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Public Lands and Climate Change: An Evaluation of the North Cascadia Adaptation Partnership

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By

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Accepted in Partial Completion
of the Requirements for the Degree
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Master's Thesis

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Kristen Doering

May 21, 2021

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A Thesis
Presented to
The Faculty of
Western Washington University

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Abstract

Public lands in the United States serve critical roles for ecosystems and humans alike, but they have become increasingly vulnerable to climate change. Many agencies have attempted to reduce negative effects of climate change through adaptation planning. This research evaluates the implementation of the North Cascadia Adaptation Partnership (NCAP), which was developed in 2010 to provide science-based guidance to land managers in the North Cascades Ecosystem (Raymond, Peterson & Rochefort, 2013). The NCAP consists of four federal land units: North Cascades National Park, Mt. Baker- Snoqualmie National Forest, Okanogan-Wenatchee National Forest, and Mt. Rainier National Park. Relying on survey and interview data, I assess how land managers are perceiving and responding to climate change, but more specifically how they are using the North Cascadia Adaptation Partnership vulnerability assessment. While some differences are apparent between the National Park Service and U.S. Forest Service agencies, common factors influencing implementation of strategies and tactics include level of collaboration, barriers, and agency culture. I conclude with recommendations for how agencies can better incorporate climate change adaptation planning and action into existing planning and decision-making processes. Adaptation partnership outcomes would be enhanced with regular revisions and repeated workshop offerings, as well as continued evaluation of climate change focused research.

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Thank you first and foremost to my advisor Tammi Laninga and my thesis committee, Dave Peterson and Grace Wang, for their continual guidance and support. Additionally, thank you to all the U.S. Forest Service and National Park Service employees who participated in interviews and the survey. Lastly, I want to acknowledge all the faculty, students and staff in the WWU Environmental Studies and Science department who challenged and helped me along the way.

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TABLE OF CONTENTS

List of Figures and Tables

Figures

Tables

List of Acronyms

BLM- Bureau of Land Management

DNR- Department of Natural Resources

NCAP- North Cascadia Adaptation Partnership

NEPA- National Environmental Policy Act

NPS- National Park Service

USFS- U.S. Forest Service

USFWS- U.S. Fish and Wildlife Service

Chapter 1: Introduction and Background

Introduction

The impacts of climate change are far reaching, complex and sometimes difficult to predict. Despite the challenges, developing an understanding of climate change impacts is crucial to adaptation efforts. Federal land managers have attempted to address these issues through the creation of climate change vulnerability assessments and adaptation plans. Public land agencies are tasked with administering massive swaths of land with varied ecosystems and uses. Trying to manage such areas for logging, recreation, habitat preservation and wildlife, to name a few, is already a complicated undertaking, and the added effects of climate change makes the process even harder. Scientists and managers from the U.S. Forest Service, National Park Service and University of Washington have evaluated specific ecosystems and created vulnerability assessments for land managers to use for climate change adaptation efforts. One particular assessment called the North Cascadia Adaptation Partnership (NCAP) offers climate change adaptation strategies and tactics for federal land agencies in the North Cascades ecosystem of Washington state (Raymond, Peterson & Rochefort, 2013). The partnership was created through a collaborative effort by and for the U.S. Forest Service and the National Park Service, along with the University of Washington and other public land agencies (see Figure 1 for a map of the agencies involved). To gain an understanding of the efficacy of these types of partnerships, it is important to evaluate their application. This research engages directly with public land agency staff through scientific synthesis to assess the implementation of the NCAP.

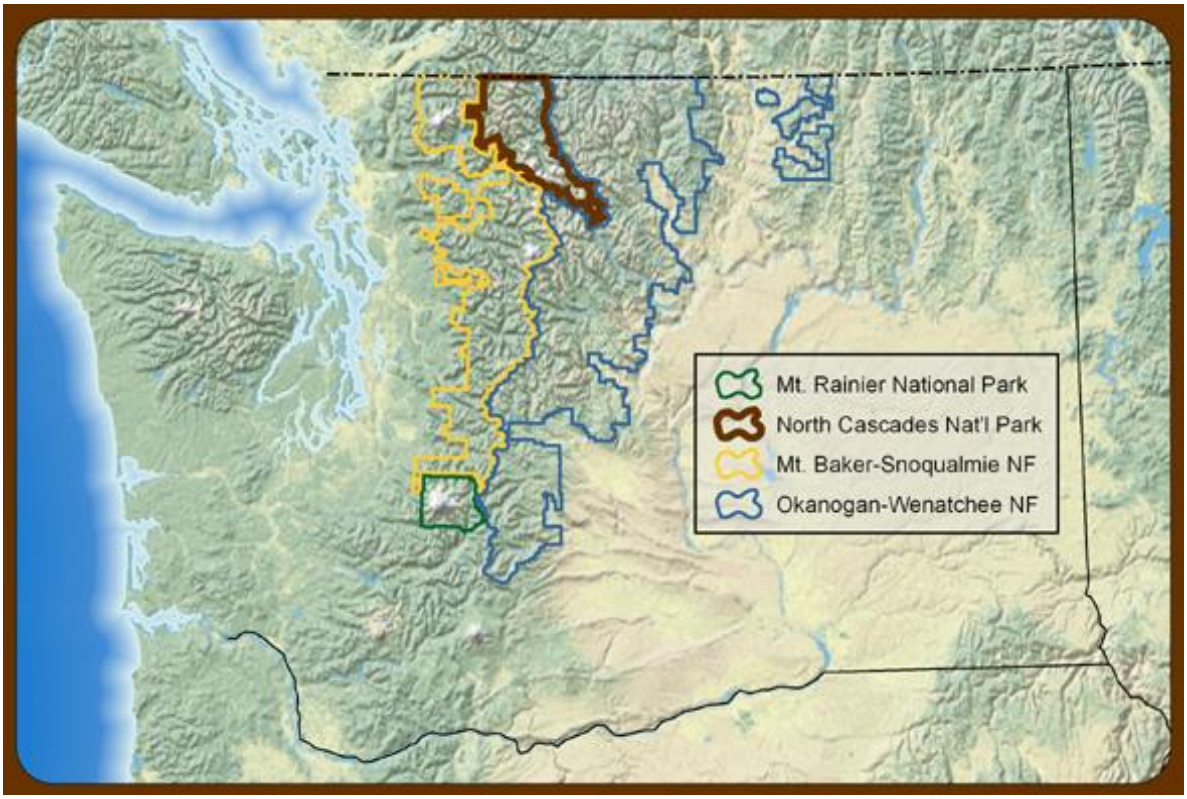


Figure 1: The four units of the North Cascadia Adaptation Partnership (*North Cascadia Adaptation Partnership—NCAP*, n.d.).

Background

The concept of climate change adaptation planning for public lands is a relatively new phenomenon. Although adaptation planning shares many characteristics with other forms of planning, such as disaster risk management, it draws on current scientific research related to the impacts of climate change on natural and built aspects of the environment (Fussel, 2007; Baron et al., 2009). Scientists have studied the various ways in which climate change impacts public lands, especially related to natural resources and visitation patterns (Gonzalez, Wang, Notaro, Vimont & Williams, 2018; Fisichelli, Schuurman, Monahan & Ziesler, 2015). In 2010, a broad range of stakeholders from federal and state agencies, environmental groups and others consolidated adaptation planning guidance and regionally specific climate change impacts to create an assessment specific to the North Cascadia ecosystem. The assessment consists of

strategies for distinct categories such as infrastructure, vegetation, wildlife and fisheries (Raymond et al., 2013; Strauch, Raymond, Rochefort, Hamlet & Lauver, 2015). Understanding how climate change will affect public lands in the form of science-based research and how that is translated into ecosystem specific tactics is fundamental to an effective plan. It is also necessary to be familiar with the legacy and policies set forth by land management agencies.

Various federal agencies have researched and formally recognized the need for guidance on addressing climate change. The U.S. Government Accountability Office published a report in 2007 acknowledging that the effects of climate change had already been observed on federal lands, yet it was not a priority in any of the agencies. They recognized that the limited guidance and lack of site-specific research created uncertainty for resource managers, and recommended that the Secretaries of Agriculture, Commerce and Interior, amongst others, develop written communication outlining how to address climate change (GAO, 2007). This recommendation was agreed upon by the agency heads at the time, and a few years later, formal documents were created. Although mandates to consider climate change in decision making have existed for decades, executive orders from the Obama administration in 2009 required that federal agencies manage for climate change (Baron et. al., 2009).

In 2011, the U.S. Forest Service (USFS) national office, which falls under the Department of Agriculture, sent out several documents intended to assist land managers in adapting to climate change. One of them titled “National Roadmap for Responding to Climate Change” highlighted key goals in the USFS response: agency capacity, partnerships and education, adaptation, and mitigation and sustainable consumption. This document also encouraged building management capacity by working with partners and establishing climate change technology transfer (USFS,

2011). Around the same time, the National Park Service (NPS), housed under the Department of the Interior, came out with a response strategy with similar goals: science, adaptation, mitigation and communication (NPS, 2010). It was followed by a Climate Change Action Plan which also emphasized partnerships to promote values within a networked system of protected areas (NPS, 2012).

Despite the momentum in the early 2010s for climate change adaptation, efforts slowed significantly under the following administration. As with any government agency, priorities and funding can shift dramatically depending on the focus of a new president. This change has been significant in the context of climate change and federal lands. The Trump administration had rolled back many of the Obama era mandates and paid little attention to climate change (Bloomer, Daniels, Wriston & Goffman, 2020). For example, the most recent strategic plan outlining the Department of the Interior Secretary's priorities does not include the phrase "climate change," but rather focuses on goals like modernizing infrastructure, generating revenue, utilizing natural resources, and expanding outdoor recreation and access (DOI, 2018). A strategic plan for the NPS was not readily available, nor was a permanent NPS director appointed during Trump's tenure (Bloomer, et al, 2020).

In contrast, recent USFS's strategic goals include "foster resilient, adaptive ecosystems to mitigate climate change," among other priorities such as providing benefits to the public and applying knowledge globally (USFS, 2015). The USFS still actively monitors adaption efforts through a Climate Change Performance Scorecard, though a similar metric is not available for NPS units (Raymond et al., 2013). Differing priorities, historic legacies, and agency missions create important distinctions between the NPS and USFS, especially when it comes to climate

change adaptation. National Forests were established under a conservation ethic, which valued the responsible use of natural resources, including timber extraction and mining. National Parks were meant to preserve ecosystems unimpaired for the enjoyment of future generations (Purdy, 2015). This translates to different land management philosophies and different policies when it comes to adaptation.

To gain a full and accurate assessment of the status of climate change adaptation on federal lands, it is necessary to understand the history and strategies surrounding such efforts. The following section builds from this background information to provide a holistic picture of the literature related to climate change adaptation. It focuses on regional and global impacts, and theory around adaptation planning and institutional capacity. This context is important for understanding the questions used in the surveys and interviews and it provides insight to the ultimate findings and implications of the study, while also setting the stage for future research.

Research Questions

A number of questions guided this inquiry into the NCAP's implementation:

- How are public land managers using the North Cascadia Adaptation Partnership vulnerability assessment?
- Are the resource sector categories selected by the Partnership appropriate?
- What factors are affecting agencies' implementation of strategies?
- What is the value of the adaptation partnership?

Chapter 2: Literature Review

The evaluation of any adaptation partnership requires a firm understanding of its context, the goal of its strategies and tactics, as well as possible limitations to its implementation. This literature review looks at those categories to give context to this research study and its evaluation methods. It begins with an overview of the North Cascades region, followed by a summary of the relevant research of climate change on public lands, with an emphasis on wildfire. It then provides a grounding of climate change adaptation planning in other types of vulnerability assessments and plans, while looking at the process for creating adaptation strategies and tactics. Lastly, it outlines some of the key considerations for successful implementation by looking at the general concept of institutional capacity, as informed by barriers, agency culture, and level of collaboration. This review is important for an informed analysis of the partnership, as well as its value and how it is being utilized by the agencies involved.

North Cascades Region

The context for the North Cascadia Adaptation Partnership is a diverse and rugged landscape defined by steep mountains and distinct ecosystems (see Figure 2). On the west side of the mountain crest, the climate is dominated by wet and temperate weather, with high annual rainfall (Raymond et al., 2013). The east side of the crest is much drier and experiences a wider temperature range, with cold winters and hot summers. There are many different ecosystems in the North Cascades, including temperate coniferous rainforests, alpine tundra, and dry coniferous forests, inhabited by diverse species of plants and animals (Raymond et al., 2013). The region is also characterized by extensive waterways fed by glaciers, some of which support hydroelectric

dams, and a network of roads and trails used for both natural resources extraction and recreation (Strauch et al., 2015).

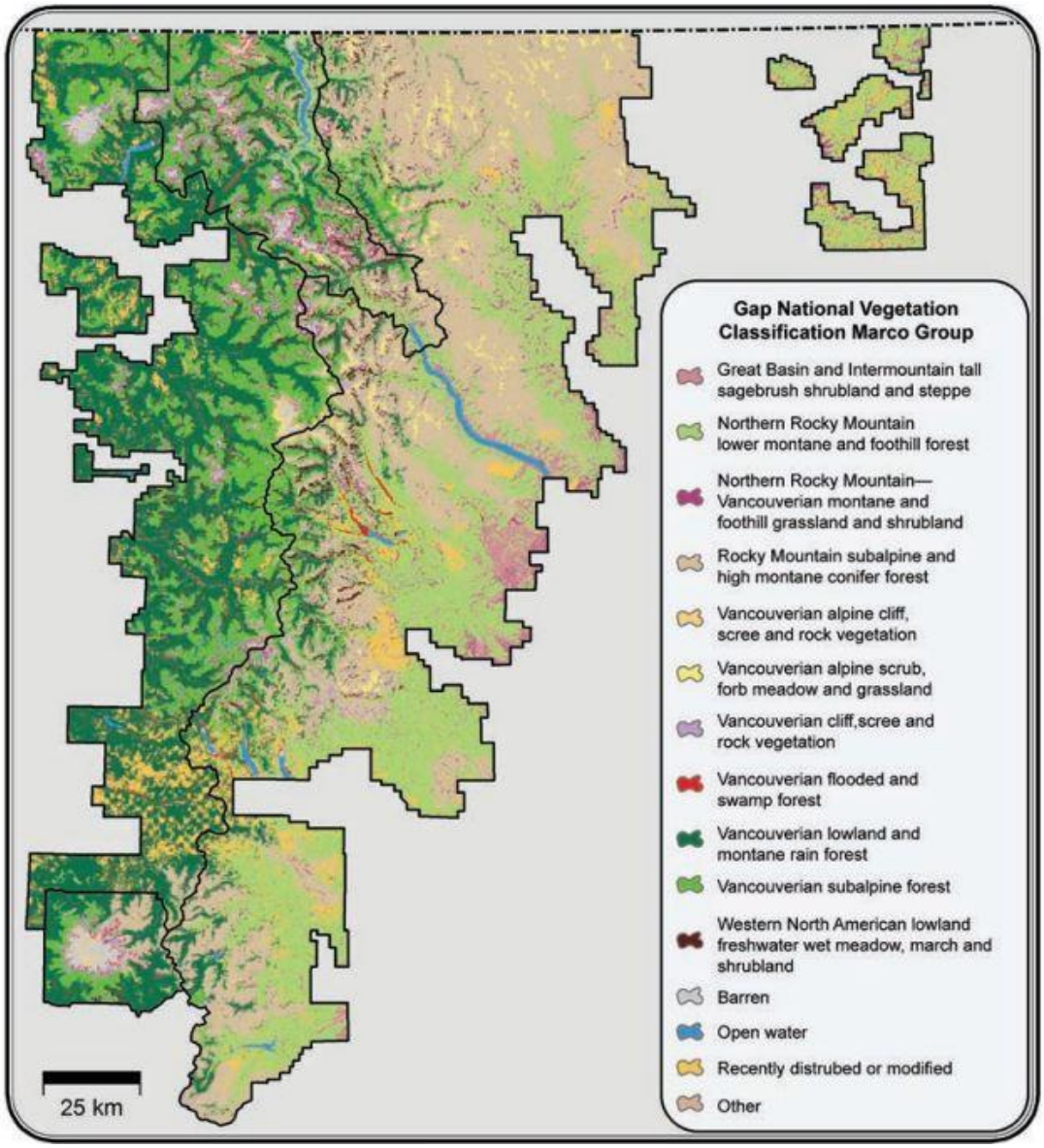


Figure 2: The North Cascades ecosystem (Raymond, Peterson & Rochefort, 2014).

