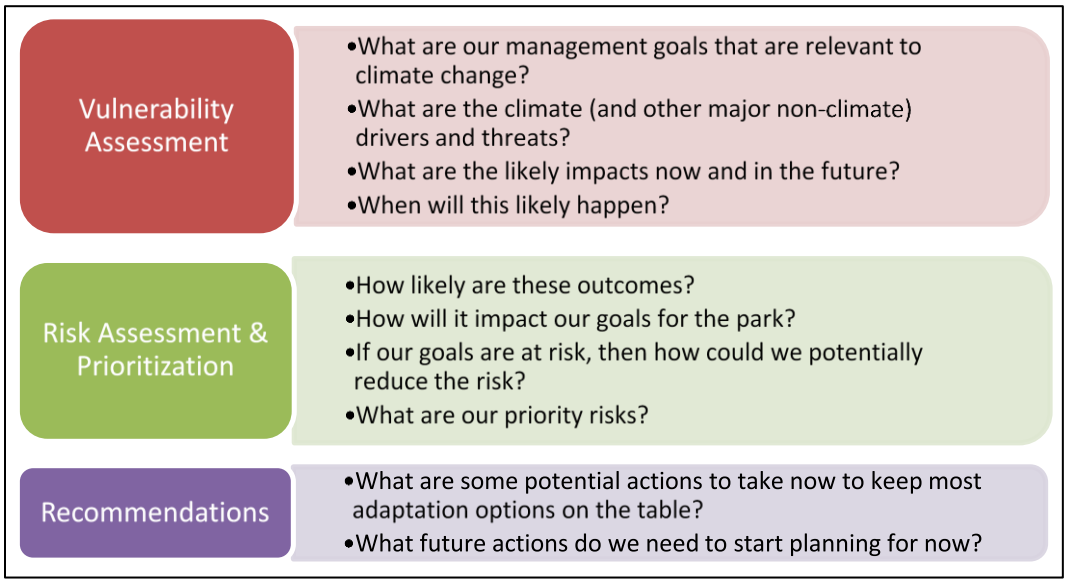


**Figure 3.** Examples of how different phases of the assessment can address common management questions related to climate change.

## Process

This assessment process needs to foster participation across divisions, as well as engage key partners with expertise in their respective fields to take a larger ecosystem and community view surrounding the park. This is aided by forming workgroups that take responsibility for each category of resource, as well as ensuring joint discussion and analysis among these workgroups takes place through structured exercises during each of the three workshops. Workshops should be about 1.5 days, requiring that as much of the background work as possible is completed in advance and presentations are kept concise. The priority is to provide enough time for the workgroups to engage one another in joint analysis, as that is a major element leading to integrating across divisions. It may be possible to achieve a quality vulnerability assessment in two workshops. The overall assessment process is described below (Figure 4) and more detailed methods for each of the workgroups is then presented in the next section.

This process and methodology were designed with the expectation that park staff may need to revisit the assessment periodically. The results are stored in basic spreadsheets that allow the park staff to update the assessment every 3-5 years or after a major change, such as a storm or new scientific developments.

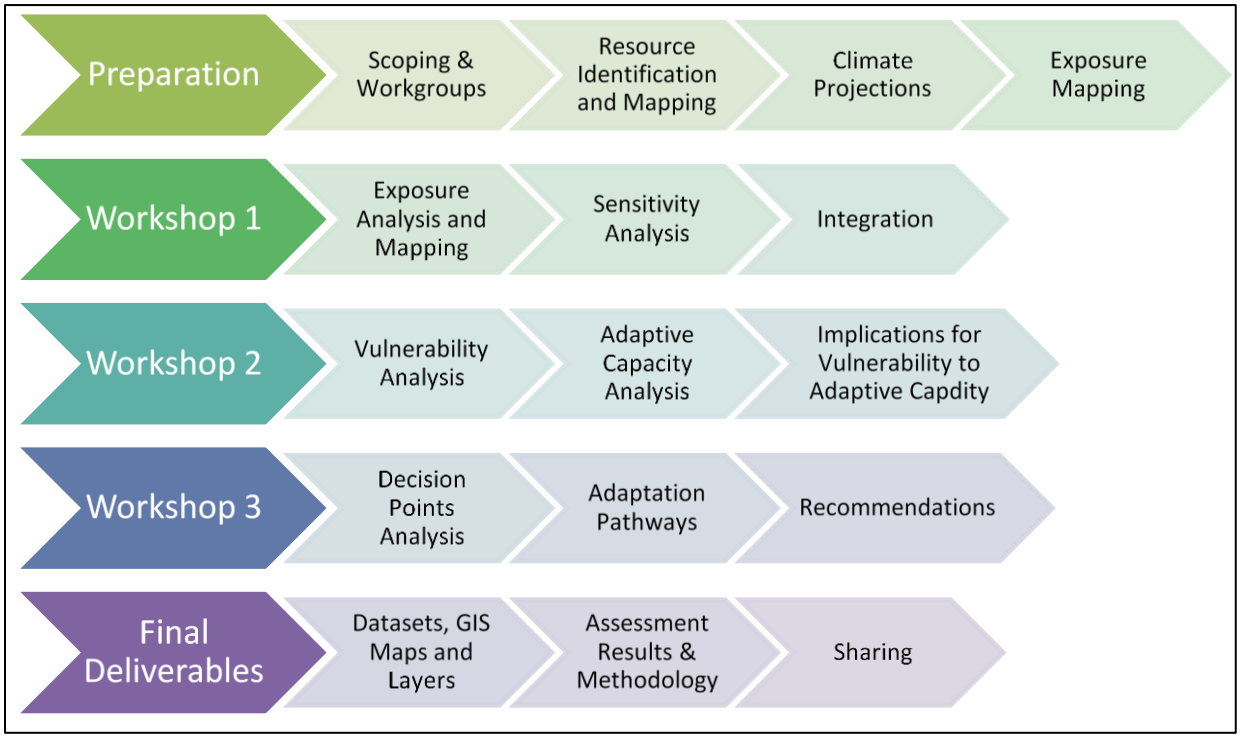


**Figure 4.** Overview of the integrated vulnerability assessment process and method.

## Preparation

### *Scoping*

To ensure that the assessment meets its goals of being relatively rapid, integrated, and based on existing information, the project scope should be outlined and agreed upon ahead of the first workshop. This can happen through a combination of a project brief, and/or a conference call with the coordination team.

Key parts of the scoping process include (see Table 1 for an example):

**Focus**: Clearly state the overall objective of the assessment. For this methodology it is most likely the entire park area and integration across all three divisions. You can also scope out the sources for determining the resources/assets to be assessed, such as all assets in the Facility Management Software System (FMSS) or whether to include an important adjoining land parcel.

**Valued Attributes**: These are larger goals and values for later consideration to understand the vulnerability implications. These attributes are also helpful for identifying which resources/assets to include in the assessment.

**Time frames**: Tying together the long-term trends due to climate change and near-term management decisions is a difficult challenge. NPS often plans in 5-10 year periods, not the longer time frames typical of climate change scenarios. One element to consider is that actions today can lock in adaptation pathways that limit long-term options. Therefore, longer time frame planning is crucial for flexible, future adaptation pathways.

**Climate Stressors**: Identify the primary and secondary stressors that will be assessed, and thus require climate projection data to begin the exposure analysis. Primary stressors are shared across all workgroups, while secondary stressors address the unique concerns of each workgroup.

**Spatial Extent**: Identify the specific geographic areas within the park for a greater degree of analysis and integration. It is helpful to have two or three areas to use as examples in the workshops, especially those that are of concern to more than one division. For the natural resources workgroup, they may identify sites where a particular habitat may need individual scores compared to a park-wide score for that habitat type.

**Table 1.** A sample scoping exercise done for Colonial National Historical Park vulnerability assessment.

| • **Factor** | **Scope Of The Vulnerability Assessment** |
|---|---|
| Focus/Objective | Vulnerability of natural and cultural resources and facility assets at Colonial NHP |
| Valued Attributes | • Guiding principles of the Colonial NHP, informed by Foundation Document<br>• Goals of the park for each of the three divisions<br>• Visitor experience<br>• Healthy ecosystem<br>• Cultural heritage preservation |
| Time Frames | 2020, 2050, 2100 |
| Climate Stressors | • Priority: sea level rise (SLR), storm surge, erosion, inland flooding<br>• Secondary: temperature, precipitation, changes in groundwater, wind<br>• Non-climate stressor: only include those that are vital – e.g. invasive species |
| Spatial Extent | Assessment for all of Colonial NHP and two to three focal areas for deeper analysis:<br>• Jamestown Island<br>• Glasshouse Point complex<br>• Colonial Parkway segments along the James & York Rivers |

### *Establishing the Coordination Team*

A small coordination team should be formed that will be responsible for the overall assessment. This should include a combination of leadership from the park and the technical team conducting the assessment. It is advised that the workgroup leaders should be part of this core team to ensure clear communication throughout, ideally including division chiefs where possible. This team will coordinate using phone calls and emails, as well as meeting at the workshops.

### *Forming Workgroups and Leaders*

While this is an integrated assessment, much of the work will be conducted through the workgroups. This ensures buy-in and use of the assessment by each division as it creates deeper analyses. This arrangement will also lead to more efficient information sharing and discussion with the other workgroups. Each workgroup should be led by a member of the coordination team. The members should include a variety of experts knowledgeable both about the resources/assets of the workgroup and the park itself. Experts should be drawn from both the NPS and external partners, such as those who have an ongoing engagement, such as active research within the park. Moreover, non-governmental organizations playing an ongoing role to support and advocate for the park, other government agencies who are actively studying and monitoring the park (United States Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA)) and regional planning bodies should be involved in the workgroups. Due to the complexity of cultural resources, it is recommended that the workgroup includes experts for each of the subcategories highlighted in this methodology. Since there are three workshops and equal or greater number of preparatory conference calls, the selection and number of members should be carefully considered so as not to lose their interest and commitment. While it would be ideal for all members to attend all workshops, it is possible to engage some through conference calls, while others rotate in attending the workshops or participate off-site through conference calls during the meetings. As long as there is continued

sharing of meeting notes and assessment documentation the goal of integration for the scope of this project will be met

Three workgroups based on divisions are suggested:

- Natural Resources
- Cultural Resources
- Facility Assets

Along with two support workgroups:

- Climate Projections
- GIS Mapping

### *Gather Existing Data and Assessments*

The workgroup leaders should coordinate with the rest of their members on identifying existing data that is available within and external to NPS (Table 2). There have been numerous studies associated with most areas whether strictly climate change or more broadly in scope that are still relevant.

**Table 2.** Potential sources of existing data to initiate the assessment.

| Climate Projections | Natural Resources | Cultural Resources | Facility Assets | General |
|---|---|---|---|---|
| Climate change summaries (temp & precipitation) and sea level rise projections have been prepared for most parks. Western Carolina University has prepared 1m SLR asset exposure information for many coastal parks. The USGS Sea-Level Rise Hazards and Decision-Support project has developed information in a consistent format for many parks. | • Natural Resource Condition Assessment<br>• Inventory & Monitoring Vital Signs<br>• Landscape Conservation Cooperatives | • Archaeological Site Management Information System (ASMIS)<br>• List of Classified Structures<br>• Cultural Landscapes Inventory<br>• Cultural Resources Stewardship Assessment (if available) | • Facilities Management Software System (FMSS)<br>• 1M SLR exposure studies<br>• Federal Highway Transportation studies | Foundation Document |

### *Preparation of Inputs to Conference Calls and Workshops*

Before convening for the first workshop, the coordination team should have completed the following tasks:

- Project description with information on the scope of the assessment.
- Coordination team formed and communicating effectively.
- Workgroups established with a leader, clarity of roles, and arranged time commitments.

- Workgroups will have selected resources and assets to assess, with the facilities workgroup only adding on to what is not covered by previous assessment – discussed in more detail in later sections.
- List of goals for each resource workgroup to compare results of assessment.
- Climate projections selected and summarized.
- Initial resource/asset map produced through GIS and broken down into each workgroup.
- Datasets for each workgroup listed as follows: the individual resources/assets to be assessed, and the exposure indicators and scores (where available from GIS analysis) for each at three time frames.
- Draft exposure maps for three time frames for each workgroup based on GIS analysis for select resources/assets.

### Workshop 1 – Scoring Exposure and Sensitivity

Three carefully planned workshops that are each 1.5 days in length can produce the analysis and develop buy-in among the participants.

The objectives, activities, and outputs for Workshop 1 are summarized in Table 3, which should focus on confirming the purpose and scope of the assessment, sharing climate change projections, and scoring the exposure and sensitivity of resources to these stressors. Since many of the participants will be new to the assessment, the first day will include an overview of the process and methods. The list of resources/assets to be assessed should be selected before the workshop as much as possible, in order to present a first draft of the exposure analysis. Note, this can be adjusted at the workshop based on review and discussion of the initial list. Initial exposure scores where available are presented at the workshop, each workgroup confirms or adjusts the scores, and then each workgroup fills in the information based on expert judgement for resources/stressors that exposure info was not available for ahead of the workshop. Much of Workshop 1 is focused on finalizing the exposure scores. The objective of the second half of the first workshop is to understand the concept of sensitivity (versus exposure and adaptive capacity) to then select appropriate sensitivity indicators. The workgroups will only have time to begin the process of scoring sensitivity. Integration across the workgroups to reveal key linkages, using focal areas, will alternate with workgroup break outs. See the next section on methods to understand the process for scoring exposure and sensitivity.

Some of the outputs will be completed at the workshop, while others may require the workgroups to continue the work after the workshop through emails and conference calls. The workload depends on how many additional changes each workgroup makes to the list of resources/assets, exposure indicators, and/or scoring.