The region's complex and varied landscape makes the process of evaluating climate change impacts challenging, as each ecosystem must be evaluated individually but also in relation to surrounding ecosystems. For example, mountain ecosystems which are very sensitive to climate change must be considered as well as the forests at lower elevations that might be impacted by

changes to snowpack and hydrologic regimes (Strauch et al., 2015). There has been a great deal of research in recent decades dedicated to climate change impacts on public lands, ranging from the specific, localized scale of the NCAP to the national level. The next section looks at relevant research related to climate change impacts on ecosystems and visitation.

Climate Change and Public Lands

Public lands are already experiencing the effects of climate change, especially in the sensitive environments contained within protected areas such as the Arctic and high elevation alpine zones. National parks and public lands preserve ecosystems that will be affected significantly by climate change. From 1880 to 2012, anthropogenic emissions of greenhouse gases have increased global temperature by nearly 1 degree Celsius, and this increase is projected to continue (Gonzalez et al., 2018). Such changes will have a cascade of effects on public lands, ranging from increased rainfall, decreased snowpack, higher instances of drought and changes to wildfire regimes. All these changes will impact natural resources and visitor experience. Another observed consequence of climate change is visitation pattern shifts. Many national parks see high visitation during warm temperate seasons, which is normally summer for higher latitude areas. But as climate change is causing warmer temperatures in fall and spring, land managers are having to plan for extended busy seasons (Fisichelli et al., 2015). Public lands are seeing longer periods of increased visitation, requiring increased staffing and budget changes.

These impacts require changes to management strategies and some researchers are advocating for total paradigm shifts. For example, Beissinger & Ackerly (2017) suggest that management plans start to account for future climactic conditions, rather than current ones. Others recommend that planning and management shifts reflect advances in research and changes in society. This

could mean a greater emphasis on social-ecological systems, collaborations, partnerships, and integrated resource management. Policy towards wildfire is a great example, as new evidence related to the ecological benefits of fire has changed management strategies that were once solely focused on suppression (Blahna et al., 2020). Despite new understandings of wildfire and ecosystem dynamics, climate change poses a complex challenge.

The frequency and severity of wildfires are expected to increase due to higher temperatures and more instances of drought (Raymond, et al., 2013). Wildfires can be extremely expensive and could be considered one of the most visible consequences of climate change. It has been documented that prior to European-American settlement, people actively managed forests in the Northwest through small, intentional burning. In dry forests, decades of fire suppression have altered forest compositions so much that they are now prone to large, severe fires as well as insect outbreaks (Hessburg, Agee, & Franklin, 2005). A long history of fire suppression has led to fuel build up and climate change is causing hotter and drier conditions. Many landscapes are at high risk for wildfire. A fire might start on national forest or park land and spread to private lands, requiring multi-jurisdictional coordination. Therefore, land management policies on federal lands have consequences for all surrounding areas when it comes to fire (Ager, Day, Short & Evers, 2016). The effects of climate change challenge public land agencies in a variety of ways. Whether federal lands are seeing more severe wildfires, or other hazard events like flooding, it is important to understand how land managers perceive the impacts of climate change, since the most salient ones can be addressed with adaptation efforts (Timberlake & Schultz, 2017). The following section looks at theories related to understanding climate change vulnerabilities and translating them into adaptation strategies and tactics.

Adaptation Planning

The concept of adaptation planning is not a new discipline, as it draws on other aspects of planning theory. But unlike urban planning or disaster planning, climate change is relatively unprecedented and can take decades for the effects to be fully felt. For this reason, many researchers encourage adaptation as well as mitigation strategies so that hazards and vulnerabilities can be proactively managed (Fussel, 2007). The availability of planning resources such as roadmaps and response strategies coupled with executive orders initially made climate change adaptation a high priority. For application on public lands, researchers advocate that land managers stay current on trends and encourage integration into all aspects of planning, since climate change impacts are ever evolving and complex (Baron et al., 2009).

Research regarding climate change impacts is generally available and up to date for most ecosystems contained by public lands. One example of this is Adaptation Partners, a research group funded by the USFS that provides climate change vulnerability assessments for several regions in the western United States (Halofsky, Peterson & Prendeville, 2018). Vulnerability is a phrase commonly applied in disaster application, but for climate change specifically it refers to exposure, sensitivity, and adaptive capacity (Timberlake & Schultz, 2019). Resilience is another related term used to describe the ability of ecosystems to recover from and absorb disturbances, although to some it is a hard to define "buzzword" (Timberlake & Schultz, 2017). These terms are used commonly in climate change vulnerability assessments.

NCAP was one of the first strategies created by the Adaptations Partners organization in 2010 for the North Cascades region. It consists of four federal land units: North Cascades National

Park, Mt. Baker-Snoqualmie National Forest, Okanogan-Wenatchee National Forest and Mt. Rainier National Park (Raymond et al., 2013; North Cascadia Adaptation Partnership, n.d.). The adaptation partnership presents vulnerabilities and adaptation options for different aspects of federal lands, ranging from flood control to fisheries enhancement to wildfire mitigation. It also focuses on the collaborative aspects of the partnership, with an emphasis on stakeholder engagement, workshop offerings and science-management solutions. A technical report from the USFS serves as a guiding document for land managers and lays out all the relevant data for the vulnerability assessment (Raymond et al., 2014). The NCAP has assessments, and associated strategies and tactics, in four categories: transportation and access, vegetation and disturbances, wildfire and habitat and fish and habitat. Later assessments have included categories such as recreation, ecosystem services, infrastructure and cultural resources (Timberlake & Schultz, 2019). The incorporation of new categories was explored in this thesis.

Adaptation strategies and tactics were developed through a series of workshops. One workshop provided climate change science for the North Cascades ecosystem. A second workshop was organized by resource sectors at each of the units in NCAP (Raymond et al., 2013). Agency staff and academic institutions used the latest research on climate change to discuss management challenges and brainstorm solutions. Workshop participants identified general approaches in the form of strategies and on-the-ground actions in the form of tactics. This process was also intended to increase organizational capacity by providing education and training on the possible effects of climate change on resources (Raymond et al., 2013).

Institutional Capacity

Institutional capacity is broadly defined as the ability of an organization or agency to achieve its mission. It can be influenced by a variety of factors such as communication, political influence, and staffing (Bloomer et. al., 2020). Public land agencies may have a singular mission, but they must juggle many tasks to be successful at that mission. Therefore, it is important to consider the overall institutional capacity of an agency to better understand its ability to implement climate change adaptation. Specific themes related to institutional capacity used in this study are barriers, agency culture and level of collaboration.

Barriers

Implementing adaptation strategies and tactics is a crucial step in effectively responding to climate change, but this process can be hindered due to barriers. One study surveyed federal land managers on the status of climate change adaptation planning after it was mandated by the Obama administration in 2010. They interviewed employees from four federal agencies and found that most respondents considered climate change to be an important issue, but found that lack of information, agency culture and budget constraints were commonly cited barriers (Archie, Dilling, Milford, & Pampel, 2012). A similar study of federal land managers in Washington state focused on barriers in the form of environmental laws and policies. Researchers found that certain laws like the National Environmental Policy Act (NEPA) were conducive to adaptation planning, whereas laws like the Endangered Species Act were inhibitive because they focus narrowly on one species instead of entire ecosystems (Jantarasami, Lawler & Thomas, 2010). Although many barriers are considered malleable and can be overcome, proper identification of pervasive barriers can help improve the implementation process (Moser &

Ekstrom, 2010). These studies highlight the significance of barriers in the form of legal and political constraints, resource limitations and socially constructed perceptions when it comes to the implementation process. Other important considerations when it comes to barriers include internal ones such as agency culture and communication.

Agency Culture

Agency culture is another important factor of institutional capacity and is influenced by staffing, issue awareness, and application of plans. Other researchers have explored this concept through a study of climate change adaptation plans for protected areas in Canada. They asked participants to rate proposed adaptation options in terms of affordability, ease of implementation, institutional capacity, and capacity to sustain over time (Lemieux & Scott, 2011). The researchers found agency culture to be dually influenced by internal perceptions and external forces, such as public pressure. Another study by the same researchers focused instead on perceptions and found that many land managers believed their agency was performing poorly at adapting to climate change, due to commonly blamed obstacles such as lack of clear mandates and inadequate financial resources (Lemieux, Thompson, Dawson, & Schuster, 2013). There is consensus in the literature that the bureaucratic structure of these agencies made timely adaptations difficult and can inhibit implementation. This can be countered however, if climate change adaptation is established as a priority and can be incorporated within a unit's management authority (Jantarasami et al., 2010).

Level of Collaboration

NCAP is an interagency partnership that focuses on collaboration. Any sort of natural resource collaboration requires unique considerations, especially related to level of cooperation amongst

stakeholders and organizational culture (Conley & Moote, 2003). Partnerships between scientists and managers are important for understanding preferences and policies from different perspectives, so collaboration amongst stakeholders and agencies must be evaluated (Timberlake & Schultz, 2019). NCAP was intended to be a common framework for federal agencies to draw from when adapting to climate change, but differing agency missions can make this challenging. For example, the USFS is a multiple use agency that allows for resource extraction and recreation, whereas the NPS is focused on the preservation of resources for the enjoyment of the public (Archie et al., 2012). The NCAP workshops were meant to act as a linking activity to bridge the missions of these two agencies, but they were conducted nearly a decade ago so awareness of the Partnership may have declined since then. In addition, the NCAP workshops did not cover climate change education for the general public (Raymond et al., 2013). An understanding of such components as collaboration, as well as agency culture, and barriers is necessary for an accurate evaluation of how climate change adaptation planning in NCAP has been implemented.

Evaluation

This review of the literature has laid out the relevant issues related to climate change and public lands as well as other important components related to institutional capacity. There has been a great deal of research related to climate change impacts on public lands, but less on the implementation of vulnerability assessments to on the ground actions. Although some researchers have studied vulnerability assessments used in the USFS such studies have not looked at partnerships across agencies (Timberlake & Schultz, 2017). The findings from this

study can be coupled with evaluations of vulnerability assessments to improve adaptation efforts on public lands.

Conceptual Framework

The conceptual framework below highlights the key factors that influence climate change adaptation on public lands (Figure 3), as informed by the relevant literature discussed above. The ability to implement strategies is dependent on institutional capacity and perceived impacts. Institutional capacity is a complex notion that is framed by agency culture, level of collaboration and various barriers, such as insufficient resources and policy constraints. This model was the basis for the survey design and interview questions.

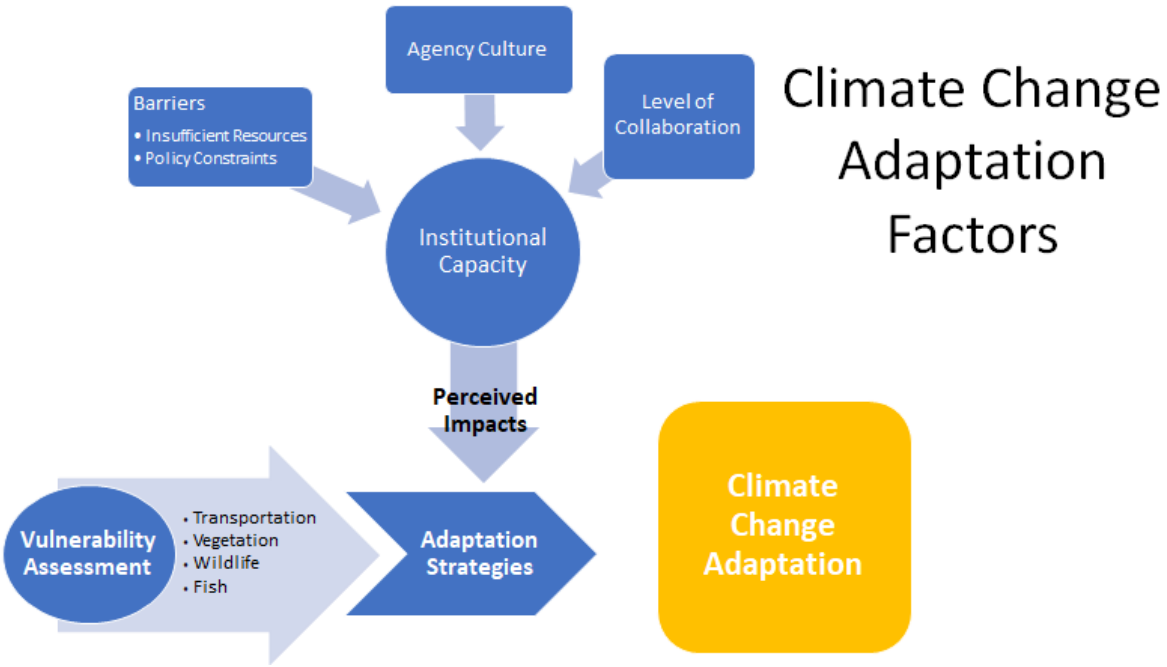


Figure 3. Conceptual framework for climate change adaptation

In considering other studies and research related to climate change adaptation planning, the next section lays out the research methodology used to examine the NCAP. It combines methods from previous studies and concepts that are specific to North Cascadia.

Chapter 3: Methods

For this study, I examined how different agencies are implementing the strategies and tactics from the North Cascadia Adaptation Partnership. I also looked at factors contributing to climate change adaptation as well as restrictions and areas for improvement. A mixed method, qualitative approach consisting of a survey and interviews was used for this study. Relying on multiple inputs for assessment increases the validation and reliability of the results (Teddlie & Yu, 2007).

Surveys

The survey was distributed in an online platform called Qualtrics and sent to relevant employees of all four of the NCAP units; it was identical, thus reinforcing reliability (Bhattacherjee, 2012). I contacted climate change coordinators, natural resource chiefs and other employees as ascertained through informant interviews. I sent a survey link to these people and asked them to distribute it to relevant staff members. This method of obtaining respondents is called snowball sampling (Parker, Scott & Geddes, 2019). The survey was open for two months from September 3 to October 30 and received a total of 30 complete responses. The survey was anonymous, but there was a link to a separate survey at the end where respondents could leave their email to receive the results of the survey or be contacted for a follow-up interview.

The survey started with general questions about the participant's demographics: job title, which agency they work for and length of employment at current agency, as well as perceptions of climate change impacts (See Appendix A for the complete survey). They were asked which of the four categories from the vulnerability assessment were most relevant to their job, with the

option to pick more than one. The remainder of the survey was divided into those four categories: transportation and access, vegetation and disturbances, wildlife and wildlife habitat, fish and fish habitat. Each category listed all the strategies for each category with a table showing the tactics associated with each strategy. Respondents were asked to select strategies they used for planning or other projects. If none of the strategies or tactics were relevant, they were able to skip to the next section. Each of the categories also had questions related to barriers, resources, and capacity to be sustained over time. This layout was repeated for each of the four categories. The survey concluded with a question about tactics and if respondents were interested in receiving the results or doing a follow up interview.

Interviews

The surveys were supplemented with interviews conducted with employees of the four NCAP agencies. I used purposive sampling to select administrators, planners, climate change coordinators, wilderness managers and resource specialists from all four units to gain a sense of "big picture" goals related to climate change adaptation. I reached out to staff members at each of the units who had left their contact information after completing the survey. To ensure that I spoke with respondents from each unit, I also reached out to informants and had them recommend key employees whose work was related to climate change adaptation. In total, I conducted 9 interviews, with 2 each from North Cascades NP, Mt. Rainier NP and Mt. Baker-Snoqualmie NF, and 3 from Okanogan-Wenatchee NF. I asked standardized, open ended questions related to institutional capacity, implementation resources, barriers, level of collaboration and agency culture (See Appendix B for the interview questions). This method increased comparability of responses and I left time at the end of the interview to allow for

informal conversations to discuss ideas not yet addressed, using a combination strategy (Patton, 2002). I originally planned to travel to each unit and conduct interviews in person, but due to the covid-19 pandemic I had to switch to a virtual modality. The interviews were conducted and recorded via Microsoft Teams, and were transcribed using software from Microsoft Stream. I reviewed the transcripts and edited them for accuracy.

I coded the interviews according to themes from my conceptual framework and linked them to the interview questions. I started with a predefined list of codes and added emergent codes as I reread the interviews. I used the recommendations of Miles and Huberman by going through multiple iterations of reviewing each interview and revising the codes accordingly, focusing on different aspects each time (1994). This method has been used by other researchers studying climate change adaptation (Timberlake & Schultz, 2017). I kept track of main themes, codes and associated narrative chunks of text in a spreadsheet, a method recommended by Renner and Taylor-Powell for ease of organization (2003). This method also made it simple to search for key phrases, sort according to each code and count the frequency of certain themes. I had a peer review two of my interviews for intercoder reliability.

Considerations

Although the results from this research are not generalizable due to the case study nature of this study, the themes such as institutional capacity, agency culture, level of collaboration, and barriers are relevant considerations for all federal land agencies when it comes to climate change adaptation. As demonstrated in the literature review, constructs such as legal and policy barriers have been used in previous studies related to climate change adaptation (Jantarasami et al., 2010;

Archie et al., 2012). Other factors such as level of collaboration and agency culture have not been explicitly used for such studies but have been proven pertinent for other related research (Conley et al., 2003; Moser et. al, 2010). This evaluation could be replicated with other land management agencies that have climate change adaptation partnerships, especially those that have been developed by Adaptation Partners, the organization that created NCAP (Halofsky, Peterson, & Prendeville, 2018). With these considerations in mind, the following section outlines the data results and analysis from this research.

Chapter 4: Results and Analysis

Survey

The results section starts with an analysis of the survey and is followed by an examination of the interviews. The survey received a total of 30 respondents split between the four NCAP units (Figure 4), comprising 16 total responses from National Park Service (NPS) staff and 14 from U.S. Forest Service (USFS) staff. Only one respondent had worked at their until for less than 1 year, with most working 1-5 or 5-10 years. Out of all 30 respondents, 8 reported that they had attended the NCAP workshops in 2011.

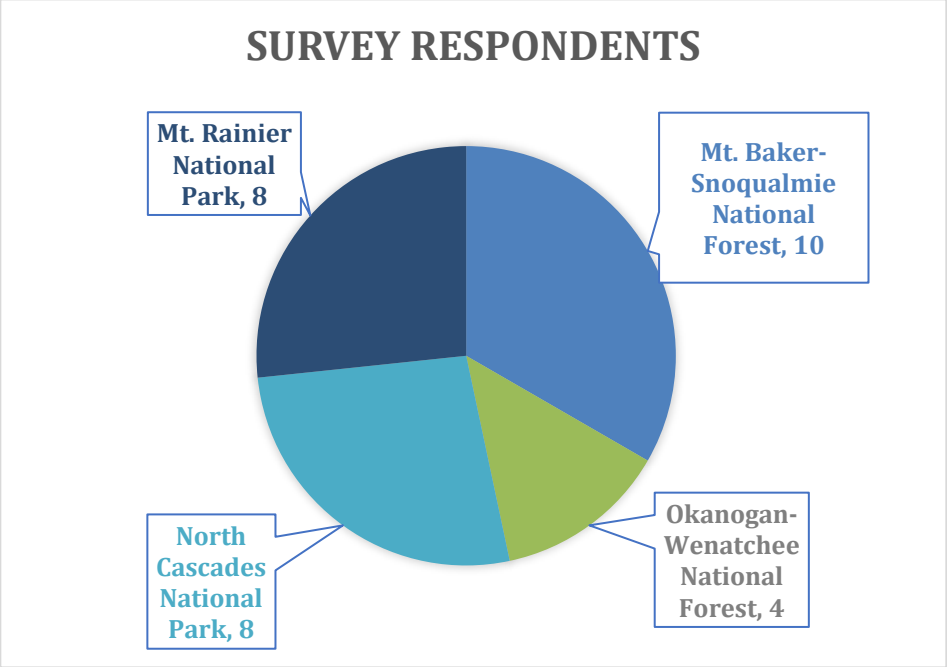
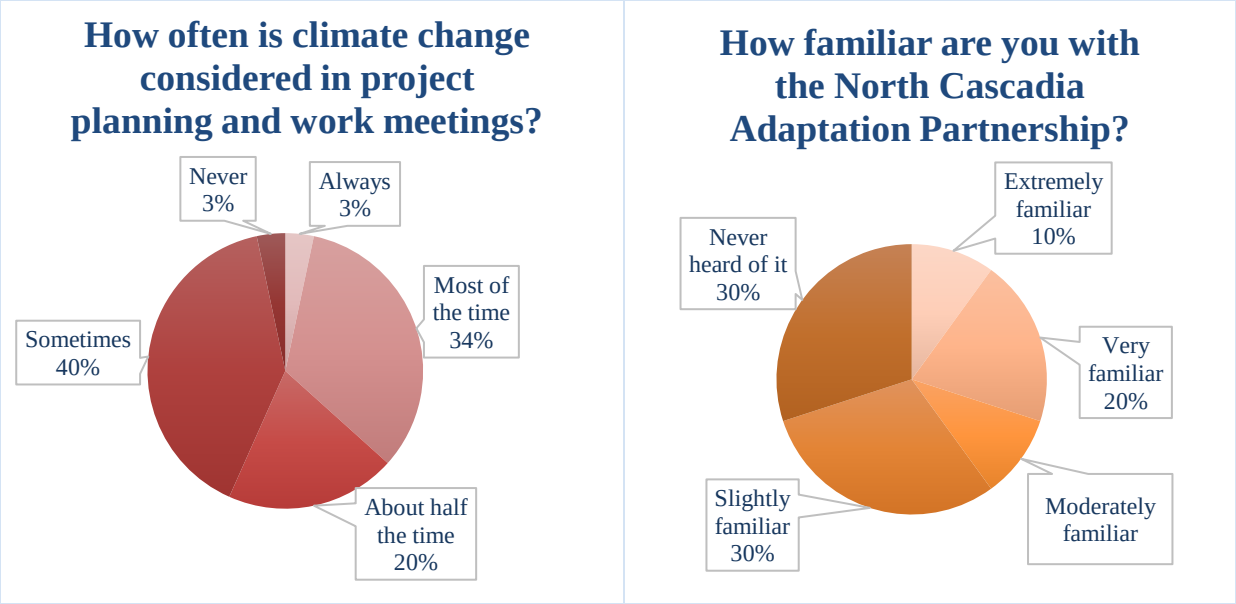


Figure 4: Distribution of survey responses amongst the four units of NCAP

Roughly half of respondents reported that they considered climate change in project planning and meetings either half of the time or most of the time (Figure 5). However, 60% of respondents said they had either never heard of or were slightly familiar with the North Cascadia Adaptation Partnership (Figure 6).



Figures 5 and 6: Responses to survey questions related to climate change and NCAP

Respondents reported that the vegetation and disturbances category was the most relevant to their job, followed by transportation and access, and fish and wildlife (Figure 7). They were given the option to pick more than one category.

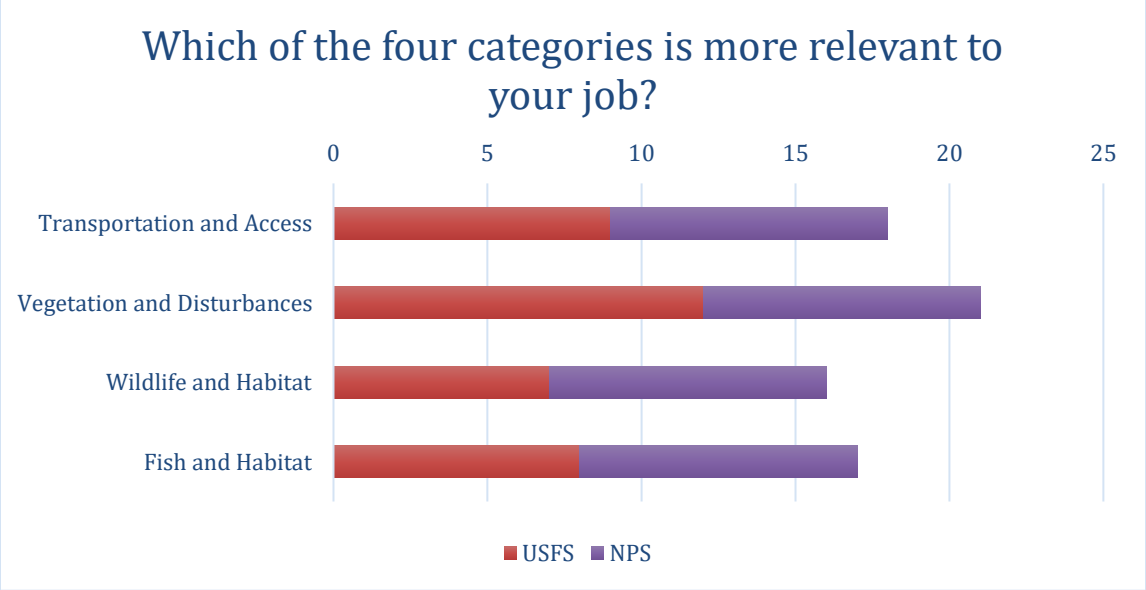


Figure 7: Relevance of the four NCAP categories to survey respondents

In the transportation and access category, the most commonly reported strategy was “Increase resilience of stream crossings, culverts and bridges to higher peak flows.” This strategy was common for both NPS and USFS, while other strategies varied between the two agencies (Figure 8). The strategies related to water flow, such as “Increase resilience to low dry-season flows with water conservation,” were not commonly reported.

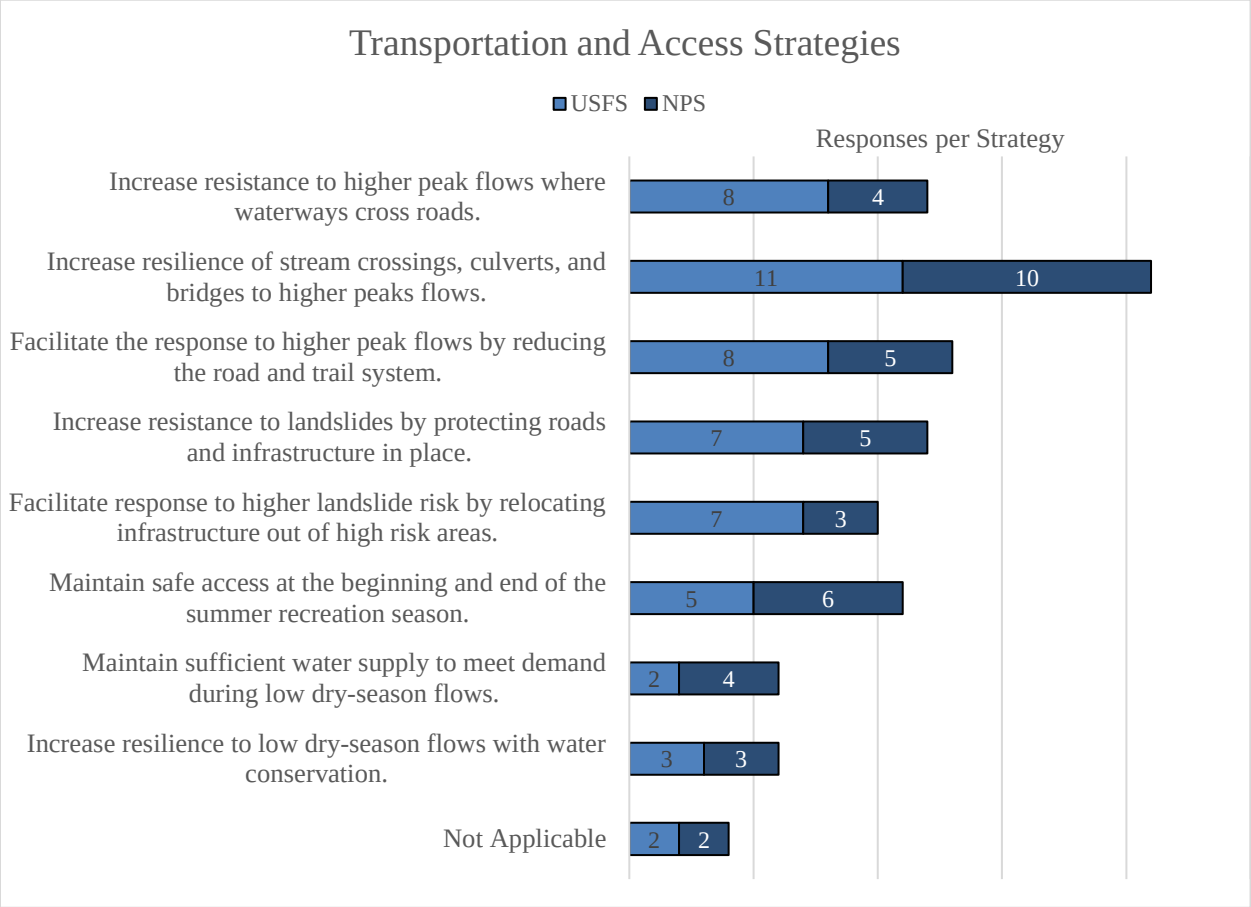


Figure 8: Responses for the implementation of strategies in the transportation and access category

The most commonly reported strategy in the vegetation and disturbances category was “Prevent widespread outbreaks of invasive species and invasive species establishment after disturbances.” Other commonly reported strategies differed between the NPS and USFS (Figure 9). The strategies in this category received more overall responses from USFS employees (n=62) than NPS (n=30). The least reported strategy was notably related to fire: “Increase ecosystem resilience through post-fire management.”