**Table 3.** Summary of the objectives, activities, and outputs for integrated vulnerability assessment Workshop 1.

| Objectives | Activities | Outputs |
|---|---|---|
| Learn and advise on the methods for conducting the assessment | • Review the purpose of the assessment, the process and methodology, the desired management questions to be addressed, and the final products to be produced. | n/a |
| Share initial analysis on exposure | • Review the draft exposure data and maps.<br>• Make changes to the list of resources/assets to include in the assessment based on the gaps identified.<br>• Revise any exposure scores based on expert judgement.<br>• Score exposure for resources without data ahead of workshop, and for added resources. | • Final list of resources/assets to be assessed<br>• Final scores for exposure for each time frame |
| Select the sensitivity indicators for each resource workgroup and begin the scoring process | • Select the sensitivity indicators, for each workgroup or resource category, by reflecting on recent major events and/or oral histories by experts to identify key indicators.<br>• Initiate scoring sensitivity to ensure the method will work. Finalize scores after the workshop. | Final set of sensitivity indicators and scores (might need more time) |
| Reveal key linkages across the divisions to understand the inter-dependence of resources to achieve management goals | Integration across divisions – how does exposure play out in focal areas? Conduct a joint exercise with all of the workgroups to understand how a focal area will be exposed for all of the resources and the likely interactions. The purpose is to identify significant linkages across the workgroups. | List of major integration linkages for a focal area that will be revisited during the final workshop. |

### Workshop 2 – Establishing Vulnerability Scores and Documenting Adaptive Capacity

Workshop 2 focuses on finalizing the sensitivity scoring within in each workgroup, reviewing the initial vulnerability scores (a combination of exposure and sensitivity for each resource), introducing the POSE framework for adaptive capacity, and beginning scoring adaptive capacity (Table 4). Integration across the workgroups needs to be pursued in more depth with an extended exercise analyzing a focal area, which all park divisions have identified as a critical concern. Some of the outputs will be completed at the workshop, however others will likely require the workgroups to complete their tasks post-workshop through emails and conference calls.

**Table 4.** Summary of the objectives, activities, and outputs for integrated vulnerability assessment Workshop 2.

| Objectives | Activities | Outputs |
|---|---|---|
| Review and finalize the sensitivity scores | Workgroups work independently to review | Final sensitivity scores |
| Analyze the vulnerability scores (combined exposure and sensitivity) for three time frames | Integrated vulnerability score analysis | Final vulnerability scores |
| Select indicators for adaptive capacity and assign scores | Adaptive capacity indicators and scoring | Draft scores for adaptive capacity |
| Reveal key linkages across divisions in a select focal area to understand the inter-dependence of assets/resources to achieve management goals/objectives | • Integration at focal areas<br>• Identifying cross-sector issues of concern for the park | List of key linkages |
| Identify final steps to conclude in the assessment | Discuss potential uses of the assessment for the park | List of potential uses to be incorporated in the final report |

## Workshop 3 – Reviewing Park Goals and Communicating Vulnerability

The focus of the third and final workshop is on the participants making sense of the final scores and developing recommendations to move forward with further analysis, communication, and interpretation to incorporate the results into the larger adaptation planning process (Table 5). This assessment will not produce adaptation actions, but this is an opportunity to demonstrate how the vulnerability assessment can be used towards developing adaptation strategies as next steps.

**Table 5.** Summary of the objectives, activities, and outputs for integrated vulnerability assessment Workshop 3.

| Objectives | Activities | Outputs |
|---|---|---|
| Review the final scores for vulnerability and adaptive capacity | Workgroups work independently to review and edit | Finalized scores for vulnerability and adaptive capacity |
| Reveal key linkages across divisions in select focal areas to understand the inter-dependence of assets/resources to achieve management goals/objectives | • For overlapping resources/assets, multiple workgroups discuss and modify scores accordingly<br>• Select key integration issues and discuss their implications for the entire park and focal areas | Summary of integration issues for the entire park as well as focal areas |
| Identify recommendations and next steps on how to use the results – such as further data needs and adaptation planning | • Conduct exercises across workgroups to reflect on the impact of the vulnerability and adaptive capacity on meeting existing goals<br>• Identify priority next steps | Recommendations for priority issues within workgroups, and between them on integrated issues |

**Table 5 (continued).** Summary of the objectives, activities, and outputs for integrated vulnerability assessment Workshop 3.

| Objectives | Activities | Outputs |
|---|---|---|
| Develop communication plans for sharing the vulnerability assessment results | • Use the NPS Every Park Has A Climate Story method to develop narratives that the interpretation division can apply<br>• Plan for sharing assessment results with key audiences | • Draft climate stories to share with the park's interpretation team for further refinement before sharing publicly<br>• Recommended next steps for communicating results with staff, partners, and the public |
| Evaluate the assessment process to inform the park staff and next iteration at a different site | Exercise to reflect on initial hopes and fears of the assessment and the overall experience/outputs | List of lessons and recommendations to improve the process/method |

## Final Deliverables

At the conclusion of the assessment, the coordination team will produce the following products:

- GIS Database: All data will be given to the NPS park's GIS manager for record keeping and uploading to the system. There is the option to share an online map viewer with the general public and partners in the assessment. Appropriate protections should be put in place to control the distribution of and not reveal archeological site locations or other sensitive spatial information.
- Vulnerability Assessment Report: A detailed assessment report will be produced for the park. It will summarize the methods and results, provide recommendations for next steps, and include the scores for all resources in the appendices.

# Methodology

Each of the workgroups should use the same process outlined in the previous section, though they may use slightly different methods based on data availability, management information needs, and other unique features related to the type of resources. In brief, the workgroups will conduct the following steps in the assessment. In each step, the workgroups will take time to share outputs to highlight key issues for integration.

Step 1: Identification of Resources and Goals

Step 2: Selection of Climate Projections

Step 3: Exposure Analysis

Step 4: Sensitivity Analysis

Step 5: Vulnerability Analysis

Step 6: Adaptive Capacity Analysis

Step 7: Integration Analysis and Recommendations

Step 8: Communicating Vulnerability

Step 9: Evaluation of Assessment Process

Each of these steps is described in greater detail in the following sections of the report. In a number of instances, workgroups for Colonial NHP found it necessary to modify the methods to accomplish their task, illustrating the need for flexibility during an assessment. Review steps 5 and 6 first to ensure the methods used by each workgroup will in fact produce the required inputs for the vulnerability and adaptive capacity analysis.

The workgroups may also find it useful to form subgroups to accelerate the scoring and analysis process before regrouping for the integration discussions. For example, if the cultural resources workgroup is large or necessary expertise is unable to participate in a workshop, they should consider dividing into subgroups based on area of expertise such as cultural landscapes, archaeology, collections, ethnographic resources, and historic structures.

*Assessing park facilities*: This integrated methodology has prioritized building on existing assessments and data of the NPS. One existing assessment is the *Coastal Hazards & Climate Change Asset Vulnerability Assessment Protocol* (NPS, 2016) developed by the NPS SOP in partnership with Western Carolina University (WCU). As of 2017, SOP/WCU has conducted over 12 climate change facility asset vulnerability assessments for coastal parks. For the pilot assessments at Colonial NHP and for the beta assessment at Fire Island National Seashore, SOP/WCU assisted by doing the facilities vulnerability assessment concurrently. This joint activity should be continued in the future.

The facilities workgroup should read the Coastal Hazards & Climate Change Asset Vulnerability Assessment Protocol for detailed guidance (NPS, 2016). Key elements of the method are highlighted in this document though the full guidance can be found in the SOP/WCU protocol. The vulnerability assessment is very similar though the methods diverge in the adaptive capacity assessment and the integration with other divisions. While the two methods are complementary, their primary goal differs in that the SOP/WCU method is designed to be comparable across parks, while this integrated method focuses on comparisons across the divisions of a single park.

*Assessing park cultural resources*: There are several examples of vulnerability and risk assessments conducted in relation to cultural resources. The NPS Northeast Museum Services Center has a risk assessment for museum collections that provides some metrics related to climate vulnerability, and others relevant to adaptive capacity. Some of the higher-level issues surrounding cultural resources vulnerability assessments are discussed in general sources like *Cultural Resources Climate Change Strategy* (Rockman et al. 2016) and *Coastal Adaptation Strategies Handbook,* Chapter 5: Cultural Resources (Beavers et al. 2016).In addition, a historic structures adaptation prioritization method that includes vulnerability and significance was piloted for Cape Lookout National Seashore (Fatorić and Seekamp, 2017) and a cultural landscape method is being developed in the Pacific West Region (Melnick et al. 2016). While the method used in this assessment was informed by all of these methods, it does not follow any of them directly. Instead a unique process was developed to work across cultural resource types and maintain relevance to the other workgroups.

*Assessing park natural resources*: The workgroup needs to determine the best level of generality to use in order to keep the analysis workable and focused, while acknowledging that other external factors may be the dominant sources of environmental change. There are several existing natural resource vulnerability assessments that have been conducted and offer methodologies that should be reviewed in advance. Refer to Ricci et al. (2017) that compiled available references to other assessments.

### Integration Across Divisions Through a Flexible Methodology

There are limited examples of vulnerability assessments for coastal parks that integrate issues across resource types. This is likely due to the numerous unique characteristics of respective resources, availability of data and communication challenges across disciplines. This methodology is unique by enabling each division to assess their resources in the manner that best suits their needs while in the end arriving at a similar degree of analysis that can enable communication and integrated analysis. The critical point is each division has options on how to apply the following methodology slightly differently, though in the end, experts understand, trust and can communicate results and address differences in perspectives across divisions. The aim is to ensure that a high vulnerability score for a cultural resource has a similar meaning under shared conditions with a high vulnerability for a natural resource or facility asset.

This methodology achieves integration through the following mechanisms:

- Selection of resources/assets: each division can select the types and scale of the resources to be assessed based on their needs and the availability of data (e.g. a habitat for natural resources and individual structures for facilities) (Step 1).
- Common climate projections: All of the divisions apply the same climate projections and thus core exposure levels for each time frame. This allows the analysis and communication of vulnerability to be comparable across the divisions for each time frame (Step 2).
- Selection of the types of indicators used for exposure and sensitivity: while most indicators are the same across the divisions and the projections used are the same, divisions can add additional indicators as appropriate (Step 3).
- Influence of exposure to final vulnerability: if a resource is not exposed to the selected indicators then there are options for how to set the sensitivity score's influence on the final vulnerability scores. For facilities workgroup which adds exposure and sensitivity together, the method does not score sensitivity for any asset with no exposure and auto-scores the asset as minimal vulnerability. The natural resources workgroup uses multiplication between the exposure and sensitivity. If a resource is not exposed then it gets a score of zero that then is multiplied by sensitivity, also resulting in a minimal vulnerability score. The end result is the same though the methods (algebra) vary based on the baseline data and alignment with pre-existing NPS methodologies (Steps 3, 4, 5).
- Modifying scores based on expert knowledge: Experts can amend raw scores for exposure, sensitivity and vulnerability based on available data or deeper understanding of systems at the park level that is not easily captured by the projection data. Scores can be adjusted based on discussions between workgroups to align scoring and appreciate the connections between resources/assets.
- Adjusting final vulnerability rankings: The placement of the boundaries between ranks (e.g. high and moderate) can be slightly adjusted based on the workgroup's interpretation of the data, root of the scores and the interactions across divisions. (Step 5). The aim is to foster understanding and agreement across the divisions as park managers move toward adaptation planning.

### Step 1. Identification of Resources and Goals

Objective

Select the specific resources/assets and park goals that will be included in the assessment. These resources/assets should be mapped, where spatial data is available, to be used in the exposure analysis.

During the preparation and scoping process at the start of the assessment, the coordination team will have identified the geographic areas of the park that will be included in the assessment, the broad valued attributes of the park, the climate stressors, and the time frames. In step 1 of this methodology, the workgroups will go deeper in the scoping process to ensure that the assessment will address their core concerns and include the necessary climate stressors to analyze vulnerability.

The sequence of topics/exercises below provide guidance for the workgroups to understand the larger context and identify linkages between goals, resources/assets, climate stressors, and upcoming major decisions by park managers.

1. **Articulate Existing Goals and Priorities:** Each workgroup should articulate about five existing goals and/or priorities, for their division. Workgroups are encouraged to state both formal and informal goals related to how they are currently managing. These goals will be used to analyze vulnerability results to determine overall risk and produce recommendations for next steps. These goals can be found in the park's founding legislation, foundation document, and/or general management plan. Note these are not limited to goals related to climate change. Starting from the foundation document would involve taking the fundamental resources and values and articulating what goals are necessary to protect those resources. A focus should remain on the larger goals, rather than the method for achieving the goals. Initially, goals should be listed without the need for negotiation or prioritization. As the analysis proceeds, the anticipated pace of climate and non-climate threats will inform the priority and achievability of each goal. The process will refer back to this list during the assessment.
2. **Identify Resources/Assets to Assess:** Resources and assets will be the focus of the assessment when evaluating vulnerability and adaptive capacity. Begin by creating a list of major resources and assets for an analysis of the entire park. The choice about how comprehensive to be in the list will affect the time commitment required as each resource will need to be scored. The project's GIS team will take the lead in mapping resources and assets identified by the workgroups using available data where possible. When identifying resources or assets, consider the units (e.g. habitats and/or species) that will be used in the analysis. The natural resources workgroup should begin with the Natural Resource Condition Assessment (NRCA), Vital Signs from the Inventory and Monitoring (I&M) program, and other studies specific to the park, in order to identify landscape, coastal, and nearshore features, as well as living resources. Bringing these studies together will lead to determining the level of detail or aggregation of information that is possible for the assessment. The workgroup will determine whether it should assess resources park-wide, limit the analysis to a few key areas of focus due to geographically different exposure or sensitivity, or both, using a phased approach. For example, a park may have extensive upland forest or other features that have low exposure, and that same forest type may also occur in a low-lying coastal area with high exposure. Rather than averaging their scores, the two need to be separated. Cultural resources can include archaeological resources, cultural landscapes, ethnographic resources, buildings and structures, and museum collections as appropriate. Refer to NPS 28: Cultural Resource Management Guideline NPS Cultural Guide for ideas. To comprehensively assess cultural landscapes, consider all of the components: boundary, natural systems and features, spatial organization, land use, topography, vegetation, circulation, buildings and structures, views and vistas, and small-scale features. The facilities workgroup uses the SOP/WCU protocol that uses all FMSS structures and transportation

assets as a starting point, though the workgroup can include additional items (e.g. culverts, seawalls).

3. **Determine Key Stressors:** For the resources and assets listed in item 2 above, identify key stressors – climate and non-climate (be very selective here) that the workgroup believes should be included in the exposure analysis. Stressors could include sea level rise, storm surge, inland flooding, temperature change and precipitation change. Non-climate stressors to consider could be invasive species or development adjacent to park. It is important that each workgroup places some limit on the number of stressors considered, to keep the analysis manageable. Since there is not weighting between stressors, it is helpful to consider whether additional stressors are much less significant than others, for example sea level rise might have a greater effect on coastal wetlands than temperature change. On the other hand, non-climate threats may be so dominant in some cases that climate impacts under any projection would not be discernable. Common resources for a park with known sensitivities to certain stressors is another way to identify which stressors to include. For a coastal park, the common types of potential climate stressors to be considered are listed in Table 6.