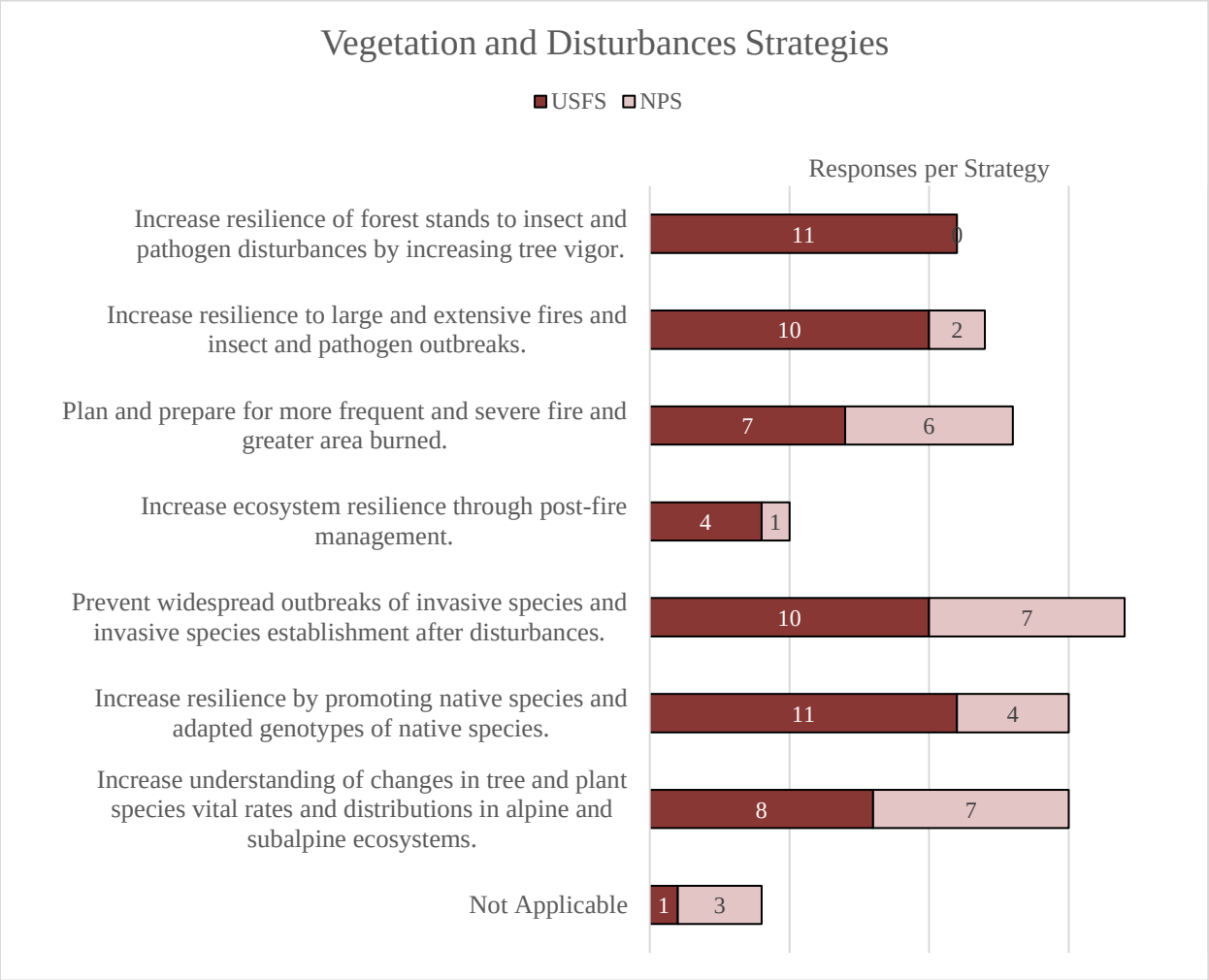


Figure 9: Responses for the implementation of strategies in the vegetation and disturbances category

In the wildlife and habitat category, the most commonly reported category for USFS employees was “Increase resilience of late-successional habitat in wet maritime forests.” For NPS employees, the most commonly reported strategy was “Maintain and protect montane habitat for American pika, hoary marmot and Cascade red fox.” The wildlife and habitat category received 66 responses overall, the least of the four categories (Figure 10).

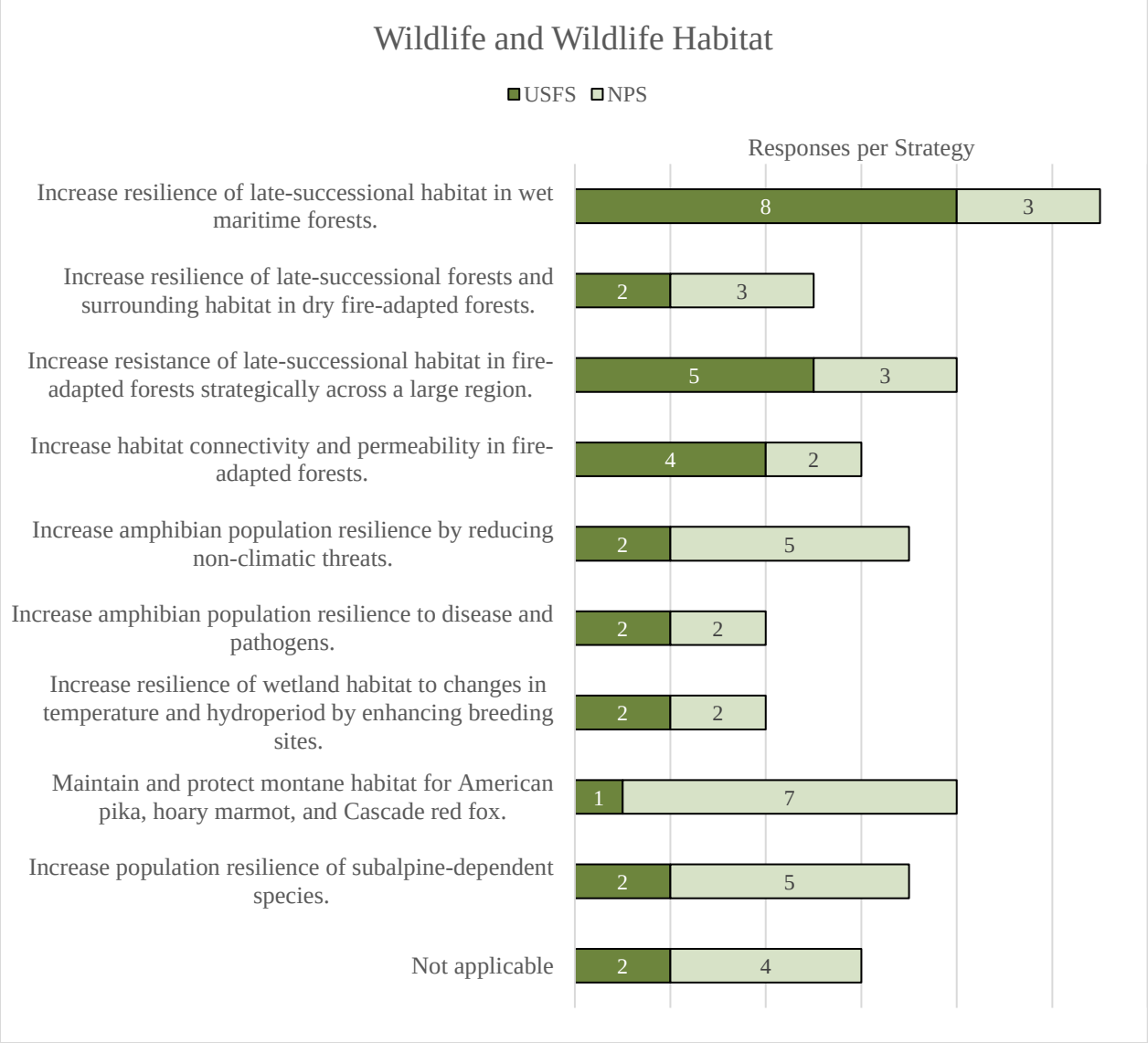


Figure 10: Responses for the implementation of strategies in the wildlife and wildlife habitat category

In the last category, fish and habitat, the most commonly reported strategy was “Increase habitat resilience to higher peak flows by reducing threats from roads and infrastructure in the floodplain.” USFS employees reported application of these strategies (n=53) more than NPS (n=34) (Figure 11). “Manage upland vegetation to retain water and snow, slowing spring snow melt and runoff,” was the least reported.

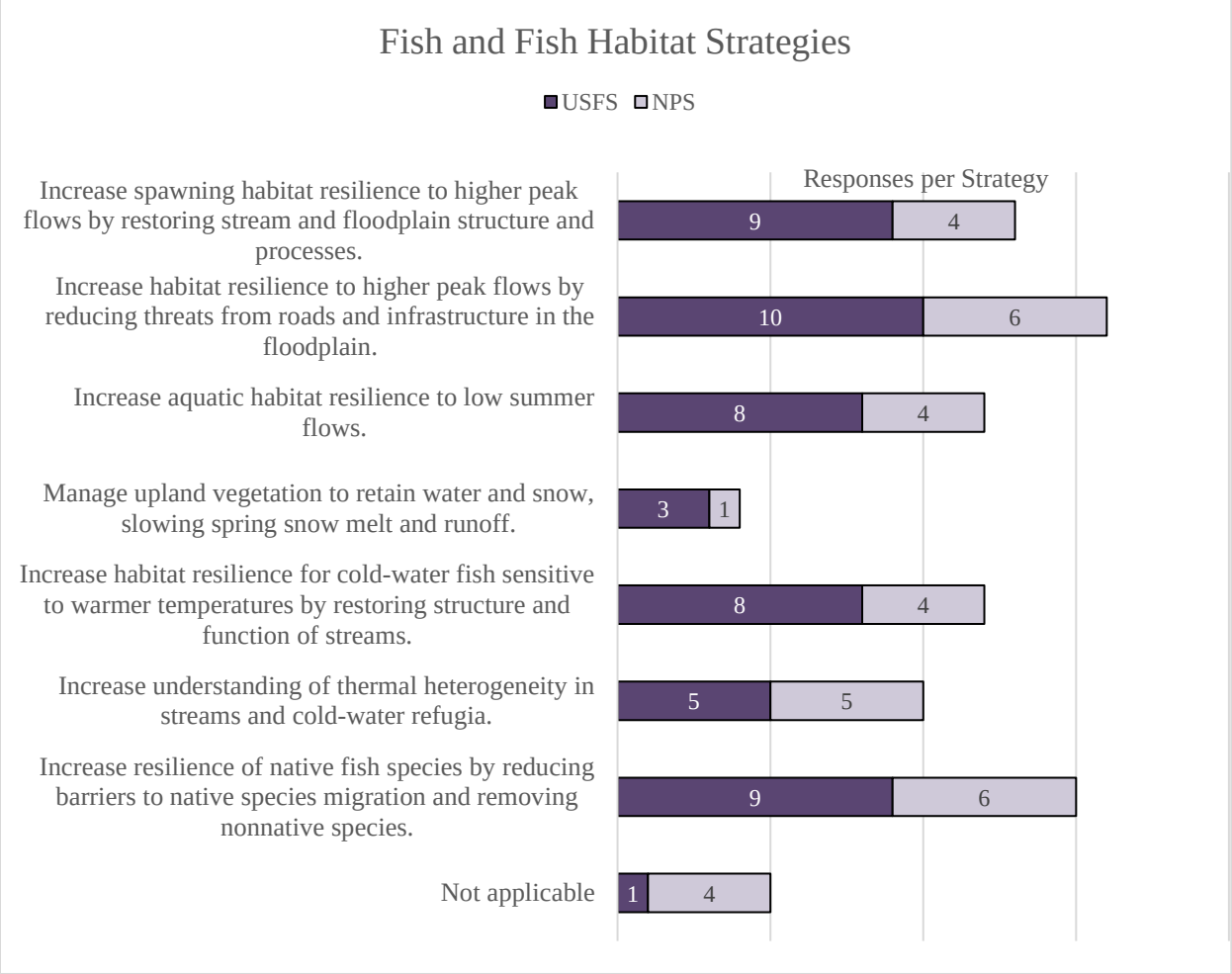


Figure 11: Responses for the implementation of strategies in the fish and fish habitat category

After the strategies were listed for each category, respondents were asked about issues or barriers they experienced during implementation. The barriers were selected from similar studies and research related to climate change adaptation (Figure 12). Across all four categories, budget constraints and insufficient staffing resources, which is influenced by budget, were the most

commonly reported. Conflicting mandates, policy or legal restrictions and stakeholder conflicts were also selected, whereas lack of specific agency direction was less common. If respondents selected "other," they were asked to explain. For the transportation and access category, one respondent reported "multi-external stakeholder perspectives and resulting non-agreement on strategies/tactics" and "constraints [that] impact us on both the planning and the implementation side of a project." In the vegetation and disturbances category, one respondent noted "these strategies affect recreation and are part of the planning process for recreation related projects, but are managed by other agency staff," so they were not familiar with implementation issues. There were no comments in the wildlife or fish categories related to other barriers.