**Table 6.** Climate stressors commonly used in coastal assessments and where to find the data.

| Climate Stressors | Data Sources |
|---|---|
| Flooding | • FEMA Flood Maps (primary)<br>• NOAA Office of Coastal Management (OCM) Digital Coast<br>• site-specific modeling using high-resolution digital elevation model (LiDAR preferred) |
| Storm Surge | • NPS-specific SLOSH model results (primary)<br>• NOAA National Hurricane Center National Storm Surge Hazard Maps<br>• site-specific modeling using high-resolution elevation model (LiDAR preferred) |
| Sea Level Rise | • NPS-specific SLR modeling (primary)<br>• NOAA OCM Digital Coast<br>• site-specific modeling using high resolution elevation model (LiDAR preferred)<br>• local tide gauge extrapolation |
| Erosion | • State/USGS erosion rate buffers (primary)<br>• shoreline proximity buffers<br>• USGS buffer zone from shoreline<br>• FEMA V ZONE<br>• COASTAL A ZONE. |
| Historical Flooding | • Park surveys/questionnaire results (primary<br>• storm imagery/reconnaissance<br>• NOAA OCM Digital Coast |
| Ground water | • USGS partnership studies with NPS<br>• USGS; State GIS Information Center |

**Table 6 (continued).** Climate stressors commonly used in coastal assessments and where to find the data.

| Climate Stressors | Data Sources |
|---|---|
| Precipitation change | • peak daily rainfall<br>• mean annual rainfall<br>• days >2" of rainfall<br>• NOAA National Centers for Environmental Information<br>• Regional Climate Adaptation Science Center |
| Drought | • NOAA National Centers for Environmental Information<br>• NWS Climate Prediction Center |
| Temperature change | • days below freezing<br>• days greater than 95 degrees<br>• change in mean daily high and low temperatures<br>• NOAA National Centers for Environmental Information<br>• Regional Climate Adaptation Science Center |
| Wind | • can use a single wind rating for the entire assessment area<br>• NOAA National Centers for Environmental Information<br>• ENERGY.GOV Office of Energy Efficiency & Renewable Energy<br>• WINDExchange |
| Humidity | • NOAA National Centers for Environmental Information<br>• Regional Climate Adaptation Science Center |

4. **Identify Major Decisions/Milestones:** Identify major decisions and/or milestones that the park is likely to make in the next 10 years. Briefly explain some of the key factors that will influence decision-making. The group will use these insights in the assessment to understand areas of integration between divisions, adaptive capacity, and pathways for change (strategies to keep options available in the future).
5. **Select Geographic Focal Areas:** Identify geographical focal areas where each workgroup would like to conduct more detailed and integrated vulnerability discussions, in conjunction with the other workgroups. Two to four focal areas are sufficient for the scope of this assessment methodology. Selection of focal areas could be based on an area having unique circumstances that requires deeper analysis. For example, the combination of groundwater change and erosion may create significant changes to an area. The workgroup should draw the location and boundary of each focal area on a map. Then, briefly explain why each area was chosen and the key aspects of the area that are important for assessing in relation to climate change.

The coordination team will compare and aggregate the responses from the resource workgroups to determine project focal areas and key stressors for analysis.

Natural Resources

The natural resources workgroup must select an appropriate level of generalization related to landscape features, determine which habitats and plant or animal species are of particular concern, and propose possible focal locations. This should be done during early discussions. A park might

have detailed mapping that identifies hundreds of distinct landscape types, for example, that should be aggregated into a few dozen or fewer broader categories that still are suitable for sensitivity analysis. The natural resources workgroup can consult with the other workgroups to determine if there are particular natural resources that contributes to facilities or cultural resources (e.g. species that are key ethnographic resources). Note, the park's NRCA or other resource inventories may have already developed resource lists and groupings of landscape features.

Cultural Resources

An initial list of cultural resources can be structured using the five cultural resource categories defined by NPS: archaeological resources, historic structures, cultural landscapes, museum collections, and ethnographic resources (Management Policies, 2006). The group can then sub-divide the park into distinct geographic units. Then, workgroup members can review existing archaeological, historic structure, and cultural landscape inventories and surveys, based on their expertise and identify key sites, structure or features in each category. Guidelines for selecting sites in each geographic unit are as follows:

1. Archaeological sites:
    - All archaeological sites considered together for exposure in each geographic area.
    - Select archaeological sites to score individually. The number will depend on total sites in the park, data availability and capacity of workgroup. For Colonial NHP, the initial plan to select only the top 5 was not practical, but aiming for 25% was reasonable.
    - Key sites based on research potential and visitor interest.
    - Sites selected to represent different periods of history in the park, with special attention to sites that represent interpretive and research priorities of the park.
2. Historic structures:
    - All historic structures considered together for exposure in each geographic area.
    - Select historic structures in the park to score individually. Similarly, to archaeological sites, the number will depend on total sites in the park, data availability and capacity of workgroup. For Colonial NHP, the initial plan to select only the top 5 was not practical, but aiming for 25% was reasonable. Note that the Facilities workgroup will be scoring all historic structures.
    - Key structures based on research potential, visitor interest, or use.
3. Museum Collections:
    - All locations where collections materials are held.
4. Cultural Landscapes:
    - Boundary
    - Natural systems and features

- Topography
- Spatial organization
- Buildings and structures
- Circulation
- Vegetation
- Views and vistas
- Small-scale features

5. Ethnographic resources:
    - Archaeological sites of social, political, or economic significance; where there was overlap, refer to scores allocated for archaeological resources.
    - Habitat features of significance.
    - Natural landscapes retaining non-developed character.
    - Floral and faunal species of significance; where there was overlap between chosen species and those evaluated by the natural resources workgroup, scores were informed by that input.

*Archaeological Sites*

Only a subset of climate stressors are relevant to archaeological sites, such as changing groundwater levels, wind, runoff, and changing precipitation intensity. Temperature changes over time may not be a major concern for archaeological resources, but humidity can have a damaging impact to some archeological resources. These stressors could change the vegetation regimes, which could benefit or harm archaeological sites. Wind events cause tree falls, which are very damaging to the context of archaeological sites or represent damage to an important historical landscape. Changing precipitation might be moderated by stable groundcover, but torrential downpours in areas that lack topographic diversity, could also negatively affect site context. Sites with few underground artifacts may not be affected by groundwater changes, but sites that have been identified but not thoroughly investigated for subsurface deposits are at risk from various groundwater changes and sea level rise.

*Historic Structures*

In addition to geographic specific considerations, such as sea level rise and storm surge, increasing intensity of rain may overwhelm rain gutter systems, causing water damage to structures. Increasing humidity or increasing sustained humid conditions may affect the biological growth of harmful organisms.

*Museum Collections*

Concerns about museum collections' exposure and sensitivity to climate change were two-fold. First, direct impacts of climate change factors may affect the integrity of storage facilities. Soil chemistry or salt water intrusion may affect the foundations of buildings, which could have implications on the long-term viability of collections storage facilities. For collection materials, the most important

factors are temperature, humidity, and the ability to maintain these conditions during storm events when electrical power is lost. Second, collections may increase as at-risk sites are excavated, which could increase the need for secure collections facilities. This will become a major financial and management responsibility for the park.

*Cultural Landscapes*

To comprehensively assess the factors comprising cultural landscapes, the cultural resources workgroup divided cultural landscapes into nine categories (listed in Step 1, part 3 above). The sensitivity of these features was determined by consulting cultural landscape inventory reports. In areas that have been identified, but not investigated, the structures and features are considered as a general category with expert knowledge. Because cultural landscapes include both natural and man-made features, the exposure and sensitivity stressors may vary greatly between resources.

*Ethnographic Resources*

Through consultation with local tribal officials or other key stakeholder communities, the list of key ethnographic resources needs to be identified. For Colonial NHP, this included archaeological sites of social, economic, or political importance, tidal and non-tidal wetlands including marshes, landscapes reverting to a non-developed state, and key floral and faunal species.

Facility Assets

The SOP/WCU Facility Assessment protocol (NPS, 2016) has detailed guidance for selecting facility assets based on a combination of the FMSS database and expert judgement. The park can then determine which assets are not necessary or should be added for this assessment. For example, culverts were added to the Colonial NHP assessment due to their critical role in flooding even though most of them are not currently included in the FMSS. The other workgroups may request additional assets be included if they have a significant influence on other key resources. The SOP/WCU protocol also identifies a standard set of climate stressors and associated indicators that could be used for assessing exposure and sensitivity.

Resource Mapping

Based on the focus of the assessment, each resource/asset that will be assessed must be identified, and, where possible, mapped. This will enable cross-division discussions on goals, potential impacts, and adaptation pathways for clusters of resources of particular concern. A strong consideration will focus on how GIS databases work, and the experts' ways of describing the systems or resources to determine how resources will be identified. Will natural resources be grouped by species, habitat types, or specific sub-geographies of particular concern? Will the units of analysis be the same across the entire park, or will the assessments apply different criteria for areas and conditions considered to be unique (such as fringing wetlands along a river versus a large contiguous area)?

To summarize information for this integrated assessment without overwhelming the analysis with excessive data points or granular detail, the groups can filter results by considering the following questions:

- How does the NPS identify and characterize resources/assets in existing databases (e.g. NRCA or FMSS)? Care needs to be taken with proper handling of sensitive data, ASMIS in particular.
- Is there a representative resource that would cover the key attributes and values of many others? For example, the natural resources workgroup might combine non-tidal wetlands in a single category, but utilize all available categories of tidal wetland types, since each of those will be sensitive in different ways to changes in precipitation, groundwater change, storms and sea level rise.
- Within the focal areas, how detailed do the descriptions of resources/assets need to be in order to provide insight to how changes are likely to unfold over time?
- Which resources/assets already have available data and are adequately characterized in existing GIS databases?

Where possible, workgroups will utilize existing resource categorization and existing databases of resources/assets. They will select from the before mentioned resources and refine where necessary, rather than requiring a new analysis. This will prove to be the case for natural resources for parks with I&M programs, NRCAs, and facility assets that have a SOP/WCU assessment completed based on the assets listed in the FMSS.

For efficiency in analysis and mapping, when practical, park GIS data resources should be combined by spatial data type (point, line, polygon) for each division. Beyond improving data organization, merging input data by class serves four purposes: 1) it reduces extensive attribute information within multiple NPS databases to the bare essentials: ID number, location coordinates, and resource name; 2) it aids in the identification of data gaps; 3) it allows for QA/QC checks to be performed on the input data, such as the identification of missing/wrong coordinates; and 4) it reduces the number of data sets that need to be reviewed by park personnel and run through the overlay analyses.

While the NPS has access to extensive GIS resources to start the mapping process, it is well worth considering incorporating information from state and county government sources, such as using Landscape Conservation Cooperative regional datasets, and making inquiries into nearby USGS and NOAA Sea Grant programs to supplement data gaps to provide a regional perspective. Each workgroup should have their own dataset and map resources to work with. GIS tools (both stand-alone and online approaches) can later be employed to overlay the datasets for more advanced analysis. Be sure to engage the GIS data managers within the Park or Region early on to ensure the final products can be properly uploaded to the NPS systems. A basic resource/asset map should be produced at the outset and verified by the working groups to avoid confusion once detailed exposure and sensitivity mapping begins. Ideally, the initial exposure analysis and associated maps should be completed prior to the first workshop to help the groups quickly analyze the exposure outputs, make changes during the workshop, and/or assign follow-up tasks. Sample data sheets from the Colonial NHP assessment are available that show how to organize the resources and data columns that work with GIS. Posting the data sets online in an interactive mapping portal in addition to having them available in desktop GIS or graphic formats will allow the assessment team and participants jointly

explore information, correct errors, examine patterns across resource types and test how well synthesis maps convey the emerging understanding and consensus of the assessment process.

Some resources of concern may vary across the park, change seasonally, and/or go beyond park boundaries, such as flyways for migrating birds. Others may be known to be present in the park, but detailed studies have not been conducted to provide spatial data, such as for particular species of reptiles and amphibians. In these cases, the workgroups will likely want to identify, then assign exposure and sensitivity scores based on climate projections and the known presence of the resource, with an eye to following up with more detailed research as needed to inform adaptation planning.

Some of the variables will show impacts that are more site specific (e.g. SLR), rather than park wide change (e.g. increased temperature). These issues should be considered when determining mapping needs.

### Step 2. Selection of Climate Projections

Objective

> To select the climate projections that will determine exposure and associated maps for each time frame selected.

Building on the principle of using existing data and knowledge, coordinate the selection of projections with how other climate assessments in the park or adjacent jurisdictions have used different projections; NPS guidance and protocols should be used as a key consideration. If there is a difference between these sources of projections, the assessment team should evaluate if there is a strong rationale for using a set of projections, with consideration of professional and scientific judgement for the site, consistency with NPS protocols, and local buy-in from stakeholders. Using significantly different scenarios from those used by local efforts can be a challenge when evaluating potential impacts and priorities for developing adaptation actions going forward. Refer to the NPS Climate Change Response Program (CCRP) for guidance.

Confirm Planning Horizon

Selecting three time frames of 2020, 2050, and 2100 balances the need for understanding long-term trends with making near-term decisions. A time frame of 2020 captures existing vulnerabilities, serves as a baseline, and recognizes that parks are currently seeing impacts. The mid-century time horizon represents the long-term planning horizon of some current and planned projects, and investments within the park. The end-of-century projection recognizes our responsibility to preserve resources for future generations and will generate a list of more distant impacts based on currently available information. These impacts may change, for better or worse, as circumstances and our understanding of them progresses. In addition to the planning horizons, different representative concentration pathways (RCP) of emissions provide scenarios of how climate variables may change. Ideally, the full context of the projections should be provided to the participants at the workshop, showing a range of emissions pathways (e.g. RCP 4.5 and RCP 8.5). For practical purposes the assessment can only include the exposure determinations based on one RCP and the high emissions pathway (RCP 8.5) is recommended as most consistent with the SOP/WCU protocol (NPS, 2016).

Compile Climate Data

Climate data will vary by park, though the CCRP has provided climate summaries for each park based on downscaling a suite of climate models (Gonzalez et al. 2018) and can assist an effort like this by providing more park- and resource-specific projections. The next step would be to identify which data sets are already available. CCRP, Department of Interior's Climate Adaptation Science Centers, and NOAA's tide station data, among others, provide different data sources, at regional and local scales. When multiple data sources are available, it is recommended to choose based on consistency with either NPS methods or to be consistent with local or regional partners.

Select Climate Projections

Once stressors have been determined by each of the resource divisions (scoping process and step 1), discussion will begin on the detail needed for completing this vulnerability assessment, and how it will be used. Data localized to the park can be extremely useful when targeting specific climate variables and metrics; discussion among the workgroups and climate scientists can help target the data needed and the effort that is necessary to localize this. Consideration should be made as to the level of effort to downscale and determine if basic trends are needed (e.g. longer heat spells), vs. quantitative change (projected change in the number of heat spells increase by 1-1.3).

For sea level rise, Caffrey et al. (2018) is recommended for internal consistency between parks, and with the SOP/WCU protocol (NPS, 2016). These are conservative when compared to NOAA's current modeling, what other local partners may be using (NOAA, 2017; USACE, 2016/2017), and/or other locally derived models for a variety of reasons including because it does not include subsidence. The timeframes associated with projections may end up occurring significantly earlier; therefore the process needs to be revisited periodically to incorporate the best available science. The vertical datum used should be NAVD88. The 2020 timeframe uses current sea level elevations.

When selecting temperature and precipitation variables and projections, this method uses the analysis completed by the Northeast Climate Science Center designed for a scenario planning workshop at Acadia National Park and applied at Colonial NHP (Star et al. 2016). For temperature and precipitation, several metrics were analyzed to determine which are expected to fall outside of the range of historical variability for each future time frame. Exposed was defined as whether (yes) or not (no) the 20-year mean (for temperature or precipitation), centered on the year (2020, 2050, or 2100), is greater than the historical (1950-2005) mean plus one standard deviation. An M (for "maybe") indicates exposure according to "major change" but not according to "least change" scenario, suggesting that exposure depends on future greenhouse gas emissions and other sources of uncertainty.

When working with resource managers and other key stakeholders, it is important to help translate the projections into more tangible decision-support tools. Where feasible, the climate projections were mapped showing areas of exposure (e.g. SLR and flooding). For temperature and precipitation, the spatial resolution of available projections did not differ widely across the park for Colonial NHP, therefore parkwide change is generalized; Table 7 summarizes the information. A summary of the stressors, key messages, and projections are useful for workshops, as seen in Table 8

**Table 7.** Climate projection exposure summary example from Colonial National Historical Park.

| Stressor | Metric | Exposure* | | |
|---|---|---|---|---|
| | | 2020 | 2050 | 2100 |
| Temperature | Mean annual temperature | Yes | Yes | Yes |
| | Daily highs | Yes | Yes | Yes |
| | Daily lows | Yes | Yes | Yes |
| | Hot days (> 95 °F) | Yes | Yes | Yes |
| | Cold nights (< 32 °F) | No | Yes | Yes |
| | Warm spells (3+ days of > 95 °F) | Yes | Yes | Yes |
| | Cold spells (3+ days of <32 °F) | No | No | Maybe |
| | Growing season length** | No | Yes | Yes |
| Precipitation | Mean annual precipitation | No | No | Maybe |
| | Days exceeding 2” precipitation | No | No | Maybe |
| | Peak daily precipitation | No | No | No |
| | Dry spell length (3+ days no rain) | No | No | No |

* Defines as whether “yes” or not “no” the 20-year mean, centered on the year (2020, 2050, or 2100), is greater than the historical (1950-2005) mean plus one standard deviation. “Maybe” indicates exposure according to “major change” but not according to “least change” scenario, suggesting that exposure depends on future greenhouse gas emissions and other sources of uncertainty.

**Table 8.** Example of climate stressors, key messages, and projections based on Colonial National Historical Park pilot.

| Stressor | Observed Changes | Projections |
|---|---|---|
| Temperature* | • Warming in all seasons<br>• Fewer nights below freezing, especially in fall<br>• Daily lows warming fastest in warm season<br>• More hot summer days (>95 °F)<br>• Longer heat spells (consecutive days >95 °F)<br>• More frequent heat waves (>95 °F) for 3+days<br>**Baseline (1996–2015):**<br>• Mean Annual Temp: 59.9F<br>• Hot days(>95F): 7.7 days | **2020**<br>• Mean Annual Temp: +1.1–1.6F<br>• Hot days (>95): +6.3–7.3 days<br>**2050**<br>• Mean Annual Temp: +3.1–4.1F<br>• Hot days (>95): +20.3–32.3 days<br>**2100**<br>• Mean Annual Temp: +4.4–8.6F<br>• Hot days (>95F): +31.3–82.3 days |
| Precipitation * | • More frequent, intense extreme events especially in fall<br>• Precipitation amounts increasing, especially in fall; decreases in summer<br>• Longer wet spells, especially summer and fall<br>• Less snow, more rain, thinner snow packs<br>**Baseline (1996–2015):**<br>• Mean Annual 51.2 in/decade (dec)<br>• Days exceeding 2” 2.8 days | **2020**<br>• Mean Annual: +1.8–2.8 in/dec<br>• Days exceeding 2”: +0.4–0.2 days<br>**2050**<br>• Mean Annual: +2.8–3.8 in/dec<br>• Days exceeding 2”: +0.4–0.7 days<br>**2100**<br>• Mean Annual: +7.8–8.8 in/dec<br>• Days exceeding 2”: +1.2–1.6 days |

**Table 8 (continued).** Example of climate stressors, key messages, and projections based on Colonial National Historical Park pilot.

| Stressor | Observed Changes | Projections |
|---|---|---|
| Wind* | • Increase in the "windiest" day per year, especially in the fall (peak hurricane season)<br>• Future projections consistently indicate globally averaged intensity of tropical cyclones to shift towards stronger storms | Trends in extreme winds (associated with hurricanes) is not available. However, there has been a fair amount of research in tropical activity that point toward more intense hurricanes. |
| Sea Level Rise | • Historical trend = over 1.5' rise since 1927 at Sewells Point, with acceleration over last few decades<br>• Overall range is from USACE and NOAA Sea Level Rise Calculator, and is within the range of that provided by Caffrey (2015). | Future projections (NAVD88) vary depending on selection of emissions (least change vs major change).<br>• 2020: current sea level<br>• 2050: 0.59–2.28' (2.1'**)<br>• 2100: 1.31–7.23' (3.81'**) |

* Based on methods Acadia National Seashore and adapted for Colonial NHP by A. Bryan, Climate Postdoctoral Fellow, USGS, DOI Northeast Climate Adaptation Science Center. See Star et al. 2016.

**Estimates based on the high Emission scenario (RCP 8.5) of Caffrey (2015), which was used by SOP/WCU assessment and therefore used as the scenario for this assessment.

## Step 3. Exposure Analysis

Objective

To develop exposure scores for each resource/asset based on the climate stressors selected at each time frame.

Scoring is accomplished by working through tables with maps for all three time frames. Results should be represented by both a map and table. Some resources/assets are not able to be mapped. In some cases, a focal area might be exposed differently as projections unfold, for example a highly exposed tidal wetland area that in a later time frame may transition to mudflat and would then expose upland landscape features. It is beyond the scope of this effort to fully represent dynamic landform change, but discussions and notes can capture that complexity for further study. Each climate stressor identified in the scoping stage gets an exposure score for use in the exposure analysis. While all workgroups follow the same general process, they may vary their algebra for calculating exposure, sensitivity, and vulnerably to be consistent with other NPS methodologies.

The basic method for scoring exposure is as follows:

1. Produce GIS layers for each climate stressor (exposure indicator) at each time frame, where possible
    - Import projections data into GIS format, as exposure is directly dependent on location.
    - Produce layers for each climate stressor; for stressors with modeling change over time available, produce a layer for each the time frame selected.

2. Overlay assets
    - Using the resources/assets identified in step 1, map each geographically to create one or more layers. See the exposure mapping section below for more guidance.
3. Run exposure analysis for each stressor at each time frame
    - For each climate stressor, run a GIS-based exposure analyses to identify resources/assets that overlap with the stressor. This is a simple overlay of stressors like sea level rise or erosion based on the layers produced from the projections.
    - Repeat this for each time frame and stressor.
    - Resources that are exposed in earlier time frames can be assumed to still be exposed in later time frames.
    - If no GIS layer exists for a stressor, then the workgroups can use expert knowledge or other data to determine the geographic spread of the stressor at each time frame. If only one time frame is available for that stressor, use expert knowledge to determine whether and how change is expected from the available time frame.
4. Score each resource/asset by stressors
    - Each resource/asset that is overlaid by a stressor layer (exposed) is assigned a yes score compared to those that are outside of the layer (unexposed). For temperature and precipitation, exposure was determined by if the 20-year mean centered on the year of the time frame was greater than the historical mean plus one standard deviation.
    - Use a binary scoring system (1 or 0) with the score of 1 representing exposure (yes). Facilities uses 4 and 1 to match the SOP/WCU protocol based on Federal Highway assessment scoring systems, for consistency. Scores will be binned and normalized before comparing across workgroups so this difference in scoring scales will not impact final results.
    - Workgroups can use expert judgement to score non-geographic or data poor resources/assets, or where there are multiple data sets informing a combined indicator. Scores can be allocated by groupings of resources/assets if there are obvious similarities across subsets of the resources/assets.
    - Note where uncertainty/confidence is high or low. This can inform an uncertainty summary statement at the end of the vulnerability assessment.
    - Note those resources/assets that overlap with another workgroup and should be discussed to ensure clarity between the scores. For example, there may be some natural resources that are also part of cultural landscapes. Discuss the matter with the respective workgroups at this step to ensure integration throughout the process.

NOTE: These next points will vary by how the workgroup is calculating the vulnerability scores. Facilities will use the SOP/WCU method which uses binning and addition. Natural resources

workgroup uses multiplication with no binning until the final vulnerability score. Cultural resources method varies by park data availability.

The bin and addition method (used by facilities and cultural resources)

5. Produce a raw composite exposure score for each resource/asset
    - Each resource/asset should have an exposure score that adds up all of the individual exposure scores from each stressor (exposure indicators). These are not weighted. There should be one set of raw composite scores for each resource/asset for each time frame.
6. Develop binned exposure scores
    - Binning in this case is defined as setting interval thresholds of scores to normalize into a score that can correspond with high, moderate, low and minimal. Binning allows comparisons across exposure and sensitivity and between divisions.
    - Develop raw binned exposure scores to assign each raw score to one of four ranking categories based on the number of exposure stressors (or zones): minimal exposure (asset does not lie within any exposed climate stressor/zone), low exposure, moderate exposure, and high exposure (most number of climate stressors exposed). Modify the break points between categories based on the number of climate stressors/exposure indicators used in the assessment. In the example in Table 9, that assessment had five indicators. Using a 1 to represent no exposure for all five indicators using the facilities' meant that the minimal overall exposure score for a facility is 5. The rest of the break points are evenly distributed for the remaining categories of low, moderate and high. The workgroup can slightly adjust the break points if merited based on a review of the data points, conversations with other workgroups on the context and systems analysis of combined stressors.
7. Modified score from auto-high option to determine final exposure score
    - If the experts believe that a specific exposure stressor is significant and would have an overwhelming influence on the overall exposure for a resource, then the experts can automatically raise the exposure score to the highest level. For instance, if an asset is in the VE flood zone which signifies breaking waves during a 100-year flood event, then the facilities workgroup gives the asset the highest exposure score. Note that natural resources and cultural resources workgroups can do this auto-high option as well when scoring exposure in bullet 4 above, but did not in the pilot case study.
    - The final binned exposure score will range from 1 to 4 after the auto-high modification has been considered. If the initial raw exposure rank score was a 2 but was exposed for an auto-high stressor, then the final exposed score would be 4.

8. Assign final exposure rank
    - Assign a final quantitative exposure score for each of the four rankings to later allow computation of vulnerability. 1 = minimal, 2 = low, 3 = moderate, 4 = high. The table below represents an example of the scoring process.
    - These ranked exposure scores will be added to the ranked sensitivity scores in step 5 to determine vulnerability.
9. Repeat the process for all three time frames
    - Since exposure can vary by each time frame, this process needs to be repeated so that each resource/asset has one exposure score for each time frame. This is a critical step for showing vulnerability over time.
    - Record the scores in a spreadsheet for each time frame.

**Table 9.** Example of the exposure scoring process for facilities and cultural resources using the binning method.

| Workgroup | Binned Raw Exposure Score | | Final Exposure Rank |
|---|---|---|---|
| | Grouping | Ranking | |
| Facilities | ≥ 15 | 4 | High |
| | ≥ 11 and ≤ 14 | 3 | Moderate |
| | ≥ 6 and ≤ 10 | 2 | Low |
| | ≤5 | 1 | Minimal |
| Cultural Resources | ≥ 8 | 4 | High |
| | ≥ 7 and ≤ 6 | 3 | Moderate |
| | ≥ 2 and ≤ 5 | 2 | Low |
| | ≤1 | 1 | Minimal |

Cultural Resources

In addition to the common climate stressors identified across the groups, cultural resources may also be concerned with the humidity, which can have a damaging impact to some archeological resources. Workgroups used local expert judgment to complete additional exposure indicators of wind, humidity, and runoff.

Although some cultural resources, especially historic structures, are represented by one discrete space, many cultural resources such as archaeological sites, cultural landscapes, and ethnographic resources encompass a larger portion of the landscape. In some cases, these resources encompass entire areas but are represented by a single point on a map. Expert judgment can allow for the exposure of the entire extent of the resource to be captured.

The binary score of exposed or not exposed to each stressor, given the projections, allows for cautious exposure assessments. Resources that are partially exposed can be considered exposed.

Although cultural landscapes and ethnographic resources have many components, if any component of these resources are exposed, the entire resource can be considered exposed.

Facilities

Facilities can follow the SOP/WCU protocol (NPS, 2016) as it has likely been used to produce a facility assets vulnerability assessment for 2050 and aligns with this larger method. For this integrated assessment, scores for erosion and sea level rise will need to be added to produce exposure scores for 2020 and 2100. Other exposure indicators stay constant across the time frames as there is often a lack of information available to make informed projections.