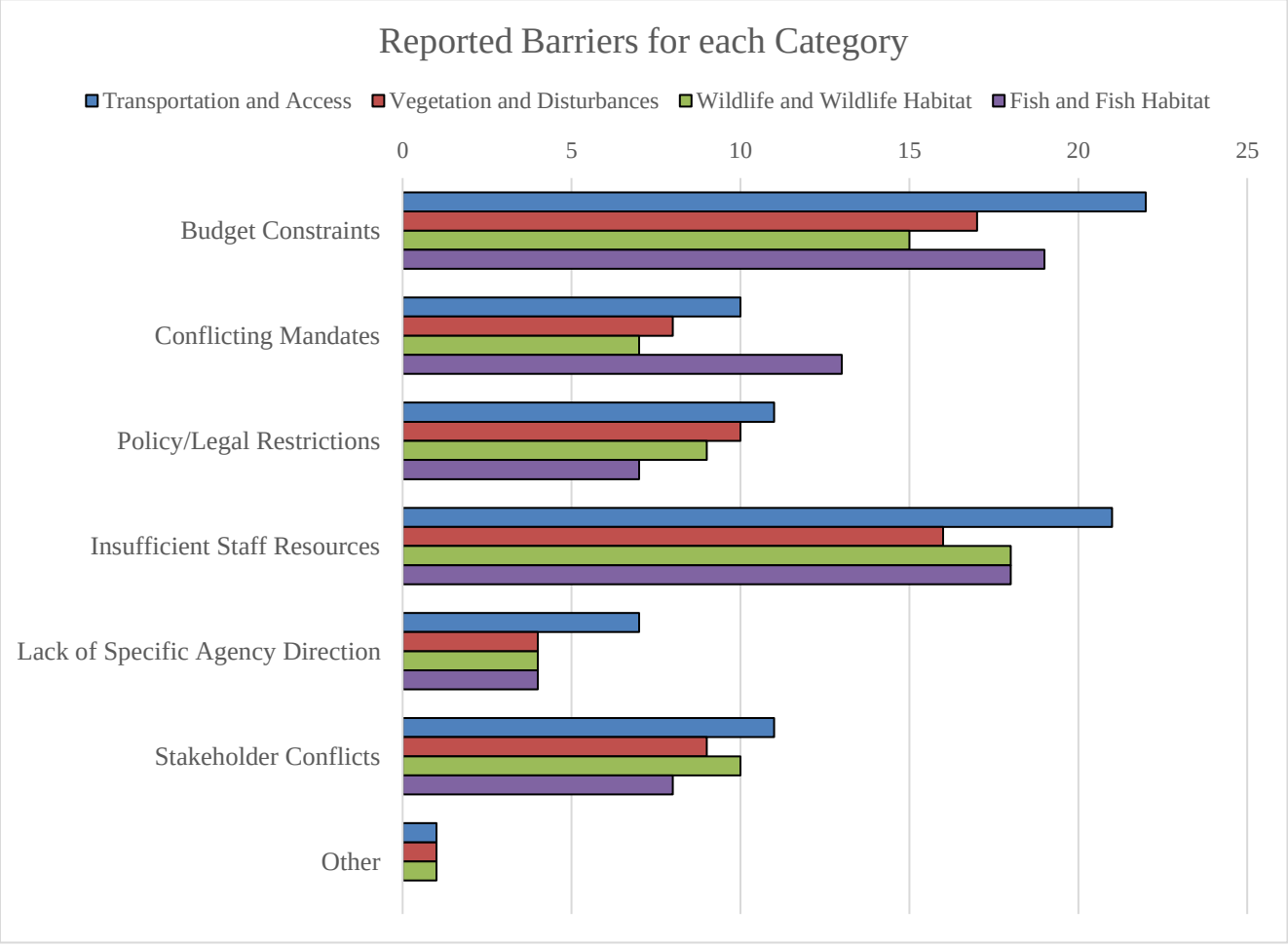


Figure 12: Implementation barriers across all four categories of NCAP

In each category, respondents were also asked about additional resources required for implementation. Table 1 shows questions related to resources and capacity to sustain over time. A majority of respondents believed that across all four categories, the strategies needed additional financial and staff resources to be sustained over time. The need for additional technological resources was more unknown.

Table 1: Distribution of responses related to capacity to sustain over time and resources

		Transportation and Access	Vegetation and Disturbances	Wildlife and Habitat	Fish and Habitat	Average
Do these strategies need additional financial resources such as budget increases or special funding to be sustained over time?	Yes	87%	83%	83%	90%	**86%**
	No	0%	4%	0%	5%	2%
	Unknown	13%	13%	17%	5%	12%
Do these strategies need additional staff resources such as additional hiring or training to be sustained over time?	Yes	91%	87%	100%	90%	**92%**
	No	4%	0%	0%	0%	1%
	Unknown	4%	13%	0%	10%	7%
Do these strategies need additional technological resources such as hardware, software, or tools to be sustained over time?	Yes	48%	61%	50%	57%	54%
	No	17%	9%	6%	10%	10%
	Unknown	35%	30%	44%	33%	**36%**

At the end of the survey, respondents were asked if they were using any strategies or tactics not mentioned in the survey. They mentioned monitoring as well as a "Whole Watershed Restoration Approach." Another respondent noted a focus on education. "We strive to educate park staff, partners, stakeholders and the general public about climate change," to motivate employees, and gain support from the public and stakeholders. The results from the survey were used to inform the interview questions, especially related to barriers and general climate change awareness. More nuanced responses can be found through the interview data, which the following section overviews.

Interviews

A total of nine people were interviewed for this study, four from the National Park Service and five from the U.S. Forest Service. The interviews were semi-structured and lasted approximately 45 minutes. The interviews are labeled according to which agency participants work for, either National Park Service (NPS) or U.S. Forest Service (USFS). The entire list of codes and definitions can be found in Appendix C.

Perceived Impacts

Participants were first asked if they saw climate change impacting their park or forest and how. The most commonly reported impacts were related changes in the wildfire regime. “We may have more fire that burns longer and I could see us not being prepared for that” (NPS 4). Participants also mentioned increased incidences of flooding, variation in snow and glacier patterns, impacts to forest health and changes in visitation (Table 2). Notably, some respondents did not report climate change impacts but rather anecdotal occurrences and in some interviews, the connection between visitation and climate change was disputed.

Table 2: Codes, definitions and narratives related to the theme of perceived impacts

Code	Definition	Narrative
Fire	Increase or change in wildfire activity	“You know what historically was low intensity, high frequency fire regime is now turned into more of a high frequency, high intensity fire regime” (USFS 4)
Flood	More frequent or severe floods or changes in water systems	“More storms, weather demonstrably creating larger runoff that in term is move having more mass that is moved through the hydrologic systems” (NPS 3)
Visitation	Changes to visitation patterns	“Climate change is part of this visitor surge that we're seeing […] that's just part of, to me, like the whole big picture” (NPS 1)
Snow/Glacier	Loss in glacier mass or shifts in snow patterns	“very like oscillating winters, summer. Just a bunch of snow and you know then other years we hardly get any” (USFS 3)
Forest Health	Decreased forest health due to pests or diseases	“Some insect outbreak is a little bit different, so probably most likely […] related to the change in our climate, that is […] it's starting to stress our trees a bit” (USFS 4)

Institutional Capacity

The next set of questions addressed institutional capacity by focusing on the subthemes of barriers, agency culture and level of collaboration.

Barriers

The most commonly reported barriers from the survey were budget and staffing constraints, so interview participants were asked if those issues impacted climate change adaptation and how. Budget constraints were mentioned frequently; "we are woefully underfunded for our budget and that has nothing to do with climate change" (USFS 1). Another commonly reported barrier related to mandates such as legal or policy restrictions that created challenges for climate change adaptation. Staffing levels and current administration priorities, such as increased access to recreation were also reported (Table 3). Although external barriers coming from the public or other agencies was not originally part of the coding scheme, it was mentioned by a few respondents in relation to road or trail access and wildfire. It was added as an emergent code.

Table 3: Codes, definitions and narratives related to the subtheme of barriers

Subtheme	Code	Definition	Narrative
Barriers	Budget Constraints	Restrictions due to budgets or funding	"Yeah, I think we are, budget wise, we're constrained. Resource wise, we're constrained" (USFS 5)
	Staffing Levels	Inadequate staffing levels or untrained staff	"We struggle just to keep up with our day-to-day annual workload, without even considering changes" (USFS 2)
	Mandates	Legal or policy restrictions	"We can push as hard as we want, but at some point the filter of policy and guidance and legal limitations will potentially dumb that down to the point where it's not even worth paying attention to it" (USFS 5)
	Administration Priorities	Priorities of the current administration	"But with the administration change, I mean, I just feel like none of that came down the pipe at all" (NPS 1)
	External	External barriers from other agencies or the public	"It's easy to run around and say, yeah, we need more fire on the landscape, but when it comes to actually implementing it, there's all these other factors that the public does not want to deal with" (NPS 2)

Agency Culture

The next questions addressed agency culture. Respondents reported general ways in which they applied climate change adaptation strategies and tactics, such as through NEPA documents. They also discussed the ease in which they could integrate strategies and tactics into management plans, with some noting that when "taking a holistic approach to land management […] climate change comes along for the ride" (USFS 1). The general awareness of climate change within the agency was discussed, along with issues due to staff turnover and public pressure influencing climate change adaptation (Table 4).

Table 4: Codes, definitions and narratives related to the subtheme of agency culture

Subtheme	Code	Definition	Narrative
Agency Culture	NEPA Application	Application of NCAP strategies and tactics in NEPA planning documents	"Our NEPA decisions, since the vulnerability assessment was published, align with the adaptation strategies" (USFS 1)
	Turnover	Employee turnover or staffing changes	"There's been a lot of turnover so I can see where that would have an impact" (USFS 2)
	Ability to be Integrated	The ease of which NCAP strategies and tactics can be integrated in current management plans	"The conversation was still I've got that report or that strategy. What do I do with it? How do I crosswalk that down into meaningful action" (USFS 5)
	Awareness	General awareness of climate change from staff knowledge or social influence	"Anyone who is involved in glacier monitoring or mountaineering can see that there's changes within, like, the human lifespan" (NPS 4)
	Public Pressure	External pressure from the public regarding climate change	"But in mechanism of a federal agency working for the greater good of the public, you end up with[...] having to meet your public's expectations" (USFS 5)

Level of Collaboration

The last aspect of institutional capacity for this study was level of collaboration. This notion was discussed in terms of collaboration between and within the units of the NCAP. Interviewees

reported various levels of collaboration, with some being uncertain how much communication was happening around climate change adaptation while others noted a lack. “There hasn’t been any additional follow up or discussion about it” (NPS 1). Some reported that conversations around climate change were open and transparent within their agencies, especially due to climate change coordinators at each USFS unit (Table 5). Others reported working with state agencies, such as Washington’s Department of Natural Resources and federal agencies such as the Federal Highway Administration.

Table 5: Codes, definitions and narratives related to the subtheme of level of collaboration

Subtheme	Code	Definition	Narrative
Level of Collaboration	Uncertainty	Uncertainty as to how much climate change is being discussed amongst staff	“I'm hopeful because I do see some references to climate change, so I'm assuming there's some communication going on, but I don't know if it's happening consistently” (USFS 4)
	Transparency	Open discussions about climate change	“There is a national thing […] first Friday all climate change talks” (USFS 2)
	Lack of Communication	Little or no discussions about climate change	“How that's going to affect climate change fire going forward? I wish we were having more of those kinds of discussions” (NPS 2)
	NGOS	Collaboration with non-governmental organizations	“You get folks on the TNC like The Nature Conservancy or there or Watershed Council folks and things like that” (USFS 1)
	State Agencies	Collaboration with Washington state agencies (Department of Natural Resources)	“We are pretty well entrenched with DNR in a lot of ways. The east side of the Cascades are a big driver for that. We've had ongoing collaborations with them” (USFS 5)
	Federal Agencies	Collaboration with other federal agencies	“We talk about this pretty frequently with the Federal Highway Administration because they are responsible for the road network in the park” (NPS 3)

Implementation Resources

The last set of questions asked about further resources needed for implementation. Such prompts were influenced by newer vulnerability assessments that include categories such as ecosystem

services and recreation. When asked about these categories, some respondents were in favor of having more specific strategies and tactics, while others thought the current categories were appropriate (Table 6). A few respondents reported the importance of partnerships with tribes when discussing climate change and suggested additional plans include consideration of tribal relations. When asked about additional resources to improve implementation of climate change adaptation, interviewees requested more funding and specific mandates, as well as more science or information, "so that we have a fact based, science-based understanding of what's going on in the ecosystem" (NPS 3).

Table 6: Codes, definitions and narratives related to the theme of implementation resources

Code	Definition	Narrative
More science or information	More research, science or general information would improve climate change adaptation	"You need to have more information to be able to fully, to know what the impacts are going to be, then you have to have the ability to more fully implement those strategies, once you know what they are" (USFS 2)
Funding	More funding or budget increases is required	"I would just say funding, I think that would help you know having more people out" (NPS 1)
Mandates	Direct and clear mandates requiring climate change adaptation	"And I think the most important thing is to have climate change be you know, addressed front and center in our forest plan revisions" (USFS 1)
Recreation	More strategies and tactics related to recreation	"Recreation, maybe breaking that out as a standalone is kind of an interesting thought" (NPS 3)
Ecosystem Services	More strategies and tactics related to ecosystem services	"We don't do a good job about speaking to ecosystem services" (USFS 4)
Tribal Relations	More strategies and tactics related to tribal relations	"They bring up almost every time […] climate change. So that's a really big deal to them also, as well as the other tribes" (USFS 2)

The results from the survey and interview provide insight into the application and value of the NCAP. The discussion analyzes the themes across both the interview and survey data, along with considerations from other research and relevant literature. It will highlight key observations and patterns that can improve future climate change adaptation efforts.

Chapter 5: Discussion

In consideration of the relevant literature and previous research, this section explores the interview and survey results in the larger context of climate change adaptation. It is organized according to the themes and subthemes used in this study to code interviews. This discussion begins by analyzing perceived climate change impacts with a deeper look into wildfire management. Next, it contextualizes institutional capacity through consideration of barriers, agency culture, and level of collaboration. It concludes by exploring implementation resources and overall reflections.

Perceived Impacts of Climate Change

An array of factors influences how land managers perceive climate change. I argue that institutional capacity influences the ability to observe impacts, as public land agencies are often focused on other aspects of their mission. Researchers have looked at this phenomenon, noting that the salience of climate change impacts influences the tendency of decision makers to implement adaptation strategies (Timberlake & Schultz, 2017). Therefore, it is crucial to understand what public land agencies are identifying as impacts to understand what tools will be useful for management decisions. Such research also helps to inform gaps between perceptions and actual impacts that might otherwise be overlooked or missed. Agencies need to acknowledge climate change impacts and they also need the capacity to implement adaptation options. This complex reality is exemplified by the relationship between park or forest visitation and climate change.

Units with significant increases in recreation or the number of people visiting might not notice how climate change is shifting normal visitation patterns. Some interview respondents were skeptical of any connection between the two. For example, one respondent noted that "the main driver of visitation is really the space around the academic calendar and precipitation […] so I can't say that's related to climate change" (NPS 4). This same respondent stated that they partially looked forward to roads washing out due to flooding, as it would give them a reprieve from visitation. Another NPS respondent said they were so busy responding to other emergencies such as motorcycle accidents or injuries that climate change was not something that had the capacity to deal with but acknowledged that it was an important concept.

Studies have demonstrated a connection between increasing temperatures and increases in total annual visits and expansion of the busy season (Fisichelli et al., 2015). This kind of information can be useful for land managers and is mentioned in the tactics under the transportation and access category: "Open trails, campgrounds, and facilities earlier in the season to accommodate higher visitation" and "Implement adaptive management—alter management as season length changes" (see Appendix A for all strategies and tactics, which are listed in the survey). However, if land managers do not perceive the relationship between visitation and climate change or feel they have the capacity to deal with it, it is unlikely to be addressed.

Although impacts such as visitation changes require somewhat more complicated solutions, other impacts, such as flooding, are more obvious and easier to address. This is demonstrated through which strategies land managers have selected to adapt to flooding impacts. The strategy with the most responses in the survey was reported 21 times and was related to flooding: "Increase

resilience of stream crossings, culverts and bridges to higher peak flows." Other commonly reported strategies were related to invasive species management and increasing habitat resilience for wildlife and fish through planting strategies and restoring floodplain habitat. Some climate change effects, whether or not staff perceive them as climate related, are easily resolved within preexisting management plans and are more likely to be addressed with climate change conscious adaptation strategies. The following section looks at wildfire, another commonly reported yet difficult to manage impact.

Wildfire as a Special Case

One climate change effect that presents a unique challenge is wildfire. Every respondent mentioned it as a perceived impact, but in the survey, results indicate that wildfire strategies were not implemented. Adaptation strategies in the vegetation and disturbances category such as "Increase resilience to large and extensive fire and insect and pathogen outbreaks" and "Plan and prepare for more frequent and severe fire and greater area burned" were reported 12 and 13 times, respectively. "Increase ecosystem resilience through post-fire management," was reported only five times. One would think these numbers would be much higher, considering how frequently wildfire was mentioned as an impact of concern. The lack of focus on wildfire strategies could be due to the fact that wildfire is currently much more common on the east side of the Cascades, and not seen as an outgrowth of climate change. In addition, such strategies are not commonly implemented on the west side due to a lack of historic wildfire activity. Other factors could be related to the risk associated with wildfire management. For example, some of the NCAP tactics recommend using prescribed burns and wildfire for resource benefits, along

with planting fire-tolerant species and assisted migration. These actions have much higher costs, so land managers are hesitant to implement them.

Unlike many other climate change adaptation strategies, wildfire management has consequences that extend beyond the boundaries of the forest or park. The wildfires that spread to nearby communities tend to occur in the wildland urban interfaces (WUIs). WUIs are areas where homes exist in close proximity to wildland vegetation and are therefore exposed to higher wildfire risks (Paveglio et al., 2015). Risks to personal property and safety are increasing due to expanding residential development into these fire prone areas, largely due to amenity migration or where people move to a place due to scenic or recreational value (Paveglio et al., 2015). Ager et al. (2016) have analyzed national forests in Washington and Oregon and found that 79% of forest lands are at high risk of spreading wildfire to nearby communities, with Okanogan-Wenatchee National Forest noted as a hotspot. As shown in Figure 13, most of the large fires that have occurred in the past decade have occurred on the east side of Washington state. Many have overlapped with NCAP land.

Further, Ager et al. (2016) recommend reducing wildfire risk through fuel management techniques, but fires that originate in wilderness and roadless areas are challenging to suppress. Trying to account for climate change and the benefits wildfire can have on ecosystems, while also preventing spread to nearby communities presents a challenge for land managers. This situation is further complicated by public opinion and fears related to wildfire management. For example, many forest supervisors feel pressure from locals to suppress wildland fires rather than let them burn, despite potential benefits to ecosystem resilience. As a result, many land managers

prefer to monitor for trends rather than plan actions for expected climate change impacts to wildfire regimes (Timberlake & Schultz, 2017).

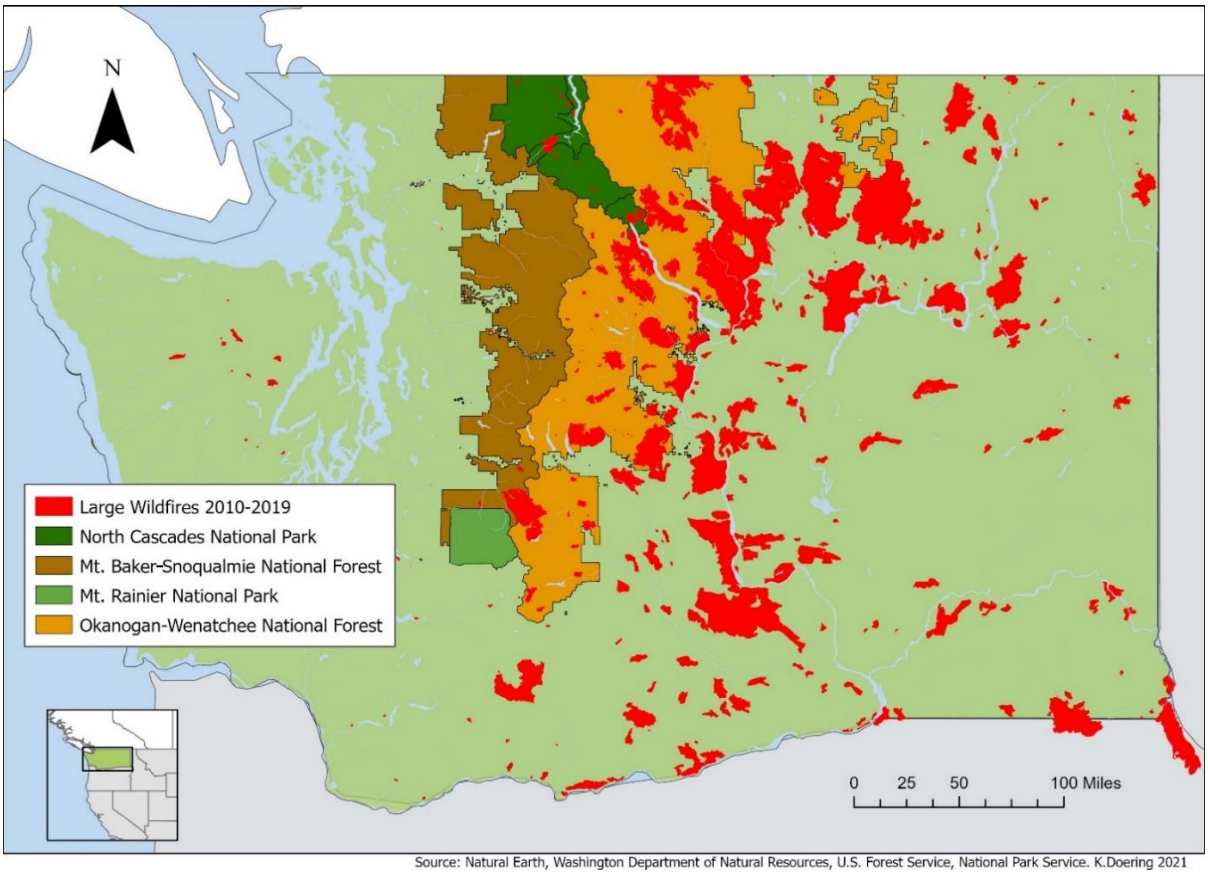


Figure 11: Large wildfires in Washington state 2010-2019

It is problematic to let fires burn when the public perceives it as a threat. One interview participant noted that there was a lot of liability in the way they managed fire, by letting it burn in wilderness areas. “It’s easy to run around and say, yeah, we need more fire on the landscape, but when it comes to actually implementing it, there’s all these other factors that the public does not want to deal with” (NPS 2). Some of those factors include the impacts to air quality and state smoke requirements: “The state tells us when we can and can’t burn and we’ll have everything lined up and they’ll be like oh no, it’s going to impact air quality and it’s pretty frustrating,” (USFS 3). NCAP tactics suggest ways to use prescribed fire, such as “Anticipate more

opportunities to use wildfire for resource benefits," and "Consider using prescribed fire to facilitate transitions to new fire regimes in mixed severity fire regimes." However, external obstacles can make implementation of these tactics difficult.

Institutional Capacity: Barriers

Several barriers impede climate change adaptation planning including pressure from the public, administration priorities, federal or state mandates and policies, as well as reductions in staffing and budgets. Pressure from the public can inhibit aspects of climate change adaptation planning related to wildfire and for other factors as well. An NCAP strategy in the transportation and access category suggests closing roads and trails that are likely to be washed out by flooding, but such actions can have negative repercussions. As one respondent noted, closing roads and trails "[is] leading to this growing public perception that somehow people are being denied access" (NPS 3). The priorities of the Department of the Interior under the Trump administration emphasized access and increased range of recreational opportunities, so closing trails and roads run counter to those priorities, even if they are smart management strategies (DOI, 2018).

The reality of working for the federal government is that agencies are beholden to the priorities of the current administration and political atmosphere. If an administration's focus is on access to recreation or use of natural resources, climate change impacts become less of a priority. Beyond weathering the inconsistencies of different administrations, federal agencies are also required to follow mandates, laws, and policies that can inhibit climate change adaptation. Some interviewees note that the burden of compliance can make any process slow going and that management plans are often outdated. Several USFS employees mentioned that many of their

plans, such as the Northwest Forest Plan, which was implemented in the 1990s, are "Legally binding documents, […] 20 or 25 years old for us" (USFS 5).

Although some respondents mentioned the National Environmental Policy Act (NEPA) as a way to integrate climate change adaptation strategies into management plans, others lamented the time and energy required to go through the NEPA process. Research related to barriers in climate change adaptation have noted similar trends in how NEPA appeal and litigation procedures can cost agencies considerable time and expense (Jantarasami, et al. 2010). However, the procedural nature of NEPA establishes a process for analyzing different management alternatives and can therefore be conducive to climate change adaptation planning. These findings are reinforced by interview responses. For example, one interviewee noted that "our NEPA decisions since the vulnerability assessment was published align with adaptation strategies" (USFS 1).

Another challenging reality of federal agencies is budget and staffing constraints. Researchers have explored this hurdle in studies similar to this, recognizing it as a problem with adaptation planning across multiple agencies (Archie et. al, 2012). These barriers were the most commonly reported in the survey for all four adaptation categories. Budget and staffing issues came up frequently in the interviews as well, although not always specifically related to climate change. Many noted that budget and staffing were interrelated and mentioned the challenge of having only enough money to hire people seasonally. Respondents also mentioned that often times money is not spent strategically. For instance, one respondent noted, "I think our resource protection and visitor access goals would be met much better by being proactive than reactive" (NPS 4).

This notion of spending money to fix problems rather than prevent them was expressed often among USFS and NPS interviewees. Several respondents noted how much money went towards fighting wildfire, yet money for fuel reduction projects, prescribed burns or other efforts to reduce wildfire risk was limited: "the direct cost of wildfire suppression are, I think, in the two to five billion range […] yet we have a hard time stringing together 300 acres of mechanical [fuel] treatment" (USFS 5). The media has highlighted this imbalance as well, noting that the USFS is dedicating over 50% of its budget to firefighting, leaving little left for preventive measures (Flesher, 2020). This same phenomenon applies to the cost to repair or rebuild roads. "The cost of any long-term solution to the way our roads are built and currently threatened is so enormous that I think there's almost like management paralysis" (NPS 4). Many respondents fully recognized the importance and need for climate change adaptation efforts but found budget restrictions to be a major challenge.

Institutional Capacity: Agency Culture

Another challenge related to staffing and agency culture was turnover. Key positions such as climate change coordinator for certain USFS units were left vacant long after employees left the position. Staff turnover contributed to a loss of knowledge. Many of the staff who were present for the original NCAP workshops were very familiar with the climate change adaptation strategies and tactics, but newer staff were not. As one respondent noted, "people who are around when it was created were aware of it, but it seems like newer folks, yeah, aren't aware of it" (NPS 3). The workshops were held a decade ago in 2011 and just 8 survey respondents said they had attended. Turnover might also explain why only 30% of survey respondents were extremely or very familiar with the NCAP vulnerability assessment (see Figure 4). However, a majority of

respondents reported that they considered climate change in project planning and work meetings (see Figure 5). This is likely due to general social awareness of climate change, and some emphasis on the topic within agency planning documents.

Although many interview respondents acknowledge that the impacts of climate change were hard to ignore, the social influence varied. Some even admitted that the phrase climate change is "taboo still within the agency because of the social disagreement" (USFS 5). Archie et al. (2012) observed the same hurdle when working with USFS respondents, noting that the lack of social acceptability and lack of perceived importance of climate change to the public impacted implementation efforts. To reduce controversies, both the NPS and USFS have come up with different ways to phrase climate change. A USFS respondent noted, "we're not managing for climate change […] our objective is ecosystem resilience" (USFS 5). Similarly, a NPS respondent stated, "we use the phrase emerging change and perhaps with a different administration, one that is more focused on climate change, we will start talking about it differently," (NPS 4).

At the same time, many interviewees noted that public demands were starting to shift, with the public starting to ask, "what are you doing about climate change?" (USFS 1). This conflict reflects the larger disagreement and politicization around climate change, "there's also varying level of support in our organization, [there are] still people that aren't necessarily climate change believers or supporters" (USFS 4). Despite the risks related to public perception or polarization, many respondents recognized that "to keep up with their professional skills and knowledge, it's

hard to avoid climate change" (USFS 2). A paradigm shift in climate change adaption might only be possible once social perceptions start to shift too.

Although agency culture was somewhat mixed with general reception towards climate change, another important consideration was the ease in which climate change adaptation efforts could be integrated into management plans. This topic came up frequently in the interviews. As one respondent explained, "I've got that report or strategy. What do I do with it? How do I crosswalk that down into meaningful action?" (USFS 5). Many recognize that smart management strategies also happen to be efficient ways to deal with climate change, whether that is developing resilience, doing vegetation restoration projects, or working on ecosystem sustainability. Other researchers have noted that managers have yet to fully integrate climate change adaptation because it seems like an additional, rather than essential, part of their job (Jantarasami et al., 2010). One respondent recommended that the agencies host more "workshops or put out a resource on integrating the partnership recommendations into the Park Foundation document and the equivalent in the Forest Service" (NPS 4). The ability to integrate into current management structures is also influenced by the level of collaboration within and among units of the NCAP.

Institutional Capacity: Level of Collaboration

One of the main objectives of the NCAP was to create a forum to discuss climate change and develop strategies that could be implemented across different agencies. This was dependent on collaboration between the USFS and NPS, and other federal and state agencies. Interview respondents said they were working with Washington state's Department of Natural Resources (DNR), especially when it came to managing for wildfire. Others reported working with the

Federal Highway Administration on road networks in their respective parks or forests and partnering with NGOs such as The Nature Conservancy. When it came to collaboration between USFS and NPS units, there seemed to be less communication. Several people cited divergent agency missions. “These are two different agencies in different departments with very different missions” (USFS 1). Other researchers have also observed this discrepancy, noting that the USFS is multiple-use focused whereas the NPS has one main mission (Archie et al., 2012). This presents a challenge for implementing adaptation options across unit boundaries. Further revisions of NCAP would be strengthened if they included strategies and tactics more catered to the mission of each agency.

Even within each unit, the level of collaboration was variable. USFS respondents mentioned the presence of climate change coordinators on each forest and monthly “all-forest climate talks,” where units across the country joined to discuss climate change related topics. NPS respondents did not mention a similar program. Many were uncertain about how often conversations related to climate change have been happening within their units. “I’m hopeful because I do see some references to climate change, so I’m assuming there’s some communication going on, but I don’t know if it’s happening consistently” (USFS 4). Many assumed that such conversations were happening at the upper management level but did not feel like that information was being passed down. Other respondents reported a lack of communication or a decline since NCAP first came out. “There’s been participation at least back then. I guess the question is now [how] you get it back on the radio” (NPS 1). Several USFS respondents noted, however, that climate change “is becoming a bigger conversation, so it is starting to grow,” (USFS 5). Many were working to actively draw in climate change to the bigger conversations.

The effects of barriers, agency culture and level of collaboration all reflect the larger influence of institutional capacity. The information provided in the NCAP strategies and tactics are helpful, but actual implementation requires separate considerations. As noted by Timberlake & Schultz (2017):

> Efforts to address climate change must occur within the structure of existing governance arrangements, working with decades old policies, navigating potentially antagonistic relationships with stakeholder groups and political pressures, and grappling with the constant challenges of limited resources for strategic planning efforts. (p. 265)

Research findings from this study support this sentiment. In order to assist land managers in successfully applying climate change adaptation efforts, institutional capacity must be considered and addressed. The following section explores implementation resources discussed by interview respondents, providing insight into what employees believe they need to make the process easier.