Natural Resources

The natural resources workgroup used the method of multiplying the individual exposure scores for each stressor by the respective sensitivity score for that stressor. This is a way to account for a particular stressor not contributing towards vulnerability if it is not exposed, even if highly sensitive to that stressor, or the reverse. It serves the same function as the method used by the facilities workgroup to reduce the analysis workload for resources that are not expected to be affected by impacts from any climate change scenario.

Exposure Mapping

Create draft exposure maps for each of the resource workgroups using their list of resources/assets and the climate projections selected. The exposure analysis will produce scores for each resource/asset for each of the climate stressor indicators. These initial maps are just to start the exposure scoring process and will not be the final scores. At the workshop the groups will add their expert judgement and provide scores for indicators without an available projection or for resources without geographic data.

Available information on some climate stressors may not be sufficient to generate a useful portrait of change, for instance with the future severe storms, groundwater effects of sea level rise, or changing precipitation patterns. The resource workgroups will need to self-score each resource/asset to complement the rest of the exposure scoring system using their best judgement. This might apply to cases such as cultural resources located near trees, where the uncertainty about damaging storms and winds creates uncertainty about the risk of uprooting and impacts to archeological resources.

The output from this exercise will enable each of the resource workgroups to produce three sets of exposure scores representing each time frame. The dataset will produce draft GIS maps (for the geographically-based resources) for each resource workgroup.

### Step 4. Sensitivity Analysis

Objective

To produce sensitivity scores for each resource/asset based on expert judgment.

Sensitivity refers to how that asset would fare when exposed to the stressor, which is a function of the inherent properties or characteristics of the asset. Unlike exposure, sensitivity is evaluated independent of location. Only one sensitivity score will be given for each resource/asset over all of the time frames. This scoring assumes that sensitivity will remain constant. When dealing with the

limits of this assumption, the workgroups can consider sensitivity to the level of exposure at the 2100-time frame. Workgroups will score their resources/assets on their own before discussing logic and scores with the other workgroups to reach final sensitivity scores.

A practical method for workgroups to determine local sensitivity for storm related stressors is to refer back to a recent hazard event and discuss how sensitive the resources/assets were in relation to the indicators, which a workgroup has chosen. What were the deciding factors to explain why some resources/assets that were exposed were impacted, while others were not? Consider the linkages between resources as this partly identifies factors for sensitivity, as well as provides focus for the integration analysis. This exercise could also be done with other types of shocks to the system that are not storm related.

Again the workgroups vary in how they score sensitivity. The facilities workgroup repeats a similar process as done for exposure by only scoring sensitivity as a yes (4) or no (1) and then binning the assets' combined sensitivity scores across all indicators. Natural resources and cultural resources vary by allocating scores based on the degree of sensitivity - low, moderate, high for cultural resources and for natural resources those three plus a category for minimal or beneficial. Their methods are provided below. While the algebra may vary, each group ends up with a sensitivity score for each resource/asset.

The basic method for scoring sensitivity is as follows, though note the variations for each workgroup:

1. Select sensitivity indicators with respect to climate stressors
    a. A set of indicators needs to be selected for sensitivity. This will be influenced by the climate stressors selected in step 1 and the exposure indicators in step 3 as there is often a mirror relationship between exposure and sensitivity indicators. Facilities have a standard set of sensitivity indicators to use (NPS 2016).
    b. Natural resources, cultural resources, and facilities workgroups will have some different indicators that are unique to the characteristics of their resources/assets (e.g. age of structure, structure material, size of artifact in ground).

2. Score sensitivity related to each indicator

    a. Provide each resource/asset with a qualitative sensitivity score. Workgroups may find it helpful to maintain a record of explanatory notes during this process.
        i) Facilities scores sensitivity using a yes (4) or no (1) scale similar to what was done for exposure.
        ii) Natural resources and cultural resources workgroups assign scores using the high (4), moderate (3), low (2), or minimal (1) scale. To save time, the group should enter the numerical score for sensitivity, though it might be easier to talk using the rankings. In this system, a score of 'high' means the resource warrants significant concern given the sensitivity to the climate stressor, 'moderate' means the resource warrants moderate concern, and 'low' indicates that the resource only warrants low levels of concern, and

'minimal or beneficial' does not warrant additional concern beyond the normal level of care and maintenance.

b. The sensitivity score is the same for all time frames.

c. Note those resources/assets that overlap with another workgroup and should be discussed to ensure clarity between the scores. This is similar to what is done during the exposure analysis to ensure integration throughout the process.

3. Facilities and Cultural Resources: Produce a raw composite sensitivity score for each resource/asset
   a. Only the facilities and cultural resources workgroups will produce a composite sensitivity score.
   b. Natural resources uses the individual sensitivity scores by stressor to multiply with the respective exposure scores to the same stressor.
   c. Each resource/asset should have a raw composite sensitivity score that adds up all of the individual sensitivity scores from each factor (sensitivity indicators). There should be one set of raw composite scores for each resource/asset across all time frames.
4. Develop binned sensitivity scores and rankings

   The benefit of binning sensitivity score (and exposure score) is to analyze the components of vulnerability by resource, not just by stressor.

   This is done only for the facilities and cultural resources workgroups.

   Develop final binned sensitivity scores by assigning each cumulative raw score to one of four categories based on the number of sensitivity stressors: minimal sensitivity (resource/asset does not respond to any sensitivity factors or for facility assets it was not assessed since minimal exposure), low sensitivity, moderate sensitivity, and high sensitivity. Modify the break points between categories based on the number of sensitivity indicators used in the assessment.

   a) Assign a final binned quantitative score for each of the four categories to allow computation of vulnerability. 1 = minimal, 2 = low, 3 = moderate, 4 = high. This should be the same scale as used for exposure.

<u>Natural Resources</u>

Natural Resources sensitivity indicators are for each resource/stressor combination. The workgroup should note why the resource is sensitive to those particular stressors (the mechanism of exposure leading to stress) and describe the result of exposure, for example change of species, dieback, or conversion to another habitat type. In some cases, a given climate stressor could be determined to be potentially beneficial to the particular resource, such as expanding the viable range of a species within the park. In this case, a score of 1 should be given. Negative sensitivity scores (which signify benefits) are not given, but notes should be made in the analysis table to explain the expected effect. Some resource types are less sensitive than others, and part of this is due to intrinsic physical factors that give the resource greater adaptive capacity. The natural resources workgroup should try to constrain its consideration on the influence of intrinsic adaptability factors in its scoring, since a more detailed analysis of adaptive capacity is a later step in the process. For sensitivity the focus

should be on the proven ability of a living resource to cope within a range of changes from a stressor. Anything beyond normal coping should be considered adaptive capacity and scored later.

Cultural Resources

For resources such as cultural landscapes and ethnographic resources, the sensitivity of the many components of the feature can be considered separately. For instance, the archaeological sites of social, political, or economic significance that contribute to ethnographic resource value may be highly sensitive to sea level rise and coastal erosion, while the species that contribute to the same ethnographic resource are less vulnerable to these stressors. The sensitivity of cultural landscape features (i.e. boundary, circulation, views and vistas) can be scored individually to capture how the sensitivity varies across these landscapes.

For resources that overlapped with the natural resources workgroup, the cultural resources workgroup should consult their scoring to inform sensitivity scores. The habitats and species identified as key to ethnographic resources should consult the natural resources workgroup's scores for these habitats and species to inform their sensitivity scores.

Facilities

The SOP/WCU protocol uses different sensitivity indicators (Table 10) for bridges compared to other assets. Refer to the protocol for detailed guidance (NPS, 2016). Also note that the SOP/WCU protocol doesn't score sensitivity if an asset had minimal exposure. Since the SOP/WCU only does one-time frame, there may be cases where an asset's exposure score changes for different time frames and thus will need a sensitivity score. Therefore, the facilities workgroup will have to fill in some sensitivity scores in those situations.

**Table 10.** Example sensitivity indicators for assessing vulnerability of facility assets.

| Sensitivity Indicator | Data Sources |
|---|---|
| Flood Damage Potential (Elevated) | Asset questionnaire; direct measurements of threshold elevation |
| Storm Resistance & Condition | Asset questionnaire; FMSS database |
| Historical Damage | Asset questionnaire; discussion with park staff |
| Protective Engineering | Asset questionnaire; field & aerial imagery analysis; WCU Engineering Inventory |
| Bridge Clearance* | National Bridge Inventory |
| Scour Rating* | National Bridge Inventory |
| Bridge Condition* | National Bridge Inventory |
| Bridge Age* | National Bridge Inventory; FMSS database |

*Additional bridge indicators

### Step 5. Vulnerability Analysis

Objective

> To produce an overall vulnerability score for each resource/asset by combining exposure and sensitivity.

In this step the exposure and sensitivity scores are used to calculate a vulnerability score for each of the three time frames. Since the workgroups used similar overall processes but different algebra to calculate exposure and sensitivity, the vulnerability computation will have to vary as well.

To calculate raw vulnerability scores:

Facilities and cultural resources method (bin and addition):

1. Add the final binned exposure scores to the binned sensitivity scores for each resource/asset from one time frame to get a raw vulnerability score for that single time frame.

Natural resources method (no bin, multiply):

1. Natural resources workgroup multiplies the exposure and sensitivity scores for each stressor combination directly, versus facilities method of adding all exposure scores together.
2. Multiply the exposure score to the sensitivity score for indicator 1 (e.g. SLR) of a resource to calculate the raw vulnerability score for that stressor (e.g. SLR).
3. Then repeat the multiplication process for each pair of indicators (e.g. erosion or storm surge).
4. Add up all of the vulnerability scores for a resource to calculate the combined raw vulnerability score.

To calculate final vulnerability score and rank:

5. Bin the raw vulnerability scores into four categories based on the scoring range (see **Table 1** for an example). Start with an even distribution then if the data supports a change, modify slightly based on the experts' judgement using the maps, discussions with other workgroups, and/or understanding the complex coastal systems involved. To test the break points review a few of the resources/assets under slightly different contexts and scores to determine if the break points represent the data signals. For example, is an asset in the same location as another asset in a different category because one is at ground level while the other is elevated out of the flood zone? Binning the vulnerability score allows for equal comparison with the other resource groups.
6. Assign vulnerability rankings for each category as follows: high = 4, moderate = 3, low = 2, minimal = 1.
7. For those resources/assets that multiple groups included in their list of items to assess, check to see if the groups analyzed and scored similarly for those items. If not, then discuss how to understand each other's logic and conclusions before deciding if a score should be changed for one or both groups. If they are concerned about different aspects or services of a resource/asset, then diverging scores are likely appropriate.

8. Repeat the process for the two other time frames so that each resource has three vulnerability scores.

**Table 11.** A template for categorizing vulnerability scores. The breaks in the raw scores will vary based on the exposure, sensitivity of the scoring method, and number of indicators.

| Resource | Vulnerability Scoring | | |
|---|---|---|---|
| | Raw Score | Final Score | Rank |
| Facilities | ≥ 15 | 4 | High |
| | ≥ 11 and ≤ 14 | 3 | Moderate |
| | ≥ 6 and ≤ 10 | 2 | Low |
| | ≤ 5 | 1 | Minimal |
| Cultural | ≥ 26 | 4 | High |
| | ≥ 16 and ≤ 25 | 3 | Moderate |
| | ≥ 6 and ≤ 15 | 2 | Low |
| | ≤ 5 | 1 | Minimal |

Statement of Uncertainty:

Due to the nature of long-term projections across a complex coastal area, the combination of qualitative and quantitative data and interactions between three NPS divisions, there are bound to be significant areas of uncertainty. This holds true for any initial screening assessment using existing data. The process should note sources of high uncertainty and a statement should be added to the vulnerability analysis to assist readers in understanding key areas of uncertainty in the data sets and scoring. The statement can be at a higher level across stressors such as the rate of sea level rise or it could be focused on a habitat/species' sensitivity or exposure to a particular stressor.

## Step 6. Adaptive Capacity Analysis

Objective

Assign adaptive capacity scores for each resource/asset based on various systems' capacity to act across all time frames.

As explained in the framework section, in this method adaptive capacity is assessed and communicated independently of vulnerability. Once both are scored, the relationship between them helps to understand the potential implications on NPS goals. Similar to sensitivity, adaptive capacity only has one set of scores – it doesn't change across time frames. To speed up the scoring process, multiple resources/assets can be bundled together if they share similar characteristics like location, type, or features.

Physical adaptive capacity is subdivided into two groupings: intrinsic ability of the resource to adapt and the ability of a resource to adapt with available technological aid. This is an important distinction for natural resources and some of the living cultural resources. For non-living resources, intrinsic ability does not need to be evaluated.

To calculate adaptive capacity:

1. Select the guiding questions/factors to be discussed within each of the four POSE categories. These factors will not be scored directly but will inform the overall adaptive capacity score for each of the POSE categories. Multiple factors for each category may be used to incorporate the multiple dimensions of adaptive capacity and the inherent tradeoffs to achieve the necessary adaptations. The specific factors and the number of them considered will vary based on the resource/asset group. Table 12 has the suggested starting adaptive capacity indicators to use.
2. Score each POSE Category. For each resource/asset determine the adaptive capacity within each of the POSE categories using the high, moderate and low scoring scale. Refer back to the exposure and sensitivity scores to understand the type of climate stressors the resource/asset will be facing over time to determine whether the degree of adaptive capacity is commensurate with the degree of vulnerability and likely need for adaptation. Only assign a score to the category and not the factors listed within each category. Those factors are only for generating honest and meaningful discussions on the potential for generating the capacity to act sufficiently and in a timely way. It is also important to not assume that the Federal government will always have the resources to resolve the issues, as showcased by disaster relief funds. Use realistic scenarios in allocating scores.
3. Determine the composite raw adaptive capacity score for each resource/asset by adding up the scores in each POSE category. There should be four category scores that get added together. First, convert high, moderate, low scores to 3, 2, 1 respectively then add together to get a sum.
4. Bin the composite raw adaptive capacity score. Create break points for each high, moderate, low (H, M, L) bin using the reference below as a guide (Table 1).
5. Assign a final adaptive capacity rank for each resource/asset. Convert the binned adaptive capacity score into the respective final adaptive capacity ranks using the guidance in Table 14.