Implementation Resources

Although the original NCAP vulnerability assessment offered strategies and tactics in four categories, newer assessments offer a wider range of adaptation options. The Adaptation Partners group, supported by the USFS Pacific Northwest Research Station, now offers an online library of strategies and tactics in several resource areas such as ecosystem services, recreation, cultural, soils and water resources (Adaptation Partners, 2019). When asked about adding new categories to NCAP such as ecosystem services and recreation, most respondents expressed interest, especially those whose job involved working with visitors. A few USFS respondents suggested

having a category related to tribal relations, noting that "what [the tribes] bring up almost every time is climate change, so that's a really big deal to them" (USFS 2). Others mentioned a need for more funding related to climate change adaptation and clearer mandates, "the most important thing is to have climate change be […] addressed front and center in our forest plan revisions" (USFS 1). Still, this is also likely to fluctuate depending on administration goals and priorities.

Beyond general desires for clearer mandates and more funding, all interview respondents expressed a need for more information. Some sought it in the form of more science and research, such as "increasing our staff knowledge and understanding that will […] help us be formulating better recommendations and then make better decisions," (NPS 3) and "tools to actually demonstrate what those climate change impacts mean or should mean in terms of us doing something different" (USFS 5). Others wanted more information to share and disseminate with the public, to increase education and inform people of what was happening in the ecosystem they were visiting. This need has been explored in similar studies, noting that land managers need help characterizing the uncertainty associated with climate change while also communicating salient issues with the public (Timberlake & Schultz, 2017). It seems logical that land managers would want more information before implementing strategies, yet they must also accept a degree of risk and uncertainty when it comes to climate change adaptation. However, as mentioned earlier, external pressure and administration priorities can severely limit direct action.

In general, survey and interview respondents were aware and interested in doing something about climate change, but the process was complicated by a variety of factors. First, their perceptions of how climate change was impacting their unit directly influenced what kind of

action they thought was necessary. Even if they did perceive impacts that were worth addressing, barriers such as budget restrictions, staffing shortages, mandates and external forces limited their ability to act. Agency culture and the level of collaboration between and within agencies also created hurdles in the implementation process. In recognition of these restrictions, respondents requested more resources to facilitate adaptation efforts. They desired more science and information to be able to make decisions and properly inform the public, and as well as more strategies and tactics in different categories. These insights are useful to inform policy recommendations and suggest further research in the field of climate change adaptation planning on federal lands. Such recommendations are explored in the conclusion.

Chapter 6: Conclusion

The North Cascadia Adaptation Partnership aims to bring land managers together across multiple agencies to address the impacts of climate change. It provides key strategies and tactics in four resource categories based on a vulnerability assessment of the North Cascadia ecosystem. Researchers have explored the possible effects of climate change on public lands and identified them as critical and requiring action. However, many factors influence the ability of land managers to implement climate change adaptations. This study has reviewed relevant literature related to climate change adaptation on public lands and examined the NCAP as a case study. Through utilizing a combination of surveys and interviews with employees of the USFS and NPS, this study offers insight into climate change implementation efforts. The results of this study have identified key factors impacting adaptation, including institutional capacity, barriers, level of collaboration and agency culture.

With the results of this study in mind, this section outlines recommendations to enhance implementation efforts for land managers. It also proposes ways to build upon existing knowledge related to climate change adaptation planning to improve outcomes. These suggestions are useful for those creating vulnerability assessments, strategies, and tactics to be used by land agencies, such as researchers in the USFS Adaptation Partners group. In addition, these recommendations will be helpful for those tasked with translating strategies and tactics into on-the-ground action. Effective climate change planning benefits from evaluation of all steps of the process, starting with the creation of adaption strategies to their integration into management plans and eventual application.

Recommendations

Some aspects of institutional capacity that impact climate change adaptation are not easily remedied. For example, budget increases require funding allocations at a federal level, and administration priorities can be difficult to change. However, based on this study I have a number of recommendations that could be helpful in supporting agency climate change adaptation and implementation efforts (see Table 7). Some of these proposals are at the national level, and others are specifically suggested at the regional level.

Table 7: Recommendations for climate change adaptation planning and implementation

National
Target funding and directives to address climate change impacts on federal lands
Continue monitoring the effects of climate change
Expand adaptation partnerships throughout the country
Taylor strategies and tactics to agency mission (NPS, USFS, etc)
Place climate change coordinators in National Park Service units
Regional
Conduct follow-up workshops for the NCAP every 10 years
Revisit adaptation partnerships every 5 years
Add resource categories related to recreation and tribal relations
Initiate regular communication channels for NCAP units to discuss challenges and successes
Host quarterly climate change coordinator meetings to discuss the status of implementation

If general sentiment from the public agrees that climate change adaptation is urgent, policy makers at the national level might impose new mandates for land managers. Some of the Obama era directives requiring climate change adaptation on federal lands could be reinstated and

accompanied by special funding, making implementation easier. Continued research into the effects of climate change on public lands is also crucial. This is still being conducted by researchers in the USFS and other agencies as they continue to create vulnerability assessments. If possible, new adaptation partnerships should also have separate considerations for each agency. The distinct missions of the NPS and USFS were discussed often in the interviews, so strategies and tactics that catered more specifically to each agency would be more effective. For example, solutions focused on recreation are more applicable for units that deal with high visitation, which is often the NPS. More agency specific strategies would allow easier integration into management plans. In addition, having climate change coordinators or some equivalent at every NPS unit would create consistency across the agencies. Encouraging these coordinators to meet on a regular basis would allow them to monitor the status of implementation and keep employees informed.

At the regional level, for adaptation partnerships that are older than five years, I recommend that revisions include newer resource categories. Land managers in the North Cascadia region were specifically interested in more strategies and tactics related to recreation and tribal relations. Another recommendation for older adaptation partnerships is a follow-up round of workshops. As demonstrated by this study, staff turnover and lack of awareness leaves many employees unfamiliar with NCAP. An additional series of workshops would reinvigorate the conversation around climate change adaptation, give researchers a chance to present new strategies and tactics, and educate employees about new research. Follow-up workshops a decade after the original NCAP vulnerability assessment would also allow employees to share ways in which they have successfully implemented strategies.

The workshops held in 2011 were a new experience for many employees, but now that some have had a chance to use the adaptation options, they will likely have insights and best practices to share. According to the surveys and interviews, some USFS units found success by integrating NCAP strategies into their NEPA documents. This technique, along with any other lessons learned, could be shared among participants, especially those who were unsure of how to best incorporate adaptation strategies. The workshop would also give employees a chance to talk about ways to overcome challenges such as external pressure, lack of communication, staff turnover, and budget constraints. Such workshops could occur regularly in 10-year intervals to hold agencies accountable for the work they have accomplished. Lastly, it would reinforce bonds between units to make communication possible and collaboration easier, which has been a challenge thus far for the partnership. Lemieux et al. (2013) encouraged a similar method of evaluation and self-reflection called the importance-performance analysis (IPA), to enhance adaptive capacity to climate change.

Although this research has uncovered useful insights for land managers attempting to address climate change in the North Cascades region, further research is required. Concepts such as institutional capacity are universal, however, climate change adaptation efforts will undoubtedly differ from region to region. Similar studies should be replicated on different adaptation partnerships to gain a broader understanding of implementation. In addition, studies could be expanded to include a wider range of USFS and NPS employees in each unit, rather than specific resource specialists or climate change coordinators. A larger audience would provide broader insights into climate change adaptation at various levels, not just in the upper management tier. More recent adaptation partnerships have expanded to other agencies such as the BLM and

USFWS, so it would be useful to gather data from those units as well. Archie et al. (2012) surveyed land managers across several agencies to gain insight into adaption efforts. Climate change adaptation is a long term and iterative process, so any research evaluating its implementation must be similar.

As mentioned earlier, while administration priorities can act as a barrier to climate change adaptation, this could change under a new president. The Biden administration has made climate change one of its central tenets by creating a climate team and issuing climate-related executive orders (South, Vangala & Hung, 2021). They have also made it their goal to embed climate change considerations into government operations. The current Secretary of the Interior, Debra Haaland, has also pledged to follow the "30-by-30" rule, preserving 30 percent of U.S. land and water from development by 2030, which would certainly benefit NPS and USFS managed land (South et al., 2021). A bill has recently been introduced to create the Civilian Climate Corps, which would employ potentially millions of Americans to address climate change effects in their communities and public lands (Yoder, 2021). These new initiatives, policies and mandates will likely alter the conversation around climate change, and hopefully cut through some of the social disagreement to achieve solutions. This study has aimed to understand the progress and highlight some of the challenges in the climate change adaptation process on federal lands in the North Cascades. It is important to identify the challenges land managers face when trying to adapt to climate change, but this recognition must be coupled with hope and a vision toward the future.

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Appendix A: Survey

Where do you work?

- Mt. Baker-Snoqualmie National Forest
- North Cascades National Park
- Okanogan-Wenatchee National Forest
- Mt. Rainier National Park

How would you describe your position?

- Permanent
- Term Limited
- Seasonal/Temporary

How long have you worked at this unit?

- Less than 1 year
- 1-5 years
- 5-10 years
- 10 + years

Display This Question if Where do you work? = North Cascades National Park or Mt. Rainier National Park

What division do you work for?

- Administration/Planning
- Natural Resources
- Cultural Resources
- Interpretation/Education
- Maintenance
- Visitor and Resource Protection
- Other

Display This Question if Where do you work? = Mt. Baker-Snoqualmie National Forest or Okanogan-Wenatchee National Forest

What division do you work for?

- Forest Leadership
- Natural Resources
- Cultural Resources
- Maintenance

- ☐ Recreation/Visitor Services
- ☐ Engineering
- ☐ Administration/Planning
- ☐ Other

How familiar are you with the climate change vulnerability assessment named the North Cascadia Adaptation Partnership?

- ○ Extremely familiar
- ○ Very familiar
- ○ Moderately familiar
- ○ Slightly familiar
- ○ Never heard of it

Did you attend any of the North Cascadia Adaptation Partnership workshops in 2011?

- ○ Yes
- ○ No

How often is climate change considered in project planning and work meetings?

- ○ Always
- ○ Most of the time
- ○ About half the time
- ○ Sometimes
- ○ Never

The following sections contain adaptation strategies and tactics from the vulnerability assessment for the North Cascadia Adaptation Partnership. Adaptation strategies were developed to address key vulnerabilities in four categories:

Transportation and access is related to roads, trails, campgrounds and other infrastructure.
Vegetation and disturbances is related to plants, forest management and wildfires.
Wildlife and habitat is related to wildlife, habitats, and regulations.
Fish and habitat is related to fish, aquatic habitats, and watersheds.

Visit this site for more information: http://adaptationpartners.org/ncap/. All the tables are retrieved from Raymond, Peterson, & Rochefort, 2013.

Which of the four categories is most relevant to your job? You may select more than one.

- ☐ Transportation and Access
- ☐ Vegetation and Disturbances
- ☐ Wildlife and Habitat
- ☐ Fish and Habitat

Transportation and access is related to roads, trails, campgrounds and other infrastructure. All the strategies are listed below, please select strategies you have used for planning or other projects. You can use the tables below for reference.

- ☐ Increase resistance to higher peak flows where waterways cross roads.
- ☐ Increase resilience of stream crossings, culverts, and bridges to higher peaks flows.
- ☐ Facilitate the response to higher peak flows by reducing the road and trail system.
- ☐ Increase resistance to landslides by protecting roads and infrastructure in place.
- ☐ Facilitate response to higher landslide risk by relocating infrastructure out of high risk areas.
- ☐ Maintain safe access at the beginning and end of the summer recreation season.
- ☐ Maintain sufficient water supply to meet demand during low dry-season flows.
- ☐ Increase resilience to low dry-season flows with water conservation.
- ☐ Not Applicable

Table 1. Adaptation strategies and tactics for transportation and access in the North Cascades.

Adaptation strategy	Adaptation tactics
Increase *resistance* to higher peak flows where waterways cross roads.	• Install hardened stream crossings. • Continue to use grade control structures, humps, and water bars to reduce velocity and redirect flow. • Use rip-rap or vegetation to stabilize banks near resources or infrastructure. • Consider using more engineered log jams to redirect flows. • Request additional funding to prepare for more trail and bridge failures.
Increase *resilience* of stream crossings, culverts, and bridges to higher peaks flows.	• Complete unit wide inventory of culverts and bridges. • Continue to replace culverts with higher capacity culverts. • Raise trail bridges higher above waterways. • Consider designing culverts for projected, rather than historical, peak flows. • Prioritize structure replacement in high risk (mid-elevation) basins. • Continue to upgrade trail bridges with stronger rot resistant materials. • Consider increasing the height of bridges above waterways.
Facilitate the *response* to higher peak flows by reducing the road and trail system.	• Reroute roads and trails and move infrastructure out of floodplains. • Continue to decommission roads and trails with high risk and low access. • Convert use of at risk roads to other uses (e.g., from vehicle to bicycle or foot). • Continue to relocate trail bridges to locations with stronger parent material. • Continue to reroute trails to locations that eliminate the need for bridges. • Change user expectations of access with public outreach and education.
Increase *resistance* to landslides by protecting roads and infrastructure in place.	• Increase road and trail maintenance frequency. • Stabilize slopes mechanically or with vegetation. • Improve drainage. • Alter road surface type and grade. • Elevate roads to allow landslides to pass underneath.

Facilitate *response* to higher landslide risk by relocating infrastructure out of high risk areas.	• Decommission roads and trails with low access and high landslide risk. • Locate new construction away from areas of high landslide risk. • Collaborate with partners to compare maps of current landslide damage with maps of soil moisture and landforms to identify sensitive areas.
Maintain safe access at the beginning and end of the summer recreation season.	• Increase public education on the risks of early and late season access. • Limit access when public safety is a concern. • Open trails, campgrounds, and facilities earlier in the season to accommodate higher visitation. • Implement adaptive management—alter management as season length changes.
Maintain sufficient water supply to meet demand during low dry-season flows. Increase *resilience* to low dry-season flows with water conservation.	• Investigate alternative water sources (e.g., groundwater). • Consider constructing new wells, cisterns, and reservoirs. • Increase water storage with artificial storage infrastructure. • Import water from outside of the region. • Educate the public about water shortages and conservation and reduce user expectations of water availability. • Reduce water provided in campgrounds and other facilities. • Reduce campground capacity and close facilities to decrease water demand.

If none of the strategies are applicable, you may skip to the next category.

- Skip
- Continue

Skip To: End of Block If If none of the strategies are applicable, you may skip to the next category. = Skip

Which of the following issues impact your ability to implement strategies and tactics related to transportation and access? Select all that apply.

- ☐ Budget Constraints
- ☐ Conflicting Mandates
- ☐ Policy/Legal Restrictions
- ☐ Insufficient Staff Resources
- ☐ Lack of Specific Agency Direction
- ☐ Stakeholder Conflicts
- ☐ Other

If you selected other, please explain here.

_____

Do these strategies need additional financial resources such as budget increases or special funding to be sustained over time?