**Table 12.** Factors for assessing the four categories of adaptive capacities.

| Physical | Organizational | Social | Economic |
|---|---|---|---|
| **Natural/intrinsic** (use only if applicable to the resource):<br>• Health<br>• Abundance<br>• Protection<br>• Sensitivity to current impacts<br>**Infrastructure**:<br>• Transportation (boats/vehicles)<br>• Facilities<br>• Shoreline structures<br>• Monitoring protocols<br>• Technology | • Laws/Authority<br>• Coordination<br>• Agreements (formal and informal)<br>• Plans<br>• Implementation<br>• Enforcement<br>• Staffing - number of staff (term vs seasonal) and training<br>• Transparency<br>• Accountability<br>• Meets multiple goals (across NPS Divisions)<br>• Number of viable management options (don't select them, just recognize the variety available)<br>• Ability to take effective action<br>• Ability to take timely action | • Significance (across a variety of sectors/communities)<br>• Cohesion<br>• Community organizations and associations<br>• Trust<br>• Diversity of livelihoods, culture, language<br>• Awareness<br>• Conflicts<br>• Equity (gender, financial)<br>• Perceptions<br>• Culture<br>• Values and attitudes<br>• CHAMPIONS (leaders that support effort)<br>• National interests<br>• Constituencies dedicated to an asset | • Base funding<br>• Competitive funding<br>• Congressional line items<br>• Emergency funding<br>• Administrative system to disburse finances in timely fashion<br>• Likely scale of economic resources required to do a variety of actions |

**Table 13.** Scoring and ranking adaptive capacity (AC).

| POSE Category Ranking | Rank Value | Binned AC Score Range | Final AC Rank |
|---|---|---|---|
| H | 3 | 10-12 | High |
| M | 2 | 7-9 | Moderate |
| L | 1 | 4-6 | Low |

<u>Natural Resources</u>

Most natural resources have some ability to intrinsically adapt to climate change. Some parks may have modeling or other studies that are tracking or predicting adaptations, such as SLAMM (Sea Level Affecting Marshes Model). The natural resources workgroup should try their best not to include this intrinsic adaptive capacity within their sensitivity scores. One way to think about the differences between sensitivity and intrinsic adaptive capacity is the degree of change required in relation to the normal/recently documented bandwidth for that resource to cope. While the two components of Physical adaptive capacity will be combined in the score, the scoring sheet should record both for future reference.

Cultural Resources

Cultural resources represent a diverse collection of materials, structures, and sites with diverse preservation requirements and adaptation abilities in the face of climate change. While those components of cultural landscapes and ethnographic resources that are natural resources may have intrinsic abilities to adapt to change, such as the ability to migrate beyond salt water intrusions or relocate with changing landscape patterns, man-made sites and memorialized viewscapes may not have the same flexibility. However, the ability of site managers and partners to aid in the climate change protection of cultural resources represents a type of adaptation. To develop a full picture of the adaptive capacity of cultural resources, this method considers the, often limited, intrinsic adaptive capacity of a site, as well as the ability of management to act in the protection of a site.

Table 1 shows key considerations for each type of cultural resource, in each of the four categories of adaptive capacity. The table also indicates categories and resource types for which the cultural resource assessment should be advised by natural resources' and facilities' adaptive capacity scores. Although Table 15 shows key considerations, the adaptive capacity of each priority site, structure, and feature in this study should be scored individually.

Facilities

This part of the assessment departs from the SOP/WCU protocol (NPS, 2016), which does not score for adaptive capacity. Facilities can use the POSE framework with a focus on what the capacities are under realistic conditions before and after an event – be it a storm, engineering failure, or end of expected life for an asset. The facilities workgroup can group score across similar assets since many of the same factors from an organizational and socio-economic perspective are the same. This allows for a faster and more efficient scoring process, which will be crucial to get through a large number of FMSS listed assets.

**Table 14.** Cultural resource adaptive capacity guidelines.

| Resource Type | Physical AC: Intrinsic | Physical AC: Technological | Organizational AC | Social AC | Economic AC |
|---|---|---|---|---|---|
| Archaeological Resources | • Default value = Low<br>• Archaeological resources have little or no ability to adapt on their own. | • Maximum value = Med.<br>• Excavation, etc. saves the story, but not the site and context. | • Default value = Med.<br>• Certain sites may have the potential for organizational partnerships. | • Minimum value = Med<br>• Well-known, or important sites may receive more support for adaptation. | • Default value = Low<br>• Adaptive actions for archaeological resources are very expensive. |
| Historic Structures | Adaptations must consider preserving the historic integrity of the structure. | Historic structures typically have a very high technological AC with historic and modern techniques. | Organizational capacity may depend on historic preservation staff. Scores advised by facilities scores. | Structures with associated community groups may have higher AC. | Structures with concession or adaptive reuse potential may have higher AC. |
| Cultural Landscapes | Natural features may have intrinsic adaptive capacity. Scores advised by natural resource scores. | Varies by landscape feature. | Organizational capacity may depend on park and regional cultural landscape expertise. | Certain parts of the landscape may have advocacy groups while others do not. | Economic AC of cultural landscapes may depend on integrated projects between NPS divisions. |
| Collections | Collections have little or no ability to adapt on their own. | Collections may already be protected in climate controlled facilities. | Organizational capacity to protect consolidated collections is generally high. | Social desire to protect consolidated collections is generally high. | Climate adaptations to collections buildings may be expensive. |
| Ethnographic Resources | Natural features may have intrinsic adaptive capacity. | Varies by ethnographic resource type. | Ethnographic resources may not be well-documented, which may present organizational challenges. | Modern uses may conflict with historic ethnographic uses. | Varies by ethnographic resource type. |

## Step 7. Integration Analysis and Recommendations

Objective

> Identify and analyze the key integration issues across resource workgroups to produce a set of recommendations for adaptation planning, further research, and interpretation.

A variety of methods are used to assist the participants to integrate across resources and divisions to draw out recommendations. The easiest means to accomplish this objective is to ensure workgroups discuss scores for resources/assets of common interest and mandate. Another method is map resources together or to display vulnerability and adaptive capacity in a matrix to understand the relationships for multiple resources within a shared focal area or issue. More advanced methods introduced in this document, though optional, use key decision points and adaptation pathways to demonstrate how the vulnerability and adaptive capacity information can be used for adaptation planning. Finally, a review of the park's goals is conducted to understand the influence of vulnerability and adaptive capacity on reaching intended goals and mandates.

Key Integration Issues

Based on the vulnerability and adaptive capacity scores, begin the process of understanding how key resources/assets link to one another. Identify the key issues.

- For resources/assets of interest to multiple workgroups, compare the scores to ensure common understanding of the stressors, vulnerability, and adaptive capacity. Revise scores if it is merited or note the differences in analysis.
- Analyze closely those resources/assets with moderate to high vulnerability and see the connections between them in general and in the focal areas. By limiting the discussion to a focal area, the interactions between resources/assets can be better understood. Participants can do flow diagrams (or systems analysis) to make the connections between climate stressors, resources/assets, and goals. Do multiple stressors act on a set of resources/assets that together could put park goals at risk? This analysis is critical, as the vulnerability scoring process focused mostly on individual resources/assets without direct analysis of supporting resources.

Vulnerability - Adaptive Capacity Relationship

Produce matrices for the resources/assets to compare the relationship between vulnerability and adaptive capacity. Matrices can be produced within divisions or across divisions based on a focal area. The focal areas for integration will need matrices that capture all of the resources/assets across the three divisions. Once they are plotted on a graph, discuss how they can be categorized, such as by quadrant, or circle connected resources, to capture the key messages as shown in an example from Colonial NHP in Figure 5. The quadrants are given names to represent how the combination can be thought of: high adaptive capacity/low vulnerability = quick wins, high vulnerability/high adaptive capacity = serious but actionable, high vulnerability/low adaptive capacity = high concern – review goals, and low vulnerability/low adaptive capacity = monitor for change. While these may not be applicable categories for all of the resources/assets plotted on the graph, it does provide a lens to quickly evaluate the relationships and spread across the matrix.

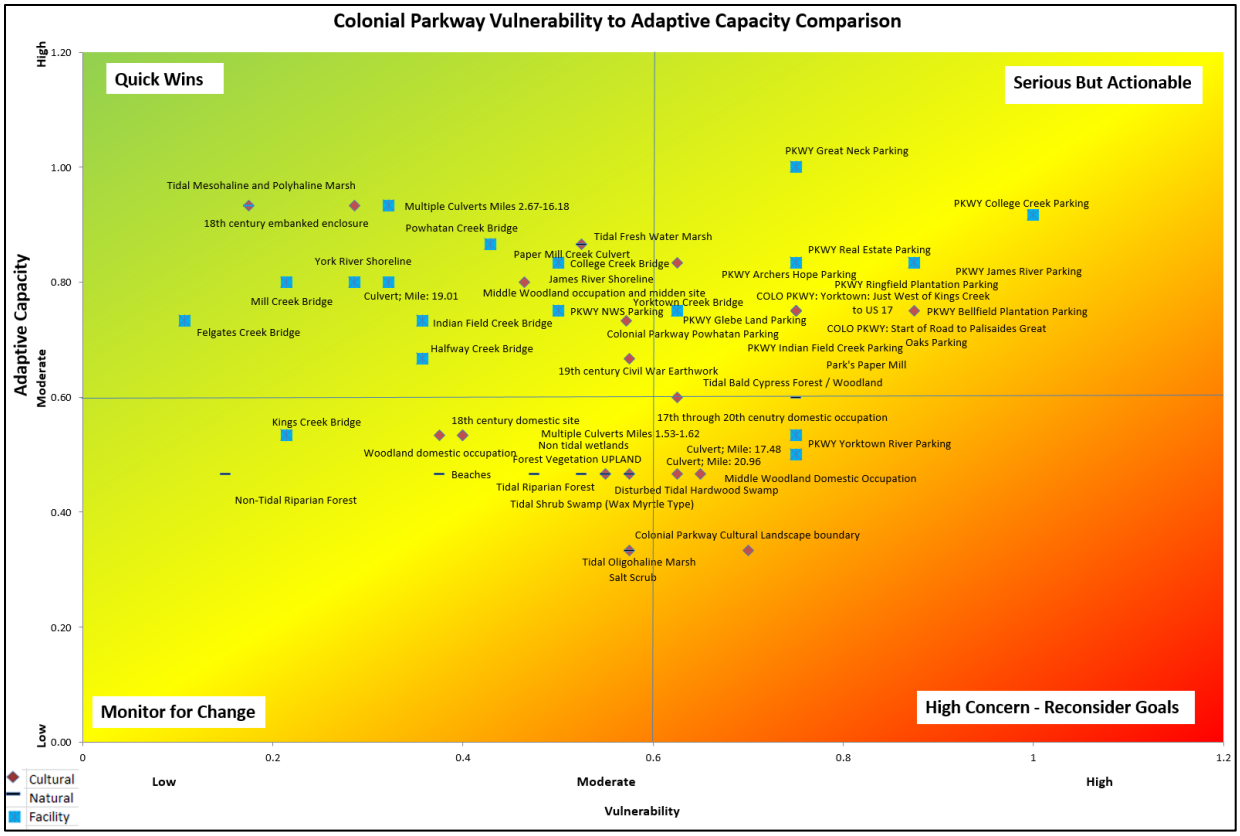


**Figure 5.** Example of a vulnerability to adaptive capacity matrix from Colonial National Historical Park.

To compare the vulnerability to adaptive capacity relationship across divisions, the scores may need to be normalized so that each group uses a similar scale for vulnerability and adaptive capacity. For instance, if the number of exposure stressors is larger for natural resources than facility assets their scoring range will be different and skew the comparison. Normalizing the scores is done by dividing the raw scores for vulnerability and adaptive capacity in each group/division by the highest potential scores respectively. Normalizing the raw scores as opposed to the final binned vulnerability scores will provide greater differentiation and spread across the matrix.

## Adaptation Pathways Analysis

Climate change increases the level of uncertainty and risk in park planning, which makes the transition to significant long-term action challenging. Therefore, new frameworks are needed to bridge the gap between the current state of analysis and future significant changes. The adaptation pathways framework is a promising and well tested approach for addressing these needs by combining aspects of vulnerability, risk and sequential adaptations (Haasnoot et al. 2013; Barnett et al. 2014). This approach differs from classical planning by beginning with identifying impacts that the system can't cope with, and then marking those decision points where changes are necessary.

The following two tools are suggested as an example of how to bridge the vulnerability analysis with adaptation planning, but could be left out of the process in the future if a scaled back process were needed.

*Decision Points:*

Decision points are points in time when adaptation actions cease to be effective and new actions are required. Another key element of decision points is lead time or how much advance warning and planning is necessary so that NPS doesn't confront a decision point unprepared. Identifying decision points is an effective tool to focus attention and bring the static vulnerability scores to life as climate change unfolds for an area.

Decision Point Exercise:

1. Select an integrated focal area (Step 1).
2. Review the vulnerabilities across time, for all of the resources/assets and identify the major decision points. Mark the decisions points on the map with a time frame and short description.
3. Craft an issue statement that pulls together the key climate change management concerns across the divisions for the focal area.
4. For each decision point identified, identify the key resources and assets that are vulnerable.
5. Have the group assess the overall adaptive capacity in light of the integrated resource/asset cluster. Refer back to the POSE categories and factors for guidance on how to informally assign an adaptive capacity score.
6. Identify the goals and or major management strategies that are relevant to this resource/asset cluster.

*Adaptation Pathways:*

Building off of the Decision Point exercise, the integrated groups next brainstorm on a menu of potential adaptation options. Each option is assessed for how long it might be effective based on climate change projections. Based on the options, a simple pathways graphic is produced to highlight the menu of options and how the park might sequentially adapt over time as the climate changes. Adaptation pathways are only indicative of options available, without further analysis and stakeholder engagement they are not a prescriptive plan for action. It is merely a tool to understand the potential for action now. Pathways are reflective of the likely conditions decades from now, so as to avoid maladaptations or unintended actions. This can reduce or avoid ineffective allocation of resources and limiting future options by getting locked into a maladaptive path forward.

*Adaptation Pathways Exercise:*

1. Continuing with the decision point analysis, identify the potential adaptation options available to address the issue and each decision point. This is a brainstorming exercise.
2. For each adaptation option assign a time frame for when it could begin and how long it would potentially continue to be effective in light of the projections used in this assessment.
3. Identify the potential connections between the options. What are the likely progressions from current actions to sequential next steps?
4. Create a simple line chart for each decision point starting with current actions. Include the top 4-8 adaptation options. Then, add their likely start and end of life time based on climate projections.

5. Finally map out the likely transitions between adaptation options through time starting with the current actions and moving to the right (to the year 2100). There can be several sequences of adaptation from small, incremental soft engineering to major infrastructural changes or changes in goals and thus management activities.
6. Insert a marker for when a decision point will likely occur, usually along the current actions line.
7. Repeat this process for each decision point, making separate pathway figures.
8. Analyze the implications, likelihood of mustering the resources, and will power to achieve the incremental changes. For those adaptation options that meet existing park goals and align the interests of one or more divisions, provide recommendations for next steps in the vulnerability assessment report.

Figure 6 and Table 1 shows an example from the Colonial NHP assessment of a decision points analysis, which can then be used to develop adaptation pathways (example in Figure 7). The integrated issue statement that the decision points are addressing is 'unless significant interventions are made the combined impacts of climate change will inundate and erode significant portions of Jamestown Island over time which will jeopardize the goals and management strategies Colonial NHP has established.' These exercises serve in most cases as a way to integrate ideas, concepts, concerns, and priorities across divisions. As in most cases, the process and discourse is of equal or greater value than the analysis from the assessment.

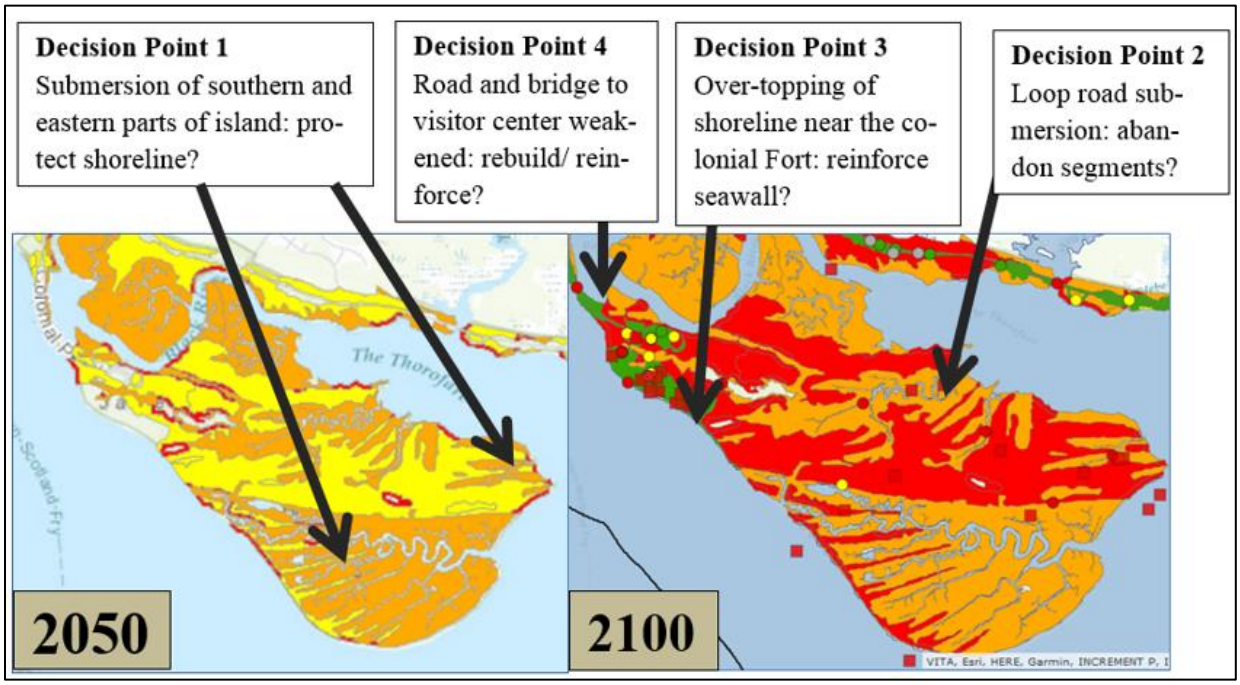


**Figure 6.** Example of mapping a decision point analysis for the Jamestown Island focal area. Accompanies Table 15 that shows the analysis element.

**Table 15.** Example of the decision point analysis for Jamestown Island focal area. Accompanies Figure 6 that shows the mapping element.

| **Decision Points (listed in columns, not in any order):** | **Southeast Jamestown Island inundated** | **Eastern Jamestown and Loop road compromised** | **Old Town seawall compromised and overtopped** | **Isthmus Bridge and roadway compromised** | **Museum Collections flooded and exposed during storms** |
|---|---|---|---|---|---|
| Resources/Assets Linked to DP: | Tidal oligohaline marsh; coastal plain-loblolly pine-oak forest | disturbed tidal hardwood swamp; Tidal oligohaline marsh; coastal plain-loblolly pine-oak forest | Archaeological sites, archeaearium, historic structures, seawall shoreline | Isthmus bridge, wooden shoreline stabilization structures, roadway | Most archaeology/text collections, building structure |
| Goals/Strategies at Risk | Protecting marsh systems, bird habitat and ecosystem integrity | Protecting marsh systems, bird habitat and ecosystem integrity | Maintain the seawall which is a historical structure and avoid additional visual impairments to the site. | Ensure access to Jamestown Visitor Center during most weather events | Protect the collections in place until they can be safely moved to higher ground off the island. |
| Currently Doing to protect: | Wetlands and shoreline protection structures around the island. James City County shore plan | Wetlands and shoreline protection structures; James City County shore plan | Maintain existing seawall in historical context | Bridge and roadway maintained and recently upgraded above floodplain where possible. | Finding a suitable location to move collection off the island. Removing some items. |
| Adaptation Pathway Options | Improve monitoring; Update the shore management plan to include climate scenarios; redeploy materials, marsh stabilization to higher priority sites; new forms of access to shore areas, revise interpretation | Improve monitoring; Reinforce Black Point protection structure, marsh stabilization; new forms of access to wetlands; revise interpretation | Continue stabilizing and repairing the seawall, increased earthen wall on the landside of the seawall | Stabilize shoreline, raise the roadway and bridge | Remove all text collections from the island |

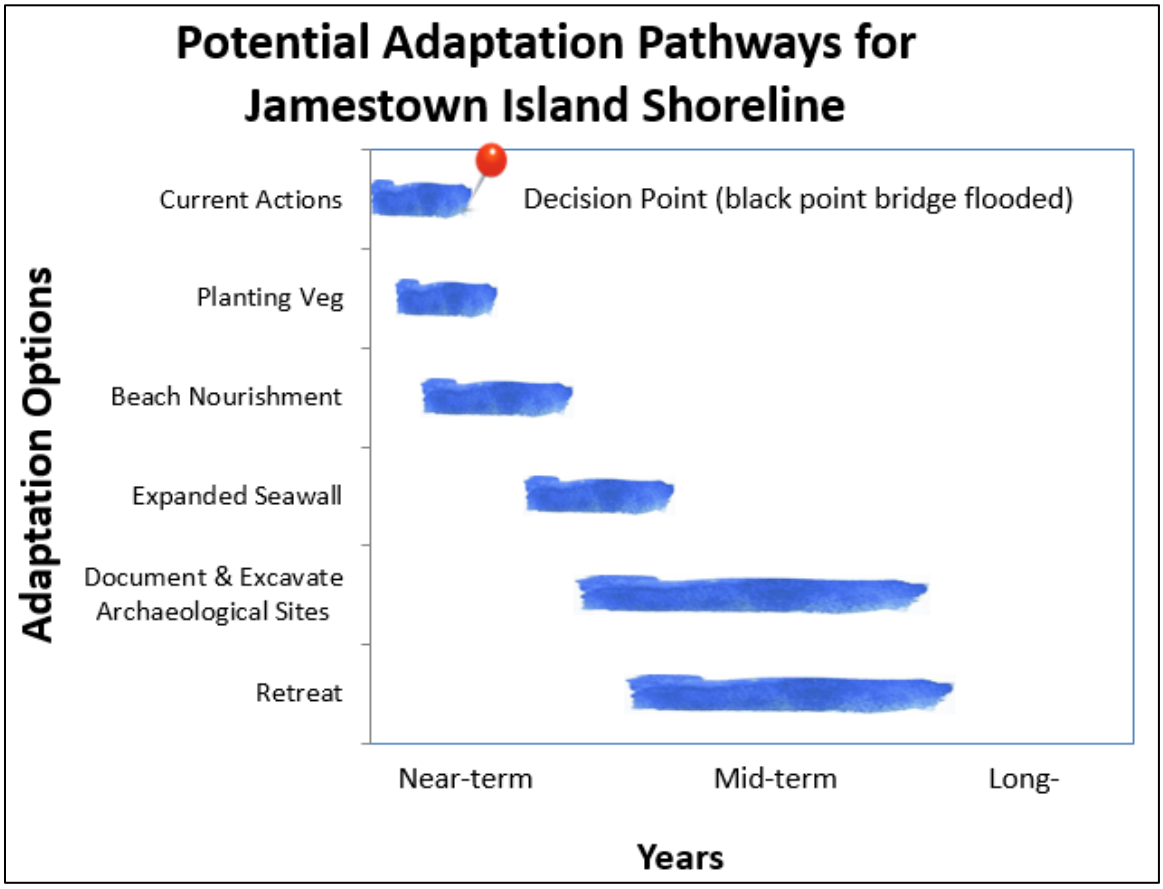


**Figure 7.** Illustrative adaptation pathway for Jamestown Island.

Goal Review and Implications

As highlighted in *Climate Smart Conservation*, an important step after a vulnerability assessment is to reconsider goals of the park itself, in light of climate change (Stein et al. 2014). At the start of the assessment, each workgroup is asked to articulate the current goals that determine current priorities and management actions. At the third workshop, with the vulnerability and adaptive capacity in mind, the group was asked to revisit these goals to determine if any will likely need to be updated in light of vulnerability. Some may no longer be attainable in the future, as informed by the adaptation pathways analysis. The integrated discussions feed into this summative review of goals.

There is another critical reason for revisiting the goals in a vulnerability assessment. Without some criteria or thresholds there isn't a clear boundary for interpreting the meaning and consequences of the vulnerability results. A risk assessment is a common tool for incorporating these elements to put potential vulnerabilities into a decision-making framework. Identifying the specific thresholds for risk analysis are challenging for many organizations. Therefore, using a combination of vulnerability and adaptive capacity scores, decision points, adaptation pathways, and goal statements, it is possible to weave together an analysis that builds off of existing materials and organizational processes. This also balances the measurements from the vulnerability assessment with the interpretation and expert judgement of the decision points, adaptation pathways and reflection on goals.

Workshop Exercise:

1. Ask the group to review their initial list of goals from Step 1. For each goal quickly assess the risk of the goal not being achieved due to the outcomes of the vulnerability and adaptive capacity assessment.
2. For those goals that are at risk, suggest a revised goal that takes climate change into consideration.
3. Highlight those goals that require revision and incorporate those key messages into the vulnerability assessment report summary. Produce some recommendations for follow-up using more in-depth analysis or adaptation planning.

Final Assessment Recommendations

The vulnerability assessment is meant to identify resources/assets that are vulnerable, recommend follow-up action to do further analysis, and sharing of information. The assessment is not meant for recommending adaptation actions – which requires further analysis and stakeholder consultation. Therefore, it is important to remind the workgroups of this point to keep the discussion on vulnerability, opportunities for adaptation actions, and implications if no action is done.

Beyond the listing of vulnerability scores for individual resources/assets, the assessment thus far does not capture the great insights to the larger picture of how impacts might happen, the linkages across resources, and the opportunities to move the discussion forward. To pull this all together consider the findings using the following dimensions.

*Area of interest.*

Develop recommendations for the integration issues that multiple divisions are interested in versus the highlighted resources/assets that only one division is concerned with addressing. The analysis needs to be useful from a park director's integrated perspective.

- Integration Issues: For each of the key integration issues selected by the groups, review the findings and recommend ways to increase awareness, knowledge, and stakeholder engagement. Highlight the mutual or supporting goals across the divisions that the issue addresses to build larger constituencies. Consider the short term and long term implications of climate change and potential next steps for advancing the issue. This includes additional data collection and key upcoming decisions or funding opportunities that consider the vulnerability issues identified in this analysis.
- Division Highlights: Similar to the integration issues, though perhaps of concern mainly to individual divisions, the groups should identify recommendations for those resources/assets that scored moderate to high for vulnerability. Consider how the adaptive capacity scores influence which of these vulnerable items remain a highlight or not. A resource with high adaptive capacity may need to be highlighted since it would benefit from the additional attention to implement the likely adaptation options, or it is a catalyst for addressing other vulnerability issues. Similarly, resources that have low adaptive capacity might not be the focus for action beyond monitoring, depending on its significance.

*High Vulnerability, Revisit Goals:*

Which resources/assets have high vulnerability and likely will need to revisit the goals in the near to medium term? If a goal does need to be revisited, then how could this influence the other parts of the park's resources or larger region? The adaptive capacity scores and discussions will be informative in identifying the resources with moderate to high vulnerability that may need their goals revisited.

*Win-Win Opportunities:*

Which resources/assets have high vulnerability and high adaptive capacity? These are likely decision points for seeking win-win opportunities. Similarly, a low vulnerability score but high adaptive capacity scores could be opportunities to begin the easy steps to adaptation and generate stronger constituencies.

- Where are the best opportunities and benefits for integrating goals and strategies across divisions? One division may have financial resources, but lack the influence that another division may have to move the park to a decision.

*Trade-offs:*

The assessment should be able to highlight the linkages across resources and divisions, such that a deeper and informed discussion on trade-offs can happen. There may be trade-offs between divisions where adaptation to protect one resource will affect the future adaptation options or timing for another resource. Consider how the vulnerability and adaptive capacity influence the trade-offs between maintaining one set of goals over another.

*Adaptive Capacity:*

Discuss how to increase adaptive capacity for key issues. These could be improved knowledge, constituency building, and policy discussions instead of the common physical adaptations. This could lend some insight into specific near term actions. Consider how some adaptation strategies can leverage other funding opportunities, while some decisions can limit future funding options for other resources.

*Mainstreaming:*

There are numerous opportunities to integrate the vulnerability and adaptive capacity findings into existing NPS projects, policies, procedures, materials, and strategies. Brainstorm on the key opportunities for mainstreaming the results into near term items. Incorporate this into the recommendations section of the final vulnerability assessment report and follow up with key staff and stakeholders of this opportunity.