- Yes
- No
- Unknown

Do these strategies need additional staff resources such as additional hiring or training to be sustained over time?

- Yes
- No
- Unknown

Do these strategies need additional technological resources such as hardware, software or tools to be sustained over time?

- Yes
- No
- Unknown

Vegetation and disturbances is related to plants, forest management and wildfires. All the strategies are listed below, please select strategies you have used for planning or other projects.
You can use the tables below for reference.

- ☐ Increase resilience of forest stands to insect and pathogen disturbances by increasing tree vigor.
- ☐ Increase resilience to large and extensive fires and insect and pathogen outbreaks.
- ☐ Plan and prepare for more frequent and severe fire and greater area burned.
- ☐ Increase ecosystem resilience through post-fire management.
- ☐ Prevent widespread outbreaks of invasive species and invasive species establishment after disturbances.
- ☐ Increase resilience by promoting native species and adapted genotypes of native species.
- ☐ Increase understanding of changes in tree and plant species vital rates and distributions in alpine and subalpine ecosystems.
- ☐ Not Applicable

Table 2. Adaptation strategies and tactics for vegetation and disturbances in the North Cascades.

Adaptation strategy	Adaptation tactics
Increase resilience of forest stands to insect and pathogen disturbances by increasing tree vigor.	• Accelerate development of late-successional forest conditions by reducing density and diversifying forest structure by thinning. • Harvest to variable densities. • Reduce density of post-disturbance artificial regeneration. • Plant resistant species or genotypes where species-specific insects or pathogens are a concern (e.g., white pine blister rust). • Increase stand-scale biodiversity and minimize monocultures.
Increase resilience to large and extensive fires and insect and pathogen outbreaks.	• Design forest gaps that create establishment opportunities. • Increase diversity of patch sizes. • Consider planting desired species (assisted migration) rather than relying on natural regeneration and migration.
Plan and prepare for more frequent and severe fire and greater area burned.	• Consider climate change in fire management plans. • Anticipate more opportunities to use wildfire for resource benefits. • Plan post-fire responses for large fires in systems not adapted to fire. • Consider using prescribed fire to facilitate transitions to new fire regimes in mixed severity fire regimes. • Consider planting fire-tolerant species after fire in areas with increasing fire frequency. • Manage for future range of variability in structure and species.
Increase ecosystem resilience through post-fire management.	• Consider climate change in post-fire rehabilitation. • Anticipate greater need for seed sources and propagated plants. • Plant native grasses after fire to compete with invasive grasses. • Increase post-fire monitoring in systems not currently monitored.
Prevent widespread outbreaks of invasive species and invasive species establishment after disturbances.	• Include invasive species prevention strategies in all projects. • Increase regular inventory to detect new populations or species. • Coordinate invasive species management, funding, and program support among agencies. • Plan for extreme events and events with low probability. • Maintain permits for aggressive herbicide or burning treatments.
Increase resilience by promoting native species and adapted genotypes of native species.	• Consider assisted migration. • Emphasize use of species in restoration projects that will be robust to warmer temperatures and lower soil moisture. • Plant species from appropriate seed zones that are genetically adapted to warmer temperatures and lower soil moisture.
Increase understanding of changes in tree and plant species vital rates and distributions in alpine and subalpine ecosystems.	• Monitor and attribute changes in tree distribution and tree establishment patterns at tree line. • Expand long-term subalpine and alpine monitoring programs. • Coordinate among agencies to improve analysis of long-term changes in vegetation.

If none of the strategies are applicable, you may skip to the next category.

- Skip
- Continue

Skip To: End of Block If If none of the strategies are applicable, you may skip to the next category. = Skip

Which of the following issues impact your ability to implement strategies and tactics related to vegetation and disturbances? Select all that apply.

- [ ] Budget Constraints
- [ ] Conflicting Mandates
- [ ] Policy/Legal Restrictions
- [ ] Insufficient Staff Resources
- [ ] Lack of Specific Agency Direction
- [ ] Stakeholder Conflicts
- [ ] Other

If you selected other, please explain here.

_____

Do these strategies need additional financial resources such as budget increases or special funding to be sustained over time?

- Yes
- No
- Unknown

Do these strategies need additional staff resources such as additional hiring or training to be sustained over time?

- Yes
- No
- Unknown

Do these strategies need additional technological resources such as hardware, software or tools to be sustained over time?

- Yes
- No
- Unknown

Wildlife and habitat is related to wildlife, habitats, and regulations. All the strategies are listed below, please select strategies you have used for planning or other projects.
You can use the tables below for reference.

- ☐ Increase resilience of late-successional habitat in wet maritime forests.
- ☐ Increase resilience of late-successional forests and surrounding habitat in dry fire-adapted forests.
- ☐ Increase resistance of late-successional habitat in fire-adapted forests strategically across a large region.
- ☐ Increase habitat connectivity and permeability in fire-adapted forests.
- ☐ Increase amphibian population resilience by reducing non-climatic threats.
- ☐ Increase amphibian population resilience to disease and pathogens.
- ☐ Increase resilience of wetland habitat to changes in temperature and hydroperiod by enhancing breeding sites.
- ☐ Maintain and protect montane habitat for American pika, hoary marmot, and Cascade red fox.
- ☐ Increase population resilience of subalpine-dependent species.
- ☐ Not applicable

Table 3. Adaptation strategies and tactics for wildlife and wildlife habitat in the North Cascades.

Adaptation strategy	Adaptation tactics
Increase resilience of late-successional habitat in wet maritime forests.	• Increase landscape biodiversity and heterogeneity by modifying species composition. • Increase diversity of age classes and restore patch mosaic. • Accelerate development of additional late-successional habitat in matrix land outside of reserves by thinning. • Protect critical habitat structures (e.g., snags and nest trees). • Consider policy changes to allow more management and adaptive management in late-successional reserves.
Increase resilience of late-successional forests and surrounding habitat in dry fire-adapted forests.	• Increase resilience of surrounding forests with thinning and prescribed burning. • Increase fuel-reduction treatments in urban growth boundaries. • Increased use of wildfire for ecological benefits.
Increase resistance of late-successional habitat in fire-adapted forests strategically across a large region.	• Protect remnant habitat from fire and insect outbreaks. • Manage and plan for growth in the wildland–urban interface. • Increase management of human ignitions sources.
Increase habitat connectivity and permeability in fire-adapted forests.	• Increase use of conservation easements. • Increase road closures and restrictions on access in critical habitats. • Accept loss of some ecosystem components to protect others.

Increase amphibian population resilience by reducing non-climatic threats.	• Reduce non-climatic threats such as invasive species, diseases, artificial barriers to water flow, and recreation traffic. • Remove exotic fish. • Facilitate recovery from past management with habitat manipulation. • Manage road, trail, and recreation impacts. • Maintain hydrology of critical habitats. • Increase habitat connectivity and heterogeneity.
Increase amphibian population resilience to disease and pathogens.	• Manage for decreased snowpack. • Educate the public about disease sensitivities. • Limit recreation and other use through restrictions or closures.
Increase resilience of wetland habitat to changes in temperature and hydroperiod by enhancing breeding sites.	• Use vegetation to increase shading of wetlands and mircohabitats. • Retain water levels in wetlands when controlled by reservoir systems. • Increase microhabitat structures (e.g., woody debris) for microclimate refugia, nesting habitat, and egg deposition structures.
Maintain and protect montane habitat for American pika, hoary marmot, and Cascade red fox.	• Monitor tree establishment in montane meadows. • Remove trees from meadows using fire and mechanical treatments. • Monitor soil development, cryptobiotic crust, and herbaceous plant establishment in previously snow-covered and glaciated areas. • Restrict visitor around montane meadow habitats.
Increase population resilience of subalpine-dependent species.	• Increase education and regulatory enforcement to prevent adverse human–wildlife interactions. • Augment currently stressed populations of mountain goats from populations that are larger and more robust.

If none of the strategies are applicable, you may skip to the next category.

- ○ Skip
- ○ Continue

Skip To: End of Block If If none of the strategies are applicable, you may skip to the next category. = Skip

Which of the following issues impact your ability to implement strategies and tactics related to wildlife and habitat? Select all that apply.

- ☐ Budget Constraints
- ☐ Conflicting Mandates
- ☐ Policy/Legal Restrictions
- ☐ Insufficient Staff Resources
- ☐ Lack of Specific Agency Direction
- ☐ Stakeholder Conflicts
- ☐ Other

If you selected other, please explain here

_____

Do these strategies need additional financial resources such as budget increases or special funding to be sustained over time?

- Yes
- No
- Unknown

Do these strategies need additional staff resources such as additional hiring or training to be sustained over time?

- Yes
- No
- Unknown

Do these strategies need additional technological resources such as hardware, software or tools to be sustained over time?

- Yes
- No
- Unknown

Fish and habitat is related to fish, aquatic habitats, and watersheds. All the strategies are listed below, please select strategies you have used for planning or other projects.
You can use the tables below for reference.

- ☐ Increase spawning habitat resilience to higher peak flows by restoring stream and floodplain structure and processes.
- ☐ Increase habitat resilience to higher peak flows by reducing threats from roads and infrastructure in the floodplain.
- ☐ Increase aquatic habitat resilience to low summer flows.
- ☐ Manage upland vegetation to retain water and snow, slowing spring snow melt and runoff.
- ☐ Increase habitat resilience for cold-water fish sensitive to warmer temperatures by restoring structure and function of streams.
- ☐ Increase understanding of thermal heterogeneity in streams and cold-water refugia.
- ☐ Increase resilience of native fish species by reducing barriers to native species migration and removing nonnative species.
- ☐ Not applicable

Table 4. Adaptation strategies and tactics for fish and fish habitat in the North Cascades.

Adaptation strategy	Adaptation tactics
Increase spawning habitat resilience to higher peak flows by restoring stream and floodplain structure and processes.	• Restore stream and floodplain complexity. • Provide alternative habitat for spawning. • Increase protection of alternative spawning habitat. • Consider removing natural barriers to increase access to spawning habitat. • Protect habitat by increased use of engineered log jams where feasible.
Increase habitat resilience to higher peak flows by reducing threats from roads and infrastructure in the floodplain.	• Designate and restore natural floodplains and associated habitat. • Increase floodplain habitat. • Remove infrastructure from floodplains. • Disconnect roads from streams. • Reduce road density near streams. • Increase culvert capacity. • Reduce flashiness of peak flows.
Increase aquatic habitat resilience to low summer flows.	• Increase off-channel habitat and refugia in side channels and channels fed by wetlands. • Protect wetland-fed streams which maintain higher summer flows.
Manage upland vegetation to retain water and snow, slowing spring snow melt and runoff.	• Increase forest cover to retain snow and decrease snow melt. • Restore mid- and high-elevation wetlands that have been altered by past management.
Increase habitat resilience for cold-water fish sensitive to warmer temperatures by restoring structure and function of streams.	• Increase habitat and refugia in side channels. • Protect wetland-fed streams, which maintain higher summer flows. • Restore structure and heterogeneity of stream channels. • Reconnect floodplains. • Remove dikes and levees. • Restore and protect riparian vegetation.
Increase understanding of thermal heterogeneity in streams and cold-water refugia.	• Identify and inventory cold water refugia, springs, and groundwater input to streams. • Identify seasonal refugia (winter and summer). • Study the influence of lakes, reservoirs, and groundwater on stream temperatures. • Study how fish use thermal refugia.
Increase resilience of native fish species by reducing barriers to native species migration and removing nonnative species.	• Remove or control nonnative fish species. • Assess migration barriers and potential new habitat for native species. • Remove barriers to fish passage where this will not increase threats from nonnative species. • Maintain or construct barriers to prevent spread of nonnative species.

If none of the strategies are applicable, you may skip to the next category.

- Skip
- Continue

Skip To: End of Block If If none of the strategies are applicable, you may skip to the next category. = Skip

Which of the following issues impacts your ability to implement strategies and tactics related to fish and habitat? Select all that apply.

- ☐ Budget Constraints
- ☐ Conflicting Mandates
- ☐ Policy/Legal Restrictions
- ☐ Insufficient Staff Resources
- ☐ Lack of Specific Agency Direction
- ☐ Stakeholder Conflicts
- ☐ Other

If you selected other, please explain here.

_____

Do these strategies need additional financial resources such as budget increases or special funding to be sustained over time?

- ○ Yes
- ○ No
- ○ Unknown

Do these strategies need additional staff resources such as additional hiring or training to be sustained over time?

- ○ Yes
- ○ No
- ○ Unknown

Do these strategies need additional technological resources such as hardware, software or tools to be sustained over time?

- ○ Yes
- ○ No
- ○ Unknown

Are there additional tactics that you are implementing that were not included in this survey? If so, please describe those here.

_____

Are interested in receiving the results of this survey or doing a follow up interview?

- ○ Yes
- ○ No

Appendix B: Interview Questions

Perceived Impacts	Have you seen climate change impact your park/forest and if so, how?
Institutional Capacity	Do you have the resources currently to respond?
Barriers	The most common barriers reported in the survey were budget constraints and insufficient staffing levels, do these barriers impact climate change adaptation planning, if so how?
Agency Culture	Are employees in your unit aware of NCAP? How do they learn about it? (Which tactics are they currently considering or implementing?) If not aware, what are the other motivations/reasons influencing their implementation of climate change tactics?
Level of Collaboration	Do you meet and collaborate within your own agency, regarding climate change adaptation? How often? Do you meet with other agencies?
Implementation Resources	How would you like to see your agency respond to climate change? With regards to NCAP, are there different categories you would like to see more strategies for, such as recreation?

Appendix C: Interview Codebook

Theme: Perceived Impacts

Code	Definition
Fire	Increase or change in wildfire activity
Flood	More frequent or severe floods or changes in water systems
Visitation	Changes to visitation patterns
Snow/Glacier	Loss in glacier mass or shifts in snow patterns
Forest Health	Decreased forest health due to pests or diseases

Theme: Institutional Capacity

Subtheme	Code	Definition
Barriers	Budget Constraints	Restrictions due to budgets or funding
	Staffing Levels	Inadequate staffing levels or untrained staff
	Mandates	Legal or policy restrictions
	Administration Priorities	Priorities of the current administration
	External	External barriers from other agencies or the public
Agency Culture	NEPA Application	Application of NCAP strategies and tactics in NEPA planning documents
	Turnover	Employee turnover or staffing changes
	Ability to be Integrated	The ease of which NCAP strategies and tactics can be integrated in current management plans
	Awareness	General awareness of climate change from staff knowledge or social influence
	Public Pressure	External pressure from the public regarding climate change

Level of Collaboration	Uncertainty	Uncertainty as to how much climate change is being discussed amongst staff
	Transparency	Open discussions about climate change
	Lack of Communication	Little or no discussions about climate change
	NGOS	Collaboration with non-governmental organizations
	State Agencies	Collaboration with Washington state agencies (Department of Natural Resources)
	Federal Agencies	Collaboration with other federal agencies

Theme: Implementation Resources

Code	**Definition**
More science or information	More research, science or general information would improve climate change adaptation
Funding	More funding or budget increases is required
Mandates	Direct and clear mandates requiring climate change adaptation
Recreation	More strategies and tactics related to recreation
Ecosystem Services	More strategies and tactics related to ecosystem services
Tribal Relations	More strategies and tactics related to tribal relations