## Step 8. Communicating Vulnerability

A key element of this methodology is to ensure that the results of the assessment get communicated with park staff, visitors, and key audiences. At workshop 3, discuss a plan to share the results with different audiences, through the report or developing other materials. One exercise that can be done at the workshop is participants can apply the NPS *Every Place Has a Climate Story* framework to develop narratives for the park in general, as well as focal areas of concern (Rockman and Masse, 2017). The interpretive team should participate in this exercise. Workshop participants should also

identify key audiences that should be informed about the vulnerability results and next steps for ensuring adaptation happens. To create a climate story, there are three key steps (Rockman and Masse, 2017) (Figure 8). Below is an example from Colonial NHP using *Every Place Has A Climate Story* and the vulnerability results.

1. Choose Theme: Changes in the Material World
2. Key Word (in one word, what is your story about?): Impermanence
3. Sentence Story (and…but…therefore)

   Twentieth century park planners established Colonial NHP to tell the story of the first permanent English colony AND built park infrastructure on the assumption of unchanging physical and climate conditions, BUT a rapidly changing climate is causing profound changes to the physical foundation of the park. THEREFORE, cultural resources and park facilities are facing challenges and threats never anticipated by park designers.

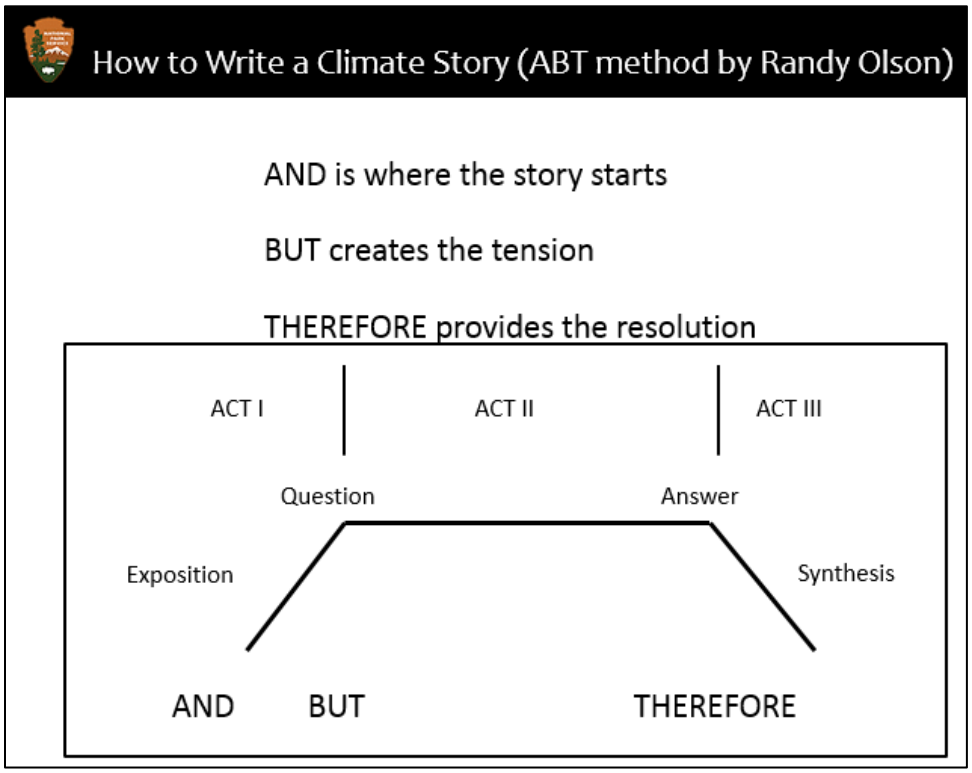


**Figure 8.** Guidance to write a climate story based on the And-But-Therefore method by Randy Olson (based on Rockman and Masse, 2017).

## Step 9. Evaluation of Assessment Process

Objective

Gather feedback from participants to inform the park and update the methodology.

At the end of the workshop and assessment process, it is encouraged that an evaluation is conducted to gather feedback from the participants to inform the park, as well as NPS for further refining the methodology. Table 16 shows suggested evaluation questions. These can be discussed in an open forum during a final session or as an evaluation questionnaire for individuals to complete before departure.

How effective was the design of integrating three divisions' concerns and thinking to influence the results of this assessment?

How helpful and effective was the assessment framework and function of vulnerability = exposure + sensitivity, the adaptive capacity POSE framework, or the vulnerability to adaptive capacity matrix to see relationships?

FOR NPS STAFF:

- How might you work across divisions to implement actions related to climate change?
- How might you work within your division to implement actions related to climate change?
- Will the results be more useful to you within your division or park-wide?

FOR PARTNERS, how will this assessment influence your actions with the NPS going forward?

FOR EVERYONE, what value did this process provide you?

**Table 16.** Example of evaluation form for workshop participants.

| Process | Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| The process was effective for facilitating worthwhile discussions and providing valuable outputs. | – | – | – | – | – |
| I would recommend this process to another coastal park | – | – | – | – | – |
| This pilot increased my ability to incorporate vulnerability into the planning and implementation of park goals | – | – | – | – | – |
| I am more likely to take action based on this information and process | – | – | – | – | – |

# Reflections and Lessons

The process and method outlined in this document are based on recent published guidance, case studies from national parks and protected areas, and the experience gained conducting a pilot assessment at Colonial NHP. Several key reflections and lessons were captured by the participants that offer insights into the reasoning behind the updated method.

Benefits of Integrated Vulnerability Assessment

- The assessment provides a generalized screening tool that integrates across divisions to explicitly link issues of climate change with a park's goals. There will be topics that the park will need to revisit with a more detailed vulnerability process at site level, as part of developing an adaptation strategy.
- Park staff recognize the need to prepare for addressing climate change in the medium to long-term scale. There are significant gaps in management knowledge and available data, including a lack of knowledge of current losses in some areas.

Integration

- The assessment provides input to various elements used by park staff for today's programing and future planning. These include:
    - Mainstream information into other documents
        - Resource Stewardship Strategy
        - Annual and 5-year work plans for Divisions
        - Environmental Impact Statements
        - Capital Investment Strategy
        - Baseline and existing conditions report (NRCA, Cultural Resources Stewardship Assessment)
        - Section 106 and 110 – Cultural resources that are on or eligible for the National Register of Historic Places
    - Contribute to other activities
        - Develop and prioritize archaeological research
        - Support for partners and collaboration on efforts
        - Foundation document follow up planning
        - Hurricane Preparedness Planning
- The importance of discussing facilities, cultural resources, and natural resources within the same process became obvious to all: they are interdependent. Not all resources and assets (across divisions or even within divisions) are valued in the same way or for the same reasons. We need a process to combine vulnerability and significance to prioritize.

- The process reveals differences between the three disciplines, as reflected by the park divisions (and even within the divisions) illustrating the varying stages of awareness, methods of assessment, and adaptation approaches. This provides opportunities for lessons to be learned across disciplines and within a park staff.
- There are numerous areas of overlap between divisions, in particular for cultural resources and facilities assets. For instance, in Colonial NHP when both groups looked at the impacts of increased rain events and temperature on historic homes, they realized that these buildings will likely have shorter repair cycles, which increases facilities and preservation costs. They are also at increased risk of losing original historic fabric.
- Engaging across disciplines in focal areas is important to interpretation, which can help articulate the integration and tell a story of the past, present, and future.
- The process benefits the cultural resources workgroup, as it facilitates a complex discussion about vulnerability and adaptive capacity across archeological resources, buildings and structures, museum collections, ethnographic resources, and cultural landscapes.

Framework

- Formulating and applying a common framework across divisions is a challenge, given the different issues and opportunities. Similarly, the cultural resources workgroup found its different subdivisions struggling at the outset to come to agreement on a common analytical approach. The process enabled them to agree upon common exposure and sensitivity features to assess and evaluate, and flexibility to adjust by resource type. The human dimension of adaptive capacity was very important to the facilities and cultural resources workgroups, where previously adaptive capacity had been assumed to only encompass intrinsic/natural adaptive capacity. Employing the POSE adaptive capacity framework brought to the foreground the realities of how society and economics could impact efforts to develop adaptation plans.
- The methodology keeps adaptive capacity separate from vulnerability. It is important to assess both of these concepts in a vulnerability assessment, but it was determined that combining in a single metric takes away from our understanding of the system and the applicability to adaptation. For park staff, the vulnerability score, without modifications from adaptive capacity, may be helpful in targeting research questions, prioritizing research efforts, selecting adaptation methods, and pursuing funding. In the pilot study, cultural resources and facilities had concerns about including management adaptive capacity in vulnerability scoring in the original framework. For instance, where a high adaptive capacity score based on assumptions, such as about funding availability, would reduce an overall vulnerability score for a highly vulnerable resource and thus the ability to attract funding to adapt based on high vulnerability.
- The cultural resources workgroup may also struggle with assessing adaptive capacity due to the complications surrounding the concepts of significance and priority. Significance was a challenge to define, though once understood it was then added to the factors of the POSE framework. There was a larger question related to prioritization. Vulnerability alone will not

determine priority for adaptation actions, it will be a combination of significance and vulnerability (Rockman et al. 2016), but it is beyond the scope of this effort to evaluate significance of each resource. Developing methods to do so will be an important next step.

- Evaluating uncertainty was initially part of the planned framework, but the plan to do so by resource was not practical in the workshop setting and time allotted. In the future, either other systemic methods to capture uncertainty need to be tested, or time made as a group to reflect on and document areas of high or low confidence in order to put some bounds on uncertainty and develop a summary statement on uncertainty.

Process

- Workgroups bring in expert judgement directly related to the park and is complemented by partner, national and regional perspectives. The effectiveness is improved with strong local leadership by having specific park staff clearly identified as the leader of each workgroup, though this is not always feasible. There are significant benefits from conducting the assessment internally with the staff and partners that can't be matched by having outside groups conduct the analysis using existing data.
- Conducting much of the assessment over the course of three face-to-face workshops builds trust and buy-in among and within the participants. It also reduces fears of the process, allows a better understanding of perspectives and priorities between divisions.
- A significant portion of the work is done outside of the workshop via conference calls. The success of the workgroups is enhanced by the opportunities to discuss materials and issues as a group during calls to prepare for, as well as analyze, the results of the three workshops. The cultural resources workgroup can be more efficient by creating subgroups that represent the five NPS cultural resource types. It is important to include enough time and funding to allow for a multi-stage process in the vulnerability assessments.
- The process of identifying stressors (for each division) enables the group to deal with many facets of the climate change issue, not just sea level rise. This makes the process more relevant for coastal and inland parks alike. The simplification of this effort to weight all stressors equally means that it is not possible to distinguish the case where sea level rise, or another stressor, has a much larger contribution towards vulnerability. One way to address this is Facilities uses an auto-high option where the option to automatically raise the exposure score to the highest level if a particular stressor is high and outweighs all the others.
- Workshop exercises drill down to particular areas of concern (focal areas) in a park to discuss adaptation strategies, which is not easy, but necessary. This is an effective way for the three divisions to work together to combine expertise, and in Colonial NHP, yielded a number of viable adaptation ideas that in many cases reinforced and supported adaptation needs of mutual benefit.

Projections

- Numerical projections that are detailed and downscaled for variables such as sea level rise, temperature and precipitation are assembled early in the assessment. The specific sea level

rise projections and associated timeframes are essential elements of mapping and analysis. For precipitation and temperature changes, parkwide projections were sufficient since available data indicated little spatial difference (e.g. number of days >95º F, peak daily precipitation, days). This should be considered as the methodology considers future assessments, especially for larger parks, and determines the appropriate level of granularity for the projections.

- Selecting three time frames of 2020, 2050, and 2100 for exposure balance the short-term demands, a moderate term of mid-century, and the climate projections over a much longer time frame. The simplification of sensitivity and adaptive capacity not changing through time may need to be revisited, but was appropriate to the scope of the effort and available data to inform the indicators for these.

Partnerships

- Local partners will be key in implementing adaptation pathways for parks. In conducting an integrated assessment, each park will have to determine which partners need to be involved in the assessment, and at what stage. Including other key stakeholders (e.g. local organizations, planners, Sea Grant extension agents, local tribal representatives), can benefit by contributing to diverse information gathering, honest discussion about issues, opportunities to build partnerships, and buy-in for taking next steps.

# Glossary

**Adaptation pathway -** a decision strategy that entails a vision for the entity exposed to climate risks, to be met through a sequence of manageable steps over time. Each is triggered by a change in environmental and social conditions leading to key decision points.

**Adaptive capacity -** the ability of a resource, asset, or process to adjust to climate change (including climate variability and extremes), i.e. to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. The framework used here includes both intrinsic/natural adaptive capacity and management adaptive capacity.

**Climate -** in a narrow sense is usually defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands of years. The classical period is 3 decades, as defined by the World Meteorological Organization.

**Climate change -** any significant change in the measures of climate lasting for an extended period of time. In other words, climate change includes major changes in temperature, precipitation, or wind patterns, among others, that occur over several decades or longer.

**Decision points -** similar to 'tipping points'**,** the points in time when adaptation actions cease to be effective and new actions are required. In this approach, adaptation is as much about actions in time as in space.

**Exposure -** magnitude of change in climate and other stressors that a resource, asset, or process has already or may experience in the future.

**Risk -** the likelihood of incurring harm, or the probability that some type of injury or loss would result from the hazard event.

**Scenario -** a plausible description of how the future may develop, based on a coherent and internally consistent set of assumptions about key relationships and driving forces (e.g. rate of technology changes, prices). Note that scenarios are neither predictions nor forecasts.

**Sea level rise -** an increase in the mean level of the ocean. Eustatic sea level rise is a change in global average sea level brought about by an increase in the volume of the world ocean. Relative sea level rise occurs when there is a local increase in sea-level relative to the land, which may be due to ocean rise and/or land level subsidence.

**Sensitivity -** degree to which a resource, asset, or process is or could be affected, either adversely or beneficially, by climate variability or change.

**Storm surge -** a rise of water level generated by a storm, over and above the predicted astronomical tide.

**Vulnerability -** the degree to which a resource, asset or process is susceptible to adverse effects of climate change, including climate variability and extremes.

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The Department of the Interior protects and manages the nation’s natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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